TEXAS HIGHWAY DEPARTMENT

1972 STANDARD SPECIFICATIONS FOR CONSTRUCTION OF HIGHWAYS, STREETS AND BRIDGES

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STANDARD SPECIFICATIONS FOR CONSTRUCTION OF HIGHWAYS, STREETS AND BRIDGES

03372

Adopted by the
State Highway Department of Texas
January 3, 1972

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PART I, GENERAL PROVISIONS

DIVISION I
GENERAL REQUIREMENTS AND COVENANTS

ITEM 1

DEFINITION OF TERMS

1.1. Definitions. Wherever in these specifications or in other contract documents, the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

1.2. State. The State of Texas, Party of the First Part.

1.3. Commission. The State Highway Commission of Texas.

1.4. Department. The State Highway Department of Texas.

1.5. County. A political subdivision of the State.

1.6. Engineer. The State Highway Engineer of Texas or his authorized representatives.

1.7. Inspector. The authorized representative of the Engineer assigned to supervise and inspect any or all parts of the work and the materials to be used therein.

1.8. Bidder. An individual, firm or corporation or any combination thereof submitting a proposal.

1.9. Contractor. The individual, firm or corporation or any combination thereof, Party of the Second Part, with which the contract is made by the State.

1.10. Superintendent. The representative of the Contractor authorized to receive and fulfill instructions from the Engineer, and who shall supervise and direct the construction.

1.11. Surety. The corporate body or bodies bound with and for the Contractor for the faithful performance of the work covered by the contract and for the payment for all labor and material supplied in the prosecution of the work.

1.12. Laboratory. The testing laboratories of the State Highway Department or any other testing laboratory that may be designated or approved by the Engineer.

1.13. Proposal. The offer of the bidder, made out on the prescribed form, giving prices for performing the work described in the plans and specifications.

1.14. Proposal Guaranty. The security designated in the proposal and furnished by the bidder as a guaranty that the bidder will enter into a contract if awarded the work.

1.15. THD Bulletin C-5. Manual of procedures and requirements for manual welding and submerged arc welding for the fabrication of structural steel.

1.16. THD Bulletin C-6. Manual of testing requirements for the qualification of welders for structural and reinforcing steel.

1.17. THD Bulletin C-11. Texas Highway Department construction bulletin outlining procedure to be followed in the design and control of portland cement concrete mixes for structures and pavements.

1.18. THD Bulletin C-14. Texas Highway Department construction bulletin outlining procedure to be followed in the design and control of asphaltic concrete paving mixtures.

1.19. Instructions to Flagmen. Texas Highway Department manual describing standard flags, signals, attire and capabilities required for flagmen.

1.20. Manual of Testing Procedures. Texas Highway Department Materials and Tests Division manual outlining testing methods and procedures.

1.21. Plans. The drawings approved by the Engineer, or true reproductions thereof, which show the location, character, dimensions, and details of the work and which are a part of the contract.

1.22. Specifications. The directions, provisions and requirements contained herein or in special specifications, supplemented by such "Special Provisions" as may be issued or made pertaining to the method and manner of performing the work or to quantities and qualities of materials to be furnished under the contract. Where the phrases "or directed by the Engineer," "ordered by the Engineer," or "to the satisfaction of the Engineer" occur, it is to be understood that the directions, orders, or instructions to which they relate are within the limitations of, and authorized by the contract. "Special Provisions" will cover work appertaining to a particular project and included in the proposal but not covered by the specifications. Where reference is made to specifications of ASTM, AASHO or Bulletins and Manuals of the Department it shall be construed to mean the latest standard or tentative standard in effect on the date of the proposal.

1.23. Supplemental Agreements. Written agreements entered into between the Contractor and the State and approved by the Surety, covering alterations and changes in plans which are necessary to the proper completion of the work.

1.24. Contract. The agreement between the State and the Contractor covering the furnishing of materials and performance of the work. The contract will include the Plans, Specifications, Special Provisions, Contract Bonds and Supplemental Agreements.

1.25. Performance Bond. The security furnished by the Contractor to guarantee the completion of the work in accordance with the terms of the contract.

1.26. Payment Bond. The security furnished by the Contractor solely for the protection of claimants, as defined by law, supplying labor and materials for the prosecution of the work in accordance with the terms of the contract.

1.27. Right of Way. The land provided for a highway.

1.28. Roadway. The portion of the highway within the limits of construction.

1.29. Roadbed. The graded portion of the roadway between the intersection of top and side slopes upon which the base course, surface course, shoulders and median are constructed.

1.30. Subgrade. That portion of the roadbed upon which the subbase, base, or pavement structure is to be placed.

1.31. Bridges. Structures of over 20-foot span measured from face to face of abutments, or in case of copings, from face to face of copings, and multiple span structures of over 20-foot length, measured between inside of end walls along the centerline of the roadbed.

1.32. Culverts. All drainage structures not defined as bridges.

1.33. Temporary Structures. All temporary bridges and structures required to maintain traffic during the construction of the work.

1.34. Substructure. That part of the structure below the bridge seats or below the springing lines of arches. Parapets, back walls and wing walls of abutments shall be considered as parts of the substructure.

1.35. Superstructure. That part of the structure above the bridge seats or above the springing lines of arches.

1.36. The Work. The work shall include the furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the contract.

1.37. Project. The specific section or sections of the highway together with all appurtenances and construction to be performed thereon under the contract.

1.38. Working Day. A working day is defined as a calendar day, not including Saturdays, Sundays, or legal holidays authorized in the list prepared by the Department for contract purposes, in which weather or other conditions not under the control of the Contractor will permit the performance of the principal units of work underway for a continuous period of not less than 7 hours between 7 a.m. and 6 p.m. For every Saturday on which the Contractor chooses to work, one day will be charged against the

contract working time when weather conditions will permit 7 hours of work as delineated above. A principal unit of work shall be that unit which controls the completion time of the contract. Nothing in this item shall be construed as prohibiting the Contractor from working on Saturdays if he so desires. Work on Sunday will not be permitted except in cases of extreme emergency and then only with the written permission of the Engineer. If Sunday work is permitted, working time will be charged on the same basis as week days.

1.39. **ASTM.** American Society for Testing Materials.

1.40. **AASHO.** American Association of State Highway Officials.

1.41. **ANSI.** American National Standards Institute.

1.42. **API.** American Petroleum Institute.

1.43. **AWS.** American Welding Society.

1.44. **NEMA.** National Electrical Manufacturers Association.

1.45. **EEI.** Edison Electric Institute.

1.46. **IES.** Illuminating Engineering Society.

1.47. **UL.** Underwriters Laboratory, Inc.

1.48. **AAN.** American Association of Nurserymen.

1.49. **AWG.** American Wire Gage.

1.50. **FHWA.** The United States Federal Highway Administration.

1.51. **IMSA.** International Municipal Signal Association.

1.52. **ITE.** Institute of Traffic Engineers.

1.53. **NBFU.** National Board of Fire Underwriters.

1.54. **NEC.** National Electrical Code (Published by NBFU).

1.55. **AWPA.** American Wood Preservers Association.

1.56. **DFPA.** Douglas Fir Plywood Association.

1.57. **Screens and Sieves.** As defined by the ASTM.

1.58. **Highway, Street or Road.** A general term denoting a public way for purposes of vehicular travel, including the entire area within the right of way. Recommended usage in urban areas—highway or street; in rural areas—highway or road.

1.59. **Arterial Highway.** A general term denoting a highway primarily for through traffic, usually on a continuous route.

1.60. **Controlled Access Highway.** Any designated State Highway within or outside the limits of any incorporated city, town or village, whether under the General Laws or by Special Charter, including Home Rule Charter cities,

to or from which access is denied or controlled, in whole or in part, from or to abutting land or intersecting streets, roads, highways, alleys or other public or private ways.

1.61. Control of Access. The condition where the right of owners or occupants of abutting land or other persons to access, light, air or view in connection with a highway is fully or partially controlled by public authority.

(1) Full Control. Full control of access means that the authority to control access is exercised to give preference to through traffic by providing access connections with selected public roads only and by prohibiting crossings at grade or direct private driveway connections.

(2) Partial Control. Partial control of access means that the authority to control access is exercised to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections.

1.62. Expressway. A divided arterial highway for through traffic with full or partial control of access and generally with grade separations at intersections.

1.63. Freeway. An expressway with full control of access.

1.64. Major Street or Major Highway. An arterial highway with intersections at grade and direct access to abutting property, and on which geometric design and traffic control measures are used to expedite the safe movement of through traffic.

1.65. Through Street or Through Highway. Every highway or portion thereof at the entrance to which vehicular traffic from intersecting highways is required by law to stop before entering or crossing the same and when stop signs are erected.

1.66. Local Street or Local Road. A street or road primarily for access to residence, business, or other abutting property.

ITEM 2
INSTRUCTIONS TO BIDDERS

2.1. Contents of Proposal Forms. Upon request, bidders will be furnished with a proposal form which will state the location and description of the proposed work, an approximate estimate of the various quantities and kinds of work to be performed or materials to be furnished, a schedule of items for which unit prices are asked, and the time within which the work is to be completed. The "Special Provisions" will be bound in the Proposal Form.

2.2. Interpretation of Estimates of Quantities. The quantities listed in the Proposal Form will be considered as approximate and will be used for the comparison of bids. Payments will be made to the Contractor only for the actual quantities of work performed or materials furnished in accordance

with the contract. The quantity of work to be done and materials to be furnished may be increased or decreased, as provided under Item 4.3.

2.3. Examination of Plans, Specifications, Special Provisions and Site of Work. Before submitting a bid, the bidder shall examine carefully the proposal, plans, specifications, special provisions, and the form of contract to be entered into for the work contemplated. He shall examine the site of work and satisfy himself as to the conditions which will be encountered relating to the character, quality, and quantity of work to be performed and materials to be furnished. The submission of a bid by bidder shall be conclusive evidence that he has complied with these requirements.

The borings, profile, and water elevations shown on the plans were obtained for use of the Department in the preparation of plans, and the bidder is hereby cautioned that the Department assumes no responsibility for the accuracy of these data. The bidder, in preparing his proposal, shall take cognizance of the difficulty of distinguishing between boulders and ledge rock, the difficulty of accurately classifying all material encountered in making foundation investigations, the possible erosion of stream channels and banks after survey data have been obtained, and the unreliability of water elevations other than for the date recorded.

Claims for additional compensation due to variations between conditions actually encountered in construction and as indicated by the plans will not be allowed.

2.4. Competency of Bidders. The bidder must be capable of performing each of the various items of work bid upon. A bid will not be considered unless the bidder shall have filed with the Department, at least 10 days prior to the date upon which bids are to be submitted, a complete statement of his financial resources and of his experience on similar work. Each bidder shall furnish, also, a statement listing the equipment available for the work being bid upon and such other information as may be called for on forms furnished by the Department.

2.5. Preparation of Proposal. The bidder shall submit his proposal on the form furnished. The blank spaces for each item as required in the proposal shall be filled in by writing in words in ink. The bidder shall submit a price for each item for which a bid is requested, except in case of an alternate. In such case, prices must be submitted for the base bid or with the items of one or more of the alternates. The proposal shall be executed with ink in the complete and correct name of the individual, firm, corporation, or combination thereof making the proposal and be signed by the person or persons authorized to bind the individual, firm, corporation or combination thereof.

2.6. Rejection of Proposals Containing Alterations, Erasures or Irregularities. Proposals may be rejected if they show any alteration of words or figures, additions not called for, conditional or uncalled for alternate bids, incomplete bids, any alteration of words or figures or erasures not initialed by the person or persons signing the proposal, or irregularities of any kind.

2.7. Proposal Guaranty. The proposal shall be accompanied by a

Proposal Guaranty of the character and in the amount as indicated in the proposal and described under "Definition of Terms", Item 1.14, Proposal Guaranty.

2.8. Delivery of Proposal. Each completed proposal shall be placed, together with the Proposal Guaranty, in a sealed envelope so marked as to indicate its contents. When submitted by mail, this envelope shall be placed in another envelope which shall also be sealed and addressed as indicated in the Notice to Contractors. Proposals will be received on or before the hour and date set for the opening thereof and must be in the hands of the official indicated by that time.

2.9. Revision of Proposal. A bidder may change a bid price entered in a proposal before it is submitted by changing the price and initialing the revision with ink. In cases where the proposal has been submitted, a bidder may change a bid price in his proposal provided his request to do so is submitted in writing and is in the hands of the State Highway Engineer prior to the time set for the opening of proposals. A request by telephone or telegraph for a change in a unit bid price will not be considered.

2.10. Withdrawal of Proposal. A bidder may withdraw his proposal provided his request in writing to do so is in the hands of the official indicated in the Notice to Contractors by the time set for opening of proposals. A request by telephone or telegraph for withdrawal of a proposal will not be considered.

2.11. Public Opening of Proposals. Proposals will be opened and read publicly at the time and place indicated in the Notice to Contractors.

2.12. Disqualification of Bidder. More than one proposal involving an individual, firm or corporation, or any combination thereof under the same or different names will not be considered. Reasonable grounds for believing that any bidder is interested in more than one proposal for the work contemplated will be cause for the rejection of all proposals in which such bidder is interested. Any or all proposals will be rejected if there is reason for believing that collusion exists among the bidders, and all participants in such collusion will not be considered in future proposals for the same work. Proposals in which the prices are obviously unbalanced may be rejected. Contracts will be awarded only to responsible bidders.

ITEM 3

AWARD AND EXECUTION OF CONTRACT

3.1. Consideration of Bids. For the purpose of award, after the proposals are opened and read, the summation of the products of the approximate quantities shown in the proposal by the unit prices bid will be considered the amount of the bid. The summations will then be compared and the results made available to the public. Until the award of the contract is made, the State reserves the right to reject any or all proposals and to waive such technicalities as may be considered for the best interest of the State.

In determining the amount of the bid as well as computing the amount due for payment of each item under the contract, the State reserves the right to round off all unit bids involving fractional parts of a cent to the nearest one-one thousandth (1/1000) cent regardless of the fraction involved. Also a unit bid of less than one-one thousandth of a cent will be considered as one-one thousandth of a cent.

3.2. Award of Contract. The award of the contract, if it be awarded, will be to the lowest reasonable bidder. The award, if made, will be within 30 days after the opening of the proposal.

3.3. Return of Proposal Guaranty. The proposal guaranty of the three lowest bidders may be retained until after the contract has been awarded, executed, and bonds made. Proposal guaranty of all except the three lowest bidders will be returned within 72 hours after the bids are opened.

3.4. Execution of Contract and Bonds. Within 15 days after written notification of award of the contract, the bidder shall execute and furnish to the Commission the contract, with (1) a performance bond and (2) a payment bond each in the full amount of the contract price, executed by a surety company or surety companies authorized to execute surety bonds under and in accordance with the laws of the State of Texas.

The (1) performance bond and (2) payment bond are to be furnished as a guarantee of the faithful performance of the work and for the protection of the claimants for labor and material as outlined in Definition of Terms, Items 1.25 and 1.26.

3.5. Execution and Approval of Contract. The contract will be approved and signed under authority of the Commission.

3.6. Failure to Execute Contract and Bonds. Should the bidder to whom the contract is awarded refuse or neglect to execute and file the contract and bonds within 15 days after written notification of the award of the contract, the proposal guaranty filed with the bid shall become the property of the State, not as a penalty, but as liquidated damages.

3.7. Beginning of Work. The Contractor shall not begin work until authorized by the Engineer in writing to do so.

ITEM 4

SCOPE OF WORK

4.1. Intent of Plans and Specifications. It is the intent of the plans and specifications to describe a completed work to be performed under the contract. Unless otherwise provided, the Contractor shall furnish all materials, supplies, tools, equipment and labor necessary for the proper prosecution and completion of the work.

4.2. Special Work. Any construction or requirements not covered by the plans or by these specifications will be covered by special specifications or

special provisions which will be included in the proposal. Such special specifications and special provisions will be considered as a part of the contract, the same as though contained fully herein.

4.3. Changes and Alterations. The Engineer will have the right to make changes and alterations in the plans or in the quantities of the work, as may be considered necessary or desirable, and such changes and alterations shall not be considered as a waiver of any condition of the contract, nor shall they invalidate any of the provisions thereof. The Contractor shall perform the work as increased or decreased, and no allowances will be made for anticipated profits.

Payment to the Contractor for contract items will be made for the actual quantities of work done and material furnished at the unit prices set forth in the contract, except as provided in specification items allowing for plan quantity payment, except as provided below for overruns or underruns of major items and except as provided below for changes in the character of the work.

When the quantity of work to be done or of materials to be furnished under any major item of the contract is more than 120 percent of the quantity stated in the proposal, then either party to the contract, upon demand, shall be entitled to revised consideration on that portion of work above 120 percent of the quantity stated in the proposal.

When the quantity of work to be done or of materials to be furnished under any major item of the contract is less than 80 percent of the quantity stated in the proposal, then either party to the contract, upon demand, shall be entitled to revised consideration on the work performed.

A "Major Item" shall be construed to be any individual bid item included in the proposal that has a total cost equal to or greater than $15,000.00 or 5 percent of the total contract cost, whichever is the lesser amount. The total contract cost shall be computed on the basis of the proposal quantities and the contract unit prices.

Work made necessary in contract items resulting in a substantial change in the character of the work which materially increases or decreases the cost of the work and which is not included in the prices bid for other items in the contract shall be, upon demand of either party to the contract, considered as "Extra Work."

Any revised consideration is to be determined by special agreement or as is hereinafter provided under "Extra Work."

4.4. Extra Work. Work made necessary by changes and alteration of plans or of quantities or for other reasons for which no prices are provided in the contract shall be defined as "Extra Work" and shall be performed by the Contractor in accordance with these specifications and as directed; provided, however, that before any extra work is begun, a "Supplemental Agreement" shall be executed or a written order issued by the Engineer to do the work on a "Force Account" basis, as hereinafter provided, under Item 9, "Measurement and Payment."

Work made necessary in contract items as a result of a substantial change in the character of the work which materially increases or decreases the cost of the work and defined as "Extra Work" as provided above shall be performed by the Contractor in accordance with these specifications and as directed; provided, however, that before any extra work is begun, a "Supplemental Agreement" shall be executed or a written order issued by the Engineer to do the work on a "Force Account" basis as hereinafter provided under Item 9, "Measurement and Payment."

4.5. Maintenance of Detours. The Contractor shall do such work as may be necessary to provide and maintain detours and facilities for safe public travel in accordance with the plans and these specifications. There shall be provided and maintained in passable condition, either by the Contractor or the State, as specified under Items 7.7 and 7.8, such temporary roads and structures as may be necessary to accommodate public travel. Temporary approaches and crossings of intersecting highways shall be provided and maintained in a safe and passable condition by the Contractor at his entire expense.

4.6. Removal and Disposal of Structures and Obstructions. All fences, buildings, and structures of any character not necessary to the construction of the work or other obstructions upon or within the limits of the right of way shall be removed by the Contractor and disposed of as directed. Unless otherwise provided in the contract, the removal and disposal of such structures and obstructions shall be performed by the Contractor at his own expense and shall be considered incidental to other items of the contract.

4.7. Rights In and Use of Materials Found on the Right of Way. The Contractor, with the approval of the Engineer, may use in the work any suitable stone, gravel, or sand found in the "Excavation" and will be paid for the excavation of such materials at the contract price bid. He shall, however, at his own expense replace with other suitable materials the materials so removed and which were intended for use in embankments, backfills, approaches, or elsewhere. No charge for materials so used will be made against the Contractor. The Contractor shall not excavate nor remove any material from within the highway which is not within the excavation, as indicated by the slope and grade lines, without written authorization from the Engineer.

4.8. Final Cleaning Up. Upon completion of the work and before acceptance and final payment is made, the Contractor shall clean, remove rubbish and temporary structures from the highway, restore in an acceptable manner all property which has been damaged during the prosecution of the work, and leave the site of the work in a neat and presentable condition throughout.

Upon the completion of any structure, all excess materials, cofferdams, construction buildings, temporary structures, and debris resulting from construction shall be removed. Where work is in a stream, all debris shall be removed to the ground line of the bed of the stream, and the stream channels, structure, and highway left unobstructed and in a neat and presentable condition. Materials cleared from the highway and deposited on property

adjacent thereto will not be considered as a satisfactory method of disposal, unless approved by the Engineer. No direct payment will be made for this work, its cost being included in the unit prices bid.

ITEM 5
CONTROL OF THE WORK

5.1. Authority of Engineer. The work will be done under the supervision of the Engineer, to his satisfaction, and in accordance with the contract, plans and specifications. The Engineer will decide all questions which may arise as to the quality or acceptability of materials furnished and work performed; the manner of performance and rate of progress of the work; the interpretations of the plans and specifications; and the acceptable fulfillment of the contract on the part of the Contractor. His decisions will be final, and he will have executive authority to enforce and make effective such decisions and orders as the Contractor fails to carry out promptly.

5.2. Engineer as Referee. The Engineer will act as referee in all questions arising under the terms of the contract between the parties thereto, and his decisions shall be final and binding.

5.3. Plans. The plans will show in detail the work to be accomplished under the contract. Where supplementary bridge plans, shop details, and working drawings are necessary, they shall be furnished by the Contractor, and approved by the Engineer prior to the beginning of the work involved. Authorized alterations will be approved by endorsement on the plans or shown on supplementary sheets. The approval by the Engineer of the Contractor's working drawings will not relieve the Contractor of any responsibility under the contract.

It is the responsibility of the Contractor to verify all quantities of materials shown on the plans before ordering same, as payment is provided for acceptable materials complete in place, and materials rejected due to improper fabrication or excess quantity or for other reasons within the control of the Contractor will not be paid for regardless of the quantities or dimensions shown on the plans. The Engineer, when requested, will check any or all material orders prepared by the Contractor, but such check will not relieve the Contractor of responsibility.

5.4. Conformity with Plans, Specifications and Special Provisions. All work performed and all materials furnished shall be in reasonably close conformity with the lines, grades, cross sections, dimensions, details, gradations, physical and chemical characteristics of materials in accordance with tolerances shown on the plans or indicated in the specifications and special provisions. The limits establishing reasonably close conformity will be as defined in these items of the contract.

In the event the Engineer finds that the work performed or the materials used are not within reasonably close conformity with the plans, specifications and special provisions, the affected material or product shall be removed and replaced or otherwise satisfactorily corrected by and at the expense of the contractor.

Deviations from the plans and approved working drawings as may be required will in all cases be determined by the Engineer and authorized in writing.

5.5. Co-ordination of Plans, Specifications and Special Provisions. The specifications, the accompanying plans, special provisions, and supplemental agreements, are essential parts of the contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be co-operative and to describe and provide for a complete work. In cases of disagreement, figured dimensions shall govern over scaled dimensions, plans shall govern over specifications, and special provisions shall govern over both specifications and plans.

5.6. Co-operation of Contractor. The Contractor will be supplied with four copies of the plans, special specifications and special provisions, and he shall have available on the work at all times one copy of each. He shall give the work his constant attention to facilitate the progress thereof and shall co-operate with the Engineer in every way possible. He shall have at all times a satisfactory and competent English-speaking Superintendent on the work, authorized to receive orders and to act for him. The Contractor shall designate to the Engineer in writing the name of such Superintendent, and he shall be furnished by the Contractor regardless of how much of the work may be sublet.

5.7. Construction Stakes. The Engineer will furnish and set construction stakes establishing lines and grades in roadway work and centerlines and benchmarks for bridge work and will furnish the Contractor with all necessary information relating to lines and grades. These stakes will be set sufficiently in advance of the work to avoid delay. The Contractor shall furnish, free of charge, additional stakes and other materials and templates necessary for marking and maintaining points and lines. The Contractor will be held responsible for the preservation of all stakes and marks, and if, in the opinion of the Engineer, any of the stakes or marks have been carelessly or wilfully destroyed or disturbed by the Contractor, the cost of replacing them will be charged against him and deducted from the payment for the work.

5.8. Authority and Duties of Inspectors. Inspectors will be authorized to inspect all work done and all materials furnished. Such inspection may extend to all or to any part of the work and to the preparation or manufacture of the materials to be used. An Inspector will be stationed on the work to report to the Engineer as to the progress of the work and the manner in which it is being performed; also to report whenever it appears that the materials furnished and the work performed by the Contractor fail to fulfill the requirements of the specifications and contract; and to call the attention of the Contractor to any such failure or other infringement. Such inspection will not relieve the Contractor from any obligation to perform the work in accordance with the requirements of the specifications. In case of any dispute arising between the Contractor and the Inspector as to materials furnished or the manner of performing the work, the Inspector will have authority to reject materials or suspend work until the question at issue can be referred to and decided by the Engineer. The Inspector will not be authorized to revoke,

alter, enlarge, or release any requirement of these specifications, nor to approve or accept any portion of work, nor to issue instructions contrary to the plans and specifications. He will in no case act as foreman or perform other duties for the Contractor nor interfere with the management of the work.

5.9. Inspection. The Contractor shall furnish the Engineer with every reasonable facility for ascertaining whether or not the work as performed is in accordance with the requirements and intent of the contract. If the Engineer so requests the Contractor shall, at any time before acceptance of the work, remove or uncover portions of the finished work as may be directed. After examination, the Contractor shall restore said portion of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering or removing and replacing of the covering or making good of the parts removed shall be paid for as "Extra Work"; but should the work so exposed or examined prove unacceptable, the uncovering or removing and the replacing of the covering or making good of the parts removed shall be at the Contractor's expense. No work shall be done nor materials used without suitable supervision or inspection.

5.10. Federal Inspection. When the United States Government is to pay a portion of the cost of the work covered by the contract, the work will be subject to the inspection of its representative. Such inspection will in no sense make the United States Government a party to the contract.

5.11. Removal of Defective and Unauthorized Work. All work which has been rejected shall be remedied or removed and replaced in an acceptable manner by the Contractor at his own expense. Work done beyond the lines and grades given or as shown on the plans, except as herein provided, or any extra work done without written authority will be considered as unauthorized and done at the expense of the Contractor and will not be paid for. Work so done may be ordered removed at the Contractor's expense. Upon failure on the part of the Contractor to comply with any order of the Engineer made under the provisions of this paragraph, the Engineer will have authority to cause defective work to be remedied or removed and replaced and unauthorized work to be removed, and the cost thereof may be deducted from any money due or to become due to the Contractor.

5.12. Final Inspection. Whenever the work provided for in, and contemplated under, the contract has been satisfactorily completed and the final cleaning up performed, the Engineer in charge of the work will notify the Engineer authorized to accept same to make the "Final Inspection". Such inspection will be made within 10 days after such notification. After such final inspection, if the work is found to be satisfactory, the Contractor will be notified in writing of the acceptance of same. No time charge will be made against the Contractor between said date of notification of the Engineer in charge and the date of final inspection of the work.

Where the work consists of concrete pavements or concrete base, the "Final Acceptance" will not release the Contractor from responsibility for the thickness of the concrete, which will be determined by means of taking cores from the pavement. The coring of the pavement will be done within 90 days from completion of the pavement.

ITEM 6

CONTROL OF MATERIALS

6.1. Sources of Supply and Quality of Materials. The source of supply of each of the materials shall be approved by the Engineer before delivery is started and at the option of the Engineer, may be sampled and tested for determining compliance with the governing specifications by the Engineer before delivery is started. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any source proves unacceptable at any time, the Contractor shall furnish materials from other approved sources. Only materials conforming to the requirements of these specifications and approved by the Engineer shall be used in the work. All materials being used are subject to inspection or test at any time during their preparation or use. Any material which has been tested and accepted at the source of supply may be subjected to a check test after delivery and all materials which, when retested, do not meet the requirements of the specifications, will be rejected. No material which after approval has in any way become unfit for use shall be used in the work.

Throughout these specifications where reference is made to ASTM, AASHO or bulletins of the Department for the quality of materials or sampling and testing, the latest standard, tentative standard or bulletin issued prior to the date of the proposal shall govern.

6.2. Samples and Tests. All materials, before being incorporated in the work, shall be inspected, tested and approved by the Engineer, and any work in which materials are used without prior test and approval or written permission of the Engineer may be ordered removed and replaced at the Contractor's expense. Sampling and testing of all materials proposed to be used, will be made by the Engineer. The selection of the method of test shall be designated by the Department. Where tests are required, other than those made in the laboratory, for the purpose of control in the manufacture of a construction item, the Contractor will be required to furnish such facilities and equipment as may be necessary to perform the tests and inspection and shall be responsible for calibration of all test equipment required. When requested, the Contractor shall furnish a complete written statement of the origin, composition, and/or manufacture of any or all materials that are to be used in the work.

6.3. Plant Inspection. If the volume of the work, construction progress, and other considerations warrant, the Engineer may undertake the inspection of materials at the source. It is understood, however, that no obligation is assumed to inspect materials in that manner.

Plant inspection will be undertaken only upon condition that:

(a) The cooperation and assistance of the Contractor and the producer with whom he has contracted for materials is assured.

(b) The representative of the Engineer shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials ordered.

(c) When required by the Engineer, the material producer shall furnish an approved weather-proof building for the use of the Inspector, such building to be located conveniently near the plant and independent of any building used by the material producer.

(d) Where inspection requirements are such that it is necessary to use scales, measures and other devices for the control of production and use of materials, the Contractor shall be responsible for furnishing and calibrating such equipment as may be required by the Department.

(e) In those cases where inspection of any item is requested for periods other than daylight hours, it shall be provided under the following conditions:

(1) Continuous production of materials for Departmental use is necessary due to the production volume being handled by the plant.

(2) The lighting provided by the plant is approved by the Engineer to be adequate to allow satisfactory inspection of the material being produced.

6.4. Storage of Materials. Materials shall be so stored as to insure the preservation of their quality and fitness for the work. When considered necessary by the Engineer, they shall be placed on wooden platforms or other hard, clean surfaces and not on the ground. They shall be placed under cover when so directed. Stored materials shall be so located as to facilitate prompt inspection.

6.5. Defective Materials. All materials not conforming to the requirements of these specifications will be rejected and shall be removed immediately from the site of the work unless permitted to remain by the Engineer. Rejected materials, the defects of which have been subsequently corrected, shall have the status of new material. Upon failure on the part of the Contractor to comply with any order of the Engineer made under the provisions of this item, the Engineer will have authority to remove and replace defective material and to deduct the cost of removal and replacement from any money due or to become due to the Contractor.

ITEM 7

LEGAL RELATIONS AND RESPONSIBILITIES TO THE PUBLIC

7.1. Laws to be Observed. The Contractor shall make himself familiar with and at all times shall observe and comply with all Federal, State, and local laws, ordinances, and regulations which in any manner affect the conduct of the work and shall indemnify and save harmless the State and its representatives against any claim arising from the violation of any such law, ordinance, or regulation, whether by himself or by his employees.

It is specifically agreed between the parties executing this contract that it is not intended by any of the provisions of any part of the contract to create the public or any member thereof a third party beneficiary hereunder, or to

authorize any one not a party to this contract to maintain a suit for personal injuries or property damage pursuant to the terms or provisions of this contract. The duties, obligations and responsibilities of the parties to this contract with respect to third parties shall remain as imposed by law.

7.2. Permits, Licenses and Taxes. The Contractor shall procure all permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incident to the due and lawful prosecution of the work.

7.3. Patented Devices, Materials and Processes. If the Contractor is required or desires to use any design, device, material, or process covered by letters of patent or copyright, he shall provide for such use by suitable agreement with the patentee or owner. The Contractor and the surety shall indemnify and save harmless the State from any and all claims for infringement by reason of the use of any patented design, device, materials, or process, or any trademark or copyright used in connection with the work and they shall indemnify the State against any costs, expenses, or damages which it may be obliged to pay, by reason of such infringement, at any time during the prosecution or after the completion of the work.

7.4. Federal Participation. On Federal-Aid projects, the United States Government participates under the Provisions of the Federal Highway Act. This act provides that the work shall be done under the direct supervision of the State Highway Department.

7.5. Restoration of Surfaces Opened by Permit. The Contractor shall not allow any party to make an opening in the highway unless a duly authorized permit signed by the Engineer is presented. Until the acceptance of the work, the Contractor shall make all necessary repairs in the roadway where openings have been made by due authority. Such repair work will be paid for on the basis of "Extra Work" as provided for in these specifications.

7.6. Sanitary Provisions. The Contractor shall, at his entire expense, provide and maintain in a neat, sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements and regulations of the State Department of Health or of other authorities having jurisdiction.

7.7. Public Safety and Convenience. The safety of the public and the convenience of traffic shall be regarded as of prime importance. Unless otherwise shown on plans or except as herein provided, all portions of the highway shall be kept open to traffic. It shall be the entire responsibility of the Contractor to provide for traffic along and across the highway as well as for ingress and egress to private property all as specified herein, as shown on plans or as directed by the Engineer.

The Contractor shall plan and execute his operations in a manner that will cause the minimum interference with traffic. The Contractor shall secure the Engineer's approval of his proposed plan of operation, sequence of work and methods of providing for the safe passage of traffic before it is placed into operation. If at any time during construction the approved plan does not accomplish the intended purpose, due to weather or other conditions

affecting the safe handling of traffic, the Contractor shall immediately make necessary changes therein to correct the unsatisfactory conditions.

If due to rains or other reasons, the shoulders, slopes and ditches become unsatisfactory for handling traffic, construction operations shall be suspended and the base course or surface area shall be opened to traffic. Where the specifications require or the Engineer directs that traffic be carried over or along the proposed work, construction operations shall be so prosecuted and new material kept so placed and spread as to allow the passage of traffic in comfort and safety.

Where an Asphalt Surface Treatment is placed for the full width in one operation, traffic shall be carried on the shoulder slopes and ditches. During the operation of placing asphalt and aggregate, the surface or pavement shall not be closed to traffic for a period of more than 45 minutes.

During construction of proposed structures, unless otherwise shown on plans, the Contractor shall provide and maintain detours including temporary structures or crossovers of adequate structural design as may be required for the safety and convenience of the traffic. Unless otherwise provided on plans, the cost of constructing such temporary detours will be paid for as "Extra Work".

At night or otherwise, all equipment not in use shall be stored in such manner and at such locations as not to interfere with the safe passage of traffic. The Contractor shall provide and maintain flagmen at such points and for such periods of time as may be required to provide for the safety and convenience of public travel and Contractor's personnel, and as directed by the Engineer. Flagmen shall be English speaking, courteous, well informed, physically and mentally able effectually to perform their duties in safeguarding and directing traffic and protecting the work, and shall be neatly attired and groomed at all times when on duty. When directing traffic, flagmen shall use the standard attire, flags and signals and follow the flagging procedures set forth in "Instructions to Flagmen" published by the Texas Highway Department.

Except as otherwise provided above or elsewhere in the contract, these provisions for directing traffic, maintenance of detours and subsequent obliteration thereof, flagmen etc., will not be paid for directly but shall be considered as subsidiary work pertaining to the various bid items of this contract.

7.8. Barricades and Danger, Warning and Detour Signs. The Contractor shall place and maintain in good condition, standard barricades and warning signs at each end of the project and at other locations therein as called for on plans or as called for in the Contractor's approved plan of operation. The signs shall be of standard design as shown on plans.

All barricades and signs remaining in place at night and all points of hazard to traffic shall be illuminated by lights between sunset and sunrise. Signs which refer to construction operations which do not apply after work has ended for the day, shall be moved to points that are not visible to traffic until construction is resumed. The term "lights", as used herein shall mean

flares, flashers or both as determined by the Engineer. The size of flasher lights shall be approved by the Engineer.

The Contractor may provide special signs not covered by plans to protect the traveling public against special conditions or hazards, provided however, that such signs are first approved by the Engineer.

Upon completion of the work, all signs and evidences thereof shall be removed by the Contractor.

All materials furnished and work performed under these provisions will not be paid for directly, but shall be considered as subsidiary work pertaining to the various bid items of the contract.

7.9. Use of Explosives. When the use of explosives is necessary for the prosecution of the work, the Contractor shall use the utmost care not to endanger life or property. All explosives shall be stored in a secure manner, and all storage places shall be marked clearly "DANGEROUS–EXPLOSIVES". The method of storing and handling explosives and highly inflammable materials shall conform with Federal and State laws and regulations.

In advance of doing any blasting work, involving the use of electric blasting caps within 200 feet of any railroad track, the Contractor shall give at least 24 hours advance notice to the nearest Roadmaster, Section Foreman, Agent, Signal Maintainer or Telegraph Operator with the request that his Superintendent be advised immediately of the pending use of explosives.

7.10. Protection of Adjoining Property. The Contractor shall take proper measures to protect the adjacent or adjoining property which might be injured by any process of construction, and, in case of any injury or damage resulting from any act or omission on the part of or on behalf of the Contractor, he shall restore at his own expense the damaged property to a condition similar or equal to that existing before such injury or damage was done, or he shall make good such injury or damage in an acceptable manner.

7.11. Responsibility for Damage Claims. The Contractor shall save harmless the State from all suits, actions or claims brought on account of any injuries or damages sustained by any person or property in consequence of any neglect in safeguarding the work by the Contractor; or from any claims or amounts arising or recovered under the "Workmen's Compensation Laws" or any other laws. He shall be responsible for all damage or injury to property of any character occurring during the prosecution of the work resulting from any act, omission, neglect, or misconduct on his part in the manner or method of executing the work; or from his failure to properly execute the work; or from defective work or materials. He shall not be released from such responsibility until all claims have been settled and suitable evidence to that effect furnished the Commission.

The Contractor's attention is directed to the fact that pipelines and other underground installations as may be shown on the plans have been taken from the best available information. There may be other pipelines or installations. The Contractor shall save harmless the State from any and all

suits or claims resulting from damage by his operations to any pipeline or underground installation.

7.12. Contractor's Responsibility for Work. Until the final acceptance of the work by the Engineer, as evidenced in writing, it shall be under the charge and care of the Contractor. The Contractor shall rebuild and make good at his own expense all injuries and damages to the work occurring before its completion and acceptance. In case of suspension of work for any cause, the Contractor shall be responsible for the preservation of all materials. He shall provide suitable drainage of the roadway and shall erect temporary structures where required. The Contractor shall maintain the roadway in good and passable condition until final acceptance.

Wherever in the opinion of the Engineer any roadway or portion thereof is in suitable condition for travel, it shall be opened to traffic, as may be directed, and such opening shall not be held to be in any way the final acceptance of the roadway or any part of it or as a waiver of any of the provisions of the contract. Where it is considered by the Engineer to be in the public interest and so ordered in writing by him, any substantially completed roadway or portion thereof may be opened to traffic as follows: (1) When work is suspended for a considerable period of time at the convenience of the State the Department will assume the responsibility for maintaining the entire roadway during the period of suspension. (2) When the roadway or portion thereof is opened to traffic during construction operations at the convenience of the State the Department will assume responsibility for the maintenance of the traveled way and shoulders during the period in which it is opened to traffic. The State in assuming responsibility for maintenance under this provision may require the work to be done as extra work or may do it with its own forces.

7.13. Personal Liability of Public Officials. In carrying out the provisions of the contract or in exercising any power or authority granted thereunder, there shall be no liability upon the Engineer or his authorized assistants, either personally or otherwise, as they are agents and representatives of the State.

ITEM 8

PROSECUTION AND PROGRESS

8.1. Subletting or Assigning of Contract. The Contractor will not be permitted to assign, sell, transfer, or otherwise dispose of the contract or any portion thereof, or his rights, title, or interest therein without the approval of the Commission. The Contractor will not be permitted to sublet any portion of the contract without the approval of the Engineer. No sub-contract will, in any case, relieve the Contractor of his responsibility under the contract and bond.

The Contractor shall perform with his own organization and with the assistance of workmen under his immediate superintendence, work of a value not less than 50 percent of the value of all work embraced in the contract

exclusive of items not commonly found in contracts for similar work, or which require highly specialized knowledge, craftsmanship and/or equipment not ordinarily available in the organizations of Contractors performing work of the character embraced in the contract. The Contractor shall give assurance that the minimum wage for labor and the maximum amount to be deducted for board, if furnished, as stated in the governing provisions shall apply to labor performed on all work sublet, assigned or otherwise disposed of in any way. Written consent to sublet, assign or otherwise dispose of any portion of the contract shall not be construed to relieve the Contractor of any responsibility for the fulfillment of the contract.

8.2. Prosecution of Work. Prior to beginning construction operations, the Contractor shall submit to the Engineer a chart or brief outlining the manner of prosecution of the work that he intends to follow in order to complete the contract within the allotted time. The Contractor shall begin the work to be performed under the contract within 30 days after the date of the authorization to begin work and shall continuously prosecute same with such dilgence as will enable him to complete the work within the time limit specified. He shall notify the Engineer at least 24 hours before beginning work at any point. He shall not open up work to the detriment of work already begun. The beginning, sequence, and prosecuting of the work shall be governed by the orders of the Engineer, and the Contractor shall conduct his operations so as to impose a minimum interference to traffic.

8.3. Workmen and Equipment. All workmen employed by the Contractor shall have such skill and experience as will enable them to properly perform the duties assigned them. Any person employed by the Contractor or a subcontractor who, in the opinion of the Engineer, does not perform his work in a proper and skillful manner, or who is disrespectful, intemperate, disorderly, or otherwise objectionable, shall at the written request of the Engineer be forthwith discharged and shall not be employed again on any portion of the work without the written consent of the Engineer. The Contractor shall furnish such suitable machinery, equipment, and construction forces as may be necessary, in the opinion of the Engineer, for the proper prosecution of the work, and failure to do so may cause the Engineer to withhold all estimates which have or may become due or the Engineer may suspend the work until his requests are complied with.

8.4. Temporary Suspension of Work. The Engineer will have authority to suspend the work, wholly or in part, for such period as he may consider necessary, and the "Time Charge" will be suspended during such period. Notice of such suspension with the reasons therefor will be given the Contractor in writing. The Contractor shall not suspend work without written authority of the Engineer.

8.5. Computation of Contract Time for Completion. The Contractor shall complete the work within the number of working days stated in the contract. For the purpose of computation, working days will be considered 15 days after the date of the written authorization by the Engineer to begin work.

The Engineer will furnish the Contractor a monthly statement on forms furnished by the Department, showing number of working days charged during the month, total number of working days allowed in contract, and the working days remaining under the contract. The Contractor will be allowed 10 days in which to protest the correctness of the statement, otherwise the statement will stand. If the satisfactory completion of the contract shall require unforeseen work or work and materials in greater amounts than those set forth in the contract, then additional working days or suspension of time charge will be allowed the Contractor equal to the time which, in the opinion of the Engineer, the work as a whole is delayed.

8.6. Failure to Complete Work on Time. If the Contractor fails to complete the contract in the working days specified, the time charge will be made for each working day thereafter.

The time set forth in the Proposal for the completion of the work is an essential element of the contract. For each working day under the conditions described in the preceding paragraph that any work shall remain uncompleted after the expiration of the working days specified in the contract, together with any additional working days allowed, the amount per day given in the following schedule will be deducted from the money due or to become due the Contractor, not as a penalty, but as liquidated damages and added expense for engineering supervision:

For Amount of Contract		Amount of Liquidated Damages Per Working Day
From More Than	To and Including	
$ 0	$ 25,000	$ 42
25,000	50,000	70
50,000	100,000	105
100,000	500,000	140
500,000	1,000,000	210
1,000,000	2,000,000	280
2,000,000	—	420

8.7. Abandonment of Work or Default of Contract. If the Contractor fails to begin the work within the time specified; or fails to perform the work with sufficient workmen and equipment; or has insufficient materials to insure the completion of the work within the contract time; or shall perform the work unsuitably; or shall neglect or refuse to remove materials or perform anew such work as may have been rejected as being defective or unsuitable; or shall discontinue the prosecution of the work without authority; or shall become insolvent or be declared bankrupt; or shall commit any act of bankruptcy or insolvency; or shall make an unauthorized assignment for the benefit of any creditor; or from any other cause whatsoever shall not carry on the work in an acceptable manner, the Engineer may give notice in writing to the Contractor and his Surety of such delay, neglect, or default, specifying the same. If the Contractor within a period of 10 days after such notice shall not proceed in accordance therewith, then the party of the first part shall, upon written certificate from the Engineer of the fact of such delay, neglect,

or default and the Contractor's failure to comply with such notice, have full power and authority, without violating the contract, to take the prosecution of the work out of the hands of the Contractor and to appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable, and enter into an agreement for the completion of the contract according to the terms and provisions thereof or use such other methods as in his opinion may be required for the completion of the contract in an acceptable manner. All costs and charges incurred by the party of the first part, together with the costs of completing the work under contract, shall be deducted from any money due, or which may become due, the Contractor. In case the cost so incurred by the party of the first part shall be less than the amount which would have been payable under the contract if it had been completed by the Contractor, the Contractor will be entitled to receive the difference. In case such cost shall exceed the amount which would have been payable under the contract, then the Contractor and the Surety shall be liable and shall pay to the party of the first part the amount of such excess.

ITEM 9

MEASUREMENT AND PAYMENT

9.1. Measurement of Quantities. All work completed under contract will be measured by the Engineer according to United States Standard Measures unless otherwise specified. All longitudinal measurements for surface area will be made along the actual surface of the roadway and not horizontally, and no deduction will be made for structures in the roadway having an area of 9 square feet or less. For all transverse measurements for areas of base courses, surface courses, and pavements, the dimensions to be used in calculating the pay areas will be the neat dimensions and shall not exceed those shown on plans or ordered in writing by the Engineer. All materials which are specified for measurement by the cubic yard in vehicles shall be hauled in approved vehicles and measured therein at the point of delivery on the roadway. Vehicles for this purpose may be of any type or size satisfactory to the Engineer provided that the body is of such type that the actual contents may be readily and accurately determined. Each approved vehicle shall bear an identification mark indicating specific approval by the Engineer and also a permanent, plainly legible number. The Inspector may reject all loads not hauled in such approved vehicles.

In those items which provide for payment by "Plan Quality", the measurement of such quantities shall be made by standard methods of calculation, using the methods described in the governing specification, and may or may not represent the exact quantity of material moved, handled or placed in the roadway or structure during the execution of the contract. The quantities shown on the plans, adjusted in accordance with the governing specification when required, will be the quantity to be paid for.

9.2. Scope of Payment. The Contractor shall accept the compensation, as provided in the contract, in full payment for furnishing all materials, supplies, labor, tools and equipment necessary to complete the work under

the contract; for any loss or damage which may arise from the nature of the work, from the action of the elements, or from any unforeseen difficulties which may be encountered during the prosecution of the work, until the final acceptance by the Engineer, except where there is conclusive evidence that such damage is due to inadequate design and not to improper prosecution of the work; for all risks of every description connected with the prosecution of the work; for all expenses and damages which might accrue to the Contractor by reason of delay in the initiation and prosecution of the work for any cause whatsoever; for any infringement of patent, trademark, or copyright; and for completing the work according to the plans and specifications. The payment of any current or partial estimate shall in no way affect the obligation of the Contractor at his own cost to repair or renew any defective parts of the construction or to replace any defective materials used in the construction and to be responsible for all damages due to such defects if such defects or damages are discovered on or before the final inspection and acceptance of the work.

9.3. Payment and Compensation for Altered Quantities. When alterations in plans or quantities of work not requiring supplemental agreements, as hereinbefore provided for, are ordered and performed, the Contractor shall accept payment in full at the contract unit prices for actual quantities of work performed and materials furnished, and no allowance will be made for anticipated profits.

9.4. Payment for Extra Work. Extra work ordered, performed, and accepted will be paid for according to the terms of "Supplemental Agreements" or on the "Force Account" basis.

9.5. Force Account. When extra work is ordered to be performed on the "Force Account" basis, payment for same will be made as follows:

For all labor and foremen the Contractor will receive the rate of wage, to be agreed upon in writing before beginning such work, for each hour that said labor and foremen are actually engaged in such work, to which shall be added an amount equal to 15 percent of the sum thereof as compensation. No charge will be made by the Contractor for organization or overhead expenses except for actual cost of premiums on public liability and workmen's compensation insurance, old age benefit social security, unemployment insurance taxes, and Contractor's bonds. No charge for superintendence will be made unless considered necessary and ordered by the Engineer.

The Contractor will receive the actual cost, including freight charges, of the materials used on such work to which cost will be added a sum equal to 15 percent thereof as compensation. In case material invoices indicate a discount may be taken, the actual cost will be the invoice price minus the discount.

For machinery, trucks, power tools, or other similar equipment which may be considered necessary or desirable to use, the Engineer will allow the Contractor a reasonable rental price, as agreed upon in writing before such work is begun, for each hour that said tools or equipment are in use on the work, which price will include the cost of fuel, lubricants, and repairs without any additional compensation percentage being added.

The compensation, as herein provided for, shall be received by the Contractor as payment in full for extra work done on the "Force Account" basis and will include use of small tools, overhead expense, and profit. The Contractor's representative and the Inspector shall compare records of extra work done on the "Force Account" basis at the end of each day. Copies of these records will be made upon suitable forms provided for this purpose by the Department Inspector and signed by both the Inspector and the Contractor's representative, one copy being forwarded to the Engineer and one to the Contractor. All claims for "Extra Work" performed on the "Force Account" basis shall be submitted to the Engineer by the Contractor upon certified statements to which shall be attached certified copies of invoices covering the cost of, and the freight charges on, all materials used in such work, and such statements shall be filed not later than the tenth day of the month following that in which the work was actually performed.

9.6. Partial Payments. The Engineer once each month will make an approximate estimate in writing of the materials in place and the amount of work performed and the value thereof at the contract unit prices.

In addition to the above and upon presentation of copies of invoices and freight bills, an estimate shall be made and included for the invoice cost of acceptable reinforcing steel, structural steel, precast concrete members, stone, gravel, sand or any other non-perishable materials delivered on the work or in acceptable storage places and which have not been used in the work prior to such estimate.

For acceptable structural steel and concrete members or units, requiring approved shop drawings, which are completely constructed and/or fabricated on the Contractor's order for a specific project, and on which an approved Test Report has been issued and in acceptable storage as established by the Materials and Tests Engineer within the State of Texas, an estimate shall be made and included for the invoice cost, exclusive of any transportation costs, of the material involved.

For precast concrete products which may be completely fabricated or constructed by the Contractor for which invoices or freight bills are not pertinent, and which have been stored in acceptable storage places, and which have not been used in the work, an estimate will be made and included for 60 percent of the unit price bid for the specified products.

Partial payments for material on hand or in acceptable storage shall not exceed the bid price.

From the total of the amounts so ascertained will be deducted 5 percent to be retained until after the completion of the entire work to the satisfaction of the Engineer, and the remaining 95 percent of the amount so ascertained will be paid to the Contractor less such amounts as may be required by the contract to be retained.

No estimate other than a final estimate will be made where the value of the work performed since the last preceding estimate is less than $1,000.00.

9.7. Acceptance and Final Payment. When the work provided for in the contract shall have been completed by the Contractor, and all parts of the

work have been approved and accepted by the Engineer, a final estimate showing the amount of the work and the amount due the Contractor under the contract will be prepared by the Engineer. The amount of the final estimate, less any sums previously paid under the contract will be paid to the Contractor.

PART II, CONSTRUCTION DETAILS

DIVISION I
EARTHWORK

ITEM 100

PREPARING RIGHT OF WAY

100.1. Description. This item shall consist of preparing the right of way for construction operations by the removal and disposal of all obstructions from the right of way and from designated easements, where removal of such obstructions is not otherwise provided for in the plans and specifications.

Such obstructions shall be considered to include remains of houses not completely removed by others, foundations, floor slabs, concrete, brick, lumber, plaster, cisterns, water wells, septic tanks, basements, abandoned utility pipes or conduits, underground service station tanks, equipment or other foundations, fences, retaining walls, outhouses, shacks, and all other debris.

This item shall also include the removal of trees and shrubs and other landscape features not designated for preservation, stumps, curb and gutter, driveways, paved parking areas, miscellaneous stone, brick, concrete, sidewalks, drainage structures, manholes, inlets, abandoned railroad tracks, scrap iron, all rubish and debris whether above or below ground except live utility facilities.

It is the intent of this specification to provide for the removal and disposal of all obstructions and objectional materials not specifically provided for elsewhere by the plans and specifications.

100.2. Construction Methods. The right of way for this project and such additional areas, including public or corporate areas, as made available for construction of this project shall be cleared of all structures and obstructions as defined above. Those trees, shrubs and other landscape features specifically designated by the Engineer for preservation shall be carefully protected from abuse, marring, or damage during construction operations. Continual parking and/or servicing of equipment under the branches of trees marked for preservation will not be permitted. Trees and shrubs designated for preservation that must be pruned shall be trimmed as directed and all exposed cuts over 2 inches in diameter shall be treated with an approved asphaltic material.

Culverts, storm sewers, manholes and inlets shall be removed in proper sequence for maintenance of traffic and drainage. Unless otherwise indicated on plans all foundations and underground obstructions shall be removed to the following depths:

(1) In areas to receive embankment, 2 feet below natural ground.

(2) In areas to be excavated, 2 feet below the lower elevation of the excavation.

(3) All other areas, 1 foot below natural ground.

Trees, stumps, brush, roots, vegetation, logs, rubbish and other objectional matter shall be removed in accordance with the Item, "Clearing and Grubbing".

All basement walls and floors, cisterns, septic tanks and storage tanks within the limits of the right of way shall be removed and the resulting holes backfilled with approved material as directed by the Engineer.

Holes remaining after removal of all obstructions, objectional material, trees, stumps, etc. shall be backfilled and tamped as directed by Engineer. The Contractor shall complete the operation of preparing right of way by blading, bulldozing, or by other approved methods, so that the prepared right of way shall be free of holes, ditches and other abrupt changes in elevations and irregularities of contour.

The remaining ends of all abandoned storm sewers, culverts, sanitary sewers, conduits, and water or gas pipes over 3 inches in diameter, shall be plugged with an adequate quantity of concrete to form a tight closure when backfilling is required.

Abandoned water wells shall be removed to the grade indicated on the plans or as directed by the Engineer.

All materials and debris removed shall become the property of the Contractor and shall be removed from the right of way, except gravel, brick, stone, or broken concrete when permitted by the Engineer may be used in the roadway embankment.

Materials placed in the embankment shall conform to the requirements of the governing specification for "Embankment".

100.3. Measurement. "Preparing Right of Way" will be measured by the "Acre" or by the "100-Foot Station" regardless of the width of the established right of way.

Measurement for payment will be made only on areas indicated and classified on plans as "Preparing Right of Way" except that required work on additional areas (such as additional right of way, additional cut and embankment areas, etc.,) not originally proposed by plans but found necessary during construction, and which comes within the purview of "Preparing Right of Way" as established on plans for the contract shall be measured accordingly.

Areas other than those set forth above will not be measured for payment.

100.4. Payment. All work performed and measured as provided under "Measurement" will be paid for at the unit price bid for "Preparing Right of Way", which price shall be full compensation for furnishing all labor, equipment, tools, supplies and incidentals necessary to complete the work.

All work performed in areas not so designated on plans as "Preparing

Right of Way", except "additional areas" as defined under "Measurement" or specifically covered otherwise, will not be paid for directly but shall be considered as subsidiary work pertaining to the various bid items.

ITEM 102

CLEARING AND GRUBBING

102.1. Description. "Clearing and Grubbing" shall consist of the removal and disposal of trees, stumps, brush, roots, vegetation, logs, rubbish and other objectionable matter.

102.2. Construction Methods. The right of way shall be cleared of stumps, brush, logs, rubbish, trees and shrubs, except such trees and shrubs and certain areas designated by the Engineer for preservation. Those trees, shrubs and other landscape features specifically designated by the Engineer for preservation shall be carefully protected from abuse, marring or damage during construction operations. Continual parking and/or servicing of equipment under the branches of trees designated for preservation will not be permitted. Trees and shrubs designated for preservation that must be pruned shall be trimmed as directed and all exposed cuts over 2 inches in diameter shall be treated with an approved asphaltic material.

Areas required for embankment construction; for roadway, channel and structural excavation; and for borrow sites and material sources shall be cleared and grubbed. On areas required for roadway, channel, or structural excavation, all stumps, roots, etc., (except for designated trees and brush) shall be removed to a depth of at least 2 feet below the lower elevation of the excavation. On areas required for embankment construction, all stumps, roots, etc., (except for designated trees and brush) shall be removed to a depth of at least 2 feet below the existing ground surface. All holes remaining after clearing and grubbing shall be backfilled and tamped as directed by the Engineer and the entire area bladed to prevent ponding of water and to provide drainage, except in areas to be immediately excavated the Engineer may direct that the holes not be backfilled. When permitted by the plans, trees and stumps may be cut off as close to natural ground as practicable on areas which are to be covered by at least three feet of embankment. On areas required for borrow sites and material sources, stumps, roots, etc., (except for designated trees and shrubs) shall be removed to the complete extent necessary to prevent such objectionable matter becoming mixed with the material to be used in construction.

All cleared and grubbed material shall be disposed of in a manner satisfactory to the Engineer. Unless otherwise provided, all merchantable timber removed as above required shall become the property of the Contractor.

When a portion of a project falls within the limits of a National Forest, as indicated on the plans, the following provisions shall apply:

(1) In the National Forest area, the United States reserves the right of sale or other disposition of merchantable timber necessarily cut by the

Contractor in the execution of his work. Merchantable timber removed shall be bucked into log lengths and the Forest Ranger notified in order that a prompt sale may be made.

(2) Burning of Brush: When burning of brush is permitted, the following shall govern:

(a) The nearest Forest Service lookout shall be notified of the intention to burn before burning any brush or other debris. Brush piles and fires shall be controlled as to size to eliminate possible dangers of forest fires.

(b) Where construction is on new location, the brush shall be piled and burned in the center of the right of way.

(c) Where construction is on an existing location through which the traveling public is to be routed during construction, brush shall be burned as near the center of the right of way as is practical without creating a hazard to traffic.

(d) In the event there are material pits which require clearing and grubbing the brush shall be placed in the center of the pit before burning.

(3) No timber shall be cut or defaced outside of the right of way lines or material pit limits as indicated on the plans or by the Engineer.

102.3. Measurement. "Clearing and Grubbing" will be measured by the "Acre" or by the "100-Foot Station" regardless of the width of the established right of way.

Measurement for payment will be made only on areas indicated and classified on plans as "Clearing and Grubbing", except that required work on additional areas (such as additional right of way, additional borrow and material sources, additional cut and embankment areas, etc.) not originally proposed by plans but found necessary during construction, and which comes within the purview of "Clearing and Grubbing" as established on plans for the contract shall be measured accordingly.

When indicated on plans, "Clearing and Grubbing (Palms)" will be measured by each palm removed. Palms not so designated for removal or ordered by the Engineer to be removed shall be preserved.

Measurement of palms for payment will not include sprouts or volunteer palms unless the sprouts or volunteer palms are more than 6 feet high measured from the ground up to the base of the head.

When indicated on the plans, "Clearing and Grubbing (Tree)" will be measured by each tree removed.

Areas other than those set forth above will not be measured for payment.

102.4. Payment. All work performed and measured as provided under "Measurement" will be paid for at the unit price bid for "Clearing and Grubbing", "Clearing and Grubbing (Palm)" and/or "Clearing and Grubbing (Tree)" of the size specified, which price shall be full compensation for furnishing all labor, equipment, tools, supplies, arranging for and providing

disposal sites for "(Palms)" if disposed of by hauling off the project, and incidentals necessary to complete the work.

All work performed in clearing and grubbing areas not so designated on plans, except "additional areas" as defined under "Measurement", will not be paid for directly but shall be considered as subsidiary work pertaining to the various bid items.

ITEM 104

REMOVING OLD CONCRETE

104.1. Description. "Removing Old Concrete" shall consist of breaking up, removing, and satisfactorily storing or disposing of old concrete existing at locations shown on plans.

104.2. Construction Methods. Existing concrete to be salvaged consisting of pavement (with or without bituminous top), floors, porches, patios, riprap, median strips, foundations, sidewalks, driveways, combined curb and gutter, or curb shall be broken up into pieces not greater than 18 inches in any dimension by air-driven machinery or other suitable means. The use of explosives for breaking up old concrete to be removed will not be permitted except when authorized in writing by the Engineer, and when so authorized, adequate precautions shall be taken to prevent damage to adjacent property. Reinforcing steel shall be cut as necessary for satisfactory salvage or disposal.

Where only a portion of the existing concrete is to be removed, special care shall be exercised to avoid damage to that portion of the concrete to remain in place. The existing concrete shall be cut to the neat lines shown on plans or established by the Engineer, and any existing concrete beyond the neat lines so established which is damaged or destroyed by these operations shall be replaced at the Contractor's entire expense.

When indicated on the plans old concrete which is removed shall be loaded, hauled and neatly stored at designated sites, or otherwise used as directed. Portions of existing concrete not specified for salvage shall be disposed of by the Contractor at locations to be obtained by him, and the provision that the concrete be broken into pieces not greater than 18 inches in any dimension shall not apply.

Work performed under this item shall be inaugurated at such time, and prosecuted in such manner as to cause a minimum of inconvenience to traffic or to the owners of adjacent property.

104.3. Measurement. Existing concrete pavement, floors, porches, patios, riprap, median strips, foundations, concrete sidewalks, and concrete driveways, removed as prescribed above, will be measured by the square yard in its original position, regardless of its thickness or the depth of covering, or by the cubic yard based on calculated volume.

Existing combined concrete curb and gutter and concrete curb, removed as prescribed above, will be measured by the linear foot in its original position, regardless of the dimensions of same.

104.4. Payment. The work performed as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Removing Old Concrete" (of the type specified), which price shall be full compensation for breaking up the concrete, cutting reinforcing steel when required, loading, hauling, unloading, and satisfactorily storing or disposing of the material, and for all labor, tools, equipment, manipulation and incidentals necessary to complete the work.

ITEM 110

ROADWAY EXCAVATION

110.1. Description. "Roadway Excavation" shall consist of the required excavation within the limits of the roadway (except excavation otherwise designated as channel excavation, structural excavation, etc.); the removal and proper utilization or disposal of all excavated materials; and the constructing, shaping and finishing of all earthwork on the entire length of roadway and approaches to same in conformity with the required lines, grades and typical cross sections and in accordance with specification requirements herein outlined. Compaction of embankments shall conform either to the method of "Ordinary Compaction" or the "Density Control" method as outlined in the Item, "Embankment". The method used shall be as shown on the plans.

110.2. Classification. All authorized roadway excavation will either be unclassified or classified as indicated on the plans.

(1) "Unclassified Road Excavation". If no classification is indicated on the plans, "Unclassified Road Excavation" shall include all materials encountered regardless of their nature or in the manner in which they are removed.

If classification is made, one or more of the following classes shall be employed.

(2) "Rock Road Excavation" or "Common Road Excavation".

(a) "Rock Road Excavation" will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than 1/2 cubic yard each in volume. In areas where blasting is not permitted, materials of rock character which require use of mechanically operated drills for removal will be classified as "Rock Road Excavation".

(b) "Common Road Excavation" will include all other materials encountered regardless of their nature.

When, in the Contractor's opinion, classified materials encountered are other than as shown on the plans, the Engineer shall be notified prior to removal of any such materials in order to permit reclassification and measurement.

Objections on the part of the Contractor to the Engineer's classification of roadway excavation shall be filed in writing with the Engineer within 15

calendar days of receipt of the partial estimate which includes the particular objectionable classification. Failure on the part of the Contractor to file such objections as outlined above will be construed as his concurrence with the classifications made.

110.3. Construction Methods. All roadway excavation and corresponding embankment construction shall be performed as specified herein and in the Item, "Embankment", and the completed roadway shall conform to the established alignment, grades and cross sections.

All suitable excavated materials shall be utilized, insofar as practicable, in constructing the required roadway sections or in uniformly widening embankments, flattening slopes, etc., as directed by the Engineer. Unsuitable roadway excavation and roadway excavation in excess of that needed for construction shall be known as "Waste" and shall become the property of the Contractor to be disposed of by him outside the limits of the right of way at a location suitable to the Engineer. "Unsuitable material encountered below subgrade elevation in roadway cuts, when declared "Waste" by the Engineer, shall be replaced, as directed by the Engineer with material from the roadway excavation or with other suitable material. All work involved shall be paid for under the pertinent bid items of the contract."

"Waste" will not be permitted unless specifically indicated on plans or required by written order of the Engineer.

Payment will not be allowed for excavation of any material which is used for purposes other than those designated except as provided in the governing specifications under Item 4, "Scope of Work".

During construction the roadbed and ditches shall be maintained in such condition as to insure proper drainage at all times and ditches and channels shall be so constructed and maintained as to avoid damage to the roadway section.

Unless otherwise indicated on plans, excavation in solid rock shall extend 6 inches below the required subgrade elevation for the entire roadbed width, and shall be backfilled with suitable selected materials as indicated on plans or as instructed by the Engineer. All slopes except in solid rock or other material which, in the judgment of the Engineer, require variation shall be accurately shaped and care shall be taken that no material is loosened below the required slopes. All breakage and slides shall be removed and disposed of as directed.

110.4. Selection of Materials. Where shown on plans, selected materials shall be utilized to improve the roadbed, in which case the work shall be performed in such manner and sequence that suitable materials may be selected, removed separately, and deposited in the roadway within limits and at elevations required.

110.5. Measurement. All roadway excavation will be measured in its original position and the volume computed in cubic yards by the method of average end areas. Measurements will include all authorized excavation below grades and slides or overbreakage, which, in the opinion of the Engineer, are

not attributed to the Contractor's carelessness, except that all overbreakage in solid rock shall be within 1 foot outside neat lines of the typical cross section shown on plans, or as set by the Engineer and shall not exceed in any 100-foot station, 10 percent of the actual quantity of rock required for the same station.

110.6. Payment. All work performed as required herein and in the Item, "Embankment" and measured as provided under "Measurement" will be paid for at the unit price bid under one of the following methods:

(1) Where the "Ordinary Compaction" method of compaction is required, payment will be made for "Unclassified Road Excavation (Ordinary Compaction)", "Rock Road Excavation (Ordinary Compaction)", or "Common Road Excavation (Ordinary Compaction)".

(2) Where the "Density Control" method of compaction is required, payment will be made for "Unclassified Road Excavation (Density Control)", "Rock Road Excavation (Density Control)", or "Common Road Excavation (Density Control)".

The prices bid shall each be full compensation for furnishing all materials, tools, equipment and incidentals necessary to complete the work. Payment for unauthorized work will not be made.

All work required for disposing of waste, including haul, will not be paid for directly but shall be considered as subsidiary work pertaining to the various contract items and such costs shall be included in the unit prices bid for these items.

When specified on the plans, all hauling of materials (including authorized waste) will not be paid for directly, but shall be considered as subsidiary work pertaining to the various contract items, and such costs shall be included in the unit prices bid. Otherwise, all hauling of materials (excluding waste) will be measured and paid for in accordance with the provisions governing the Item, "Overhaul".

ITEM 120

CHANNEL EXCAVATION

120.1. Description. "Channel Excavation" shall consist of required excavation for all channels, both on and outside the limits of the highway; the removal and proper utilization or disposal of all excavated materials; and constructing, shaping and finishing of all earthwork involved in conformity with the required lines, grades and typical cross sections and in accordance with specification requirements herein outlined. Compaction of embankments shall conform either to the method of "Ordinary Compaction" or the "Density Control" method as outlined in the Item, "Embankment". The method used shall be as shown on the plans.

120.2. Classification. All authorized channel excavation will either be unclassified or classified as indicated on the plans.

(1) **"Unclassified Channel Excavation".** If no classification is indicated on the plans, "Unclassified Channel Excavation" shall include all materials encountered regardless of their nature or the manner in which they are removed.

If classification is made by the Engineer, one or more of the following classes shall be employed:

(2) **"Rock Channel Excavation" or "Common Channel Excavation".**

(a) **"Rock Channel Excavation"** will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than 1/2 cubic yard each in volume. In areas where blasting is not permitted, materials of rock character which require use of mechanically operated drills for removal will be classified as "Rock Channel Excavation".

(b) **"Common Channel Excavation"** will include all other materials encountered regardless of their nature.

When, in the Contractor's opinion, classified materials encountered are other than as shown on the plans, the Engineer shall be notified prior to removal of any such material in order to permit reclassification and measurement.

Objections on the part of the Contractor to the Engineer's classification of channel excavation shall be filed in writing with the Engineer within 15 calendar days of receipt of the partial estimate which includes the particular objectionable classification. Failure on the part of the Contractor to file such objections as outlined above will be construed as his concurrence with the classifications made.

120.3. Construction Methods. All suitable materials removed from the excavation shall be used, insofar as practicable, in the formation of embankments as required by the Item, "Embankment", or shall be otherwise utilized or satisfactorily disposed of as indicated on plans, or as directed, and completed work shall conform to the established alignment, grades and cross sections. During construction, the channel shall be kept drained, insofar as practicable, and the work shall be prosecuted in a neat workmanlike manner.

Unsuitable channel excavation in excess of that needed for construction shall be known as "Waste" and shall become the property of the Contractor to be disposed of by him outside the limits of the right of way.

Payment will not be allowed for excavation of any material which is used for purposes other than those designated, except as provided in the governing specifications under Item 4, "Scope of Work".

120.4. Selection of Materials. Where shown on plans, selected materials shall be utilized in the formation of embankment or to improve the roadbed, in which case the work shall be performed in such manner and sequence that suitable materials may be selected, removed separately and deposited in the roadway within limits and at elevations required.

120.5. Measurement. All channel excavation will be measured in its original position and the volume computed in cubic yards by the method of average end areas.

120.6. Payment. All work performed as required herein and in the Item, "Embankment" and measured as provided under "Measurement" will be paid for at the unit price bid under one of the following methods:

(1) Where the "Ordinary Compaction" method is required, payment will be made for "Unclassified Channel Excavation (Ordinary Compaction)", "Rock Channel Excavation (Ordinary Compaction)" or "Common Channel Excavation (Ordinary Compaction)".

(2) Where the "Density Control" method of compaction is required, payment will be made for "Unclassified Channel Excavation (Density Control)", "Rock Channel Excavation (Density Control)" or "Common Channel Excavation (Density Control)".

The prices bid shall each be full compensation for furnishing all labor, materials, tools, equipment and incidentals necessary to complete the work. Payment for unauthorized work will not be made.

All work required for disposing of waste, including haul, will not be paid for directly but shall be considered as subsidiary work pertaining to the various contract items, and such costs shall be included in the unit prices bid for these items.

When specified on the plans, all hauling of materials will not be paid for directly, but shall be considered as subsidiary work pertaining to the various contract items, and such costs shall be included in the unit prices bid. Otherwise, all hauling of materials (excluding waste) will be measured and paid for in accordance with the provisions governing the Item, "Overhaul".

ITEM 130

BORROW

130.1. Description. "Borrow" shall consist of required excavation, removal and proper utilization of materials obtained from designated or approved sources. Compaction of embankments constructed from borrow as provided herein shall conform either to the method of "Ordinary Compaction" or the "Density Control" method as outlined in the Item, "Embankment".

Borrow will be resorted to only when shown on plans or directed by the Engineer and then only from designated or approved sources.

130.2. Classification. All authorized borrow will either be unclassified or classified as indicated on the plans.

(1) "Unclassified Borrow". If no classification is indicated on the plans, "Unclassified Borrow" shall include all materials encountered regardless of their nature or the manner in which they are removed.

If classification is made, one or more of the following classes shall be employed:

(2) "Rock Borrow" or "Common Borrow".

(a) **"Rock Borrow"** will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than 1/2 cubic yard each in volume. In areas where blasting is not permitted, materials of rock character which require use of mechanically operated drills for removal will be classified as "Rock Borrow".

(b) **"Common Borrow"** will include all other materials encountered regardless of their nature.

When, in the Contractor's opinion, classified materials encountered are other than as shown on the plans, the Engineer shall be notified prior to removal of any such materials in order to permit reclassification and measurement.

Objections on the part of the Contractor to the Engineer's classification of borrow shall be filed in writing with the Engineer within 15 calendar days of receipt of the partial estimate which includes the particular objectionable classification. Failure on the part of the Contractor to file such objections as outlined above will be construed as his concurrence with the classifications made.

130.3. Construction Methods. All suitable materials removed from the excavation shall be used, insofar as practicable, in the formation of embankments as required by the governing Item for "Embankment", or shall otherwise be utilized as indicated on plans or as directed, and the completed work shall conform to the established alignment, grades and cross section. During construction, the borrow sources shall be kept drained, insofar as practicable, and the work shall be prosecuted in a neat and workmanlike manner.

Payment will not be allowed for excavation of any material which is used for purposes other than those designated, except as provided in the governing specifications under Item 4, "Scope of Work".

Site of the borrow operation shall be left in a suitable and sightly condition, such as to provide proper drainage where practical and to permit accurate measurement. Where indicated on plans, the sides and/or ends of borrow pits shall be sloped to the dimensions indicated by the plans.

The Engineer shall be notified sufficiently in advance of opening any designated borrow source to permit necessary testing, staking and measurement.

130.4. Selection of Materials. Where shown on plans, selected materials shall be utilized in the formation of embankment or to improve the roadbed, in which case the work shall be performed in such manner and sequence that suitable materials may be selected, removed separately and deposited in the roadway within limits and at elevations required. Where required, acceptable borrow material, when tested by standard laboratory methods, shall meet the requirements indicated on the plans.

Tolerances: When tolerances are permitted by the plans, the limits establishing reasonably close conformity with the specified plasticity index are defined by the following:

The Engineer may accept the material providing not more than 20% of any 10 consecutive **plasticity index** samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

130.5. Measurement. Borrow will be measured in its original position and the volume computed in cubic yards by the method of average end areas.

130.6. Payment. All work performed as required herein and in the Item, "Embankment" and measured as provided under "Measurement" will be paid for at the unit price bid under one of the following methods:

(1) Where the "Ordinary Compaction" method is required, payment will be made for "Unclassified Borrow (Ordinary Compaction)", "Rock Borrow (Ordinary Compaction)" or "Common Borrow (Ordinary Compaction)".

(2) Where the "Density Control" method of compaction is required, payment will be made for "Unclassified Borrow (Density Control)", "Rock Borrow (Density Control)" or "Common Borrow (Density Control)".

The prices bid shall each be full compensation for furnishing all labor, for all royalty, materials, tools, equipment and incidentals necessary to complete the work. Payment for unauthorized work will not be made.

Payment will not be allowed the Contractor for any materials excavated prior to staking out and cross sectioning the borrow sources by the Engineer.

When specified on the plans, all hauling of materials will not be paid for directly, but shall be considered as subsidiary work pertaining to the various contract items, and such cost shall be included in the unit prices bid. Otherwise, all hauling of materials will be measured and paid for in accordance with the provisions governing the Item, "Overhaul".

ITEM 131

BORROW
(Delivered)

131.1. Description. "Borrow" shall consist of required excavation, removal and proper utilization of materials secured from sources obtained by the Contractor and approved by the Engineer. Compaction of embankments constructed from borrow as provided herein shall conform either to the method of "Ordinary Compaction" or the "Density Control" method as outlined in the Item, "Embankment".

Borrow will be resorted to only when shown on plans or directed by the Engineer and then only from approved sources.

131.2. Types. All authorized borrow shall conform to one of the following types:

Type A (Select Borrow). This material shall consist of sand or other suitable granular material, free from vegetation or other objectionable matter,

reasonably free from lumps of earth and when tested by standard Texas Highway Department laboratory methods shall meet the following requirements:

The liquid limit shall not exceed 45
The plasticity index shall not be less than 4
nor more than 15

Type B. This material shall consist of suitable earth material such as loam, clay or other such materials that will form a stable embankment.

Type C. This material shall conform to the specification requirements shown on the plans.

131.3. Construction Methods. All suitable material shall be used in the formation of embankments as required by the governing Item for "Embankment", or shall otherwise be utilized as indicated on plans or as directed, and the completed work shall conform to the established alignment, grades and cross section. During construction the borrow sources shall be kept drained, insofar as practicable, to permit final cross sections to be taken when required.

The borrow source shall be left in a suitable condition, so as to provide proper drainage where practical and to permit accurate measurement when required.

The Engineer shall be notified sufficiently in advance of opening any approved borrow source to permit necessary testing, staking and measurement, when required.

131.4. Measurement. Borrow will be measured by the method described as either Class 1, 2 or 3 as follows and as specified on the plans:

When Class 1 measurement is specified, borrow will be measured in its original position and the volume computed in cubic yards by the method of average end areas.

When Class 2 measurement is specified, borrow will be measured by the cubic yard in vehicles as delivered on the road.

When Class 3 measurement is specified, borrow will be measured by the cubic yard in its final position as the volume of embankment computed in place between (1) the original ground surfaces or the surface of embankment constructed from Roadway Excavation and (2) the lines, grades and slopes of the accepted embankment, by the average end area method. The Contractor shall schedule his operations in such a manner as to facilitate the measurement of the various pay items.

131.5. Payment. All work performed as required herein and in the Item "Embankment" and measured as provided under "Measurement" will be paid for at the unit price bid under one of the following methods:

(1) Where the "Ordinary Compaction" method is required, payment will be made for "Borrow (Delivered) (Ordinary Compaction)" of the type and class indicated on the plans.

(2) Where the "Density Control" method of compaction is required, payment will be made for "Borrow (Delivered) (Density Control)" of the type and class indicated on the plans.

The prices bid shall each be full compensation for furnishing all labor; for all materials; for all royalty and freight involved; for all hauling and delivering on the road; and for all tools, equipment and incidentals necessary to complete the work. Payment for unauthorized work will not be made.

When Class 1 measurement is specified, payment will not be allowed the Contractor for any materials excavated prior to staking out and cross sectioning the borrow sources by the Engineer.

ITEM 132

EMBANKMENT

132.1. Description. This item shall govern the placement and compaction of all materials obtained from roadway, borrow, channel and structural excavation for utilization in the construction of roadway embankments, levees and dykes.

132.2. Construction Methods.

(1) General. Prior to placing any embankment, all "Preparing Right of Way" and/or "Clearing and Grubbing" operations shall have been completed on the excavation sources and areas over which the embankment is to be placed. Stump holes or other small excavations in the limits of the embankments shall be backfilled with suitable material and thoroughly tamped by approved methods before commencing embankment construction. The surface of the ground, including plowed loosened ground or surface roughened by small washes or otherwise shall be restored to approximately its original slope by blading or other methods and, where indicated on plans or required by the Engineer, the ground surface thus prepared shall be compacted by sprinkling and rolling.

Unless otherwise indicated on plans the surface of the ground of all unpaved areas other than rock which are to receive embankment shall be loosened by scarifying or plowing to a depth of not less than 4 inches. The loosened material shall be recompacted with the new embankment as hereinafter specified.

Where indicated on plans or directed by the Engineer, the surface of hillsides to receive embankment shall be loosened by scarifying or plowing to a depth of not less than 4 inches, or cut into steps before embankment materials are placed. The embankment shall then be placed in layers, as hereinafter specified, beginning at the low side in part width layers and increasing the widths as the embankment is raised. The material which has been loosened shall be recompacted simultaneously with the embankment material placed at the same elevation.

Where embankments are to be placed adjacent to or over existing roadbeds, the roadbed slopes shall be plowed or scarified to a depth of not

less than 6 inches and the embankment built up in successive layers, as hereinafter specified, to the level of the old roadbed before its height is increased. Then, if directed, the top of the old roadbed shall be scarified and recompacted with the next layer of the new embankment. The total depth of the scarified and added material shall not exceed the permissible depth of layer.

Trees, stumps, roots, vegetation or other unsuitable materials shall not be placed in embankment.

Except as otherwise required by the plans, all embankment shall be constructed in layers approximately parallel to the finished grade of the roadbed and unless otherwise specified each layer shall be so constructed as to provide a uniform slope of 1/4 inch per foot from the center line of the roadbed to the outside, except that on superelevated curves each layer shall be constructed to conform to the superelevation required by the governing standard.

Embankments shall be constructed to the grade established by the Engineer and completed embankments shall correspond to the general shape of the typical sections shown on the plans and each section of the embankment shall correspond to the detailed section or slopes established by the Engineer. After completion of the roadway, it shall be continuously maintained to its finished section and grade until the project is accepted.

(2) Earth Embankments. Earth embankments shall be defined as those composed principally of material other than rock, and shall be constructed of accepted material from approved sources.

Except as otherwise specified, earth embankments shall be constructed in successive layers for the full width of the individual roadway cross section and in such lengths as are best suited to the sprinkling and compaction methods utilized.

Layers of embankment may be formed by utilizing equipment which will spread the material as it is dumped, or they may be formed by being spread by blading or other acceptable methods from piles or windrows dumped from excavating or hauling equipment in such amounts that material is evenly distributed.

Minor quantities of rock encountered in constructing earth embankment shall be incorporated in the specified embankment layers, or may be placed in accordance with the requirements for the construction of rock embankments in the deeper fills within the limits of haul shown on the plans, provided such placement of rock is not immediately adjacent to structures. Also, rock may be placed in the portions of embankments outside the limits of the completed roadbed width where the size of the rock prohibits their incorporation in the normal embankment layers.

Each layer of embankment shall be uniform as to material, density and moisture content before beginning compaction. Where layers of unlike materials abut each other, each layer shall be featheredged for at least 100 feet or the material shall be so mixed as to prevent abrupt changes in the soil. No material placed in the embankment by dumping in a pile or windrow shall

be incorporated in a layer in that position, but all such piles or windrows shall be moved by blading or similar methods. Clods or lumps of material shall be broken and the embankment material mixed by blading, harrowing, disking or similar methods to the end that a uniform material of uniform density is secured in each layer. Water required for sprinkling to bring the material to the moisture content necessary for maximum compaction shall be evenly applied and it shall be the responsibility of the Contractor to secure a uniform moisture content throughout the layer by such methods as may be necessary. In order to facilitate uniform wetting of the embankment material, the Contractor may apply water at the material source if the sequence and methods used are such as not to cause an undue waste of water. Such procedure shall be subject to the approval of the Engineer.

All earth cuts, full width or part width cuts in side hill, which are not required to be excavated below subgrade elevation for base and backfilled, shall be scarified to a uniform depth of at least 6 inches below grade, and the material shall be mixed and reshaped by blading and then sprinkled and rolled in accordance with the requirements outlined above for earth embankments and to the same density as that required for the adjacent embankment.

Compaction of embankments shall be obtained by the method hereinafter described as "Ordinary Compaction" or the method hereinafter described as the "Density Control" method.

Ordinary Compaction.

When the "Ordinary Compaction" method is specified, the following provisions shall govern: Each layer shall not exceed 8 inches of loose depth, and shall be compacted until there is no evidence of further compaction, in accordance with provisions governing the Item or Items of "Rolling". Prior to and in conjunction with the rolling operation, each layer shall be brought to the moisture content ordered by the Engineer, and shall be kept leveled with suitable equipment to insure uniform compaction over the entire layer.

Density Control.

When the "Density Control" method of compaction is specified, each layer shall be compacted to the required density by any method, type and size of equipment which will give the required compaction. The depth of layers, prior to compaction, shall depend upon the type of sprinkling and compacting equipment used. Prior to and in conjunction with the rolling operation, each layer shall be brought to the moisture content necessary to obtain the required density and shall be kept leveled with suitable equipment to insure uniform compaction over the entire layer.

For each layer of earth embankment and select material, it is the intent of this specification to provide the density as required herein, unless otherwise shown on the plans. Swelling soils (soils with plasticity index of 20 or more) shall be sprinkled as required to provide not less than optimum moisture and compacted to the extent necessary to provide not less than 98 percent nor more than 102 percent of the density as determined in accordance with Test Method Tex-114-E. Non-swelling soils (soils with plasticity index less than 20) shall be sprinkled as required and compacted to the extent necessary to provide not less than 100 percent of the density as

determined in accordance with Test Method Tex-114-E. Field density determinations will be made in accordance with approved methods.

After each layer of earth embankment or select material is complete, tests as necessary will be made by the Engineer. If the material fails to meet the density specified, the course shall be reworked as necessary to obtain the specified compaction, and the compaction method shall be altered on subsequent work to obtain specified density. Such procedure shall be determined by, and subject to, the approval of the Engineer.

When provided by the plans, the Engineer may order proof rolling to test the uniformity of compaction of the embankment layers. All irregularities, depressions, weak or soft spots which develop shall be corrected immediately by the Contractor.

Should the subgrade, due to any reason or cause, lose the required stability, density or finish before the pavement structure is placed, it shall be recompacted and refinished at the sole expense of the Contractor. Excessive loss of moisture in the subgrade shall be prevented by sprinkling, sealing or covering with a subsequent layer or granular material. Excessive loss of moisture shall be construed to exist when the subgrade soil moisture content is more than 4 percent below the optimum for compaction ratio density.

(3) Rock Embankments. Rock embankments shall be defined as those composed principally of rock, and shall be constructed of accepted material from approved sources.

Except as otherwise specified, rock embankments normally shall be constructed in successive layers for the full width of the individual roadway cross section and of 18 inches or less in depth. When, in the opinion of the Engineer, the rock sizes necessitate a greater depth of layer and the height of fill will permit, the layer depth may be increased as necessary, but in no case shall the depth of layer exceed 2-1/2 feet. Each layer shall be constructed by starting at one end and dumping the rock on top of the layer being constructed, then pushing the material ahead with an approved "Bulldozer" in such manner that the larger rock will be placed on the ground or preceding embankment layer and the interstices between the larger stones will be filled with small stones and spalls by this operation and from the placing of succeeding loads of material.

The maximum dimension of any rock used in embankment shall be less than the depth of the embankment layer, and in no case shall any rock over 2 feet in its greatest dimension be placed in the embankment.. All oversized rock which is otherwise suitable for construction shall be broken to the required dimensions and utilized in embankment construction where proposed by plans, except that when preferred by the Contractor and acceptable to the Engineer, such rock may be placed at other points where the embankment layer is of greater depth, thus requiring less breakage. Compensation for additional haul involved in such alternate manipulations will not be allowed. Wasting of excavated rock other than that proposed by plans or ordered by the Engineer may be resorted to only upon written permission of the Engineer, which permission will be granted only upon agreement between the Contractor and the Engineer as to the point of

disposal within the right of way or upon the presenting by the Contractor of written permission to place the material on property outside of the right of way. Where excavated rock is to be wasted under the procedure, cited above, the Contractor shall, at his entire expense, replace the rock so wasted with other suitable materials.

Unless otherwise provided, the upper or final layer of the embankment shall contain no stones larger than 4 inches in their greatest dimension, and, insofar as such is available by selection from the excavation, shall be compos of material so graded that the density and uniformity of the surface layer may be secured by the methods and requirements as set forth for "Ordinary Compaction" or "Density Control" method.

Exposed oversize material shall be reduced by sledging or other methods.

When the "Ordinary Compaction" method of compaction is specified, each embankment layer shall be rolled as directed, and where the embankment materials require, shall be sprinkled when and to the extent directed by the Engineer.

When the "Density Control" method of compaction is specified, each layer shall be compacted to the required density as outlined for "Earth Embankment", except in those layers where rock will make density testing difficult, the Engineer may require the layer to be proof rolled to insure proper compaction.

(4) At Culverts and Bridges. Embankments adjacent to culverts and bridges which cannot be compacted by use of the blading and rolling equipment used in compacting the adjoining sections of embankment shall be compacted in the manner prescribed under the Item, "Structural Excavation".

Embankments placed around spill-through type abutments shall be constructed in 6-inch loose layers of uniform suitable material placed in such manner as to maintain approximately the same elevation on each side of the abutment, and all materials shall be mixed, wetted and compacted as specified above.

As a general rule, embankment material placed adjacent to any portion of any structure and in the first two layers above the top of any culvert or similar structure shall be an earth free of any appreciable amount of gravel or stone particles more than 4 inches in greatest dimension and of such gradation as to permit thorough compaction. When, in the opinion of the Engineer, such material is not readily available, the use of rock or gravel mixed with earth will be permitted, in which case no particles larger than 12 inches in greatest dimension and 6 inches in least dimension may be used and the percentage of fines shall be sufficient to fill all voids and insure a uniform and thoroughly compacted mass of proper density.

(5) Tolerances. When tolerances are permitted by the plans, the limits establishing reasonably close conformity with the percent density specified is defined by the following:

The Engineer may accept the work providing not more than 25 percent of the density tests performed each day are outside the specified density by

no more than 3 percentage points and where no two consecutive tests on continuous work are outside the specified limit.

132.3. Selection of Materials. In addition to the requirements in the excavation items of the specifications covering the general selection and utilization of materials to improve the roadbed, embankments shall be constructed in proper sequence to receive the select material layers shown on plans, with such modifications as may be directed by the Engineer. The layer of embankment immediately preceding the upper layer of select material shall be constructed to the proper section and grade within a tolerance of not more than 0.10 foot from the established section and grade when properly compacted and finished to receive the select material layer.

132.4. Payment. Except as specified below, the work prescribed by this item will not be paid for directly, but shall be considered as subsidiary work pertaining to the several types and classes of excavation involved.

All sprinkling and rolling performed as required for "Ordinary Compaction" will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively. When the "Density Control" method of compaction is specified, required sprinkling and rolling performed will not be paid for directly but shall be considered as subsidiary to the several types and classes of excavation involved, except proof rolling as required will be paid for in accordance with the Item, "Rolling (Proof)".

When specific provisions are made in the plans for direct payment for blading embankment, all blading performed as required will be measured and paid for in accordance with the provisions governing the Item, "Blading". Measurement for payment will be made only after the material has been spread into the specified layers.

When provisions are not made in the plans for separate payment for blading embankments, such blading as necessary to satisfactorily complete the embankment in accordance with the requirements herein specified, will not be paid for directly but shall be considered as subsidiary work pertaining to the various items of embankment construction.

ITEM 140

OVERHAUL

140.1. Description. "Overhaul" shall consist of performing all operations necessary for moving previously excavated embankment materials over 600 feet from designated or approved sources to the required points of disposal.

The "Haul Length" shall be the distance between the centers of mass of the material in its original and final positions, measured along the shortest practical haul route.

140.2. Measurement and Computation. Measurement of all materials for computing "Overhaul" will be made in the original position by the method of average end areas.

"Overhaul" will be computed by multiplying the number of cubic yards of material hauled by the "Haul Length" minus 600 feet, converted to quarter miles and/or fractions thereof.

The unit of measurement for "Overhaul" will be the "Yard Quarter".

Hauling materials 600 feet or less will be considered as "Free Haul" for which no direct compensation will be made.

140.3. Payment. All work performed and measured as provided under "Measurement" will be paid for at the unit price bid for "Overhaul", which price shall be full compensation for all labor, tools, equipment, and incidentals necessary to complete the work.

ITEM 150

BLADING

150.1. Description. "Blading" shall consist of blading those portions of the roadway so designated on plans, or as ordered by the Engineer.

Work performed under this item shall not include blading or other work specified for payment under other specification items.

150.2. Equipment. All equipment shall be approved by the Engineer prior to use and shall be able to efficiently produce the desired results. Equipment used for blading shall be a power maintainer and shall be tight and in good operating condition. The power maintainer shall have dual or four-wheel drive, shall be equipped with pneumatic tires; shall have a blade of not less than 12 feet in length, and a wheel base of not less than 16 feet. Unless the maintainer is equipped with a satisfactory scarifier attachment, a scarifier of approved type shall be provided.

150.3. Construction Methods. The work shall be performed on the designated portions of the roadway by the use of the equipment specified, which shall be operated by competent operators. All areas shall be completed to the section, line and grade shown on the plans, or established by the Engineer.

When necessary to loosen materials prior to blading, or at other points when so directed, the scarifier attachment or separate scarifier shall be used. When a separate scarifier is used, it shall be drawn by suitable power equipment of adequate tractive effort. Around and adjacent to structures, trees, and other obstructions where it is impractical to do the required work with a blade, such work shall be done by hand methods or other approved means.

The dragging, pushing, or scraping of materials along or across completed pavements will not be permitted.

150.4. Measurement. Work as prescribed by this item will be measured by the actual number of hours of blading or scarifying performed as ordered by the Engineer.

150.5. Payment. The work performed as prescribed by this item, and

measured as provided under "Measurement", will be paid for at the unit price bid for "Blading", which price shall be full compensation for furnishing and operating all equipment, for all labor, fuel, materials, tools and incidentals necessary to complete the work.

All work required to be done by hand labor methods adjacent to structures, trees and other obstructions will not be paid for directly, but shall be considered as subsidiary work to this item.

ITEM 152

ROAD GRADER WORK

152.1. Description. "Road Grader Work" shall consist of the construction of a roadway in conformity with the typical cross sections shown on the plans when the topography is such that it will not be necessary to control the finished grade line for purposes other than to obtain a uniform riding surface and to provide the desirable earth cover over culverts. The limits of "Road Grader Work" shall be shown on the plans, and no section of "Road Grader Work" shall consist of less than 5 consecutive 100-foot stations.

The work shall be done in accordance with the specification requirements herein outlined. The work performed under this item shall not include work specified for payment under other specification items pertaining to the project.

152.2. Construction Methods. All undesirable materials shall first be removed from within the limits of the section to be graded and disposed of as directed by the Engineer. The roadway shall then be graded and shaped to the typical section shown on the plans and to a finished profile uniform and consistent with the topography and as indicated by the plans.

When required by the plans, "Road Grader Work" may be supplemented by "Scraper Work" and/or "Bulldozer Work" in accordance with the requirements of the governing specifications for these items.

During the shaping or manipulation of the roadbed, in the event insufficient moisture is present in the existing earth material, water shall be applied as necessary to facilitate compaction of the roadbed, by the method specified, prior to the placing of the base materials.

When the existing natural ground or the roadbed of an existing road is not in a uniformly compacted state, the existing ground or roadbed, as the case may be, shall be scarified for the full width of the new roadbed for a minimum depth of 6 inches and then sprinkled and rolled as directed by the Engineer, in conjunction with the new material placed on the roadbed and slopes, in order that the resultant subgrade will be uniformly compacted. Compaction shall be in accordance with the method specified on the plans and as outlined in the Item, "Embankment".

All equipment shall be operated by capable and efficient operators at the locations established by the Engineer to the extent, in the manner, and in the sequence of work as directed by the Engineer, all within the limits of "Road Grader Work" as shown on the plans.

152.3. Measurement. "Road Grader Work" will be measured by the 100-foot station.

152.4. Payment. The work performed as prescribed for this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Road Grader Work (Ordinary Compaction)" or "Road Grader Work (Density Control)" as the case may be, which price shall be full compensation for all labor, tools, equipment, and incidentals necessary to complete the work, except as follows:

All "Scraper Work" and "Bulldozer Work", performed as required, will be paid for at the unit price bid for those items respectively.

When "Ordinary Compaction" is specified, "Sprinkling" and "Rolling", performed as required, will be paid for at the unit price bid for those items respectively.

When "Density Control" method of compaction is specified, "Sprinkling" and "Rolling" will not be paid for separately, but shall be considered as subsidiary work pertaining to the Item, "Road Grader Work".

ITEM 154

SCRAPER WORK

154.1. Description. "Scraper Work" shall consist of required excavation within the limits of the roadway as shown on plans or as directed by the Engineer; the removal and proper utilization or disposal of excavated materials; and the constructing, shaping, and finishing of earthwork, except as hereinafter specified, on the designated sections of the roadway and approaches to same, in conformity with the required lines, grades, and typical cross sections and in accordance with specification requirements herein outlined.

154.2. Equipment. Unless otherwise indicated by plans, the equipment shall consist of a scraper of not less than 8 cubic yards capacity (as rated loaded flush by the manufacturer) self propelled or drawn by suitable power equipment of adequate tractive effort. The equipment shall be capable of self loading to capactiy or additional necessary power equipment shall be provided to push or pull the scraper unit to load to capacity. The scraper with the power unit or units shall be considered a scraper unit. All such equipment shall be tight and in good operating condition.

154.3. Construction Methods. "Scraper Work" shall be performed only on those portions of the road as shown on plans or designated by the Engineer.

The work shall be performed on the above sections by the use of the equipment specified, which shall be operated by competent and efficient operators.

All material placed under this item shall be constructed in successive layers, for the full width of the cross section where practicable, and in such lengths as are suited to the sprinkling and compaction methods utilized.

Compaction shall be in accordance with the method specified on the plans and as outlined in the Item, "Embankment".

Where plans designate "Scraper Work" and "Blading" or "Road Grader Work" within the same limits, the "Scraper Work" shall be roughed in as directed by the Engineer and finished in accordance with specifications for the pertinent supplementing item.

154.4. Measurement. Work as prescribed by this item will be measured by the hour or by the yard hour. A scraper unit's cubic yard hour shall consist of the scraper's capacity in cubic years (as rated loaded flush by the manufacturer or flush capacity as determined by the Engineer) multiplied by the actual number of hours of scraper work performed as ordered by the Engineer.

154.5. Payment. The work performed as prescribed by this item, and measured as provided under "Measurement" will be paid for at the unit price bid for "Scraper Work (Ordinary Compaction)" or "Scraper Work (Density Control)" as the case may be, which price shall be full compensation for furnishing and operating all equipment, for all hauling, labor, fuel, materials, tools and incidentals necessary to complete the work, except that any "Blading" or "Road Grader Work" required to be performed on sections constructed under this item will be measured and paid for in accordance with specifications for those respective items.

When "Ordinary Compaction" is specified, "Sprinkling" and "Rolling", performed as required, will be paid for at the unit price bid for those items respectively.

When "Density Control" method of compaction is specified, "Sprinkling" and "Rolling" will not be paid for separately, but shall be considered as subsidiary work pertaining to the Item, "Scraper Work".

ITEM 156

BULLDOZER WORK

156.1. Description. "Bulldozer Work" shall consist of required excavation as shown on plans or as directed by the Engineer; the removal and proper utilization or disposal of excavated materials; and the constructing, shaping, and finishing of earthwork, except as hereinafter specified, in conformity with the required lines, grades, and typical cross sections and in accordance with specification requirements herein outlined.

156.2. Equipment. The equipment shall consist of a tractor with a bulldozer attachment, and where the work is of such nature as to require use of a heavy duty scarifier or ripper for efficient performance of the work, such attachments designed for operation with the required tractor shall also be furnished. The tractor shall be either of the crawler type or rubber tired tractor of the same minimum horsepower and shall be of adequate tractive effort to perform the work in an efficient manner.

The bulldozer attachment shall have not less than a 8-foot blade.

All equipment shall be tight and in good operating condition.

156.3. Construction Methods. "Bulldozer Work" shall be performed only on those portions of the road as shown on plans or designated by the Engineer.

The work shall be performed on the above sections by the use of the equipment specified, which shall be operated by competent and efficient operators.

All material placed under this item shall be constructed in successive layers, for the full width of the cross section where practicable, and in such lengths as are suited to the sprinkling and compaction methods utilized, and shall otherwise conform to the requirements of the governing specifications for "Embankment".

Where plans designate "Bulldozer Work" and "Blading" or "Road Grader Work" within the same limits, the bulldozer work shall be roughed in as directed by the Engineer and finished in accordance with specifications for the pertinent supplementing item.

156.4. Measurement. Work prescribed by this item will be measured by the actual number of hours the equipment is operated either as a bulldozer or as a scarifier as ordered by the Engineer.

156.5. Payment. The work performed as prescribed by this item, and measured as provided under "Measurement" will be paid for at the unit price bid for "Bulldozer Work (Ordinary Compaction)" or "Bulldozer Work (Density Control)" as the case may be, which price shall be full compensation for furnishing and operating all equipment, for all hauling, labor, fuel, materials, tools, and incidentals necessary to complete the work, except that any "Blading" or "Road Grader Work" required to be performed on sections constructed under this item will be measured and paid for in accordance with specifications for those respective items.

When "Ordinary Compaction" is specified, "Sprinkling" and "Rolling", performed as required, will be paid for at the unit price bid for those items respectively.

When "Density Control" method of compaction is specified, "Sprinkling" and "Rolling" will not be paid for separately, but shall be considered as subsidiary work pertaining to the Item, "Bulldozer Work".

ITEM 160

SALVAGING AND PLACING TOPSOIL

160.1. Description. "Salvaging and Placing Topsoil" shall consist of salvaging topsoil and placing, where required, to the depth shown on plans for planting of specified right of way areas.

160.2. Construction Methods. The existing topsoil shall be moved from within the limits of construction as indicated on the plans and stockpiled in a windrow along the right of way line or at designated locations or spread over an area that is ready for topsoil application in accordance with the plans or as directed by the Engineer.

Trash, wood, brush, stumps and other objectional materials encountered shall be removed and disposed of as directed by the Engineer prior to beginning of work required by this item.

After the roadway has been completed to required alignment, grades and cross-sections, and prior to the spreading of the salvaged topsoil, the clay or tight soil surfaces shall be scarified by plowing furrows approximately 4 inches deep along horizontal slope lines at 2 foot vertical intervals. The spreading of the salvaged topsoil shall be undertaken as soon as the grading has been completed or at such time as directed by the Engineer. The topsoil shall be spread, as directed by the Engineer, so as to form a cover of uniform thickness as shown on the plans. After the topsoil has been placed and shaped, it shall be sprinkled and/or rolled if directed by the Engineer.

160.3. Measurement. Salvaging and/or placing topsoil will be measured by the 100-foot station, by the square yard complete in place, by the cubic yard in vehicles as delivered on the road, or by the cubic yard in stockpile as shown on plans. Measurement for payment will be made only on areas indicated on plans or as directed by the Engineer.

160.4. Payment. All work performed as ordered and measured as provided under "Measurement", will be paid for at the unit price bid for "Salvaging and Placing Topsoil", "Salvaging Topsoil" or "Placing Topsoil" which price shall be full compensation for excavating (except as noted below), loading, hauling, placing and furnishing all labor, equipment, tools, supplies, and incidentals necessary to complete the work, except sprinkling and rolling.

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

Note: All excavation required by this item in cut sections will be measured and paid for in accordance with the provisions of the various excavation items involved with the provision that excavation will be measured and paid for once only, regardless of the manipulations involved.

ITEM 162

SODDING FOR EROSION CONTROL

162.1. Description. "Sodding for Erosion Control" shall consist of providing and planting Bermudagrass or other acceptable sod along or across such areas as are designated on the plans and in accordance with specification requirements herein outlined.

162.2. Materials. The sod shall consist of live, growing Bermudagrass or other acceptable sod secured from sources where the soil is fertile. Bermuda sod shall have a healthy virile root system of dense, thickly matted roots throughout the soil of the sod for a thickness of at least 3 inches. St. Augustine sod shall have a healthy, virile root system of dense, thickly matted roots throughout the soil of the sod for a minimum thickness of 1 inch. The Contractor shall not use sod from areas where the grass is thinned out, nor where the grass roots have been dried out by exposure to the air and sun to

such an extent as to damage its ability to grow when transplanted. The sod shall be free from noxious weeds or other grasses and shall not contain any matter deleterious to its growth or which might affect its subsistence or hardiness when transplanted. Unless the area has been closely pastured, it shall be closely mowed and ranked to remove all weeds and long-standing stems. Sources from which sod is to be secured shall be approved by the Engineer.

Care shall be taken at all times to retain the native soil on the roots of the sod during the process of excavating, hauling and planting. Sod material shall be kept moist from the time it is dug until planted. When so directed by the Engineer, the sod existing at the source shall be watered to the extent required prior to excavating.

Planting Season. All planting shall be done between the average date of the last freeze in the Spring and six weeks prior to the average date for the first freeze in the Fall according to the Texas Almanac or U.S. Weather Bureau for the area in which the project is located except as specifically authorized in writing.

Fertilizer shall conform to the requirements of the Item, "Fertilizer".

Straw mulch shall be oat, wheat or rice straw, Prairiegrass, Bermudagrass, or other hay approved by the Engineer. The hay shall be free of Johnsongrass or other noxious weeds and foreign materials. It shall be kept in a dry condition and shall not be molded or rotted.

Asphaltic Material shall be of the type and grade shown on the plans and shall conform to the requirements of the Item "Asphalt, Oils and Emulsions".

162.3. Construction Methods. After the designated areas have been completed to the lines, grades, and cross sections shown on plans and as provided for in other items of this contract, sodding of the type specified shall be performed in accordance with the requirements hereinafter described.

(1) Watering. The sodded areas shall be watered at such times and in the manner and quantity as directed by the Engineer.

(2) Finishing. Where applicable, the shoulders, slopes and ditches shall be smoothed after planting has been completed and shaped to conform to the desired cross sections. Any excess dirt from planting operations shall be spread uniformly over adjacent areas or disposed of as directed by the Engineer so that the completed surfaces will present a neat appearance.

162.4. Spot Sodding.

(1) Bermuda. Furrows parallel to the roadway and approximately 5 inches deep and 18 inches on centers shall be opened on areas to be sodded. In two furrows adjacent to the roadways, sod shall form a continuous row not less than 3 inches wide. In all other furrows, sod approximately 3 inches square shall be placed on 15-inch centers.

Unless otherwise indicated on the plans, fertilizer shall be applied

uniformly in the furrows or rows in accordance with the applicable provisions of the Item, "Fertilizer".

(2) **St. Augustine.** Prior to planting, the area to be sodded shall be shaped by blading or other approved methods to the final finish desired. St. Augustinegrass sod shall be not less than 3 inches square and shall be planted on a maximum of 18-inch centers. Planting of the sod may be in furrows of uniform depth or in holes of like depth. Sod shall be placed so that when it has been firmed against the bottom of the furrow or hole, the top of the sod shall not be more than 1/2 inch below finished grade. Soil shall be firmed against all sides of the sod and covering of the sod will not be permitted except for small amounts of soil incidental to raking or leveling provided the quantity of soil is not enough to hinder growth in the opinion of the Engineer. Unless otherwise indicated on the plans, fertilizer shall be applied uniformly in the furrows or holes in accordance with the applicable provisions of the Item, "Fertilizer".

162.5. Block Sodding. At locations shown on plans or where directed, sod blocks shall be carefully placed on the prepared areas. The fertilizer shall then be applied in accordance with the applicable provisions of the Item, "Fertilizer" and thoroughly watered. When sufficiently dry, the sodded area shall be rolled or tamped to form a thoroughly compacted, solid mat. Any voids left in the block sodding shall be filled with additional sod and tamped. Surfaces of block sod, which, in the opinion of the Engineer, may slide due to the height and slope of the surface or nature of the soil, shall, upon direction of the Engineer, be pegged with wodden pegs driven through the sod blocks into firm earth sufficiently close to hold the block sod firmly in place. Edges along curbs and drives, walkways, etc., shall be carefully trimmed and maintained until accepted.

162.6. Grass Retards. Trenches shall be excavated across the side ditches or along the side or back slopes to the lines and dimensions shown on plans. After the trenches have been prepared, they shall be filled with sod blocks to an elevation flush with the adjacent ground surface. The fertilizer shall then be applied in accordance with the applicable provisions of the Item, "Fertilizer", and thoroughly watered. When sufficiently dry, the sodded area shall be rolled or tamped to form a thoroughly compacted, solid mat. Any voids left between the sod blocks shall be filled with additional sod and tamped.

162.7. Broadcast Sprigging. Except on areas recently loosened by construction, all ground on which sprigging is to be placed shall be loosened by disking or other approved methods to a depth of not less than 4 inches. All large clods shall be pulverized and boulders, rocks or other debris shall be removed as directed. The Contractor shall take full advantage of weather conditions, but the work may be suspended when, in the judgment of the Engineer, the continuation of the same may result in unfavorable planting conditions.

The sod source shall be disked in two directions, cutting the sod thoroughly to a depth of approximately 4 inches, which shall be the maximum depth of excavation. The disked sod may be windrowed, or

otherwise handled in a manner satisfactory to the Engineer. Sod material shall be loaded in such manner as to avoid taking soil containing no roots. The material shall be rejected if not kept in a moist condition.

The sod material shall be uniformly spread over the prepared area at the rate of approximately 1 cubic yard per 24 square yards of area. Fertilizer shall be uniformly distributed over the area in accordance with the applicable provisions of the Item, "Fertilizer". The area shall then be disked immediately in order to thoroughly incorporate the grass with the soil. Then the area shall be finished in accordance with Article 3 and the planted area shall be rolled with a corrugated roller of the "Cultipacker" type. All rolling of slope areas shall be on the contour.

162.8. Mulch Sodding. The sod source shall be disked in two directions cutting the sod thoroughly to a depth of not less than 4 inches. Sod material shall be excavated to a depth of not less than 4 inches or more than 10 inches, being careful to avoid having soil containing no grass roots. The disked sod may be windrowed, or otherwise handled in a manner satisfactory to the Engineer. The material shall be rejected if not kept in a moist condition.

Prior to placing mulch sod, the cut slopes shall be scarified by plowing furrows 4 inches to 6 inches deep along horizontal slope lines at 2-foot vertical intervals. Excavated material from the furrows shall not protrude more than 3 inches above the original surface of the cut. Fertilizer shall be distributed uniformly over the area in accordance with the applicable provisions of the Item, "Fertilizer". The sod shall then be dumped upon the prepared area and spread uniformly to the required approximate thickness shown on plans.

Any section not true to lines and cross sections shall be remedied by the addition of sod material or by reshaping the material to meet the requirements of "Finishing" in Article 3. After the sod material has been spread and shaped, it shall be compacted with a corrugated roller of the "Cultipacker" type. All rolling of slope areas shall be on the contour.

162.9. Straw Mulch. Where applicable, "Spot Sodding", "Broadcast Sprigging" and "Mulch Sodding" shall have straw mulch spread uniformly over the area indicated on plans or as directed by the Engineer. The rate of application shall be 1-1/2 to 2 tons of hay or 2 to 2-1/2 tons of straw per acre. A mulching machine approved by the Engineer shall be equipped to inject asphaltic material uniformly into the straw as it leaves the equipment at a rate of 0.05 to 0.10 gallons of asphalt per square yard of mulched area or as directed by the Engineer. If the straw and asphalt are placed by hand, then the rate of application for asphalt shall be approximately 0.15 gallons per square yard of mulched area.

162.10. Measurement. Work and acceptable material for "Spot Sodding", "Block Sodding", "Grass Retards", and "Straw Mulch" will be measured by the square yard complete in place. Work and acceptable material for "Broadcast Sprigging" and "Mulch Sodding" will be measured by the square yard complete in place or by the cubic yard in vehicles as delivered to the place of planting.

162.11. Payment. The work performed and materials furnished and measured as provided under "Measurement" will be paid for at the unit price bid for "Spot Sodding", "Block Sodding", "Grass Retards", "Straw Mulch", "Broadcast Sprigging", or "Mulch Sodding", as the case may be, which prices shall each be full compensation for completing the work except as follows:

All water, except that used for maintaining and preparing the sod prior to planting, will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

Water used for preparing the sod for digging and keeping the sod moist from the time it is removed from the source until it is planted shall be considered subsidiary to the various pay items involved.

Fertilizer used as indicated on the plans or as directed by the Engineer shall be measured and paid for in accordance with the Item, "Fertilizer".

ITEM 164

SEEDING FOR EROSION CONTROL

164.1. Description. "Seeding for Erosion Control" shall consist of preparing ground, providing for sowing of seeds, mulching with straw and other management practices along and across such areas as are designated on the plans and in accordance with these specifications.

164.2. Materials. All seed must meet the requirements of the Texas Seed Law including the labeling requirements for showing purity, germination, name and type of seed. Seed furnished shall be of the previous season's crop and the date of analysis shown on each bag shall be within nine months of the time of delivery to the project. Each variety of seed shall be furnished and delivered in separate bags or containers. A sample of each variety of seed shall be furnished for analysis and testing when directed by the Engineer. The amount of seed planted per acre shall be of the type specified below and shall equal or exceed the following percentages for purity and germination or an equivalent amount of pure live seed.

Common Name	Scientific Name	Purity	Germination
Green Sprangletop	Leptochloa dubia	60%	50%
Sideoats Grama (El Reno or Premier)	Bouteloua curtipendula	20%	50%
Blue Grama (Texas Grown)	Bouteloua gracilis	40%	40%
Buffalo Grass (Treated)	Buchloe dactyloides	60%	40%
Western Wheatgrass	Agropyron smithii	65%	65%
Blackwell Switchgrass	Panicum virgatum	80%	50%
Caucasian Bluestem	Andropogon caucasicus	25%	40%
K.R. Bluestem	Andropogon ischaemum	20%	50%
Lehmann Lovegrass	Eragrostis lehmanniana	75%	45%
Buffelgrass	Pennisetum ciliare	90%	75%

Common Name	Scientific Name	Purity	Germination
Rhodesgrass	Chloris gayana	75%	50%
Bermuda and Giant Bermudagrass (Hulled)	Cynodon dactylon	95%	90%
Sanddropseed	Sporobolus cryptandrus	90%	60%
Bahiagrass (Pensacola)	Paspalum notatum	90%	80%
Weeping Lovegrass	Eragrostic curvula	90%	85%
Sand Bluestem	Andropogon hallii	50%	65%

Planting Season. All planting shall be done between the dates specified for each highway district except as specifically authorized in writing.

The seeds planted per acre shall be of the type specified with the mixture, rate and planting dates as follows except as specifically shown on plans:

District and Planting Dates	Mixture for Clay or Tight Soils		Mixture for Sand or Sandy Soils
1—Jan. 1 to June 1	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.		Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. Bahiagrass (Pensacola), 15 lbs.
	(Eastern Section)	(Western Section)	
2—Jan. 1 to May 15	Green Sprangletop, 4 lbs. K.R. Bluestem, 10 lbs. Sideoats Grama (El Reno), 5 lbs. Bermudagrass, 8 lbs.	Green Sprangletop, 4 lbs. K.R. Bluestem, 10 lbs. Sideoats Grama (El Reno), 5 lbs. Lehmann Lovegrass, 2 lbs. Blackwell Switchgrass, 5 lbs.	Green Sprangletop, 4 lbs. K.R. Bluestem, 10 lbs. Sideoats Grama (El Reno), 5 lbs. Bermudagrass, 8 lbs.
	(Eastern Section)	(Western Section)	
3—Jan. 1 to June 1	Green Sprangletop, 4 lbs. Sideoats Grama (El Reno), 5 lbs. Caucasian Bluestem, 5 lbs. Bermudagrass, 8 lbs.	Green Sprangletop, 4 lbs. Sideoats Grama (El Reno), 5 lbs. Caucasian Bluestem, 5 lbs. Western Wheatgrass, 5 lbs. Blackwell Switchgrass, 5 lbs.	Green Sprangletop, 4 lbs. Sideoats Grama (El Reno), 5 lbs. Caucasian Bluestem, 5 lbs. Bermudagrass, 8 lbs.
4—Jan. 15 to June 15	Green Sprangletop, 4 lbs. Sideoats Grama (El Reno), 5 lbs. Blue Grama, 15 lbs. Buffalograss, 5 lbs.		Green Sprangletop, 4 lbs. Sideoats Grama (El Reno), 5 lbs. Blue Grama, 15 lbs. Blackwell Switchgrass, 5 lbs.
5—Jan. 15 to June 15	Green Sprangletop, 4 lbs. Sideoats Grama (El Reno), 5 lbs. Blue Grama, 15 lbs. Buffalograss, 5 lbs.		Green Sprangletop, 4 lbs. Sideoats Grama (El Reno), 5 lbs. Blue Grama, 15 lbs. Blackwell Switchgrass, 5 lbs.
6—Jan. 1 to May 15 (NE Half of Dist.)	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. Blue Grama, 15 lbs. Lehmann Lovegrass, 2 lbs. Sanddropseed, 2 lbs.		Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. Blue Grama, 15 lbs. Lehmann Lovegrass, 2 lbs. Sanddropseed, 2 lbs.

District and Planting Dates	Mixture for Clay or Tight Soils		Mixture for Sand or Sandy Soils
7—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. K.R. Bluestem, 10 lbs. Lehmann Lovegrass, 2 lbs.		Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. K.R. Bluestem, 10 lbs. Lehmann Lovegrass, 2 lbs.
8—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Blackwell Switchgrass, 5 lbs. Sideoats Grama (El Reno), 5 lbs. K.R. Bluestem, 10 lbs. Lehmann Lovegrass, 2 lbs.		Green Sprangletop, 4 lbs. Blackwell Switchgrass, 5 lbs. Sideoats Grama (El Reno), 5 lbs. K.R. Bluestem, 10 lbs. Lehmann Lovegrass, 2 lbs.
	(E. of IH 35)	(W. of IH 35)	
9—Jan 1 to May 15	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. K.R. Bluestem, 10 lbs. Blackwell Switchgrass, 5 lbs.	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs. Blackwell Switchgrass, 5 lbs.
10—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs.		Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. Bahiagrass (Pensacola), 15 lbs.
11—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs.		Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. Bahiagrass (Pensacola), 15 lbs.
12—Dec. 1 to May 1 & HU	Bermudagrass, 8 lbs. K.R. Bluestem, 8 lbs. Bahiagrass (Pensacola), 12 lbs.		Bermudagrass, 8 lbs. K.R. Bluestem, 8 lbs. Bahiagrass (Pensacola), 12 lbs.
13—Dec. 1 to May 1	Bermudagrass, 8 lbs. K.R. Bluestem, 8 lbs. Bahiagrass (Pensacola), 12 lbs.		Bermudagrass, 8 lbs. K.R. Bluestem, 8 lbs. Bahiagrass (Pensacola), 12 lbs.
	(E. of IH 35)	(W. of IH 35)	
14—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Buffalograss, 5 lbs. K.R. Bluestem, 10 lbs. Sideoats Grama (Premier), 5 lbs.	Green Sprangletop, 4 lbs. K.R. Bluestem, 10 lbs. Bermudagrass, 8 lbs. Sideoats Grama (Premier), 5 lbs.
	(E. of US 281)	(W. of US 281)	
15—Dec. 1 to May 1	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. Rhodesgrass, 2 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs. Buffelgrass, 6 lbs. Rhodesgrass, 2 lbs.
	(E. of US 77)	(W. of US 77)	
16—Dec. 1 to May 1	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Sideoats Grama, (Premier), 5 lbs. Rhodesgrass, 2 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs. Buffelgrass, 6 lbs. Rhodesgrass, 2 lbs.

District and Planting Dates	Mixture for Clay or Tight Soils		Mixture for Sand or Sandy Soils
17—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.		Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.
18—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.		Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs. Blackwell Switchgrass, 5 lbs.
19—Jan. 1 to June 1	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs.		Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. Bahiagrass (Pensacola), 15 lbs.
20—Dec. 1 to May 1	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs.		Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. Bahiagrass (Pensacola), 15 lbs.
	(E. of US 281)	(W. of US 281)	
21—Dec. 1 to May 1	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. Rhodesgrass, 2 lbs. K.R. Bluestem, 10 lbs.	Green Sprangletop, 4 lbs. Bermudagrass, 8 lbs. K.R. Bluestem, 10 lbs. Buffelgrass, 6 lbs. Rhodesgrass, 2 lbs.
22—Dec. 1 to May 1	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. K.R. Bluestem, 10 lbs.		K.R. Bluestem, 10 lbs. Lehmann Lovegrass, 2 lbs. Buffelgrass, 6 lbs. Rhodesgrass, 4 lbs.
23—Jan. 1 to May 15	Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. K.R. Bluestem, 10 lbs. Lehmann Lovegrass, 2 lbs.		Green Sprangletop, 4 lbs. Sideoats Grama (Premier), 5 lbs. K.R. Bluestem, 10 lbs. Lehmann Lovegrass, 2 lbs.
25—Jan. 1 to June 1	Green Sprangletop, 4 lbs. Blackwell Switchgrass, 5 lbs. Sideoats Grama (El Reno), 5 lbs. Caucasian Bluestem, 5 lbs. Western Wheatgrass, 5 lbs. Buffalograss, 5 lbs.		Green Sprangletop, 4 lbs. Blackwell Switchgrass, 5 lbs. Sideoats Grama (El Reno), 5 lbs. Caucasian Bluestem, 5 lbs. Sand Bluestem, 8 lbs.

Fertilizer shall conform to the requirements of the Item "Fertilizer". For this project the fertilizer used shall have an analysis of 16-20-0, 16-8-8, or the analysis shown on the plans.

Straw Mulch shall be oat, wheat or rice straw, Prairiegrass, Bermudagrass, or other hay approved by the Engineer. The hay shall be free of Johnsongrass or other noxious weeds and foreign materials. It shall be kept in a dry condition and shall not be molded or rotted.

Asphalt shall be of the type and grade shown on the plans and shall conform to the requirements of the Item "Asphalts, Oils and Emulsions".

164.3. Construction Methods. After the designated areas have been completed to the lines, grades and cross-sections shown on the plans and as provided for in other items of this contract, seeding shall be performed in accordance with the requirements hereinafter described. All areas to be seeded shall be cultivated to a depth of at least 4 inches. The seed-bed shall be cultivated sufficiently to reduce the soil to a state of good tilth. The seed-bed shall be deemed in a state of good tilth when the soil particles on the surface are small enough and lie closely enough together to prevent the seed from being covered too deep for optimum germination. Cultivation of seed-bed will not be required in loose sand where depth of sand is four inches or more.

(1) Watering. Water shall be used to moisten the seed-bed only for "Asphalt Mulch Seeding".

(2) Finishing. The cross-section previously established shall be maintained throughout the process of cultivation and any necessary reshaping shall be done prior to any planting of seed.

164.4. Broadcast Seeding. The seed or seed mixture in the quantity specified shall be uniformly distributed over the areas shown on plans or where directed. If the sowing of seed is by hand, rather than by mechanical methods, the seed shall be sown in two directions at right angles to each other. If mechanical equipment is used, all varieties of seed as well as fertilizer may be distributed at the same time provided that each component is uniformly applied at the specified rate. When seed and fertilizer are to be distributed as a water slurry, the mixture shall be applied to the area to be seeded within 30 minutes after all components are placed in the equipment. After planting, the planted area shall be rolled with a corrugated roller of the "Cultipacker" type. All rolling of the slope areas shall be on the contour.

164.5. Straw Mulch Seeding. The seed or seed mixture in the quantity specified shall be uniformly distributed over the areas shown on plans or where directed. If the sowing of seed is by hand, rather than by mechanical methods, the seed shall be sown in two directions at right angles to each other. If mechanical equipment is used, all varieties of seed as well as fertilizer may be distributed at the same time provided that each component is uniformly applied at the specified rate. When seed and fertilizer are to be distributed as a water slurry, the mixture shall be applied to the area to be seeded within 30 minutes after all components are placed in the equipment. Upon completion of planting of the seed, straw mulch shall be spread uniformly over the area seeded at the rate of approximately 1-1/2 to 2 tons of hay or 2 to 2-1/2 tons of straw per acre. A mulching machine approved by the Engineer shall be equipped to inject asphaltic material into the straw uniformly as it leaves the equipment at a rate of 0.05 to 0.10 gallon of asphalt per square yard of mulched area. If the straw and asphalt are placed by hand, then the rate of application for asphalt shall be approximately 0.15 gallon per square yard.

164.6. Asphalt Mulch Seeding. The cultivated area or seed-bed shall have relatively smooth surface without ruts or tracks. Water shall be applied to the seed-bed until a minimum depth of 4 inches is uniformly moistened. The water shall be applied in such a manner as not to erode the smooth surface.

After the watering, when the surface of the seed-bed has become sufficiently dry to permit planting, the seed or seed mixture specified shall then be planted at the rate required and the application shall be uniform. If the sowing of seed is by hand, rather than mechanical methods, the seed shall be sown in two directions at right angles to each other. Seed and fertilizer may be distributed at the same time provided the specified uniform rate of application for both is obtained. When seed and fertilizer are to be distributed as a water slurry, the mixture shall be applied to the area to be seeded within 30 minutes after all components are placed in the equipment. Upon the completion of the sowing of the seed, the application of the asphalt shall follow as rapidly as possible. Immediately prior to the application of the asphalt, the planted area shall be watered sufficiently to assure uniform moisture from the surface to a minimum of 4 inches in depth. Application of the asphalt shall be at the rate of approximately 0.3 gallon per square yard. It shall be applied to the area in such a manner that a complete film is obtained and the finished surface shall be comparatively smooth.

164.7. Accent Seeding. In Districts 1, 10, 11, 12, 17, 19, and 20, over areas shown on plans or where directed by the Engineer, Weeping Lovegrass seed shall be uniformly distributed at the rate of 4 pounds per acre. If the sowing of seed is by hand, rather than by mechanical methods, the seed shall be sown in two directions at right angles to each other. If mechanical equipment is used, the seed as well as fertilizer may be distributed at the same time provided that each component is uniformly applied at the specified rate. When seed and fertilizer are to be applied in a water slurry, the mixture shall be applied to the area to be seeded within 30 minutes after all components are placed in the equipment.

164.8. Straw Mulch. Straw mulch shall be spread uniformly over the area indicated on plans or as designated by the Engineer at the rate of approximately 1-1/2 to 2 tons of hay or 2 to 2-1/2 tons of straw per acre. A mulching machine approved by the Engineer shall be equipped to inject asphaltic material into the straw uniformly as it leaves the equipment at a rate of 0.05 to 0.10 gallon of asphalt per square yard of mulched area. If the straw and asphalt are placed by hand, then the rate of application for asphalt shall be approximately 0.15 gallon per square yard.

164.9. Measurement. Work and acceptable material for "Broadcast Seeding", "Straw Mulch Seeding", "Asphalt Mulch Seeding", "Accent Seeding", and "Straw Mulch" will be measured by the square yard or by the acre, complete in place.

164.10. Payment. The work performed and materials furnished and measured as provided under "Measurement" will be paid for at the unit price bid for "Broadcast Seeding", "Straw Mulch Seeding", "Asphalt Mulch Seeding", "Accent Seeding", or "Straw Mulch", of the type specified, as the

case may be, which prices shall be full compensation for furnishing all materials, including water for seed-fertilizer slurry, and for performing all operations necessary to complete the work except as follows:

All fertilizer will be measured and paid for in accordance with the provisions governing the Item "Fertilizer".

Water for sprinkling cultivated area or seed-bed, when required, shall meet the requirements of and will be measured and paid for in accordance with the provisions governing the Item "Sprinkling".

ITEM 166
FERTILIZER

166.1. Description. "Fertilizer" shall consist of providing and distributing fertilizer over such areas as are designated on the plans and in accordance with these specifications.

166.2. Materials. All fertilizer used shall be delivered in bags or containers clearly labeled showing the analysis. The fertilizer is subject to testing by the State Chemist in accordance with the Texas Fertilizer Law. A pelleted or granulated fertilizer shall be used with an analysis of 16-20-0 or 16-8-8 or having the analysis shown on the plans. The figures in the analysis represent the percent of nitrogen, phosphoric acide, and potash nutrients respectively as determined by the methods of the Association of Official Agricultural Chemists.

In the event it is necessary to substitute a fertilizer of a different analysis, it shall be a pelleted or granulated fertilizer with a lower concentration. The total amount of nutrients furnished and applied per acre shall equal or exceed that specified for each nutrient.

166.3. Construction Methods. When an item for fertilizer is included in the plans and proposal, pelleted or granulated fertilizer shall be applied uniformly over the area specified to be fertilized and in the manner directed for the particular item of work. The fertilizer shall be dry and in good physical condition. Fertilizer that is powdered or caked will be rejected. Distribution of fertilizer for the particular item of work shall meet the approval of the Engineer.

Unless otherwise indicated on the plans, fertilizer shall be applied uniformly at the average rate of 300 pounds per acre for all types of "Sodding for Erosion Control" and 400 pounds per acre for all types of "Seeding for Erosion Control".

166.4. Measurement. Work and acceptable material for "Fertilizer" will be measured by the ton of 2,000 pounds as determined by approved scales or guaranteed weight of sacks shown by the manufacturer.

166.5. Payment. The work performed and materials furnished and measured as provided under "Measurement" will be paid for at the unit price bid for "Fertilizer", of the analysis specified, which price shall be full compensation for furnishing all materials and performing all operations necessary to complete the work.

ITEM 170

OBLITERATING ABANDONED ROAD

170.1. Description. "Obliterating Abandoned Road" shall consist of the obliteration of designated sections of abandoned road by appropriate grading.

170.2. Construction Methods. After the designated sections of an old road, or detours, are no longer needed for traffic, the ditches shall be filled and the roadway graded, either to restore approximately the original contour of the ground or to produce a pleasing appearance by forming natural rounded slopes. Where shown on plans, borrow required for the new roadway shall be taken from fills on the old road, and surplus or waste material from the new roadway shall be placed in cuts on the old road. Old structures shall be broken down and buried or removed. All material with salvage value shall be carefully removed to avoid damage, and stored at designated sites or used in the construction of the new road where provided. The area of the old road surfacing shall be scarified or plowed to mix it effectively with earth, and the entire area of the old roadway shall be smoothed by blading or other methods.

Where directed, suitable topsoil or humus material shall be conserved and used in covering necessary areas for the purpose of facilitating regrowth of vegetation. No extra payment will be made or allowed for conserving such "Topsoil" material or for such humus material or for the utilization thereof save the payment of any "Overhaul" involved.

170.3. Measurement. Work as prescribed for in this item will be measured by the 100-foot station.

170.4. Payment. The work performed as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Obliterating Abandoned Road", which price shall be full compensation for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

Embankment materials removed from the old road for use in the new roadway, and excavated materials from the new roadway wasted on old road areas, and haul on such materials will be measured and paid for in accordance with the provisions governing the Items of "Borrow", "Roadway Excavation" and "Overhaul".

Structures designated on plans for removal will be measured and paid for in accordance with the provisions governing the Item, "Removing Old Structures".

ITEM 180

FINISHING ROADWAY

180.1. Description. "Finishing Roadway" shall consist of shaping, finishing and cleaning the entire right of way as herein specified on such portions of the project as shown on the plans.

180.2. Construction Methods. After the work as contemplated by the contract has been completed except for the exactness of finish as required by this item, the roadway shoulders, slopes and ditches shall be smoothly shaped; all ditches and channels within the right of way shall be cleared of all debris and obstructions; any excess earth or other waste material adjacent to structures, poles, trees or other objects shall be leveled down or otherwise disposed of as directed by the Engineer. All loose stones, rocks and boulders within the right of way that would fail to pass a 3-inch ring shall be removed from the shoulders and neatly piled along the edge of the right of way. All roots, trash and other debris shall be disposed of as directed and the entire right of way placed in a neat and presentable condition.

The dragging, pushing or scraping of material along or across the surface of the completed pavement will not be permitted.

180.3. Measurement. Acceptable work as prescribed for this item will be measured by the 100-foot station.

180.4. Payment. The work performed as required by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Finishing Roadway", which price shall be full compensation for furnishing and operating all equipment, all loading, hauling, unloading, furnishing all labor, fuel, materials, tools and implements incidental to the satisfactory performance of the work.

ITEM 190

ROADSIDE PLANTING

190.1. Description. "Roadside Planting" shall consist of the initial planting and any replanting of specified plants at points indicated on plans, or as directed by the Engineer.

Planting Season. All planting shall be done between November 15 and March 15, except as otherwise noted on plans, or as specifically permitted by written order of the Engineer.

190.2. Materials. Plant material shall be first-class grade, true to name, and of the size shown on the plans. All plants shall be nursery-grown unless otherwise noted on plans. When the Engineer is furnished sufficient evidence that a specified plant cannot practically be obtained, the Engineer may approve in writing the use of collected native material. Plant material having any of the following features will be rejected:

1. Undue abrasions of the bark.
2. Dried root system.
3. Dried top wood of deciduous plants or dried foliage of evergreens.
4. Prematurely opened buds, or with buds stripped off.
5. Diseased or insect-infested plants.

6. Balled and burlapped plants which have dry, loose, broken, and/or undersized balls which do not conform to sizes shown on plans.
7. Showing evidence of heating, molding or freezing.
8. Plants in containers that are overgrown or root-bound.
9. Plants with bench balls.
10. Plant ball encased in plastic or other impervious material.

(1) Standard Nomenclature. Botanical names as specified in "Standardized Plant Names" by the American Joint Committee on Horticultural Nomenclature shall govern.

(2) Delivery. Material shall not be delivered to the project until ordered in writing by the Engineer, and when so ordered, the Engineer shall be notified of a proposed delivery of plant material at least 24 hours prior to its arrival at the project. Each shipment shall be accompanied by an invoice showing the number, size and name of each of the several kinds of plant material included with each kind of plant adequately identified by tags. The entire plant shall be properly protected from sun and air damage from the time of digging until delivery on the project. Upon arrival, the Engineer shall make an immediate inspection and shall accept for planting or "heeling-in" all plants complying with these specifications; and any plants rejected under the same shall be immediately removed from the project. Unless plants are placed in pre-dug holes and planted as specified herein, they shall be "heeled-in" and inspected again prior to planting. If delivered to pre-dug planting holes, balled and burlapped plants shall be planted within 1 to 6 hours depending upon the drying effect of the wind and sun. No bare rooted plants shall be placed in pre-dug holes from the delivery truck unless actual planting occurs immediately after removal from its moist packing.

(3) Receipt of Plants. No shipment of plant material shall be accepted, planted and/or "heeled-in" by the Contractor until such material shall have been inspected and accepted by the Engineer. The Contractor shall assist the Engineer in the inspection of material.

(4) Size. The caliper for trees shall be taken 12 inches above original ground line. Plant measurement for height shall be measured from where the main part of the plant ends and not to the top of a thin shoot. Plants having a spreading or semi-spreading habit shall be measured by the average diameter of the spread. Size of special plant classes like roses, vines, and groundcovers, will be measured in accordance with appropriate notes on plans. Container-grown plants which are well established in adequate size containers and are of equal quality and size to the specified balled plants may be accepted in lieu of balled plants; likewise, balled plants of equal quality and size may be substituted for container-grown plants when permitted by the Engineer. Soil shall be approximately 3/4 depth of container and contain roots of the plant throughout the soil.

The ball size for a balled and burlapped plant shall be equal to, or in excess of, the ball sizes shown on plans. Collected plant material substituted for a nursery-grown plant shall have a ball or root system one-fourth greater in diameter and in depth than the nursery-grown plant for which it is substituted. The ball size shall be the average of the diameters taken at 90°.

(5) Mulch. Mulch material shall consist of loose organic residue derived from plants, or other granular material approved by the Engineer, and shall be of such nature that adequate protection is provided against sun baking and quick drying-out of the soil, will not impede aeration or water penetration nor deplete the soil of nitrogen. Mulch material shall be free of excess amounts of large leaves and sticks that would prevent proper dressing of the mulched surface, free of harmful chemicals and free of detrimental amounts of soil or other foreign matter that would promote early compaction, matting or deterioration of the mulch.

190.3. Construction Methods. Immediately following delivery and acceptance at the job, all plants shall be planted or "heeled-in" in adequate moist material. All plants "heeled-in" shall be properly maintained by the Contractor until planted. In handling plants, the utmost care shall be exercised to prevent injuries to the plants. The solidity of the ball of balled and burlapped plants shall be carefully preserved, and such plants shall not be handled by the stems.

Plants with exposed roots shall be protected from drying-out during the time the plants are removed from the "heeling-in" bed and until actually planted.

(1) Preparation of Planting Holes. Planting holes may be dug by hand or by mechanical means. Trimming of the sides or bottom of the hole to uniform shape will not be required. Planting holes shall have a minimum horizontal dimension of 2 times the specified diameter of the ball of balled and burlapped plants or the average root spread of bare-rooted plants. Planting holes shall be excavated to a depth of at least 4 inches but not more than 8 inches greater than the depth of the ball of balled and burlapped plants or the depth of the root system of bare-rooted plants. Holes dug to excess depths shall be backfilled with topsoil and tamped to bring the holes to the specified depth. The depth of holes on slopes shall be measured at the lower side. Special sized holes shall be shown on plans. Where holes are dug with an auger and the sides of the holes become plastered or glazed, this plastered or glazed surface shall be scarified.

Topsoil from the planting hole may be used for backfilling provided it is kept separate from subsoil and rendered loose and friable. Additional topsoil required to backfill the holes shall be furnished in the amount directed and from a source approved by the Engineer.

(2) Pruning Roots. Root pruning shall be limited to the amount necessary to prune away broken and badly damaged roots.

(3) Pruning of Tops. Plants shall not be pruned before delivery to the job, except by written permission of the Engineer.

Pruning of plants shall conform to the best horticultural practice, and shall be appropriate to the various types of plants and the special requirements of each. Deciduous (non-evergreen) shrubs and trees with heavy tops shall have about one-third to one-half of the top growth removed. Plants otherwise acceptable, but with broken or badly bruised branches, shall have such branches removed with a clean cut. All cut surfaces over 1 inch in diameter shall be painted with a tree pruning compound.

(4) Planting and Backfilling.

(a) Depth of Transplanting. In general, plants shall stand after settlement of the backfill, approximately one inch deeper than they stood in the nursery or collecting field.

(b) Bare Root Plants. After the soil in the bottom of the hole has been firmed and the plant placed in the proper position, loose friable topsoil (or loam) shall be worked about the roots and thoroughly settled with water as the backfill is made. Care should be taken to avoid bruising or breaking the roots. No sticks, sods, clods or other material which would tend to form large air pockets in the soil shall be included in the backfill.

(c) Balled and Burlapped Plants. Plants of this type shall not be handled by the stems nor in such manner that the soil of the ball will be loosened. The burlap shall not be removed from the ball. After the soil in the bottom of the hole has been firmed and the plant placed in the proper position, loose friable soil shall be worked about the ball until the hole is two-thirds full. The hole then shall be filled with water and the backfilling completed, working the soil and water well to prevent any air pockets.

(d) Container-Grown Plants. At the time of planting container-grown plants, the root ball and plant shall be removed from the container with a minimum damage to the root ball. If, in the opinion of the Engineer, a sufficient amount of soil has fallen off or the ball has been broken to such an extent as to reduce the chances of the plant to grow, the plant will be rejected. Container-grown plants shall be acclimated to outside growing conditions. Container-grown plants shall be planted in the same manner as balled and burlapped plants.

(e) Finishing Surface after Backfilling. A basin, 8 to 10 inches deep, shall be formed by constructing a neat levee around the planting hole. The inside measurement of the basin shall be not less than the minimum specified diamater of the planting hole, unless otherwise stated on plans. On slopes, the soil on the lower side shall be graded in such a manner that an adequate basin will be provided.

Material excavated from the planting holes which is unsuitable for backfilling may be used to form a basin around the plant. Excess excavated material may be scattered thinly and leveled off provided it is of such consistency and character that it can be readily scattered in an acceptable manner. In case the scattering of material will interfere with drainage, mowing, or otherwise be detrimental, all such material shall be removed and disposed of as directed by the Engineer.

(5) Bracing Trees. All trees, 1 ¼ inches and over in caliper, shall be adequately braced immediately after the plants have settled. Unless otherwise stated on plans, trees 1¼ to 2 inches in diameter shall be braced with one (1) brace of sawed lumber, 2 x 2 inches (nominal size), firmly fastened to the tree at a point 5 to 6 feet above ground, or as directed by the Engineer. Braces shall be of sufficient length to provide adequate bracing when firmly driven into the ground. The tree trunk shall be adequately padded with a section of flexible hose at the point of attachment with a figure 8 tie. Trees 2 inches to 4 inches in diameter shall be braced with wires at a height of 6 to 8 feet that are firmly attacked to three equally-spaced concentric stakes which are firmly driven into the ground. The trunk of the tree shall be adequately and securely padded with rubber at the point of attachment of the wires to prevent damage. Wire shall be number 16 gauge galvanized.

Trees, larger than 4 inches in diameter, shall be braced in accordance with notes on plans. The Contractor shall repair braces as often as required until acceptance of the project for "Plant Establishment".

(6) Tree Trunk Protection. For protection of the tree trunk, all trees so specified on the plans shall be neatly and securely wrapped with a commercial "Tree-Wrapping Paper" (asphalt core type) approved by the Engineer. The tree wrapping is to begin at the base of the trunk and extend upward with a 50 percent overlap to the first major branch. Secure the tree-wrapping paper at the top of wrap with soft twine or weather-proof type tape, or any suitable method, approved by the Engineer.

(7) Mulching. All plants shall receive mulching to a depth of 2 inches within the planting basin unless otherwise specified on plans. A small amount of soil shall be sprinkled or top of organic mulch to hold it in place if directed by the Engineer. If hay is used, the depth shall be 4 inches loose measurement.

(8) Maintenance and Initial Plant Replacement. The Contractor shall water the plants as often as necessary to keep the ground moist well below the root system, cut the weeds and grass around the planted area including the plant basin and bracing, prune the plants, treat the plants in accordance with approved methods of horticultural practice where insects or disease affect the plants after planting, and repair or replace the bracing as may be required or as ordered by the Engineer until the planting project has been accepted for "Plant Establishment".

If the Contractor completes the initial planting prior to March 1 he will not be required to maintain the plants, unless "Plant Establishment" is a pay item; however, he will be required to replant all material found to be missing, damaged, or dead during this time. This replanting shall be done between March 1 and March 15, or as directed by the Engineer.

In the event that the planting project is not completed by March 15 and no further planting is permitted until the following "Planting Season", the partial planting will be accepted for "Plant Establishment."

190.4. Plant Establishment. Unless shown on the bid proposal as a pay item, the Contractor will not be required to perform the following work, "Plant Establishment". The period of "Plant Establishment" commences with the completion of the initial planting as described under "Construction Methods" and extends to the following November 15. For the work of "Plant Establishment", all possible means shall be employed to preserve the plants in a healthy and vigorous growing condition to insure their successful establishment. Such work shall consist of watering the plants, cutting weeds and grass around the planted area including the plant basin and bracing, pruning the plants, and repair or replacement of bracing as may be required or as ordered by the Engineer. Where insects or disease affect the plants after planting, the plants shall be treated in accordance with approved methods of horticultural practices. Plants that die during the period of "Plant Establishment" shall be removed from the project.

190.5. Acceptability of Plants. Between June 1 and June 10 following the initial planting and initial plant replacement, the Engineer will make an inspection of the project to determine the acceptability of the plant material. At this time, an inventory of missing, dead, or rejected plant material will be made and the Contractor notified that the plants on the inventory are to be replanted the following planting season between November 15 and December 15, or as specifically permitted by the Engineer. Plant material for the replacement planting shall meet all the requirements specified for the original plant material and shall be planted in accordance with the planting instructions listed under "Construction Methods", except that no further plant replacement will be required. Working days stated in the Contract shall apply to the initial construction period only and will not include the time necessary for replanting. A final inspection shall be made within ten days after the replacement planting is completed.

190.6. Measurement. Work and accepted materials as prescribed for this item will be measured as each plant in place except for "Plant Establishment". Work and accepted materials necessary for "Plant Establishment" will be measured as a complete lump-sum unit.

190.7. Payment. Work and accepted material as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for each plant of the various plants specified in place, except for "Plant Establishment", which price shall be full compensation for all items necessary to complete the work. The work performed and materials furnished for "Plant Establishment" shall be paid for at the contract lump-sum price bid for "Plant Establishment" which price shall be full compensation for all items necessary for "Plant Establishment".

PART II, CONSTRUCTION DETAILS

DIVISION II
SUBBASE AND BASE COURSES

ITEM 200
STRIPPING

200.1. Description. "Stripping" shall consist of the excavation, removal, and satisfactory disposal of unsuitable materials encountered within the limits of the designated or approved material sources, including fine material screened out to meet the required gradation for the base material.

200.2. Construction Methods. The Engineer shall be notified sufficiently in advance of opening any material source to permit necessary staking and measurement. Overburden and other unsatisfactory material shall be excavated, removed, and placed in designated spoil banks or shall otherwise be disposed of as directed, in such manner as not to create an unsightly or objectionable condition and to permit accurate measurement of the quantity of material stripped. Measurement will be made as soon as practicable after the satisfactory completion of the stripping operations.

200.3. Measurement. Unless otherwise specified, stripping will be measured in spoil banks and the volume computed in cubic yards by the method of average end areas, except that in unusual cases where such measurement is impracticable, a comparable method acceptable to the Engineer and Contractor may be used.

200.4. Payment. Stripping performed and measured as provided under "Measurement" will be paid for at the unit price bid for "Stripping" which price shall be full compensation for all hauling, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 204
SPRINKLING

204.1. Description. "Sprinkling" shall consist of the authorized application of water on those portions of the roadway as shown on plans or as directed and as herein specified.

204.2. Materials. Water shall be furnished by the Contractor and shall be clean and free from industrial wastes and other objectionable matter.

204.3. Construction Methods. This work will be done only when ordered by the Engineer. The Contractor shall furnish and operate approved sprinklers equipped with positive and rapidly working cut-off valves and approved spray bars which will insure the distribution of water in a uniform and controllable rate of application. The Contractor shall apply the water in the required quantity where shown on plans or as directed by the Engineer.

204.4. Measurement. Sprinkling performed as provided above will be measured by the 1000 gallons as delivered on the roadway.

204.5. Payment. The water furnished and the work performed as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Sprinkling", which price shall be full compensation for all costs in connection with furnishing the water; for all costs in connection with furnishing and operating approved sprinklers and all necessary measuring devices; and for applying the water as directed, including all hauling, equipment, tools, materials, labor, and incidentals necessary to complete the work.

ITEM 210

ROLLING
(Flat Wheel)

210.1. Description. "Rolling (Flat Wheel)" shall consist of the compaction of embankment, flexible base, or surface treatments, by the operation of approved power rollers as herein specified and as directed by the Engineer.

210.2. Equipment.

(1) Embankments and Flexible Bases. Power rollers shall be of the three-wheel, self-propelled type, weighing not less than 10 tons and shall provide a compression on the rear wheels of not less than 325 pounds per linear inch of tire width. All wheels shall be flat, the rear wheels shall have a diameter of not less than 48 inches, and each shall have a tire width of not less than 20 inches.

(2) Surface Treatments. Power rollers shall be the three-wheel or tandem, self-propelled type, weighing not less than 3 tons nor more than 6 tons. All wheels shall be flat.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction in the same period of time as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction within the same period of time as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

210.3. Construction Methods. This work shall be done only when ordered by the Engineer. Sufficient rollers shall be provided to compact the material in a satisfactory manner, the minimum number of rolling units to be governed by the basis of estimate for rolling shown in the plans and progress in placing the materials to be compacted. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily, additional roller units shall be provided and operated as directed by the Engineer.

(1) Embankments and Flexible Base. The embankment layer or the base course shall be sprinkled if directed, and rolling with a power roller shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half of the width of the rear wheel of the power roller. On superelevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the roller shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer. The rollers, unless otherwise directed, shall be operated at a speed between 2 and 3 miles per hour.

(2) Surface Treatments. Rolling shall be done as called for in surface treatment items. The sequence of work shall be as specified for embankment layer or base course as ordered by the Engineer. The operating speed shall be determined from rates shown on plans or shall be as directed by the Engineer.

210.4. Measurement. Rolling, performed as provided above, will be measured by the actual hours the power roller works as ordered by the Engineer.

210.5. Payment. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rolling (Flat Wheel)", which price shall be full compensation for furnishing and operating all equipment; and for all labor, fuel, tools, and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

ITEM 211

ROLLING
(Tamping)

211.1. Description. "Rolling (Tamping)" shall consist of the compaction of embankment or of flexible base by the operation of approved tamping rollers as herein specified and as directed by the Engineer.

211.2. Equipment. The tamping rollers shall consist of two metal rollers, drums, or shells of 40 inches minimum diameter; each not less than 42 inches in length and unit-mounted in a rigid frame in such manner that each roller may oscillate independently of the other; and each roller, drum, or shell shall be surmounted by metal studs with tamping feet projecting not less than 7 inches from the surface and spaced not less than 6 inches nor more than 10 inches measured diagonally center to center; and the cross-sectional area of each tamping foot, measured perpendicularly to the axis of the stud, shall be not less than 5 nor more than 8 square inches. The roller shall be supplemented with cleaning teeth to provide self cleaning. The roller shall be so designed that by ballast loading, the load on each tamping foot may be varied uniformly from 125 to not less than 175 pounds per square inch of cross-sectional area. The load per tamping foot will be determined by dividing the total weight of the roller by the number of tamping feet in one row

parallel to or approximately parallel to the axis of the roller. The compression to be provided at any time shall be as directed by the Engineer. The tamping roller shall be drawn by suitable power equipment of adequate tractive effort. Two tamping rollers, consisting of four cylinders, conforming to the above prescribed requirements, drawn by approved power equipment, shall be considered a roller unit.

Where turning is impractical or detrimental to the work and when specifically directed by the Engineer, one tamping roller consisting of two cylinders, fastened to the front end of approved power equipment, shall be considered a roller unit.

If approved by the Engineer, the Contractor may substitute rollers conforming to requirements in the Item, "Rolling (Heavy Tamping)" in lieu of rollers specified above. Such units shall be considered a roller unit.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction in the same period of time as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction within the same period of time as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

211.3. Construction Methods. This work shall be done only when ordered by the Engineer. The embankment layer or the base course shall be sprinkled if directed, and rolling with a tamping roller unit shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half of the width of the tamping roller unit. On superelevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the unit shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer. The tamping roller unit, unless otherwise directed, shall be operated at a speed between 2 and 3 miles per hour.

Sufficient rollers shall be provided to compact the material in a satisfactory manner, the minimum number of rolling units to be governed by the basis of estimate for rolling shown in the plans and progress in placing the material to be compacted. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily, additional roller units shall be provided and operated as directed by the Engineer.

211.4. Measurement. Rolling performed as provided above will be measured by the actual hours the tamping roller unit works as ordered by the Engineer.

211.5. Payment. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rolling (Tamping)", which price shall be full

compensation for furnishing and operating all equipment; and for all labor, fuel, tools and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

ITEM 212

ROLLING
(Heavy Tamping)

212.1. Description. "Rolling (Heavy Tamping)" shall consist of the compaction of embankment, roadbed treatment, flexible base or other courses, by the operation of approved tamping rollers as herein specified, and as directed by the Engineer.

212.2. Compaction Equipment. The heavy tamping roller shall consist of two or three metal drums, rolls, or shells of 60 inches minimum diameter. If the two-drum type is furnished, each drum shall be not less than 60 inches in length. If the three-drum type is furnished, the roller shall consist of two forward drums and one rear drum, the drums to be so arranged that the rear drum will compact the space between the two forward rolls, and rollers of this type shall have an overall width of not less than 10 feet.

The drums shall be unit-mounted in a rigid frame in such manner that each drum may oscillate independently of the other.

Each drum shall be surmounted by metal studs with tamping feet projecting not less than 7 inches from the surface and shall be so spaced as to result in one tamping foot for each 0.65 to 0.7 square foot of drum area. The area of each tamping foot shall be approximately 7 square inches, but shall be not less than 6 nor more than 8 square inches. All rollers shall be provided with cleaning teeth so designed and attached as to prevent the accumulation of material between the tamping feet.

The roller shall be so designed that by ballast loading, the load on each tamping foot may be varied up to at least 550 pounds per square inch of cross sectional area. The load per tamping foot will be determined by dividing the total weight of the roller by the number of tamping feet in one row parallel to or approximately parallel to the axis of the roller. The compression to be provided at any time shall be as directed by the Engineer.

One tamping roller, consisting of two drums or three drums, conforming to the above requirements and drawn by an approved type tractor of adequate tractive effort, shall be considered a heavy tamping roller unit.

Where turning is impractical or detrimental to the work, and when specifically directed by the Engineer, the roller shall be attached to the front end of the power equipment.

When operations are confined to narrow widths and when specifically directed by the Engineer in writing, one roller, either pushed or pulled, by adequate power equipment shall be considered a roller unit.

In lieu of the rolling equipment specified, the Contractor may, upon

written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction in the same period of time as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction within the same period of time as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

The roller unit shall be maintained in good repair and operating condition and shall be approved by the Engineer.

212.3. Construction Methods. This work shall be done only when ordered by the Engineer. The embankment layer shall be sprinkled if directed, and rolling with a tamping roller unit shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half of the width of the tamping roller. On superelevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the unit shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer. The tamping roller unit, unless otherwise directed, shall be operated at a speed between 2 and 3 miles per hour.

Sufficient rollers shall be provided to compact the material in a satisfactory manner, the minimum number of rolling units to be governed by the basis of estimate for rolling shown in the plans and progress in placing the material to be compacted. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within one working day. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily, additional roller units shall be provided and operated as directed by the Engineer.

212.4. Measurement. Rolling performed as provided above will be measured by the actual hours the tamping roller unit works as ordered by the Engineer.

212.5. Payment. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rolling (Heavy Tamping)", which price shall be full compensation for furnishing and operating all equipment; and for all labor, fuel, tools, and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

ITEM 213

ROLLING
(Pneumatic Tire)

213.1. Description. "Rolling (Pneumatic Tire)" shall consist of the compaction of embankment, flexible base, surface treatments, or pavements by the operation of approved pneumatic tire rollers as herein specified and as directed by the Engineer.

213.2. Equipment.

(1) The light pneumatic tire roller shall consist of not less than nine pneumatic tired wheels, running on axles in such manner that the rear group of tires will cover the entire gap between adjacent tires of the forward group, and mounted in a rigid frame and provided with a loading platform or body suitable for ballast loading. The front axle shall be attached to the frame in such manner that the roller may be turned within a minimum circle. The pneumatic tire roller under working conditions shall have an effective rolling width of approximately 60 inches and shall be so designed that by ballast loading, the total load may be varied uniformly from 9,000 pounds or less to 18,000 pounds or more. The roller shall be equipped with tires that will afford ground contact pressures to 45 pounds per square inch or more. The operating load and tire air pressure shall be within the range of the manufacturer's chart as directed by the Engineer. The Contractor shall furnish the Engineer with charts or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of loadings for the particular tires furnished. The roller under working conditions shall provide a uniform compression under all wheels. The pneumatic tire roller shall be drawn by either a suitable crawler type tractor, a pneumatic tired tractor, or a truck of adequate tractive effort, or may be of the self propelled type, and the roller, when drawn or propelled by either type of equipment, shall be considered a light pneumatic tire roller unit.

(2) The medium pneumatic tire roller (Type A) shall consist of not less than seven pneumatic tired wheels, running on axles in such manner that the rear group of tires will cover the entire gap between adjacent tires of the forward group, and mounted in a rigid frame and provided with a loading platform or body suitable for ballast loading. The front axle shall be attached to the frame in such manner that the roller may be turned within a minimum circle. The pneumatic tire roller under working conditions shall have an effective rolling width of approximately 84 inches and shall be so designed that by ballast loading the total load may be varied uniformly from 23,500 pounds or less to 50,000 pounds or more. The roller shall be equipped with tires that will afford ground contact pressures to 80 pounds per square inch or more. The operating load and tire air pressure shall be within the range of the manufacturer's chart as directed by the Engineer. The Contractor shall furnish the Engineer with charts and tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of loadings for the particular tires furnished.

The pneumatic tire roller shall be drawn by either a suitable crawler type tractor, a pneumatic tired tractor, or a truck of adequate tractive effort, or may be of the self-propelled type, and the roller, when drawn or propelled by either type of equipment, shall be considered a medium pneumatic tire roller unit. The power unit shall have adequate tractive effort to properly move the operating roller at variable uniform speeds up to approximately 5 miles per hour.

(3) The medium pneumatic tire roller (Type B) shall conform to the requirements for Medium Pneumatic Tire Roller, Type A as specified in

Article 213.2(2) except that the roller shall be equipped with tires that will afford ground contact pressures to 90 pounds per square inch or more.

When used on seal coats, asphaltic surface treatments and bituminous mixture pavements, the roller shall be self-propelled and equipped with smooth tread tires whether "Rolling (Light Pneumatic Tire)" or "Rolling (Medium Pneumatic Tire)" is specified on the plans. The roller shall be so constructed as to be capable of being operated in both a forward and a reverse direction. When used on bituminous mixture pavements, the roller shall have suitable provisions for moistening the surface of the tires while operating.

Where turning is impractical or detrimental to the work, and when specifically directed by the Engineer, the roller shall be of the self-propelled type.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction in the same period of time as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction within the same period of time as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

213.3. Construction Methods. This work shall be done only when ordered by the Engineer. The embankment layer or the base course shall be sprinkled if directed, and rolling with a pneumatic tire roller shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half of the width of the pneumatic tire roller. On superelevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the roller shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer.

The light pneumatic tire roller shall be operated at speeds directed by the Engineer which shall be between 4 and 12 miles per hour for asphalt surfacing work and between 2 and 6 miles per hour for all other work.

The medium pneumatic tire roller shall be operated at speeds as directed by the Engineer.

Sufficient rollers shall be provided to compact the material in a satisfactory manner, the minimum number of rolling units to be governed by the basis of estimate for rolling shown in the plans and progress in placing the materials to be compacted. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily additional roller units shall be provided and operated as directed by the Engineer.

213.4. Measurement. Rolling performed as provided above will be measured by the actual hours the pneumatic tire roller unit works as ordered by the Engineer.

213.5. Payment. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rolling (Light Pneumatic Tire)", "Rolling (Medium Pneumatic Tire) (Type A)" or "Rolling (Medium Pneumatic Tire) (Type B)", as the case may be, which price shall be full compensation for furnishing and operating all equipment, and for all labor, fuel, tools and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

ITEM 214

ROLLING
(Heavy Pneumatic)

214.1. Description. "Rolling (Heavy Pneumatic)" shall consist of the compaction of embankment subgrade, flexible base, foundation course, roadbed treatment, old concrete pavement (previously broken) or pavements by the operation of approved heavy pneumatic tire rollers as herein specified and as directed by the Engineer.

214.2. Equipment. The heavy pneumatic tire roller shall consist of not less than four pneumatic tire wheels, running on axles carrying not more than two wheels, and mounted in a rigid frame and provided with a loading platform or body suitable for ballast loading. All wheels shall be arranged so that they will carry approximately equal loads when operating on uneven surfaces.

The roller under working condition shall have a rolling width of from 8 feet to 10 feet, and shall be so designed that, by ballast loading, the gross load may be varied uniformly from 25 tons to 50 tons. The tires shall be capable of operating under the various loads with variable air pressure up to 150 pounds per square inch. The operating load and tire air pressure shall be within the range of the manufacturer's chart as directed by the Engineer. Tires shall be practically full of liquid. (Tires shall be considered as being practically full when liquid will flow from the valve stem of a fully inflated tire with the stem in the uppermost position). The Contractor shall furnish the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of the tire inflation pressures and for the full range of loadings for the particular tires furnished.

There shall be a sufficient quantity of ballast available to load the equipment to a maximum gross weight of 50 tons.

Rubber tired tractive equipment shall be used on base courses and asphalt pavements. Other type tractive equipment may be used on embankment subgrade. The heavy pneumatic tire roller unit shall be capable of turning 180 degrees in the crown width.

The heavy pneumatic tire roller shall be drawn by a suitable crawler type tractor, or rubber tired tractor of adequate effort, or may be of the self-propelled type, and the roller, when drawn or propelled by either type of equipment, shall be considered a heavy pneumatic tire roller unit.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction in the same period of time as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction within the same period of time as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

214.3. Construction Methods. This work shall be done only when ordered by the Engineer. The embankment layer or the base course shall be sprinkled if directed. Rolling with the pneumatic tire roller shall start longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least one-half the width of the pneumatic tire roller. On superelevated curves, rolling shall begin at the low sides and progress to the high sides. Alternate trips of the roller shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer.

The rollers shall be operated at speeds directed by the Engineer which shall be between 2 and 6 miles per hour.

Sufficient rollers shall be provided to compact the material in a satisfactory manner, the minimum number of roller units to be governed by the basis of estimate for rolling shown on the plans and progress in placing the materials to be compacted. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily, additional roller units shall be provided and operated as directed by the Engineer.

214.4. Measurement. Rolling performed as provided above will be measured by the actual hours the heavy pneumatic tire roller unit works as ordered by the Engineer.

214.5. Payment. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rolling (Heavy Pneumatic)", which price shall be full compensation for furnishing and operating all equipment; and for all labor, tools, fuel and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

ITEM 215

ROLLING
(Grid)

215.1. Description. "Rolling (Grid)" shall consist of the compaction of embankments and bases or for breaking up existing asphalt mats or base materials, by the operation of approved grid rollers as herein specified and as

directed by the Engineer. This type roller is to be used only where the character of materials is suitable to this method of rolling.

215.2. Equipment. The grid roller shall consist of two metal rollers 66 inches minimum diameter, 32 inches minimum width, mounted in a rigid frame with weight boxes to permit weight to be varied between 10,000 and 25,000 pounds. The surface of the roller shall consist of a cast or welded steel fabric grid, composed of undulating bars 1½ inches wide spaced 5 inches center to center each way. The bars shall be undulating in each direction approximately 1 inch between the high and low points. The grid roller shall be drawn by suitable crawler type tractor of adequate tractive effort. The grid roller, conforming to the above prescribed requirements, drawn by an approved crawler type tractor, shall be considered a roller unit.

Where turning is impractical or detrimental to the work, and when specifically directed by the Engineer, the roller shall be attached to the front end of the power equipment.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction in the same period of time as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction within the same period of time as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

215.3. Construction Methods. This work shall be done only when ordered by the Engineer. The embankment layer or the base course shall be sprinkled if directed, and rolling with a grid roller unit shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half of the width of the grid roller unit. On superelevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the unit shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer.

Old asphalt mats or pit run material to be broken up shall be rolled with a grid roller unit as directed by the Engineer.

The grid roller unit, unless otherwise directed, shall be operated at a speed between 2 and 3 miles per hour.

Sufficient rollers shall be provided to perform the work in a satisfactory manner, the minimum number of rolling units to be governed by the basis of estimate for rolling shown on the plans and progress in placing the materials to be compacted. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from ane another that one roller unit cannot perform the required compaction satisfactorily, additional roller units shall be provided and operated as directed by the Engineer.

215.4. Measurement. Rolling performed as provided above will be measured by the actual hours the grid roller unit works as ordered by the Engineer.

215.5. Payment. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rolling (Grid)", which shall be full compensation for furnishing and operating all equipment; and for all labor, fuel, tools and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

ITEM 216

ROLLING
(Proof)

216.1. Description. "Rolling (Proof)" shall consist of furnishing and operating heavy pneumatic tired compaction equipment for compacting and testing the compaction of embankment subgrade, flexible base, foundation course, roadbed treatment or pavements. Proof rolling is designed to either achieve additional compaction, locate unstable areas, or both.

216.2. Equipment. The proof rolling equipment shall consist of not less than four pneumatic tired wheels, running on axles carrying not more than two wheels, and mounted in a rigid frame and provided with loading platform or body suitable for ballast loading. All wheels shall be arranged so that they will carry approximately equal loads when operating on uneven surfaces.

The proof roller under working conditions shall have a rolling width of from 8 feet to 10 feet, and shall be so designed that, by ballast loading, the gross load may be varied uniformly from 25 tons to 50 tons. The tires shall be capable of operating under the various loads with variable air pressure up to 150 pounds per square inch. Tires shall be practically full of liquid. (Tires shall be considered as being practically full when liquid will flow from the valve stem of a fully inflated tire with the stem in the upper-most position). The operating load and tire-pressure shall be within the range of the manufacturer's chart as directed by the Engineer. The Contractor shall furnish the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of loadings for the particular tires furnished.

The proof roller shall be drawn by a suitable crawler type tractor or rubber tired tractor of adequate tractive effort, or may be of self-propelled type, and the roller unit when drawn or propelled by either type of equipment shall be considered a heavy pneumatic tire proof roller unit.

There shall be a sufficient quantity of ballast available to load the equipment to a maximum gross weight of 50 tons.

Rubber tired tractive equipment shall be used on base courses and asphalt pavements. Other type tractive equipment may be used on embankment subgrade. The heavy pneumatic tire roller unit shall be capable of turning 180 degrees in the crown width.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent results in the same period of time as the specified

equipment. If the substituted compaction equipment fails to produce the desired results within the same period of time as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

216.3. Construction Methods. This work shall be done only when ordered by the Engineer. On embankment compaction each layer will be placed to specified thickness at optimum moisture and compacted with conventional equipment to comply with requirements of governing embankment item. Prior to placing the overlaying course the layer shall be further compacted with the proof roller. Proper moisture control is of utmost importance in proof rolling. The moisture content shall range from optimum moisture to not more than 3 percent below optimum moisture for the particular layer of material being rolled. For cohesive soils whose optimum moisture is near its plastic limit, the range shall be from 2 percent to 3 percent below optimum moisture.

Within the ranges set forth in Article 216.2 of this item, the load and tire inflation pressures shall be adjusted as directed by the Engineer. It is proposed to use a contact pressure corresponding as nearly as practical to the maximum supporting value of the subgrade. As stronger layers are placed the load and tire inflation pressures shall be increased to the maximum contact pressure specified. A minimum of two coverages of the proof roller will be required. Each succeeding trip of the proof roller shall be offset by not greater than one tire width.

Where the operation of the proof roller unit shows an area to be unstable or non-uniform, such area shall be brought to satisfactory stability and uniformity by additional compaction or by removal of unsuitable materials, replacement with suitable materials and recompaction. The subgrade shall then be checked for conformity with line and grade, and any irregularities corrected.

Rollers shall be operated at speeds directed by the Engineer which shall be between 2 and 6 miles per hour.

Flexible bases, foundation courses, roadbed treatments or asphaltic pavements shall be compacted and tested in a manner similar to that described above and as directed by the Engineer.

216.4. Measurement. Proof Rolling performed as provided above will be measured by the actual hours the heavy pneumatic tire proof roller unit works as ordered by the Engineer.

216.5. Payment. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rolling (Proof)", which price shall be full compensation for furnishing and operating all equipment; for all labor, tools, fuel and incidentals necessary to satisfactorily perform the work, except sprinkling. All sprinkling performed as required, will be measured and paid for as follows:

(a) When used in connection with density control sprinkling will not be paid for directly but will be subsidiary to other bid items.

(b) When used in connection with ordinary compaction all sprinkling will be measured and paid for in accordance with the provisions governing the Item, "Sprinkling".

Unless otherwise provided on the plans or in the special provisions, payment for reworking unstable or non-uniform areas, removing and replacing materials, addition of stabilizing materials, and all compaction and incidentals necessary to correct all irregularities will not be made directly but will be considered as subsidiary to the various bid items.

ITEM 230

ROADBED TREATMENT

230.1. Description. "Roadbed Treatment" shall consist of treating designated sections of the roadbed by the addition of suitable material and shall be constructed as herein specified in conformity with the typical sections shown on the plans and to the lines and grades as established by the Engineer.

When plans include the Item "Roadbed Treatment (Stockpiled)" with a specified type shown, the material shall be stockpiled at sites designated on the plans or by the Engineer. The Contractor shall be responsible for the proper preparation of stockpile areas before roadbed treatment is placed thereon, including leveling and cleaning of debris necessary for protection of the roadbed treatment to prevent any contamination thereof.

230.2. Material. The material shall be approved by the Engineer, and shall meet the following requirements for the type or types specified on the plans:

Type A. This material shall consist of selected clay or calcareous clay, with or without stones, conglomerate or sand of a proper quality to secure a well bonded course.

Type B. This material shall consist of sand or other suitable granular material, free from lumps of earth, vegetation or other objectionable matter.

Type C. This material shall conform to the specification requirements shown on the plans.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

230.3. Material Sources. Should the Contractor elect to obtain the specified materials from local pits, the material may be secured from the sources shown on plans or approved by the Engineer.

Material pits shall be stripped, if required, and any material considered unacceptable by the Engineer shall be removed from the pits.

Pits, as utilized, shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material and, unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

230.4. Construction Methods. Prior to the inauguration of this work the roadbed shall have been graded and/or shaped, compacted and finished to conform to the typical sections shown on the plans and to the lines and grades established by the Engineer. Unstable material or material not intended to remain in the roadbed for use in this work shall have been removed and all operations incidental thereto shall have been performed and, if so specified, paid for under other items of work. The roadbed shall be firm and free of holes, ruts and depressions and in condition to receive the roadbed treatment.

The material shall be delivered in approved vehicles of uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. The material shall be spread to proper section by the use of blades, drags or other suitable equipment.

If the material is not well mixed or contains oversize material, it shall be thoroughly mixed, after spreading, and all oversize material shall be broken by raking, blading, disking, harrowing, scarifying or other approved methods.

Upon completion of this work, the course shall be reshaped to conform to the typical sections shown on plans and prepared and finished to receive the succeeding course or layer of subbase, base or pavement structure.

The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereon, or the work is accepted. During this maintenance, additional material shall be added, if ordered by the Engineer, as necessary for the maintenance of a satisfactory surface.

In those cases where additional compaction is desired, it shall be obtained by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The material shall be sprinkled and rolled as directed by the Engineer. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding or removing material as

required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density shown on the plans as determined in accordance with Test Method Tex-114-E. The field density determination shall be made in accordance with approved methods. In addition to the requirements specified for density, the entire depth of the roadbed treatment as shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of roadbed treatment is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density specified, it shall be reworked as necessary to meet these requirements. All irregularities, depressions or weak spots which may develop shall be corrected immediately by scarifying the areas affected, adding or removing material as required, reshaping and recompacting by sprinkling and rolling. The completed course shall be smooth and free of segregation, ruts or depressions. The compacted roadbed treatment shall be maintained by the Contractor until subsequent base and surface courses have been completed, and should the roadbed treatment due to any reason or cause, lose the required stability, density and finish before the subsequent base and surfacing have been completed, it shall be recompacted and refinished at the sole expense of the Contractor.

230.5. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2,000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

Material to be stockpiled will be measured in the same manner as that delivered on the road, except that it will be measured as delivered to the stockpile site.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

230.6. Payment. The work performed and material furnished as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above, will be paid for at the unit price bid by one of the following methods: (1) "Roadbed Treatment (Ordinary Compaction)" of the type specified and "Additional Quarter Mile Haul" or (2) "Roadbed treatment (Density Control)" of the type specified and "Additional Quarter Mile Haul".

The unit prices bid for roadbed treatment shall each be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; loosening, excavating and loading the material; hauling the first one-quarter mile and delivering on the road; for spreading, mixing, breaking oversize material and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except as follows:

When the plans include the Item "Roadbed Treatment (Stockpiled)", of the type specified, the unit prices bid for this material shall be full compensation for preparing the stockpile area; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling the first quarter mile and delivering in the stockpile; for spreading and shaping the material in the stockpile; and for all manipulations, labor, tools and incidentals necessary to complete the work except as otherwise provided for in this specification.

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Hauling material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise shown on plans, all stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

ITEM 232

FLEXIBLE BASE
(Caliche)

232.1. Description. "Flexible Base (Caliche)" shall consist of a foundation course for surface course or for other base courses; shall be composed of caliche and stone materials; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

When plans include the Item "Flexible Base (Stockpiled)" with a specified type and grade shown, the material shall be stockpiled at sites designated on the plans. The Contractor shall be responsible for the proper preparation of stockpile areas before flexible base is placed thereon, including leveling and cleaning of debris necessary for protection of the flexible base to prevent any contamination thereof.

232.2 Material. The material shall consist of argillaceous limestone, calcareous or calcareous clay particles, with or without stone, conglomerate, gravel, sand or other granular materials. The material source shall be approved by the Engineer. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". All the acceptable material shall be screened, and the oversize shall be crushed and returned to the screened material again in such manner that a uniform product will be produced. Samples for testing the material shall be taken prior to the compaction operations.

232.3. Types. The types of material are identified as follows:

(1) Type A. Type A flexible base shall consist of processed or crushed material as described in "Material" above.

(2) Type B. Type B flexible base shall consist of processed or crushed material as described in "Material" above and shall be screened or partially screened or otherwise manipulated in a manner satisfactory to the Engineer, prior to crushing in order that all soil, clay and other objectionable material will be removed.

232.4. Grades. The material shall conform to the requirements of either Grade 1 or Grade 2 as follows:

(1) Grade 1. When tested by Texas Highway Department standard laboratory methods, the flexible base material shall meet the following requirements:

Passing 1-3/4 inch sieve	100%
Retained on No. 40 sieve	50 to 85%

Material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements when prepared in accordance with Test Method Tex-101-E procedure:

The liquid limit shall not exceed 40
The plasticity index shall not exceed 12

(2) **Grade 2.** The grading, soil constants and/or triaxial requirements and other specification data for Grade 2 flexible base material shall be as shown on the plans.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

232.5. Material Sources. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or approved by the Engineer. These pits, as utilized, shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured (by blasting if necessary) in successive vertical cuts extending through all of the exposed strata.

When shown on the plans, the processed material shall not be hauled directly to the road but shall be stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of processed material not to exceed the depth shown on the plans. After a sufficient stockpile, as determined by the Engineer, has been constructed as specified, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

232.6. Construction Methods.

(1) **Preparation of Subgrade.** The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material.

The surface of the subgrade shall be finished true to line and grade as established and in conformity with the typical section shown on plans. Any deviation in excess of 1/2 inch in cross section and in length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing

material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) **First Course.** Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day unless otherwise directed by the Engineer in writing. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged and shaped to conform to typical sections as shown on the plans. All areas and "nests" of segregated course or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming or by other approved methods.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provision shall apply:

The course shall be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longtiudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified

under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the base course, due to any reason or cause, lose the required stability, density and finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

(4) Density. When the "Density Control" method of compaction is indicated on the plans, each course of flexible base shall be compacted to the precent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

Tolerances: The limits establishing reasonably close conformity with present density specified is defined by the following:

The Engineer may accept the work, providing not more than 25% of the density tests performed each day are outside the specified density by no more than 3 pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

232.7. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

Material to be stockpiled will be measured, in the same manner as that delivered on the road, except that it will be measured as delivered to the stockpile site.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the applicable requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

232.8. Payment. Except as provided herein, the work performed and material furnished (including additional binder if required) as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above, will be paid for at the unit price bid, by one of the following methods: (1) "Flexible Base (Ordinary Compaction)" of the type and grade specified and "Additional Quarter Mile Haul" or (2) "Flexible Base (Density Control)" of the type and grade specified and "Additional Quarter Mile Haul".

When plans include the Item "Flexible Base (Stockpiled)", of the type and grade specified, the unit prices bid for this material shall be full compensation for preparing the stockpile area; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for all hauling and delivering in the stockpile; for spreading and shaping the material in the stockpile; and for all manipulation, labor, tools and incidentals necessary to complete the work except as otherwise provided for in this specification.

The unit prices bid for flexible base shall each be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required, for loading all materials; for hauling the first one quarter mile and delivering on the road; for spreading, blading, dragging, shaping and finishing; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless specified otherwise on plans hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work", respectively. Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work", or "Scraper Work".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item, "Stripping".

ITEM 234

FLEXIBLE BASE
(Shell with Sand Admixture)

234.1. Description. "Flexible Base (Shell with Sand Admixture)" shall consist of a foundation course for surface course or other base courses, shall be composed of shell and binder, and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

234.2. Materials.

(1) Shell. Shell shall consist of durable particles of shell with or without its natural binder material and may be either washed, partially washed or unwashed.

(2) Sand. Sand shall consist of fine sand or sandy loan and shall be practically free from roots, grass and other foreign materials.

(3) Flexible Base. All materials shall be obtained from sources designated on the plans or approved by the Engineer. Both the shell and sand shall be of such quality that when properly proportioned and mixed a satisfactory flexible base material will be produced. Samples for testing shall be taken prior to the compaction operations.

When the shell is received in barges, where storage space permits, the shell shall be unloaded into stockpile in such a manner that several barges will be mixed in loading the shell from the stockpile into vehicles for delivery to the road. The Contractor will be responsible for mixing the shell to the extent that segregation will be corrected and a uniform material will be delivered on the road. When the shell is loaded directly from reefs or pits into vehicles for delivery to the road, the material shall be excavated in such manner as to mix the various layers of material in the reef or pit. The Contractor will be responsible for furnishing shell and sand which, when properly mixed, will produce a satisfactory uniform mixture as specified.

234.3. Grades. The combined material shall conform to the requirements of either Grade 1 or Grade 2 as follows:

(1) Grade 1. When properly slaked and tested by standard Texas Highway Department laboratory methods, the flexible base material shall meet the following requirements:

Passing 1-1/4 inch sieve 90-100%
Retained on No. 40 sieve 45-65%

The material passing the No. 40 sieve shall be known as soil binder and shall meet the following requirements when prepared in accordance with Test Method Tex-101-E procedure:

The Liquid Limit shall not exceed 35
The Plasticity Index shall not exceed 10

(2) Grade 2. The grading, soil constants and/or triaxial requirements and other specification data for Grade 2 flexible base shall be as shown on the plans.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

234.4. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and, if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established, and be in conformity with the typical section shown on plans and any deviation in excess of 1/2 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed. Any

additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section, and corrections made if necessary.

All materials shall be delivered in approved vehicles of a uniform capacity. The required amount of shell shall be uniformly spread across the section and allowed to dry sufficiently to insure proper slaking and mixing of the binder material. Immediately upon completion of the drying period, as determined by the Engineer, the specified amount of sand admixture shall be spread uniformly across the shell. The material shall then be sprinkled as required and thoroughly mixed by blading and harrowing, or other approved methods.

If approved by the Engineer in writing, a central mixing plant, or a road mixing machine or a combination of machine, which will produce a uniform material meeting all of the requirements of this specification may be used in place of the road mixing described hereinbefore.

Failure to proceed with the placing of sand admixture or mixing and placing operations will be grounds for the suspension of placing of shell. Under no conditions will the Contractor be allowed to place an excessive amount of shell without proceeding with the mixing and placing operations.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

After mixing, all material shall be windrowed, and then spread over the section in layers not to exceed 2 inches in loose depth. If necessary to prevent segregation, the material shall be wetted in the windrow prior to spreading. After each lift is spread, it shall be sprinkled and rolled to secure maximum compaction as directed by the Engineer. Succeeding layers shall then be placed similarly until the course is completed. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading; and the surface, upon completion, shall be smooth and in conformity with the typical sections shown on plans, and to the established lines and grades.

In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisons shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specifed under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the base course, due to any reason or cause, lose the required stability, density and finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

(4) Density. When the "Density Control" method of compaction is indicated on the plans each course of flexible base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

234.5. Measurement. Work and accepted material as prescribed for this item will be measured for payment in accordance with the method indicated on the plans and proposal, the method of measurement being as follows:

(1) When bids are requested on "Flexible Base (Ordinary Compaction)" of the grade specified, "Sand Admixture" and "Additional Quarter Mile Haul (Sand Admixture)" or "Flexible Base (Density Control)" of the grade specified, "Sand Admixture" and "Additional Quarter Mile Haul (Sand Admixture)", measurement will be by the cubic yard, in vehicles as delivered on the road, the shell and sand admixture to be measured separately. Measurement for hauling sand admixture material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and the point of delivery on the road.

(2) When bids are requested only on "Flexible Base (Ordinary Compaction)" of the grade specified or "Flexible Base (Density Control)" of the

grade specified, measurement will be by the ton of 2000 pounds dry weight of combined shell and sand admixture.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the applicable requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer, except that when the material is weighed in mixing or batching, platform truck scales and reweighing will not be necessary.

234.6. Payment. The work performed and material furnished as prescribed by this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above will be paid for at the unit price bid by one of the following methods:

(1) "Flexible Base (Ordinary Compaction)" of the grade specified, "Sand Admixture" and "Additional Quarter Mile Haul (Sand Admixture)" or "Flexible Base (Density Control)" of the grade specified, "Sand Admixture" and "Additional Quarter Mile Haul (Sand Admixture)". (Cubic yard measurement with direct payment for hauling sand admixture beyond the first quarter mile).

(2) "Flexible Base (Ordinary Compaction)" of the grade specified or "Flexible Base (Density Control)" of the grade specified. (Ton measurement of combined shell and sand admixture without direct payment for hauling).

The unit prices bid for flexible base shall each be full compensation for securing and furnishing all materials, including all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for all processing and loading; for all hauling except as provided herein; for delivering, stockpiling if required, placing, spreading, mixing, blading, shaping, dragging and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except as follows:

The unit price bid shall include all hauling when payment is by the ton of combined shell and sand admixture. When unit bid prices are requested for "Flexible Base", "Sand Admixture" and "Additional Quarter Mile Haul (Sand Admixture)", the unit price bid for "Sand Admixture" shall include hauling only the first quarter mile, and hauling such material beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul (Sand Admixture)".

When "Ordinary Compaction" is indicated on the plans all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but shall be subsidiary to other bid items.

Unless otherwise provided by the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation", and "Borrow",

respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved.

When shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of shoulders and slopes, and for finishing roadway shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work". Payments under the Item, "Roadway Excavation" will not be allowed within the limits designated for the Items, "Blading", "Road Grader Work" or "Scraper Work".

ITEM 236
FLEXIBLE BASE
(Bank-run Gravel)

236.1. Description. "Flexible Base (Bank-run Gravel)" shall consist of a foundation course for surface course or for other base courses; shall be composed of bank-run gravel; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

When plans include the item "Flexible Base (Stockpiled)" with a specified grade shown, the material shall be stockpiled at sites designated on the plans. The Contractor shall be responsible for the proper preparation of stockpile areas before flexible base is placed thereon, including leveling and cleaning of debris necessary for the protection of the flexible base to prevent any contamination thereof. The stockpile areas shall also meet the approval of the Engineer before any material is placed thereon.

236.2. Material. The material shall consist of durable particles of gravel mixed with approved binding material; and shall be free from thin or elongated pieces, lumps of clay, soil, loam or vegetable matter. The material may be bank-run or the binder may be added and incorporated by approved methods as herein specified. The material source shall be approved by the Engineer. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". Material containing gravel or conglomerate over 2 inches in their largest dimensions shall be broken up and uniformly mixed with the remainder of the material. Samples for testing the material shall be taken prior to the compaction operations.

236.3. Grades. Unless otherwise shown on plans the material shall conform to the requirements of either Grade 1 or Grade 2 as follows:

Grade 1: When properly slaked and tested by standard Texas Highway Department laboratory methods, the flexible base material shall meet the following requirements:

Retained on 1-3/4 inch sieve	0 to 5%
Retained on No. 4 sieve	30 to 75%
Retained on No. 40 sieve	65 to 85%

Material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements when prepared in accordance with Test

Method Tex-101-E procedure:

The liquid limit shall not exceed 35
The plasticity index shall not exceed 10

Grade 2: The grading, soil constants and/or triaxial requirements and other specification data for Grade 2 flexible base material shall be as shown on the plans.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

236.4. Material Sources. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or approved by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

When shown on the plans, the processed material shall not be hauled directly to the road but shall be temporarily stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of processed material not to exceed the depth shown on the plans. After a sufficient stockpile, as determined by the Engineer, has been constructed as specified, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

236.5. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water, reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of 1/2 inch in cross section and in a length of 16 feet measured longitudinally shall be

corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) **First Course.** Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day unless otherwise directed by the Engineer in writing. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming or by other approved methods.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The course shall be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified

under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the base course, due to any reason or cause, lose the required stability, density or finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

(4) Density. When the "Density Control" method of compaction is indicated on the plans each course of flexible base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

Tolerances: The limits establishing reasonably close conformity with precent density specified are defined by the following:

The Engineer may accept the work, providing not more than 25% of the density tests performed each day are outside the specified density by no more than 3 pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

236.6. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

When the plans include the Item, "Flexible Base (Stockpiled)", material will be measured in the stockpile and the volume computed in cubic yards by the method of average end areas. Measurement for payment will be made only after the stockpile has been constructed as specified on the plans and approved by the Engineer.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the applicable requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

236.7. Payment. Except as provided herein, the work performed and material furnished (including additional binder if required) as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above, will be paid for at the unit price bid, by one of the following methods: (1) "Flexible Base (Ordinary Compaction)" of the grade specified and "Additional Quarter Mile Haul" or (2) "Flexible Base (Density Control)" of the grade specified and "Additional Quarter Mile Haul".

When plans include the item "Flexible Base (Stockpiled)", of the grade specified, the unit prices bid for this material shall be full compensation for preparing the stockpile area; for all royalty involved; for loosening or blasting, excavating and breaking oversize material; for loading all materials; for hauling the first one-quarter mile and delivering to the stockpile area; for spreading; for all shaping of the stockpile; and for all manipulation, labor, tools, and incidentals necessary to complete the work.

The unit prices bid for flexible base shall each be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating and breaking oversize material; for temporary stockpiling where required; for loading all materials; for hauling the first one-quarter mile and delivering on the road; for spreading, blading, dragging, shaping and finishing; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

When "Ordinary Compaction" is indicated on the plans all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless provided otherwise on plans, hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively,

with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work", respectively. Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work" or "Scraper Work".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item, "Stripping".

ITEM 238

FLEXIBLE BASE
(Processed Gravel)

238.1. Description. "Flexible Base (Processed Gravel)" shall consist of a foundation course for surface course or for other base courses; shall be composed of screened and processed gravel; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

When plans include the item "Flexible Base (Stockpiled)" with a specified grade shown, the material shall be stockpiled at sites designated on the plans. The Contractor shall be responsible for the proper preparation of stockpile areas before flexible base is placed thereon, including leveling and cleaning of debris necessary for the protection of the flexible base to prevent any contamination thereof. The stockpile areas shall also meet the approval of the Engineer before any material is placed thereon.

238.2. Material. The material shall consist of durable particles of gravel mixed with approved binding material. The material may be bank-run or the binder may be added and incorporated by approved methods as herein specified. The material source shall be approved by the Engineer. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". All the acceptable material shall be screened, and the oversize shall be crushed and returned to the screened material again in such manner that a uniform product will be produced. Samples for testing the material shall be taken prior to the compaction operations.

238.3. Grades. Unless otherwise shown on plans, the material shall conform to the requirements of either Grade 1 or Grade 2 as follows:

(1) Grade 1. When properly slaked and tested by standard Texas Highway Department laboratory methods the flexible base material shall meet the following requirements:

Retained on 1-3/4 inch sieve	0%
Retained on 3/8 inch sieve	20 to 60%
Retained on No. 4 sieve	40 to 75%
Retained on No. 40 sieve	65 to 85%

Material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements when prepared in accordance with Test Method Tex-101-E procedure:

The liquid limit shall not exceed 35
The plasticity index shall not exceed 10

(2) Grade 2. The grading, soil constants and/or triaxial requirements and other specification data for Grade 2 flexible base material shall be as shown on the plans.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

238.4. Material Sources. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or approved by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

When shown on the plans, the processed material shall not be hauled directly to the road but shall be stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of processed material not to exceed the depth shown on the plans. After a sufficient stockpile, as determined by the Engineer, has been constructed as specified, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

238.5. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the

typical section shown on plans, and any deviation in excess of 1/2 inch in cross section and in a length of 16 feet measured longitudinally, shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day unless otherwise directed by the Engineer in writing. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming or by other approved methods.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The course shall be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the base course, due to any reason or cause, lose the required stability, density and finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

(4) Density. When the "Density Control" method of compaction is indicated on the plans each course of flexible base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide, in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

Tolerances: The limits establishing reasonably close conformity with percent density specified are defined by the following:

The Engineer may accept the work, providing not more than 25% of the density tests performed each day are outside the specified density by no more than 3 pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

238.6. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

When the plans include the Item, "Flexible Base (Stockpiled)", material will be measured in the stockpile and the volume computed in cubic yards by the method of average end areas. Measurement for payment will be made only after the stockpile has been constructed as specified on the plans and approved by the Engineer.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the applicable requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

238.7. Payment. Except as provided herein the work performed and material furnished (including additional binder if required) as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above, will be paid for at the unit price bid by one of the following methods: (1) "Flexible Base (Ordinary Compaction)" of the grade specified and "Additional Quarter Mile Haul" or (2) "Flexible Base (Density Control)" of the grade specified and "Additional Quarter Mile Haul".

The unit price bid for flexible base shall each be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling the first one quarter mile and delivering on the road; for spreading, blading, dragging, shaping and finishing; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

When plans include the item "Flexible Base (Stockpiled)", of the grade specified, the unit prices bid for this material shall be full compensation for preparing the stockpile area; for all royalty involved; for all clearing and grubbing; for loosening or blasting, excavating and crushing oversize material; for loading all materials; for hauling the first one-quarter mile and delivering to the stockpile area, for spreading; for all shaping of the stockpile; and for all manipulation, labor, tools and incidentals necessary to complete the work.

When "Ordinary Compaction" is indicated on the plans, sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless otherwise specified on plans hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders

and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work" respectively. Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work" or "Scraper Work".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item, "Stripping".

ITEM 240

FLEXIBLE BASE
(Iron Ore)

240.1. Description. "Flexible Base (Iron Ore)" shall consist of a foundation course for surface course or for other base courses; shall be composed of iron ore material; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

When plans include the Item "Flexible Base (Stockpiled)" with a specified type and grade shown, the material shall be stockpiled at sites designated on the plans. The Contractor shall be responsible for the proper preparation of stockpile areas before flexible base is placed thereon, including leveling and cleaning of debris necessary for protection of the flexible base to prevent any contamination thereof.

240.2. Material. The material shall consist of hematite, hydrated hematite or limonite ore, occurring with or without sand, as found at or near the surface, which, when loaded from the material pit, shall not contain an excess of free clay. The material source shall be approved by the Engineer. Material containing gravel or hard pieces of ore exceeding the maximum specified size in their largest dimension shall be broken up and uniformly mixed with the remainder of the material.

240.3. Grades. The material shall conform to the requirements of either Grade 1 or Grade 2 as follows:

(1) Grade 1. When properly slaked and tested by standard Texas Highway Department laboratory methods the flexible base material shall meet the following requirements:

Retained on 2-1/2 inch sieve	0%
Retained on No. 40 sieve	50 to 85%

Material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements when prepared in accordance with Test Method Tex-101-E Procedure:

The liquid limit shall not exceed 35
The plasticity index shall not exceed 12

(2) Grade 2. The grading, soil constants and/or triaxial requirements and other specification data for Grade 2 flexible base shall be as shown on the plans.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

240.4. Material Sources. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or approved by the Engineer. It shall be the charge of the Contractor to remove grass, weeds, rubbish or other objectionable materials; to break up by crushing, sledging or other approved methods, material over the maximum specified size in its largest dimensions; and to thoroughly mix the base course material in the pit before loading same, in order that a uniform material may be delivered on the road. This mixing process may be done by blading the material into windrows or by other approved methods. When permitted by the Engineer, the material may be delivered to the road and all oversize material broken and thoroughly mixed to provide the gradation specified.

When shown on the plans, the processed material shall not be hauled directly to the road but shall be stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of processed material not to exceed the depth shown on the plans.

After a sufficient stockpile, as determined by the Engineer, has been constructed as specified, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

240.5. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable

material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material and, if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished true to line and grade as established and in conformity with the typical section shown on plans. Any deviation in excess of 1/2 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. The material shall be delivered in approved vehicles of uniform capacity and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day unless otherwise directed by the Engineer in writing. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, it shall be scarified and spread as early as possible as directed by the Engineer.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The material shall be scarified, thoroughly wetted, mixed, manipulated and bladed so as to secure a uniformly wetted material and pulled in over the subgrade in courses and set under the action of blading and rolling. The work of mixing, blading, rolling, shaping and subsequent maintenance shall be performed by the continuous use of a sufficient number of satisfactory power maintainers with satisfactory scarifier attachments and the specified rollers. The above described operations shall continue until, in the opinion of the Engineer, the base course is sufficiently compacted and set to permit the application of the succeeding course or courses. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the base course, due to any reason or cause, lose the required stability, density and finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

(4) Density. When the "Density Control" method of compaction is indicated on the plans each course of flexible base shall be compacted to the precent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

Tolerances: The limits establishing reasonably close conformity with percent density specified are defined by the following:

The Engineer may accept the work, providing not more than 25% of the density tests performed each day are outside the specified density by no more than 3 pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

240.6. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

Material to be stockpiled will be measured, in the same manner as that delivered on the road, except that it will be measured as delivered to the stockpile site.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

240.7. Payment. Except as provided herein the work performed and material furnished (including additional binder if required) as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above, will be paid for at the unit price bid, by one of the following methods: (1) "Flexible Base (Ordinary Compaction)" of the grade specified and "Additional Quarter Mile Haul" or (2) "Flexible Base (Density Control)" of the grade specified and "Additional Quarter Mile Haul".

The unit prices bid for flexible base shall each be full compensation for shaping and fine grading the roadbed; for removing grass, weeds, rubbish and other objectionable matter from the surface of the material source; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening, blasting, excavating, crushing or breaking oversize material; for temporary stockpiling where required; for loading all materials; for hauling the first one quarter mile and delivering on the road; for spreading, blading, dragging, shaping and finishing; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

When plans include the Item "Flexible Base (Stockpiled)", of the grade specified, the unit prices bid for this material shall be full compensation for preparing the stockpile area; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling the first quarter mile and delivering in the stockpile; for spreading and shaping the material in the stockpile; for all manipulations, labor, tools and incidentals necessary to complete the work except as otherwise provided for in this specification.

When "Ordinary Compaction" is indicated on the plans all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless specified otherwise on plans hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans all excavation required by this item in the preparation of the subgrade and procurement of additional material for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow". However, where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Scraper Work" or "Road Grader Work". Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Scraper Work" or "Road Grader Work".

ITEM 242

FLEXIBLE BASE
(Crushed Stone)

242.1. Description. "Flexible Base (Crushed Stone)" shall consist of a foundation course for surface course or for other base courses; shall be composed of crusher-run broken stone; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

When plans include the Item "Flexible Base (Stockpiled)" with a specified type and grade shown, the material shall be stockpiled at sites designated on the plans. "Flexible Base (Stockpiled)" may be hauled directly from the crusher to the designated stockpile site. Preparation of the stockpile area, and shaping and spreading of "Flexible Base (Stockpiled)" shall be the responsibility of the Contractor.

242.2. Material. The material shall be crushed and shall consist of durable particles of stone mixed with approved binding material. The material source shall be approved by the Engineer. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". Samples for testing the material shall be taken prior to the compaction operations.

242.3. Types. The types of flexible base material are identified as follows:

(1) Type A. Type A flexible base shall consist of crushed material as described in "Material" above.

(2) Type B. Type B flexible base shall consist of crushed material as described in "Material" above and shall be screened or partially screened or otherwise manipulated in a manner satisfactory to the Engineer, prior to crushing, in order that all soil, clay and other objectionable material will be removed.

242.4. Grades. The material shall conform to the requirements of either Grade 1, Grade 2 or Grade 3 as follows:

(1) Grade 1. When properly slaked and tested by standard Texas Highway Department laboratory methods, the flexible base material shall meet the following requirements:

Retained on 1-3/4" sieve	0%
Retained on 1" sieve	5 to 25%
Retained on 1/2" sieve	30 to 50%
Retained on No. 4 sieve	45 to 65%
Retained on No. 40 sieve	70 to 80%

Material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements when prepared in accordance with Test Method Tex-101-E procedure:

The liquid limit shall not exceed	40
The plasticity index shall not exceed	10

The material shall have a Wet Ball Mill Value not exceeding 40 when tested in accordance with Texas Highway Department Standard laboratory test Tex-116-E. Unless otherwise shown on plans the increase in soil binder resulting from this test shall not exceed 20.

(2) Grade 2. When properly slaked and tested by standard Texas Highway Department laboratory methods, the flexible base material shall meet the following requirements:

Retained on 1-3/4 inch sieve	0%
Retained on No. 4 sieve	45 to 75%
Retained on No. 40 sieve	60 to 85%

Material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements when prepared in accordance with Test Method Tex-101-E procedure:

The liquid limit shall not exceed	40
The plasticity index shall not exceed	12

(3) Grade 3. The grading, soil constants and/or triaxial requirements and other specification data for Grade 3 flexible base material shall be as shown on the plans.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

242.5. Material Sources. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or approved by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata.

When shown on the plans, the processed material shall not be hauled directly to the road but shall be stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of processed material not to exceed the depth shown on the plans. After a sufficient stockpile, as determined by the Engineer, has been constructed as specified, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

242.6. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of 1/2 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day unless otherwise directed by the Engineer in writing. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if

directed, and shall then be bladed, dragged and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming or by other approved methods.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The course shall be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the base course, due to any reason or cause, lose the required stability, density and finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

(4) Density. When the "Density Control" method of compaction is indicated on the plans each course of flexible base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

242.7. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

Unless otherwise specified on the plans, material to be stockpiled will be measured in the same manner as that delivered on the road except that it will be measured as delivered at the stockpile site.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

242.8. Payment. Except as provided herein, the work performed and material furnished (including additional binder if required) as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above, will be paid for at the unit price bid, by one of the following methods: (1) "Flexible Base (Ordinary Compaction)" of the type and grade specified and "Additional Quarter Mile Haul or (2) "Flexible Base (Density Control)" of the type and grade specified and "Additional Quarter Mile Haul".

The unit prices bid for flexible base shall each be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling the first one quarter mile and delivering on the road; for spreading, blading, dragging, shaping and finishing; and for all manipulation, labor, tools and incidentials necessary to complete the work except as follows:

When plans include the Item "Flexible Base (Stockpiled)" of the type and grade specified, the unit price bid for this material shall be full compensation for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling the first quarter mile and delivering in the stockpile, and for all manipulations, labor, tools, and incidentals necessary to complete the work except as otherwise provided for in this specification.

When "Ordinary Compaction" is indicated on the plans all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless specified otherwise on plans hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work", respectively. Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work" or "Scraper Work".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item, "Stripping".

ITEM 244

FLEXIBLE BASE
(Class 1)

244.1. Description. "Flexible Base (Class 1)" shall consist of a foundation course for surface course or for other base courses; shall be composed of crusher-run broken stone; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

244.2. Material. The material shall be crushed, and shall consist of durable particles of stone mixed with approved binding materials. The material source shall be approved by the Engineer. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping".

244.3. Types. Types of flexible base material are identified as follows:

(1) Type A. Type A flexible base shall consist of crushed material as described in "Material" above.

(2) Type B. Type B flexible base shall consist of crushed material as described in "Material" above and shall be screened or partially screened or otherwise manipulated in a manner satisfactory to the Engineer, prior to crushing, in order that all soil, clay and other objectionable material will be removed.

244.4. Grades. The material shall conform to the requirements of either Grade 1 or Grade 2 as follows:

(1) Grade 1:

After placing on the road and compacting to the specified density and prior to dry curing, the flexible base material shall meet the following requirements:

Retained on 1-3/4 inch sieve	0%
Retained on 7/8 inch sieve	8 to 30%
Retained on 3/8 inch sieve	30 to 50%
Retained on No. 4 sieve	45 to 65%
Retained on No. 40 sieve	70 to 80%

Material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements when prepared in accordance with Test Method Tex-101-E procedure:

The liquid limit shall not exceed	40
The plasticity index shall not exceed	10

The processed material shall be of such soundness that when tested in accordance with Test Method Tex-116-E, the resulting soil binder content (material passing the No. 40 sieve) shall not exceed 40 percent by weight, of the total sample tested and the increase in soil binder shall not exceed 20.

When tested in accordance with Test Method Tex-117-E, the material shall conform to the requirements for a Class 1 base material.

Additives may be used with the written permission of the Engineer in order to meet the above requirements.

(2) Grade 2:

The grading, soil constants and/or triaxial requirements and other specification data for Grade 2 flexible base material shall be as shown on the plans.

244.5. Material Sources. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or approved by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata.

When shown on the plans, the processed material shall not be hauled directly to the road but shall be stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of processed material not to exceed the depth shown on the plans. After a sufficient stockpile, as determined by the Engineer, has been constructed as specified, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

244.6. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of ½ inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with the grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same

day unless otherwise directed by the Engineer in writing. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the Engineer.

The material shall be sprinkled, if required, and shall then be shaped to conform to typical sections as shown on plans in such a manner that a uniformity in grading of the material in place will be obtained that will not vary at any point on the road on any of the screen sizes from the grading of the material as specified above. All areas and "nests" of segregated coarse or fine material, not meeting the above requirement, shall be corrected, or removed, if directed by the Engineer and replaced with material meeting this requirement. The course shall then be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. In that area on which pavement is to be placed any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable materials as required, reshaping and recompacting by sprinkling and rolling.

Should the base course, due to any reason or cause, lose the required stability, density or finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor. Excessive loss of moisture in the completed base shall be prevented by sprinkling.

Traffic shall be controlled such that the repetitious application of heavy loads on unfinished base will be held to the absolute minimum.

During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

Prior to placing the surfacing on the completed base, the final course of base shall be "dry cured" to the extent directed by the Engineer.

(4) Density. Each course of flexible base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

244.7. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

244.8. Payment. The work performed and material furnished as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above will be paid for at the unit price bid for "Flexible Base" of the type and grade specified which price shall be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for additives, if permitted; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling the first one quarter mile and delivering on the road; for spreading, blading, dragging, sprinkling, compacting, shaping and finishing; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

Unless specified otherwise on plans hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be

performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work", respectively. Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work" or "Scraper Work".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item, "Stripping".

ITEM 246

FOUNDATION COURSE

246.1. Description. "Foundation Course" shall consist of a foundation course for surface course or for additional foundation courses; and shall be composed of material or mixture of materials constructed in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

246.2. Material. The material source shall be approved by the Engineer. Only such material removed from pits or quarries or designated sources within roadway limits or channels reserved for use under this item as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". The material shall be free of vegetation or other objectionable matter and when prepared by standard Test Method Tex-101-E, the material and/or mixtures of materials, shall meet the requirements specified by the plans and shall be unprocessed or processed as may be necessary to comply with the requirements set out in the plans. Samples for testing the material shall be taken prior to the compaction operations.

Tolerances: The limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

246.3. Material Sources. The specified material shall be produced from sources shown on the plans or approved by the Engineer. Where pits, quarries, roadway or channel sources are utilized, they shall be opened and operated in

a manner to provide proper mixture of acceptable material and/or segregation of materials considered unacceptable by the Engineer.

Vegetation and stripping from pits or quarries shall be disposed of as directed by the Engineer and the site shall be left in a satisfactory and sightly condition.

When material is obtained from sources reserved from roadway cuts or channels, only that material actually used in the work under this item shall be measured and paid for as provided herein, and the remainder of the material in the source shall be measured and paid for as "Roadway Excavation" or "Channel Excavation" in accordance with the provisions of those items, and all provisions thereof, including completion to established alignment, grades and cross sections shall apply.

When shown on the plans, the processed material shall not be hauled directly to the road but shall be temporarily stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of processed material not to exceed the depth shown on the plans. After a sufficient stockpile, as determined by the Engineer, has been constructed as specified, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

246.4. Construction Methods. Prior to the inauguration of this work the roadbed shall have been graded and/or shaped, compacted and finished to conform to the typical sections shown on the plans and to the lines and grades established by the Engineer. Unstable material or material not intended to remain in the roadbed for use in this work shall have been removed and all operations incident thereto shall have been performed and, if so specified, paid for under other items of work.

(1) Preparation of Subgrade. The roadbed shall be shaped to conform to the subgrade section indicated on plans. It shall be firm and to the line and grade established by the Engineer and free of holes, ruts and depressions.

(2) Placing and Manipulation of Material. The material shall be delivered in approved vehicles of uniform capacity and it shall be the charge of the Contractor that the required amount of material for each operation is delivered and uniformly distributed in each 100-foot station. Material shall be uniformly and thoroughly mixed on the subgrade or preceding course by blading, harrowing, disking or other approved methods before compaction. Where plans indicate an admixture of materials to be performed on the subgrade, the heavier course shall be uniformly and thoroughly mixed and spread prior to delivery of other material which shall then be spread and the combined material uniformly and thoroughly mixed by operations above specified. Where plans indicate an admixture using material existing on the roadway, the existing material shall be scarified to the depth indicated on plans, pulverized by use of blades, scarifiers, harrows, disks or other implements, uniformly and thoroughly mixed and placed in a layer prior to the delivery of the material to be added. The added material shall be

uniformly distributed and the two materials shall then be uniformly and thoroughly mixed by operations above specified.

The Contractor shall at all times provide proper and sufficient equipment and conduct his operations in a satisfactory and workmanlike manner. Failure to manipulate materials promptly and perform the various operations required in a continuous and coordinated manner will be grounds for suspension of any part of the work.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

Prior to compaction the mixed material shall be windrowed. It shall then be bladed to position for compaction by sprinkling and rolling in thin, successive layers and approved suitable equipment shall be kept in operation to maintain the section and grade. Compaction shall be carried to the extent directed by the Engineer. Irregularities which may develop shall be corrected immediately by scarifying the areas affected, adding and incorporating suitable material as required, recompacting and reshaping. The completed course shall be smooth and free of segregation, ruts or depressions.

When the plans indicate that the "Density Control" method of compaction is to be used the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the full depth of foundation course shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of foundation course is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. All irregularities, depressions or weak spots which may develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the foundation course, due to any reason or cause, lose the required stability, density and finish before the succeeding course or surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

(4) Density. When the "Density Control" method of compaction is indicated on the plans each course of foundation course shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that

part of the foundation course included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

Tolerances: The limits establishing reasonably close conformity with percent density specified is defined by the following:

The Engineer may accept the work, providing not more than 25% of the density tests performed each day are outside the specified density by no more than 3 pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

246.5. Measurement. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

When the plans indicate that measurement of the material is to be by the ton, a set of standard platform truck scales conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated or approved material source or sources and point of delivery on the road.

246.6. Payment. Except as provided herein the work performed and material furnished as prescribed for this item and measured in accordance with the method indicated on the plans and proposal and accordance with the applicable provisions of "Measurement" above, will be paid for at the unit price bid, by one of the following methods: (1) "Foundation Course (Ordinary Compaction)" and "Additional Quarter Mile Haul" or (2) "Foundation Course (Density Control)" and "Additional Quarter Mile Haul".

The unit prices bid for foundation course shall each be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening, crushing, sledging, handpicking or other suitable methods of reducing objectionable or oversize material; for temporary stockpiling where required; for loading all materials; for hauling the first one quarter mile and delivering on the road, for all mixing involved; for spreading, blading, dragging, shaping and finishing; for maintaining; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless specified otherwise on plans hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item, "Stripping".

Excavation required in the preparation of shoulders and slopes to conform to the typical sections shown on the plans will be paid for in accordance with the provisions of the items covering this phase of the work as indicated on the plans, with the provision that work will be measured and paid for once only, regardless of the manipulations involved.

ITEM 248

FLEXIBLE BASE

248.1. Description. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of either caliche, crushed stone, gravel, iron ore topsoil, shell, etc.; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

248.2. Materials. The material shall be crushed or uncrushed as necessary to meet the requirements hereinafter specified, and shall consist of durable coarse aggregate particles mixed with approved binding materials. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping".

248.3. Types. Type A material shall consist of crushed or broken aggregate. Type B material shall consist of gravel aggregate. Type C material shall consist of iron ore topsoil. Type D material shall consist of shell aggregate with sand admixture. Type E material shall consist of shell aggregate with sand and caliche admixture. Unless the type of material to be used is specified on the plans, the Contractor may use any one of these types, provided the material proposed for use by the Contractor meets the requirements set forth in the specification test limits tabulation.

248.4. Grades. It is the intent of this specification that unless otherwise indicated on the plans, the final course of the base material shall consist of Grades 1 or 2 and other base courses or subbase materials may consist of Grades 1, 2 or 3. All grades shall, when tested by standard Texas Highway Department laboratory test procedures, meet the physical requirements as set forth in the specification test limits tabulation.

Where pilot grading is required in the plans, the Engineer will designate the grading and allowable tolerances to govern during production. The flexible base produced shall not vary from the designated pilot grading by more than

the tolerances specified by the Engineer. The pilot grading may be varied by the Engineer as necessary to insure that the base material produced will meet the physical requirements specified.

Testing of flexible base materials shall be in accordance with the following Texas Highway Department standard laboratory test procedures:

Preparation for Soil
Constants and Sieve Analysis Tex-101-E
Liquid Limit Tex-104-E
Plastic Limit Tex-105-E
Plasticity Index Tex-106-E
Sieve Analysis Tex-110-E
Wet Ball Mill Tex-116-E
Triaxial Test ..... Tex-117-E (Part II)

Unless otherwise specified on the plans, job-control samples for testing the material for Soil Constants, Gradation and Wet Ball Mill shall be taken prior to the compaction operations.

Unless otherwise specified on the plans, job-control samples for triaxial tests shall be taken from the stockpile or from production, as directed by the Engineer, where temporary stockpiling is required and from production where temporary stockpiling is not required.

PHYSICAL REQUIREMENTS FOR FLEXIBLE BASE MATERIALS

	GRADES			
TYPES	Grade 1: (Triaxial Class 1) Min. compressive strength, psi: 45 at 0 psi lateral pressure and 175 at 15 psi lateral pressure	Grade 2: (Triaxial Class 1 to 2.3) Min. compressive strength, psi: 35 at 0 psi lateral pressure and 175 at 15 psi lateral pressure	Grade 3: (Unspecified Triaxial Class)	Grade 4
TYPE A Crushed or Broken Aggregate	Retained on % Sq. Sieve 1-3/4" .....0 7/8" ..... 10-35 3/8" ..... 30-50 No. 4 ..... 45-65 No. 40 ..... 70-85 Max LL ..... .35 Max PI .....10 *Max Wet Ball Mill 40	Retained on % Sq. Sieve 1-3/4" ..... 0-10 No. 4 ..... 45-75 No. 40 ..... 60-85 Max LL .....40 Max PI ..... 12 *Max Wet Ball Mill 50	Retained on % Sq. Sieve 1-3/4" ..... 0-10 No. 40 ..... 60-85 Max LL .....45 Max PI .....15 *Max Wet Ball Mill 55	As Shown on Plans
TYPE B Gravel Aggregate		Retained on % Sq. Sieve 1-3/4" ..... 0-10 No. 4 ..... 30-75 No. 40 ..... 70-85 Max LL .....35 Max PI 12	Retained on % Sq. Sieve 1-3/4" ..... 0-5 No. 4 ..... 30-75 No. 40 ..... 65-85 Max LL .....35 Max PI 12	As Shown on Plans

TYPE C Iron Ore Topsoil		Retained on % Sq. Sieve 2-1/2" .....0 No. 40 .... 50-85 Max LL . .....35 Max PI 12	Retained on % Sq. Sieve 2-1/2" . .. . .0 No. 40 ..... 45-85 Max LL .....35 Max PI 12	As Shown on Plans
TYPE D Sand-Shell		Retained on % Sq. Sieve 1-3/4" ..... 0-10 No. 4 ..... 45-65 No. 40 ..... 50-70 Max LL . .....35 Max PI 12	Retained on % Sq. Sieve 1-3/4" .. . .0-10 No. 40 ..... 45-65 Max LL .. ....35 Max PI ..... .12	As Shown on Plans
TYPE E Shell with Sand and Caliche Admixture		Retained on % Sq. Sieve 1-3/4" ....0 No. 40 .... 45-65 Max LL .....35 Max PI 10	Retained on % Sq. Sieve 1-3/4" ..... . .0 No. 40 ... 45-65 Max LL .... ..35 Max PI 12	As Shown on Plans

*Unless otherwise shown on plans the maximum increase in material retained on the number 40 sieve resulting from the Wet Ball Mill Test shall not exceed 20.

Tolerances: When tolerances are permitted by the plans, the limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limit on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limit.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than 2 points and where no two consecutive tests are outside the specified limit.

248.5 Material Sources. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or approved by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata.

When shown on the plans, the material shall not be hauled directly to the road but shall be stockpiled on the area designated on the plans. The stockpile shall be not less than the height indicated and shall be made up of layers of material not to exceed the depth shown on the plans. After a sufficient stockpile has been constructed as specified on the plans, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

248.6. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of 1/2 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course, Type A, Type B and Type C Material. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day unless otherwise directed by the Engineer in writing. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming or by other approved methods.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The course shall be sprinkled as required and rolled as directed until a

uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. Should the base course, due to any reason or cause, lose the required stability, density or finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) First Course Type D Material. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section, and corrections made if necessary.

All materials shall be delivered in approved vehicles of a uniform capacity. The required amount of shell shall be uniformly spread across the section and allowed to dry sufficiently to insure proper slaking and mixing of the binder material. Immediately upon completion of the drying period, as determined by the Engineer, the specified amount of sand admixture as required to produce a combined material meeting the requirements hereinbefore specified, shall be spread uniformly across the shell. The material shall then be sprinkled as required and thoroughly mixed by blading and harrowing, or other approved methods.

Failure to proceed with the placing of sand admixture or mixing and placing operations will be grounds for the suspension of placing of shell.

Under no conditions will the Contractor be allowed to place an excessive amount of shell without proceeding with the mixing and placing operations.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

After mixing, all material shall be windrowed, and then spread over the section in layers not to exceed 2 inches in loose depth. If necessary to prevent segregation, the material shall be wetted in the windrow prior to spreading. After each lift is spread, it shall be sprinkled and rolled to secure maximum compaction as directed by the Engineer. Succeeding layers shall then be placed similarly until the course is completed. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading; and the surface, upon completion, shall be smooth and in conformity with the typical sections shown on plans, and to the established lines and grades. In that area on which pavement is to be placed any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the compaction methods shall be the same as prescribed for Types A, B and C material.

When indicated on the plans or permitted by the Engineer, Type D material may be mixed in a central mixing plant and delivered to the road as a combined mixture. When this method is used the combined mixture shall meet the requirements for Type D material as hereinbefore specified and the placing and compaction requirements shall be the same as prescribed for Types A, B and C material.

(4) First Course, Type E Material. The construction methods for placing the first course of Type E material shall be the same as prescribed for Type D material except that after the shell and sand have been placed, the prescribed amount of caliche shall then be spread across the sand and shell. The composite mixture shall then be sprinkled as required and thoroughly mixed by blading and harrowing or other approved methods.

Compaction of the first course of Type E material shall be the same as prescribed above for Type D material.

Failure to proceed with placing the sand and caliche admixture or mixing and placing operations will be grounds for the suspension of placing of shell. Under no conditions will the Contractor be allowed to place an excessive amount of shell without proceeding with the mixing and placing operations.

(5) Succeeding Courses. Construction methods shall be the same as prescribed for the first course. Prior to placing the surfacing on the completed base the base shall be "dry cured" to the extent directed by the Engineer.

(6) Density. When the "Density Control" method of compaction is indicated on the plans each course of flexible base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

Tolerances: When tolerances are permitted by the plans, the limits establishing reasonably close conformity with the percent density specified are defined by the following:

The Engineer may accept the work, providing not more than 25% of the density tests performed each day are outside the specified density by no more than 3 pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

248.7. Measurement. Work and accepted material as prescribed for this item will be measured by the method described as either Class 1, 2 or 3 as follows and as specified on the plans:

When Class 1 measurement is specified, "Flexible Base", "Sand Admixture", "Caliche" and "Shell" will be measured by the cubic yard in vehicles as delivered on the road.

When Class 2 measurement is specified, "Flexible Base" will be measured by the ton of 2000 pounds dry weight in vehicles as delivered on the road.

When Class 3 measurement is specified, "Flexible Base" will be measured by the cubic yard in its final position as the volume of base course computed in place between the original subgrade or subbase surfaces, and the lines, grades and slopes of the accepted base course by the method of average end areas. When "Flexible Base (Stockpiled)" is specified it shall be measured in its stockpiled position by the method of average end areas as described above.

Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated material source or sources and point of delivery on the road. No direct measurement for hauling shell will be made.

Type of Material	Class	Method of Measurement
A, B and C	1, 2 or 3	As Described Above.
D	1	When provided by the plans, the shell and sand admixture shall be measured separately by the cubic yard in vehicles as delivered on the road.

Type of Material	Class	Method of Measurement
	2	When provided by the plans, the combined shell and sand admixture shall be measured by the ton of 2000 pounds dry weight as prescribed for Class 2 measurement. No direct measurement for hauling the mixture will be made.
	3	As Described Above.
E	1	The shell, sand admixture and caliche admixture shall be measured separately by the cubic yard in vehicles as delivered on the road as prescribed for Class 1 measurement.
	3	As Described Above.

When the plans indicate that measurement of Type A, B, C or D material is to be by the ton, a set of standard platform truck scales conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer, except that when the material is weighed in mixing or batching, platform truck scales and reweighing will not be necessary. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material.

The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

Material to be stockpiled will be measured in the same manner as that delivered on the road except that it will be measured as delivered to the stockpile site.

248.8. Payment. The work performed and material furnished as prescribed by this item and measured in accordance with the applicable provisions of "Measurement" above will be paid for as follows:

Type of Material	Description of Bid Items
A, B and C	"Flexible Base" of the compaction method specified, type (when specified on the plans), class and grade; and "Additional Quarter Mile Haul".

Type of Material	Description of Bid Items
D	(1) "Flexible Base Type D" of the compaction method, class and grade specified; "Sand Admixture"; and "Additional Quarter Mile Haul (Sand Admixture)". (Cubic yard measurement with the sand admixture and shell being measured separately).
	(2) "Flexible Base Type D, Class 2" of the compaction methods and grade specified. (Ton measurement of combined shell and sand admixture with no direct payment for hauling).
E	"Flexible Base Type E" of the compaction method, class and grade specified. "Sand Admixture"; "Additional Quarter Mile Haul (Sand Admixture)"; "Caliche Admixture"; and "Additional Quarter Mile Haul (Caliche Admixture)".

The unit prices bid shall each be full compensation for shaping and fine grading the roadbed; for securing and furnishing all materials, including all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening, blasting, excavating, screening, crushing and temporary stockpiling when required; for loading all materials; for hauling the first one quarter mile and delivering on the road; for spreading, mixing, blading, dragging, shaping and finishing; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

When the plans include the Item "Flexible Base (Stockpiled)", of the type, class and grade specified, the unit prices bid for this material shall be full compensation for preparing the stockpile area; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling the first quarter mile and delivering in the stockpile; for spreading and shaping the material in the stockpile; and for all manipulations, labor, tools and incidentals necessary to complete the work, except as otherwise provided for in this specification.

When "Ordinary Compaction" is indicated on the plans all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

No direct payment will be made for hauling shell. Hauling materials, other than shell, into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul", "Additional Quarter Mile Haul (Sand Admixture)" or "Additional Quarter Mile Haul (Caliche Admixture)", except that when bids are requested on combined shell and sand admixture and measurement is by the ton, the cost of all hauling will be subsidiary to other bid items.

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work", respectively. Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work" or "Scraper Work".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item, "Stripping".

ITEM 249

FLEXIBLE BASE
(Delivered)

249.1. Description. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of either caliche, crushed stone, gravel, iron ore topsoil, shell, synthetic aggregate, crushed slag, etc., and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. The synthetic aggregate shall be produced by fuzing raw shale or clay under intense heat into predominantly amorphous silicate.

249.2. Materials. The materials shall be crushed or uncrushed as necessary to meet the requirements hereinafter specified, and shall consist of durable coarse aggregate particles mixed with approved binding materials.

249.3. Types. Type A material shall consist of crushed or broken aggregate. Type B material shall consist of gravel aggregate. Type C material

shall consist of iron ore topsoil. Type D material shall consist of shell aggregate with sand admixture. Type E material shall consist of shell aggregate with sand and caliche admixture. Type F material shall consist of synthetic aggregate with sand admixture. Type G material shall consist of crushed slag. Unless the type of material to be used is specified on the plans, the Contractor may use any one of these types, provided the material proposed for use by the Contractor meets the requirements set forth in the specification test limits tabulation.

249.4. Grades. It is the intent of this specification that unless otherwise indicated on the plans, the final course of the base material shall consist of Grades 1 or 2 and other base courses or subbase materials may consist of Grades 1, 2 or 3. All grades shall, when tested by standard Texas Highway Department laboratory test procedures, meet the physical requirements as set forth in the specification test limits tabulation.

Where pilot grading is required in the plans, the Engineer will designate the grading and allowable tolerances to govern during production. The flexible base produced shall not vary from the designated pilot grading by more than the tolerances specified by the Engineer. The pilot grading may be varied by the Engineer as necessary to insure that the base material produced will meet the physical requirements specified.

Testing of flexible base materials shall be in accordance with the following Texas Highway Department standard laboratory test procedures:

Preparation for Soil Constants and Sieve Analysis	Tex-101-E	Plasticity Index	Tex-106-E
Liquid Limit	Tex-104-E	Sieve Analysis	Tex-110-E
Plastic Limit	Tex-105-E	Wet Ball Mill	Tex-116-E
Pressure Slaking Value of Synthetic Coarse Aggregate	Tex-431-A Tentative May 1969	Triaxial Tests	Tex-117-E (Part II)
		*Unit Weight of Aggregate	Tex-404-A Rev. Sept. 1965

*If the unit weight of any shipment of synthetic aggregate differs by more than 4 percent from that of the sample submitted for approval, the aggregates in the shipment may be rejected. Tests shall be in accordance with Test Method Tex 404-A, Revised September 1965, except that the aggregate shall be tested in an oven-dry condition.

PHYSICAL REQUIREMENTS FOR FLEXIBLE BASE MATERIALS

	GRADES			
TYPES	Grade 1: (Triaxial Class 1) Min. compressive strength, psi: 45 at 0 psi lateral pressure and 175 at 15 psi lateral pressure	Grade 2: (Triaxial Class 1 to 2.3) Min. compressive strength, psi: 35 at 0 psi lateral pressure and 175 at 15 psi lateral pressure	Grade 3: (Unspecified Triaxial Class)	Grade 4
TYPE A Crushed or Broken Aggregate	Retained on % Sq. Sieve 1-3/4" .....0 7/8" .....10-35 3/8" .....30-50 No. 4 .....45-65 No. 40 .....70-85 Max LL .....35 Max PI .....10 *Max Wet Ball Mill 40	Retained on % Sq. Sieve 1-3/4" .....0-10 No. 4 .....45-75 No. 40 .....60-85 Max LL .....40 Max PI .....12 *Max Wet Ball Mill 50	Retained on % Sq. Sieve 1-3/4" .....0-10 No. 40 .....60-85 Max LL .....45 Max PI .....15 *Max Wet Ball Mill 55	As Shown on Plans
TYPE B Gravel Aggregate		Retained on % Sq. Sieve 1-3/4" .....0-10 No. 4 .....30-75 No. 40 .....70-85 Max LL .....35 Max PI 12	Retained on % Sq. Sieve 1-3/4" .....0-5 No. 4 .....30-75 No. 40 .....65-85 Max LL .....35 Max PI 12	As Shown on Plans
TYPE C Iron Ore Topsoil		Retained on % Sq. Sieve 2-1/2" .....0 No. 40 .....50-85 Max LL .....35 Max PI 12	Retained on % Sq. Sieve 2-1/2" .....0 No. 40 .....45-85 Max LL .....35 Max PI 12	As Shown on Plans
TYPE D Sand-Shell		Retained on % Sq. Sieve 1-3/4" .....0-10 No. 4 .....45-65 No. 40 .....50-70 Max LL .....35 Max PI 12	Retained on % Sq. Sieve 1-3/4" .....0-10 No. 40 .....45-65 Max LL .....35 Max PI 12	As Shown on Plans
TYPE E Shell with Sand and Caliche Admixture		Retained on % Sq. Sieve 1-3/4" .....0 No. 40 .....45-65 Max LL .....35 Max PI 10	Retained on % Sq. Sieve 1-3/4" .....0 No. 40 .....45-65 Max LL .....35 Max PI 12	As Shown on Plans

TYPE F Synthetic Aggregate with Sand Admixture	Retained on Sq. Sieve % 2" .....0 3/8" .... 30-50 No. 4 ..... 45-65 No. 40 ..... 70-85 Max LL .....35 Max PI .....10 Max Wet Ball Mill .....40 Pressure Slaking Max .....10 Min. dry, loose unit Wt .....35 pcf	Retained on Sq. Sieve % 2" .....0 No. 4 ... .. 30-75 No. 40 ..... 60-85 Max LL .....40 Max PI .....10 Max Wet Ball Mill .....45 Pressure Slaking Max .....10 Min dry, loose unit Wt .....35 pcf	Retained on Sq. Sieve % 2" ....0 No. 40 ..... 60-85 Max LL .....40 Max PI .. ...12 Max Wet Ball Mill .....50 Pressure Slaking Max .....10 Min. dry, loose unit Wt .....35 pcf	As Shown on Plans
TYPE G Crushed Blast furnace Slag				As Shown on Plans

*Unless otherwise shown on plans the maximum increase in material retained on the number 40 sieve resulting from the Wet Ball Mill Test shall not exceed 20.

Unless otherwise specified on the plans, job-control samples for testing the material for Soil Constants, Gradation and Wet Ball Mill shall be taken prior to the compaction operations.

Unless otherwise specified on the plans, job-control samples for triaxial tests shall be taken from the stockpile or from production, as directed by the Engineer, where stockpiling is required and from production where stockpiling is not required.

Tolerances: When tolerances are permitted by the plans, the limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

The Engineer may accept the material, providing not more than 2 out of 10 consecutive gradation tests performed are outside the specified limits on any individual or combination of sieves by no more than 5% and where no two consecutive tests are outside the specified limits.

The Engineer may accept the material providing not more than 2 out of 10 consecutive plasticity index samples tested are outside the specified limit by no more than two points and where no two consecutive tests are outside the specified limit.

249.5. Material Sources. The material shall be secured from sources obtained by the Contractor. The pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata.

When specified on the plans, the material shall be stockpiled prior to delivery on the road. The stockpile shall be not less than the height indicated and shall be made up of layers of material not to exceed the depth shown on the plans. After a sufficient stockpile has been constructed as specified on the plans, the Contractor may proceed with loading from the stockpile for delivery to the road. In loading from the stockpile for delivery to the road, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

If the Contractor elects to produce the Type A material from more than one material or more than one source, each material shall be crushed separately and placed in separate stockpiles so that at least 75 percent of the material in the coarse aggregate stockpiles will be retained on the No. 4 sieve and at least 70 percent of the material in the fine aggregate stockpile will pass the No. 4 sieve. The materials shall be combined in a central mixing plant in the proportions determined by the Engineer to produce a uniform mixture which meets all of the requirements of the specification. In the event that combinations of the materials produced fail to meet all of the specification requirements, the Contractor will be required to secure other materials which will meet specification requirements. The central mixing plant shall be either the batch or continuous flow type, and shall be equipped with feeding and metering devices which will add the materials into the mixer in the specified quantities. Mixing shall continue until a uniform mixture is obtained.

249.6. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of 1/2 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course, Type A, Type B, Type C and Type G Material. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100 foot station. Material deposited upon the subgrade shall be spread and shaped the same day. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and supplied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming or by other approved methods.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The course shall be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the full depth of flexible base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of flexible base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the

typical sections shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

Should the base course, due to any reason or cause, lose the required stability, density or finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

(3) First Course Type D or Type F Material. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section, and corrections made if necessary.

All materials shall be delivered in approved vehicles of a uniform capacity. The required amount of shell or synthetic aggregate shall be uniformly spread across the section and allowed to dry sufficiently to insure proper slaking and mixing of the binder material. Immediately upon completion of the drying period, as determined by the Engineer, the specified amount of sand admixture as required to produce a combined material meeting the requirements hereinbefore specified, shall be spread uniformly across the shell or synthetic aggregate. The material shall then be sprinkled as required and thoroughly mixed by blading and harrowing, or other approved methods.

Failure to proceed with the placing of sand admixture or mixing and placing operations will be grounds for the suspension of placing of shell or synthetic aggregate. Under no conditions will the Contractor be allowed to place an excessive amount of shell or synthetic aggregate without proceeding with the mixing and placing operations.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary compaction method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

After mixing, all material shall be windrowed, and then spread over the section in layers. Except for synthetic aggregate the layers shall not exceed 2 inches in loose depth. If necessary to prevent segregation, the material shall be wetted in the windrow prior to spreading. After each lift is spread, it shall be sprinkled and rolled to secure maximum compaction as directed by the Engineer. Succeeding layers shall then be placed similarly until the course is completed. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading; and the surface, upon completion, shall be smooth and in conformity with the typical sections shown on plans, and to the established lines and grades. In that area

on which pavement is to be placed, any deviation in excess of ¼ inch in cross section in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the compaction method shall be the same as prescribed for Type A, Type B, Type C and Type G material.

When indicated on the plans or permitted by the Engineer, Type D or Type F material may be mixed in a central mixing plant and delivered to the road as a combined mixture.

When this method is used, the combined mixture shall meet the requirements for Type D or Type F material as hereinbefore specified and the placing and compaction requirement shall be the same as prescribed for Type A, Type B, Type C and Type G material.

(4) First Course Type E Material. The construction methods for placing the first course of Type E material shall be the same as prescribed for Type D material except that after the shell and sand have been placed, the prescribed amount of caliche shall then be spread across the sand and shell. The composite mixture shall then be sprinkled as required and thoroughly mixed by blading and harrowing or other approved methods.

Compaction of the first course of Type E material shall be the same as prescribed above for Type D material.

Failure to proceed with placing the sand and caliche admixture or mixing and placing operations will be grounds for the suspension of placing of shell. Under no conditions will the Contractor be allowed to place an excessive amount of shell without proceeding with the mixing and placing operations.

(5) Succeeding Courses. Construction methods shall be the same as prescribed for the first course. Prior to placing the surfacing on the completed base, the base shall be "dry cured" to the extent directed by the Engineer.

(6) Density. When the "Density Control" method of compaction is indicated on the plans, each course of flexible base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

(7) Tolerances. When tolerances are permitted by the plans, the limits establishing reasonably close conformity with percent density specified are defined by the following:

The Engineer may accept the work providing not more than 25 percent of the density tests performed each day are outside the specified density by no more than three pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

249.7. Measurement. Work and accepted material as prescribed for this item will be measured by the method described as either Class 1, 2 or 3 as follows and as specified on the plans:

When Class 1 measurement is specified, "Flexible Base (Delivered)", "Sand Admixture", "Caliche", "Shell" and/or "Synthetic Aggregate" will be measured by the cubic yard in vehicles as delivered on the road.

When Class 2 measurement is specified, "Flexible Base (Delivered)" will be measured by the ton of 2000 pounds dry weight in vehicles as delivered on the road.

When Class 3 measurement is specified, "Flexible Base (Delivered)" will be measured by the cubic yard in its final position as the volume of base course computed in place between the original subgrade or subbase surfaces, and the lines, grades and slopes of the accepted base course by the method of average end areas. When "Flexible Base (Delivered) (Stockpiled)" is specified it shall be measured in its stockpiled position by the method of average end areas.

Type of Material	Class	Method of Measurement
A, B, C and G	1, 2 or 3	As Described Above.
D and F	1	The shell and sand admixture or synthetic aggregate and sand admixture shall be measured separately as prescribed for Class 1 measurement or
	2	The combined shell and sand admixture or synthetic aggregate and sand admixture shall be measured as prescribed for Class 2 measurement or
	3	As Described Above.
E	1	The shell, sand admixture and caliche admixture shall be measured separately as prescribed for Class 1 measurement or
	2	The combined shell, sand admixture and caliche shall be measured as prescribed for Class 2 measurement or
	3	As Described Above.

When the plans indicate that measurement of material is to be by the ton, a set of standard platform truck scales conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer, except that when the material is weighed in mixing or batching, platform truck scales and reweighing will not be necessary. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

The Contractor shall schedule his operations in such manner as to facilitate the measurement of the various pay items.

Material to be stockpiled will be measured in the same manner as that delivered on the road except that it will be measured as delivered to the stockpile site.

249.8. Payment. The work performed and material furnished as prescribed by this item and measured in accordance with the applicable provisions of "Measurement" above will be paid for as follows:

Type of Material	Description of Bid Items
A, B, C and G	"Flexible Base (Delivered)" of the type (when specified on the plans), class, grade and compaction method specified.
D and F	"Flexible Base (Delivered)" of the type (when specified on the plans), class, grade and compaction method specified. (Cubic yard measurement of combined shell or synthetic aggregate and sand admixture) or "Shell" or "Synthetic Aggregate" and "Sand Admixture" of the type, class, grade and compaction method specified. (Cubic yard measurement with the sand admixture and shell or synthetic aggregate being measured separately) or "Flexible Base (Delivered)" of the type (when specified on the plans), class, grade and compaction method specified. (Ton measurement of combined shell or synthetic aggregate and sand admixture).
E	"Flexible Base (Delivered)" of the type (when specified on the plans), class, grade and compaction method specified. (Cubic yard measurement of combined shell, sand admixture and caliche admixture) or

"Shell", "Sand Admixture" and "Caliche Admixture" of the type, class, grade and compaction method specified. (Cubic yard measurement with sand admixture, caliche admixture and shell being measured separately) or

"Flexible Base (Delivered)" of the type (when specified on the plans), class, grade and compaction method specified. (Ton measurement of combined shell, sand admixture and caliche admixture).

The unit prices bid shall each be full compensation for shaping and fine grading the roadbed; for securing and furnishing all materials, including all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening, blasting, excavating, screening, crushing and temporary stockpiling when required; for loading all materials; for all hauling and delivering on the road; for spreading, mixing, blading, dragging, shaping and finishing; and for all manipulation, labor, tools and incidentals necessary to complete the work except as follows:

When the plans include the Item "Flexible Base (Delivered) (Stockpiled)" of the type, class and grade specified, the unit prices bid for this material shall be full compensation for preparing the stockpile area; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening or blasting, excavating, screening and crushing; for temporary stockpiling where required; for loading all materials; for hauling; for spreading and shaping the material in the stockpile; and for all manipulations, labor, tools and incidentals necessary to complete the work except as otherwise provided for in this specification.

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work" or "Scraper Work".

ITEM 250

SCARIFYING AND RESHAPING BASE COURSE

250.1. Description. "Scarifying and Reshaping Base Course" shall consist of scarifying and reshaping the existing base course (with or without asphalt surfacing) as herein specified and in conformity with the typical sections shown on plans and to the lines and grades established by the Engineer.

250.2. Construction Methods. Prior to scarifying the existing base or base and asphalt surfacing, the shoulders and slopes of the existing roadway shall be excavated or built up, sprinkled and compacted to conform to the typical sections, lines and grades shown on the plans or as directed by the Engineer. The existing base and surface shall then be thoroughly cleaned of all dirt and other objectionable material by blading, supplemented by brooming or other approved methods. The existing base and surface shall then be scarified for its full width and depth unless otherwise shown on the plans and then bladed and shaped to conform to the typical sections shown on the plans. However, in no case shall the underlying subgrade be disturbed.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The course shall be sprinkled as required and rolled as directed. All holes, ruts or depressions in the surface shall be repaired by scarifying, reshaping, sprinkling and rolling as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical cross sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The Contractor shall at all times provide proper and sufficient equipment and conduct his operations in a satisfactory and workmanlike manner. Failure to manipulate materials promptly and perform the various operations required in a continuous and co-ordinated manner will be grounds for suspension of any part of the work.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisons shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". In addition to the requirements specified for density, the

full depth of the scarified and reshaped base course shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical cross sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of ¼ inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and re-compacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling. The Contractor shall at all times provide proper and sufficient equipment and conduct his operations in a satisfactory and workmenlike manner. Should the base course, due to any reason or cause, lose the required stability, density and finish before it is accepted, it shall be recompacted and refinished at the sole expense of the Contractor.

250.3. Density. When the "Density Control" method of compaction is indicated on the plans, each course of base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

When tolerances are permitted by the plans, the limits establishing reasonably close conformity with percent density specified are defined by the following:

The Engineer may accept the work providing not more than 25 percent of the density tests performed each day are outside the specified density by no more than three pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

250.4. Measurement. Scarifying and reshaping base course, including any asphalt surfacing, as provided herein shall be measured by the 100-foot station.

250.5. Payment. The work performed as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid, by one of the following methods: (1) "Scarifying and Reshaping Base Course (Ordinary Compaction)" or (2) "Scarifying and Reshaping Base Course (Density Control)".

The unit prices bid for scarifying and reshaping base course shall each be full compensation for cleaning and scarifying the existing base and surface; for all spreading, blading, dragging, shaping and finishing of the scarified material; and for all manipulations, labor, tools and incidentals necessary to complete the work except as follows:

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling, performed as required, will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly, but the cost of all sprinkling and rolling shall be subsidiary to other bid items.

Excavation required in the preparation of shoulders and slopes to conform with the typical sections shown on the plans will be paid for in accordance with the provisions of the items covering this phase of work as indicated on the plans, with the provision that work will be paid for once only, regardless of the manipulations involved.

ITEM 252

SALVAGING AND REPLACING BASE

252.1. Description. "Salvaging and Replacing Base" shall consist of removing the existing base material where shown on plans, such temporary storage as is necessary, and the replacement of this material on the prepared roadbed as herein specified and in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

252.2. Construction Methods.

(1) Salvaging Existing Base. The existing base, including any bituminous mat not shown on plans to be salvaged, shall first be cleaned of all dirt or other objectionable material by blading, brooming or other approved methods, then scarified to the width and depth as may be required to provide the estimated amount of salvaged material per station as shown on the plans; however, in no case shall the underlying subgrade be disturbed.

The material thus salvaged shall be placed in stockpiles or windrows until sufficient subgrade has been prepared to receive the salvaged material; then, if the Contractor so elects, the remaining old base material as salvaged may be placed directly upon the prepared subgrade as directed by the Engineer, thus eliminating the necessity of stockpiling. It shall be the responsibility of the Contractor that all the available material shall be salvaged and replaced and shall be kept reasonably free of soil from the subgrade or roadbed during the salvaging and replacing operations. When material is windrowed or stockpiled, it shall be so placed as not to interfere with traffic, proper drainage or the general progress of the work.

(2) Preparation of Subgrade. When the salvaged material is to be replaced directly upon the subgrade, the roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water, reshaped, and rolled to the extent directed in order to place the

subgrade in an acceptable condition to receive the salvaged base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of ½ inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed. Any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(3) Replacement of Salvaged Material. The material shall then be deposited on the subgrade or other base course, sprinkled if directed, and bladed, dragged and shaped to conform to typical sections shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with satisfactory salvaged material as directed by the Engineer.

The course shall be compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method of compaction as indicated on the plans.

When the plans indicate that the "Ordinary Compaction" method is to be used, the following provisions shall apply:

The course shall be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

When the plans indicate that the "Density Control" method of compaction is to be used, the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as hereinafter specified under "Density". The testing will be as outlined in Test Method Tex-114-E. In addition to the requirements specified for density, the depth of the salvaged material shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section of salvaged base is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the

surface upon completion shall be smooth and in conformity with the typical sections shown on the plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of 1/4 inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the area affected, adding suitable material as required, reshaping and recompacting by sprinkling and compaction methods. Should the base course, due to any reason or cause, lose the required stability, density and finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the Contractor.

252.3. Density. When the "Density Control" method of compaction is indicated on the plans each course of base shall be compacted to the percent density shown on the plans. The testing will be as outlined in Test Method Tex-114-E. It is the intent of this specification to provide in that part of the base included in the top 8 inches immediately below the finished surface of the roadway, not less than 100 percent of the density as determined by the compaction ratio method. Field density determination shall be made in accordance with approved methods.

Tolerances: The limits establishing reasonably close conformity with percent density specified are defined by the following:

The Engineer may accept the work, providing not more than 25% of the density tests performed each day are outside the specified density by no more than 3 pounds per cubic foot and where no two consecutive tests on continuous work are outside the specified limits.

252.4. Measurement. Work, as prescribed for this item, will be measured by the 100-foot station of base in its original position, by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight of material in vehicles as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined by Test Method Tex-103-E, at least one time each day and more often if conditions warrant.

252.5. Payment. The work performed as prescribed by this item and measured in accordance with "Measurement" above, will be paid for at the unit price bid by one of the following methods: (1) "Salvaging and Replacing Base (Ordinary Compaction)" or (2) "Salvaging and Replacing Base (Density Control)".

The unit prices bid for salvaging and replacing base shall each be full compensation for shaping and fine grading the roadbed; for cleaning and scarifying, removing, windrowing or stockpiling all salvaged material; for all hauling; for replacing the salvaged material on the prepared subgrade; for spreading, blading, dragging, shaping and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except as follows:

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

Unless otherwise indicated on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively with the provision that yardage will be measured and paid for once only, regardless of the manipulation involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for, in accordance with the provisions governing the Items of "Blading", "Road Grader Work" or "Scraper Work", respectively. Payment under the Item, "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work" or "Scraper Work".

ITEM 254

SCARIFYING EXISTING PAVEMENT

254.1. Description. This item consists of scarifying existing asphalt surfacing and flexible base course material to the lines and grades as shown on the plans or established by the Engineer.

254.2. Construction Methods. The existing asphalt surfacing and flexible base course material at points shown on the plans or designated by the Engineer shall be scarified to the depth and width shown by the lines and grades on the plans or established by the Engineer. The existing material to be removed shall be scarified until it is broken into particles small enough to be easily removed.

254.3. Measurement. This item will be measured by the 100-foot station regardless of the width of the old base and pavement or, when provided by the plans, measurement will be made by the square yard of the old pavement in its original position.

254.4. Payment. The work performed as prescribed for this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Scarifying Existing Pavement", which price shall be full compensation for furnishing all labor, tools, equipment, supplies and incidentals necessary to satisfactorily complete the work.

Excavating, hauling and disposing of the scarified material will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Overhaul".

ITEM 260

LIME TREATMENT FOR MATERIALS IN PLACE

260.1. Description. This item shall consist of treating the subgrade, existing subbase or existing base by the pulverizing, addition of lime, mixing and compacting the mixed material to the required density. This item applies to natural ground, embankment, or existing pavement structure and shall be constructed as specified herein and in conformity with the typical sections, lines and grades as shown on the plans or as established by the Engineer.

260.2. Materials.

(1) The lime shall meet the requirements of the Item, "Hydrated Lime and Lime Slurry", for the type of lime specified.

When Type B, Commercial Lime Slurry, is specified, the Contractor shall select, prior to construction, the grade to be used and shall notify the Engineer in writing before changing from one grade to another.

(2) If the minimum design strength or percent of lime to be used for the treated subgrade, existing subbase or existing base is specified, it will be determined by preliminary tests performed in accordance with Test Method Tex-121-E.

260.3. Equipment.

(1) The machinery, tools and equipment necessary for proper prosecution of the work shall be on the project and approved by the Engineer prior to the beginning of construction operations.

All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

(2) Hydrated lime shall be stored and handled in closed weatherproof containers until immediately before distribution on the road. If storage bins are used they shall be completely enclosed. Hydrated lime in bags shall be stored in weatherproof buildings with adequate protection from ground dampness.

(3) If lime is furnished in trucks, each truck shall have the weight of lime certified on public scales or the Contractor shall place a set of standard platform truck scales or hopper scales at a location approved by the Engineer.

Scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

(4) If lime is furnished in bags, each bag shall bear the manufacturer's certified weight. Bags varying more than 5 percent from that weight may be rejected and the average weight of bags in any shipment, as shown by weighing 50 bags taken at random, shall not be less than the manufacturer's certified weight.

260.4. Construction Methods.

(1) General. It is the primary requirement of this specification to secure a completed course of treated material containing a uniform lime mixture, free from loose or segregated areas, of uniform density and moisture content, well bound for its full depth and with a smooth surface suitable for placing subsequent courses. It shall be the responsibility of the Contractor to regulate the sequence of his work, to use the proper amount of lime, maintain the work and rework the courses as necessary to meet the above requirements.

The roadbed shall be constructed and shaped to conform to the typical sections, lines and grades as shown on the plans or as established by the Engineer. The material, either before or after lime is added, shall be excavated to the secondary grade (proposed bottom of lime treatment) and removed or windrowed to expose the secondary grade. Any wet or unstable materials below the secondary grade shall be corrected, as directed by the Engineer, by scarifying, adding lime, and compacting until it is of uniform stability.

If the Contractor elects to use a cutting and pulverizing machine that will remove the subgrade material accurately to the secondary grade and pulverize the material at the same time, he will not be required to expose the secondary grade nor windrow the material. However, the Contractor shall be required to roll the subgrade, as directed by the Engineer, before using the pulverizing machine and correct any soft areas that this rolling may reveal. This method will be permitted only where a machine is provided which will insure that the material is cut uniformly to the proper depth and which has cutters that will plane the secondary grade to a smooth surface over the entire width of the cut. The machine shall be of such design that a visible indication is given at all times that the machine is cutting to the proper depth.

(2) Application. Lime shall be spread only on that area where the first mixing operations can be completed during the same working day.

The application and mixing of lime with the material shall be accomplished by the methods hereinafter described as "Dry Placing" or "Slurry Placing". When Type A, Hydrated Lime, is specified, the Contractor may use either method.

(a) Dry Placing. The lime shall be spread by an approved spreader or by bag distribution at the rates shown on the plans or as directed by the Engineer.

The lime shall be distributed at a uniform rate and in such manner as to reduce the scattering of lime by wind to a minimum. Lime shall not be applied when wind conditions, in the opinion of the Engineer, are such that blowing lime becomes objectionable to traffic or adjacent property owners. A motor grader shall not be used to spread the lime.

The material shall be sprinkled as directed by the Engineer, until the proper moisture content has been secured.

(b) Slurry Placing. The lime shall be mixed with water in trucks with approved distributors and applied as a thin water suspension or slurry.

Type B, Commercial Lime Slurry, shall be applied with a lime percentage not less than that applicable for the grade used. The distribution of lime at the rates shown on the plans or as directed by the Engineer shall be attained by successive passes over a measured section of roadway until the proper moisture and lime content has been secured. The distributor truck shall be equipped with an agitator which will keep the lime and water in a uniform mixture.

(3) Mixing. The mixing procedure shall be the same for "Dry Placing" or "Slurry Placing" as hereinafter described.

(a) First Mixing. The material and lime shall be thoroughly mixed by approved road mixers or other approved equipment, and the mixing continued until, in the opinion of the Engineer, a homogeneous, friable mixture of material and lime is obtained, free from all clods or lumps. Materials containing plastic clays or other material which will not readily mix with lime shall be mixed as thoroughly as possible at the time of the lime application, brought to the proper moisture content and left to cure 1 to 4 days as directed by the Engineer. During the curing period the material shall be kept moist as directed.

(b) Final Mixing. After the required curing time, the material shall be uniformly mixed by approved methods. If the soil binder-lime mixture contains clods, they shall be reduced in size by raking, blading, discing, harrowing, scarifying or the use of other approved pulverization methods so that when all nonslaking aggregates retained on the No. 4 sieve are removed the remainder of the material shall meet the following requirements when tested dry by laboratory sieves:

	Percent
Minimum Passing 1-3/4" Sieve	100
Minimum Passing No. 4 Sieve	60

During the interval of time between application and mixing, hydrated lime that has been exposed to the open air for a period of 6 hours or more or to excessive loss due to washing or blowing will not be accepted for payment.

(4) Compaction. Compaction of the mixture shall begin immediately after final mixing and in no case later than 3 calendar days after final mixing, unless approval is obtained from the Engineer. The material shall be aerated or sprinkled as necessary to provide the optimum moisture. Compaction shall begin at the bottom and shall continue until the entire depth of mixture is uniformly compacted by the method of compaction hereinafter specified as the "Ordinary Compaction" method or the "Density Control" method as indicated on the plans.

If the total thickness of the material to be treated cannot be mixed in one operation, the previously mixed material shall be bladed to a windrow

just beyond the area to be treated and the next layer mixed with lime as specified in Section (3). The first layer of the treated material shall be compacted in such a manner that the treated material will not be mixed with the underlying material.

When the "Ordinary Compaction" method is indicated on the plans the following provisions shall apply:

The material shall be sprinkled and rolled as directed by the Engineer. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding or removing material as required and reshaping and recompacting by sprinkling and rolling. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereon or the work is accepted.

When the "Density Control" method of compaction is indicated on the plans the following provisions shall apply:

The course shall be sprinkled as required and compacted to the extent necessary to provide the density specified below as determined by the use of the compaction ratio method:

Description	Density, Percent
For lime treated subgrade, existing subbase or existing base that will receive subsequent subbase or base courses.	Not less than 95 except when otherwise shown on the plans.
For lime treated existing subbase or existing base that will receive surface courses.	Not less than 98 except when otherwise shown on the plans.

The testing will be as outlined in Test Method Tex-114-E or other approved methods. In addition to the requirements specified for density, the full depth of the material shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. Should the material due to any reason or cause, lose the required stability, density and finish before the next course is placed or the work is accepted, it shall be recompacted and refinished at the sole expense of the Contractor.

260.5. Finishing, Curing and Preparation for Surfacing. After the final layer or course of the lime treated subgrade, subbase or base has been compacted, it shall be brought to the required lines and grades in accordance with the typical sections. The completed section shall then be finished by rolling as directed with a pneumatic tire or other suitable roller sufficiently light to prevent hair cracking. The completed section shall be moist-cured for

a minimum of 7 days before further courses are added or any traffic is permitted, unless otherwise directed by the Engineer. In cases where subgrade treatment or subbase sets up sufficiently to prevent objectionable damage from traffic, such layers may be opened to traffic 2 days after compaction. If the plans provide for the treated material to be sealed or covered by other courses of material, such seal or course shall be applied within 14 days after final mixing is completed, unless otherwise directed by the Engineer.

260.6. Measurement. Lime treatment of the subgrade, existing subbase, and existing base shall be measured by the square yard to neat lines as shown on the typical sections.

When Type A, Hydrated Lime is used, the quantity of lime will be measured by the ton of 2,000 pounds, dry weight.

When Type B, Commercial Lime Slurry, is used, the quantity of lime shall be calculated from the required minimum percent solids based upon the use of Grade 1, Grade 2, or Grade 3 as follows:

Grade 1: The "Dry Solids Content" shall be at least 31 percent by weight of the slurry and the quantity of lime will be calculated by the ton of 2000 pounds based on the 31 percent, as delivered on the road.

Grade 2: The "Dry Solids Content" shall be at least 35 percent by weight of the slurry and the quantity of lime will be calculated by the ton of 2000 pounds based on the 35 percent, as delivered on the road.

Grade 3: The "Dry Solids Content" shall be at least 46 percent by weight of the slurry and the quantity of lime will be calculated by the ton of 2000 pounds based on the 46 percent, as delivered on the road.

260.7. Payment. Work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for as follows:

Lime will be paid for at the unit price bid per ton on 2,000 pounds for "Lime" of the type specified which price shall be full compensation for furnishing all lime.

"Lime Treated Subgrade (Ordinary Compaction)", "Lime Treated Existing Subbase (Ordinary Compaction)" and "Lime Treated Existing Base (Ordinary Compaction)" or "Lime Treated Subgrade (Density Control)", "Lime Treated Existing Subbase (Density Control)" and "Lime Treated Existing Base (Density Control)" will be paid for at the unit price bid per square yard. The unit price bid shall be full compensation for all correction of secondary subgrade, for loosening, mixing, pulverizing, spreading, drying, application of lime, water content of the slurry, shaping and maintaining, for all manipulations required, for all hauling and freight involved, for all tools, equipment, labor, and for all incidentals necessary to complete the work except as specified below:

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly but the cost of all sprinkling and rolling will be subsidiary to other bid items.

ITEM 262

LIME TREATMENT FOR BASE COURSES

262.1. Description. This item shall consist of treating base and subbase by addition of lime, mixing and compacting the mixed material in accordance with the specifications governing the base and subbase courses. This item applies to the treatment of base or subbase courses placed under this contract and shall be constructed as herein specified and in conformity with the items governing the base or subbase courses.

262.2. Materials.

(1) Base and subbase materials shall meet the requirements shown on the plans or in the pertinent specifications.

(2) The lime shall meet the requirements of the Item, "Hydrated Lime and Lime Slurry" for the type of lime specified.

When Type B, Commercial Lime Slurry, is specified, the Contractor shall select, prior to construction, the grade to be used and shall notify the Engineer in writing before changing from one grade to another.

(3) If the minimum design strength or percent lime to be used for the treated base or subbase is specified, it will be determined by preliminary tests performed in accordance with Test Method Tex-121-E.

262.3. Equipment.

(1) The machinery, tools and equipment necessary for proper prosecution of the work shall be on the project and approved by the Engineer prior to the beginning of construction operations. All machinery, tools and equipment used shall be maintained in a satisfactory working condition. The Contractor shall employ adequate methods in performing the work and shall conduct his operations in a satisfactory and workmanlike manner.

(2) Hydrated lime shall be stored and handled in closed, weather-proof containers until immediately before distribution on the road. If storage bins are used, they shall be completely enclosed. Hydrated lime in bags shall be stored in weatherproof buildings with adequate protection from ground dampness.

(3) If lime is furnished in trucks, each truck shall have the weight of lime certified on public scales or the Contractor shall place a set of standard platform truck scales or hopper scales at a location approved by the Engineer. Scales shall meet the requirements of the Item, "Weighing and Measuring Equipment."

(4) If lime is furnished in bags, each bag shall bear the manufacturer's certified weight. Bags varying more than 5 percent from that weight may be rejected and the average weight of bags in any shipment, as shown by weighing 50 bags taken at random, shall not be less than the manufacturer's certified weight.

262.4. Construction Methods.

(1) General. It is the primary requirement of this specification to secure a completed course of treated base or subbase material containing a uniform lime mixture, free from loose or segregated areas, of uniform density and moisture, well bound for its full depth and with a smooth surface suitable for placing additional subbase, base or surface courses. It shall be the responsibility of the Contractor to regulate the sequence of his work, to use the proper amount of lime, maintain the work and rework the courses as necessary to meet the above requirements.

Prior to placing base or subbase material, the subgrade shall be shaped to conform to the typical sections, lines and grades as shown on the plans or as established by the Engineer.

The base or subbase material, as provided in the governing specification, shall be delivered, placed and spread in the required amount per station. The material shall be manipulated as specified for the base or subbase course or as directed by the Engineer and thoroughly mixed prior to the addition of the lime.

(2) Application. Lime shall be spread only on that area where the mixing operations can be completed during the same working day.

The application and mixing of lime with the material shall be accomplished by the methods hereinafter described as "Dry Placing" or "Slurry Placing". When Type A, Hydrated Lime is specified, the Contractor may use either method.

(a) Dry Placing. The lime shall be spread by an approved spreader or by bag distribution at the rates shown on the plans or as directed by the Engineer.

The lime shall be distributed at a uniform rate and in such a manner as to reduce the scattering of lime by wind to a minimum. Lime shall not be applied when wind conditions, in the opinion of the Engineer, are such that blowing lime becomes objectionable to traffic and adjacent property owners. A motor grader shall not be used to spread the lime.

The material shall be sprinkled as directed by the Engineer, until the proper moisture content has been secured.

(b) Slurry Placing. The lime shall be mixed with water in trucks with approved distributors and applied as a thin water suspension or slurry. Type B, Commercial Lime Slurry shall be applied with a lime percentage not less than that applicable for the grade used. The distribution of lime at the rates shown on the plans or as directed by the Engineer, shall be attained by successive passes over a measured section of roadway until the proper

moisture and lime content has been secured. The distributor truck shall be equipped with an agitator which will keep the lime and water in a consistent mixture.

(3) Mixing. The base or subbase material, lime and required water shall be thoroughly mixed and blended by approved road mixers or other approved equipment, and the mixing continued until, in the opinion of the Engineer, a homogeneous, friable mixture is obtained. When lime is placed as a slurry and mixed by the use of blades, the material shall be bladed as the lime-water mixture is applied, and after the total amount has been placed the mixture shall be thoroughly blended to the satisfaction of the Engineer.

During the interval of time between application and mixing, hydrated lime that has been exposed to the open air for a period of 6 hours or more or to excessive loss due to washing or blowing will not be accepted for payment.

(4) Compaction. Compaction of the mixture shall begin immediately after mixing and in no case later than 3 calendar days after mixing unless approval is obtained from the Engineer. The material shall be aerated or sprinkled as necessary to provide the optimum moisture. Compaction shall begin at the bottom and shall continue until the entire depth of mixture is uniformly compacted to the density required by the plans or by the methods provided in the governing specifications.

If the total thickness of the material to be treated cannot be mixed in one operation, the previously mixed material shall be bladed to a windrow just beyond the area to be treated and the next layer mixed with lime as specified in Section (3). The first layer of the treated material shall be compacted in such a manner that the treated material will not be mixed with the underlying material.

When the "Ordinary Compaction" method for base and subbase materials is indicated on the plans the following provisions shall apply:

The material shall be sprinkled and rolled as directed by the Engineer. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding or removing material as required, reshaping and recompacting by sprinkling and rolling. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereon, or the work is accepted.

When the "Density Control" method of compaction for base and subbase materials is indicated on the plans the following provisions shall apply:

The bottom course shall be sprinkled as required and compacted to the extent necessary to provide not less than 95 percent of the density as determined by the use of the compaction ratio method or to the density shown on the plans. All other subsequent courses treated under this item shall be compacted to a minimum of 98 percent of compaction ratio density.

The testing will be as outlined in Test Method Tex-114-E or other approved methods. In addition to the requirements specified for density, the full depth of the material shown on the plans shall be compacted to the

extent necessary to remain firm and stable under construction equipment. After each section is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. Should the material due to any reason or cause, lose the required stability, density and finish before the next course is placed or the work is accepted, it shall be recompacted and refinished at the sole expense of the Contractor.

262.5. Finishing, Curing and Preparation for Surfacing. After the final layer or course of the subbase or base has been compacted, it shall be brought to the required lines and grades in accordance with the typical sections. The completed section shall then be finished and rolled as directed with a pneumatic tire or other suitable roller sufficiently light to prevent hair cracking. The completed section shall be moist-cured for a minimum of 7 days before further courses are added or any traffic is permitted unless otherwise directed by the Engineer. In cases where subbase sets up sufficiently to prevent objectionable damage from traffic, such layers may be opened to traffic 2 days after completion. If the plans provide for the treated material to be sealed or covered by other courses of material such seal or course shall be applied within 14 days after compaction unless otherwise directed by the Engineer.

262.6. Alternate Construction Methods. With written approval of the Engineer the Contractor will be permitted to utilize alternate construction methods, such as a central mixing plant, provided such methods result in producing a satisfactorily treated material meeting the specifications herein described.

262.7. Measurement. When lime is added to the base and subbase materials provided under pertinent specifications, the specification applicable to that item shall govern except that manipulation of the materials and application, mixing, measurement and payment for lime shall be as required herein.

When Type A, Hydrated Lime is used, the quantity of lime will be measured by the ton of 2000 pounds, dry weight.

When Type B, Commercial Lime Slurry is used, the quantity of lime shall be calculated from the required minimum percent solids based upon the use of Grade 1, Grade 2, or Grade 3 as follows:

Grade 1: The "Dry Solids Content" shall be at least 31 percent by weight of the slurry and the quantity of lime will be calculated by the ton of 2000 pounds based on the 31 percent, as delivered on the road.

Grade 2: The "Dry Solids Content" shall be at least 35 percent by weight of the slurry and the quantity of lime will be calculated by the ton of 2000 pounds based on the 35 percent, as delivered on the road.

Grade 3: The "Dry Solids Content" shall be at least 46 percent by weight of the slurry and the quantity of lime will be calculated by the ton of 2000 pounds based on the 46 percent, as delivered on the road.

262.8. Payment. Work performed and materials furnished as prescribed by this specification and measured as provided under "Measurement" will be paid for at the unit price bid per ton for "Lime", of the type specified, which price shall be full compensation for supplying the lime, for all mixing, spreading, drying, application of the lime, water content of the slurry, mixing water, shaping and maintaining, for all manipulations required, for all hauling and freight involved, for all tools, equipment, labor and for all incidentals necessary to satisfactorily complete the work, except as hereinafter specified.

Payment for the preparation of the subgrade will be measured and paid for in accordance with the pertinent excavation items.

Measurement and payment for all other items involved in constructing base or subbase courses, including sprinkling and rolling, will be as provided in the governing base or subbase item.

ITEM 264

HYDRATED LIME AND LIME SLURRY

264.1. Description. This item establishes the requirements for hydrated lime and commercial lime slurry of the type and grade considered suitable for use in the treatment of natural or processed materials or mixtures for subgrade, subbase and base construction.

264.2. Types. The various types and grades are defined and identified as follows:

(1) Type A, Hydrated Lime, shall consist of a dry powder obtained by treating quicklime with enough water to satisfy its chemical affinity for water under the conditions of its hydration. This material is to consist essentially of calcium hydroxide or a mixture of calcium hydroxide and a small allowable percentage of calcium oxide, magnesium oxide and magnesium hydroxide.

When sampled and tested according to prescribed Texas Highway Department procedure, hydrated lime shall conform to the following requirements as to chemical composition:

Hydrate Alkalinity, percent by weight $Ca(OH)_2$ . . . . . Min. 90.0%
Unhydrated lime content, percent by weight CaO . . . . . Max. 5.0%
"Free water" content, percent by weight H_2O . . . . . Max. 4.0%

The percent by weight of residue retained shall conform to the following requirements:

Residue retained on a No. 6 (3360-micron) sieve . . . . . None
Residue retained on a No. 10 (2000-micron) sieve . . Max. 1.0%
Residue retained on a No. 30 (590-micron) sieve . . . Max. 2.5%

Specifications for Type A applies specifically to the normal hydrate of lime made from "high-calcium" type limestone. Hydrated Lime for stabilization purposes shall be applied, as provided in the governing specifications, as a dry powder or mixed with water to form a slurry.

(2) **Type B, Commercial Lime Slurry,** shall be a pumpable suspension of solids in water. The water or liquid portion of the slurry shall not contain dissolved material in sufficient quantity and/or nature injurious or objectionable for the purpose intended. The solids portion of the mixture, when considered on the basis of "solids content", shall consist principally of hydrated lime of a quality and fineness sufficient to meet the following requirements as to chemical composition and residue.

(a) Chemical Composition. The "solids content" of the lime slurry shall have a Hydrate alkalinity Ca $(OH)_2$ of not less than 90 percent by weight.

(b) Residue. The percent by weight of residue retained in the "Solids content" of lime slurry shall conform to the following requirements:

Residue retained on a No. 6 (3360-micron) sieve ..... None
Residue retained on a No. 10 (2000-micron) sieve .. Max. 1.0%
Residue retained on a No. 30 (590-micron) sieve ... Max. 2.5%

Type B, Commercial Lime Slurry, shall conform to one of the following three grades:

Grade 1: The "Dry Solids Contents" shall be at least 31 percent by weight of the slurry.

Grade 2: The "Dry Solids Contents" shall be at least 35 percent by weight of the slurry.

Grade 3: The "Dry Solids Contents" shall be at least 46 percent by weight of the slurry.

264.3. Sampling and Testing. The sampling and testing of lime slurry shall be as determined by Test Method Tex-600-J, "Lime Testing Procedure".

264.4. Measurement and Payment. Lime will be measured and paid for in accordance with the governing specifications for the items of construction in which lime is used.

ITEM 270

PORTLAND CEMENT TREATMENT FOR MATERIALS IN PLACE

270.1. Description. This item shall consist of treating the subgrade, existing subbase or existing base by the pulverizing, addition of portland cement, mixing, wetting and compacting the mixed material to the required density. This item applies to natural ground, embankment, or existing pavement structure and shall be constructed as specified herein and in conformity with the typical sections, lines and grades as shown on the plans or as established by the Engineer.

Cement treatment shall not be mixed or placed when the air temperature is below 40 F and is falling, but may be mixed or placed when the air temperature is above 35 F and is rising, the temperature being taken in the shade and away from artificial heat and with the further provision that cement treatment shall be mixed or placed only when weather conditions, in the opinion of the Engineer, are suitable.

270.2. Materials.

(1) Soil. Soil shall consist of approved material free from vegetation or other objectionable matter encountered in the existing roadbed and other acceptable material used in preparation of the roadbed in accordance with this specification.

(2) Portland Cement. Cement shall be Type 1 of a standard brand of Portland cement and shall conform to the requirements of ASTM Designation: C 150.

One sack, containing 1 cubic foot of cement, shall be considered as weighing 94 pounds net. One barrel of cement shall be considered as weighing 376 pounds net and containing 4 cubic feet.

The Contractor, at his option, may use bulk cement, provided the apparatus for handling, weighing and spreading the cement is approved by the Engineer in writing. Cement weighing equipment shall be as specified below.

(3) Water. Water shall be free from substances deleterious to the hardening of the cement treatment and shall be approved by the Engineer.

(4) If the minimum design strength of the cement treatment mixture or the percent of cement is specified on the plans, it will be determined by preliminary tests performed in accordance with Test Method Tex-120-E.

270.3. Equipment.

General. Equipment utilized where materials are specified to be measured or proportioned by weight shall conform to the requirements of the Item, "Weighing and Measuring Equipment". Equipment necessary for the proper construction of the work shall be on the project, in first-class working condition, and be approved by the Engineer, both as to type and condition, prior to the start of construction operations. The Contractor shall at all times provide sufficient equipment to enable continuous prosecution of the work and its completion in the required number of working days.

Portland cement treatment for materials in place may be constructed with any machine or combination of machines and auxiliary equipment that will produce results as outlined in this specification.

Mixing may be accomplished by (1) a multiple-pass traveling mixing plant or (2) a single-pass traveling mixing plant.

The equipment provided by the Contractor shall be operated by experienced and capable workmen and shall be that necessary to provide a cement treatment meeting the requirements herein specified.

270.4. Construction Methods.

(1) General. It is the primary requirement of this specification to secure a completed course of treated material containing a uniform portland cement mixture free from loose or segregated areas, of uniform density and moisture content, well bound for its full depth and with a smooth surface suitable for placing subsequent courses. It shall be the responsibility of the Contractor to regulate the sequence of his work, to process a sufficient quantity of material to provide full depth as shown on plans, to use the proper amount of portland cement, maintain the work and rework the courses as necessary to meet the above requirements.

(2) Preparation of Roadbed. Before other construction operations are begun, the roadbed shall be graded and shaped as required to construct the portland cement treatment for material in place in conformance with the lines, grades, thickness and typical cross section shown on the plans. Unsuitable soil or material shall be removed and replaced with acceptable soil.

The subgrade shall be firm and able to support without displacement the construction equipment and the compaction hereinafter specified. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

(3) Pulverization. The soil shall be so pulverized that, at the completion of moist-mixing, 100 percent by dry weight passes a 1-inch sieve, and a minimum of 80 percent passes a No. 4 sieve, exclusive of gravel or stone retained on these sieves. Old bituminous wearing surface shall be pulverized so that 100 percent will pass a 2-inch sieve.

(4) Application of Cement (Roadmix). Portland cement shall be spread uniformly on the soil at the rate specified on the plans or approved by the Engineer. If a bulk cement spreader is used, it shall be positioned by string lines or other approved method during spreading to insure a uniform distribution of cement.

Cement shall be applied only to such an area that all the operations can be continuous and completed in daylight within 6 hours of such application.

The percentage of moisture in the soil, at the time of cement application, shall not exceed the quantity that will permit uniform and intimate mixture of soil and cement during dry mixing operations, and it shall not exceed the specified optimum moisture content for the soil cement mixture.

No equipment, except that used in spreading and mixing, will be allowed to pass over the freshly spread cement until it is mixed with the soil.

(5) Mixing and Processing. Unless otherwise shown on the plans, either method (a) or (b) below may be used at the option of the Contractor.

(a) Multiple-Pass Traveling Mixing Plant. After the cement has been applied it shall be dry-mixed with the soil. Mixing shall continue until the cement has been sufficiently blended with the soil to prevent the formation of cement balls when water is applied. Any mixture of soil and cement that has not been compacted and finished shall not remain undisturbed for more than 30 minutes.

Immediately after the dry mixing of soil and cement is complete, water as necessary shall be uniformly applied and incorporated into the mixture. Pressurized equipment and supply provided shall be adequate to insure continuous application of the required amount of water to sections being processed within 3 hours of application of the cement. Proper care shall be exercised to insure proper moisture distribution at all times. After the last increment of water has been added, mixing shall continue until a thorough and uniform mix has been obtained.

(b) Single-Pass Traveling Mixing Plant. After the cement has been applied it shall be sufficiently dry-mixed with the soil to prevent the formation of cement balls when water is applied. Unpulverized soil lumps in the soil cement mixture immediately behind the mixer that are dry will not be allowed. Should this condition prevail, the Contractor shall "pre-wet" the raw soil as necessary to correct this condition.

The mixer shall be provided with means for visibly and accurately gaging the water application. The water shall be applied uniformly through a pressure spray bar.

After cement is spread, mixing operations shall proceed as follows:

The mixer shall in one continuous operation mix the air-dry soil and cement full depth, and the required moisture uniformly, thoroughly moist-mix the soil, cement and water, spread the completed soil cement mixture evenly over the machine processed width of the subgrade and leave it in a loose condition ready for immediate compaction.

The soil and cement mixture shall not remain undisturbed, after mixing and before compacting, for more than 30 minutes.

(6) Compaction and Finishing. The material shall be compacted to not less than the density shown on the plans. At the start of compaction, the percentage of moisture in the mixture and in unpulverized soil lumps, based on oven-dry weights, shall not be below or more than two percentage points above the specified optimum moisture content and shall be less than that quantity which will cause the soil cement mixture to become unstable during compaction and finishing. When the uncompacted soil cement mixture is wetted by rain so that the average moisture content exceeds the tolerance given at the time of final compaction, the entire section shall be reconstructed in accordance with this specification at the sole expense of the Contractor.

The specified optimum moisture content and density shall be determined in the field by Test Method Tex-114-E or other approved methods, on representative samples of soil cement mixture obtained from the area being processed.

Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth. The loose mixture then shall be uniformly compacted to the specified density within 2 hours.

After the soil and cement mixture, excepting the top mulch, is compacted, water shall be uniformly applied as needed and thoroughly mixed in with a spiketooth harrow or equal. The surface shall then be reshaped to

the required lines, grades and cross section and then lightly scarified to loosen any imprint left by the compacting or shaping equipment.

The resulting surface shall be thoroughly rolled with a pneumatic tire roller and "clipped", "skinned" or "tight bladed" by a power grader to a depth of approximately 1/4 inch, removing all loosened soil and cement from the section. The surface shall then be thoroughly compacted with the pneumatic roller, adding small increments of moisture as needed during rolling. If plus No. 4 aggregate is present in the mixture, one complete coverage of the section with the flat wheel roller shall be made immediately after the "clipping" operation. When directed by the Engineer, surface finishing methods may be varied from this procedure provided a dense, uniform surface, free of surface compaction planes, is produced. The moisture content of the surface material must be maintained at its specified optimum during all finishing operations. Surface compaction and finishing shall proceed in such a manner as to produce, in not more than 2 hours, a smooth, closely knit surface, free of cracks, ridges or loose material conforming to the crown, grade and line shown on the plans.

270.5. Curing.

(1) Protection and Cover. After the cement treated course has been finished as specified herein, the surface shall be protected against rapid drying by either of the following curing methods for a period as shown on plans but in no case less than 3 days or until the surface or subsequent courses are placed:

(a) Maintain in a thorough and continuously moist condition by sprinkling.

(b) Apply a 2-inch layer of earth on the completed course and maintain in a moist condition.

(c) Apply an asphalt membrane to the treated course, immediately after same is completed. The quantity and type of asphalt approved for use by the Engineer shall be sufficient to completely cover and seal the total surface of the base and fill all voids. If the Contractor elects to use this method, it shall be his responsibility to protect the asphalt membrane from being picked up by traffic by either sanding or dusting the surface of same. The asphalt membrane may remain in place when the proposed surface or other base courses are placed.

(2) Surface. The surface or other base courses may be applied on the finished base as soon after completion as operations will permit.

270.6. Construction Joints. At the end of each day's construction a straight transverse construction joint shall be formed by cutting back into the total width of completed work to form a true vertical face free of loose and shattered material.

Cement treatment for large, wide areas shall be built in a series of parallel lanes of convenient length and width meeting the approval of the Engineer.

270.7. Traffic. Completed sections of cement treated material in place may be opened immediately to local traffic and to construction equipment and to all traffic after the curing period, provided the cement treated course has hardened sufficiently to prevent marring or distorting the surface by equipment or traffic.

270.8. Maintenance. The Contractor shall be required, within the limits of his contract, to maintain the cement treated course in good condition until all work has been completed and accepted. Maintenance shall include immediate repairs of any defects that may occur. This work shall be done by the Contractor at his own expense and repeated as often as may be necessary to keep the area continuously intact. Faulty work shall be replaced for the full depth of treatment. It is the intent of this specification that the Contractor construct the plan depth of cement treatment in one homogeneous mass. The addition of thin stabilized layers will not be permitted in order to provide the minimum specified depth.

270.9. Measurement. The work performed and material furnished as prescribed by this item will be measured as follows:

Cement treatment for materials in place will be measured by the square yard of surface area of completed and accepted work.

Portland cement specified by the Engineer for incorporation in the cement treatment will be measured by the barrel of 376 pounds of cement.

270.10. Payment. The work performed and material furnished as prescribed by this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above will be paid for at the unit price bid for "Cement Treatment (Existing Materials)" and "Portland Cement".

The unit prices bid shall each be full compensation for preparing the roadbed; for furnishing all material; for all freight involved; for furnishing scales and labor involved in weighing the material; for pulverizing, applying cement, water, all processing, mixing, spreading, sprinkling, compacting, finishing and curing the cement treated soil; and for all manipulations, labor, equipment, fuels, tools and incidentals necessary to complete the work except as follows:

All earthwork involved in preparation of subgrade, other than that incidental to the specified fine grading, and manipulation necessary to reshape and compact the existing section and to compact the material added, will be measured and paid for in accordance with the provisions governing the pertinent roadway items. No direct payment will be made for blading, wetting or rolling, this being considered as subsidiary work pertaining to the construction of the cement treated course.

ITEM 272

PORTLAND CEMENT TREATMENT FOR BASE COURSES

272.1. Description. This item shall consist of treating base and subbase by addition of portland cement, mixing, wetting and compacting the mixed material in accordance with the specifications governing the base and subbase courses. This item applies to the treatment of base or subbase courses placed under this contract and shall be constructed as herein specified and in conformity with the items governing the base or subbase courses.

Portland cement treatment shall not be mixed or placed when the air temperature is below 40 F and is falling, but may be mixed or placed when the air temperature is above 35 F and is rising, the temperature being taken in the shade and away from artificial heat and with the further provision that portland cement treatment for base courses shall be mixed or placed only when weather conditions, in the opinion of the Engineer, are suitable.

272.2. Materials.

(1) Base and subbase materials shall meet the requirements shown on the plans or in pertinent specifications.

(2) Portland cement shall be Type 1 of a standard brand of portland cement and shall conform to the requirements of ASTM Designation: C 150.

One sack, containing 1 cubic foot of cement, shall be considered as weighing 94 pounds net. One barrel of cement shall be considered as weighing 376 pounds net, and containing 4 cubic feet.

The Contractor, at his option, may use bulk cement, provided the apparatus for handling, weighing and spreading the cement is approved by the Engineer in writing. Cement weighing equipment shall be as specified below.

(3) Water shall be free from substances deleterious to the hardening of the treated base or subbase, and shall be approved by the Engineer.

(4) If the minimum design strength of the portland cement treated base or subbase or the percent of cement is specified on the plans, it will be determined by preliminary tests performed in accordance with Test Method Tex-120-E.

272.3. Equipment. Where materials are specified to be measured or proportioned by weight, equipment shall conform to the requirements of the Item, "Weighing and Measuring Equipment". Equipment necessary for proper prosecution of the work shall be on the project and approved by the Engineer prior to the beginning of construction operations. All equipment used shall be maintained in a satisfactory working condition. The Contractor shall employ adequate methods in performing the work and shall conduct his operations in a satisfactory and workmanlike manner.

Portland cement treatment for base and subbase may be constructed with any machine or combination of machines and auxiliary equipment that will produce results as required by this specification.

Mixing may be accomplished by (1) a multiple-pass traveling mixing plant, (2) a single-pass traveling mixing plant or (3) a central mixing plant.

272.4. Construction Methods.

(1) General. The primary requirement of this specification is to secure a completed course of base or subbase material containing a uniform portland cement mixture, free from loose or segregated areas, of uniform density and moisture content, well bound and compacted for its full depth with a smooth surface suitable for placing additional subbase, base or surface courses. It shall be the responsibility of the Contractor to regulate the sequence of his work, to process a sufficient quantity of material to provide full depth as shown on plans, to use the proper amount of portland cement, maintain the work and rework the courses as necessary to meet the above requirements.

The subgrade shall be prepared and shaped to the typical sections, lines and grades in accordance with pertinent base and subbase specifications, as shown on plans or as established by the Engineer.

The base or subbase material, as provided in the governing specifications, shall be delivered, placed and spread in the required amount per station. The material shall be manipulated as specified for the base or subbase course or as directed by the Engineer and thoroughly mixed prior to addition of the portland cement.

Where in the opinion of the Engineer, pulverization is required, the base or subbase material shall be so pulverized that, at the completion of moist mixing, 100 percent by dry weight passes a 1-inch sieve, and a minimum of 80 percent passes a No. 4 sieve, exclusive of gravel or stone retained on these sieves.

(2) Application of Cement (Roadmix). Portland cement shall be spread uniformly on the base or subbase at the rate specified on the plans or approved by the Engineer. If a bulk cement spreader is used, it shall be positioned by string lines or other approved method during spreading to insure a uniform distribution of cement.

Cement shall be applied only to such an area that all the operations can be continuous and completed in daylight within 6 hours of such application.

The percentage of moisture in the base or subbase material, at the time of cement application, shall not exceed the quantity that will permit uniform and intimate mixture of the material and cement during dry mixing operations, and it shall not exceed the specified optimum moisture content for the portland cement treatment mixture.

No equipment, except that used in spreading and mixing, will be allowed to pass over the freshly spread cement until it is mixed with the base or subbase material.

(3) Mixing and Processing. Unless otherwise shown on the plans, either method (a), (b) or (c) below may be used at the option of the Contractor.

(a) Multiple-Pass Traveling Mixing Plant. After the cement has been applied it shall be dry-mixed with the base or subbase material. Mixing shall continue until the cement has been sufficiently blended with the base or subbase material to prevent the formation of cement balls when water is applied. Any mixture that has not been compacted and finished shall not remain undisturbed for more than 30 minutes.

Immediately after the dry mixing of base or subbase material and cement is complete, water as necessary shall be uniformly applied and incorporated into the mixture. Pressurized equipment and supply provided shall be adequate to insure continuous application of the required amount of water to sections being processed within 3 hours of application of the cement. Proper care shall be exercised to insure proper moisture distribution at all times. After the last increment of water has been added, mixing shall continue until a thorough and uniform mix has been obtained.

(b) Single-Pass Traveling Mixing Plant. After the cement has been applied it shall be sufficiently dry-mixed with the base or subbase material to prevent the formation of cement balls when water is applied. Unpulverized soil lumps in the portland cement treatment mixture immediately behind the mixer that are dry will not be allowed. Should this condition prevail the Contractor shall "pre-wet" the raw base or subbase material as necessary to correct this condition.

The mixer shall be provided with means for visibly and accurately gaging the water application. The water shall be applied uniformly through a pressure spray bar.

After cement is spread, mixing operations shall proceed as follows:

The mixer shall in one continuous operation mix the air-dry base or subbase material and cement full depth, add the required moisture uniformly, thoroughly moist-mix the base or subbase material, cement and water, spread the completed portland cement treatment mixture evenly over the machine processed width of the subgrade and leave it in a loose condition ready for immediate compaction.

The portland cement treatment for base and subbase mixture shall not remain undisturbed, after mixing and before compacting, for more than 30 minutes.

(c) Central Mixing Plant. The base or subbase material, cement and water shall be dry-mixed in a pugmill of either the batch or continuous-flow type. The plant shall be equipped with feeding and metering devices which will add the base or subbase material, cement and water into the mixer in the specified quantities. Base or subbase material and cement shall be mixed sufficiently to prevent cement balls from forming when water is added. Mixing shall continue until a uniform and intimate mixture of base or subbase material, cement and water is obtained.

The mixture shall be hauled to the construction site in suitable vehicles equipped with protective covers. The mixture shall be placed on the moistened subgrade in a uniform layer by an approved spreader or spreaders. Not more than 30 minutes shall elapse between the placement of portland cement treatment in adjacent lanes at any location except at longitudinal construction joints. Not more than 30 minutes shall elapse between the start of spreading the base or subbase material and cement mixture and the start of compaction. Not more than 60 minutes shall elapse between the start of moist mixing and the start of compaction of soil cement. The layer of portland cement treatment shall be uniform in thickness and surface contour, and in such quantity that the completed base will conform to the required grade, cross section and governing base or subbase specification. Dumping of the mixture in piles or windrows upon the subgrade will not be permitted.

(4) Compaction and Finishing. The material shall be compacted to not less than the density shown on the plans. At the start of compaction, the percentage of moisture in the mixture and in unpulverized soil lumps, based on oven-dry weights, shall not be below or more than two percentage points above the specified optimum moisture content, and shall be less than that quantity which will cause the portland cement treatment mixture to become unstable during compaction and finishing. When the uncompacted mixture is wetted by rain so that the average moisture content exceeds the tolerance given at the time of final compaction, the entire section shall be reconstructed in accordance with this specification at the sole expense of the Contractor.

The specified optimum moisture content and density shall be determined in the field by Test Method Tex-114-E or other approved method, on representative samples of portland cement treatment mixture obtained from the area being processed.

Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth. The loose mixture then shall be uniformly compacted to the specified density within 2 hours.

After the base or subbase material and cement mixture, excepting the top mulch, is compacted, water shall be uniformly applied as needed and thoroughly mixed in with a spiketooth harrow or equal. The surface shall then be reshaped to the required lines, grades and cross section and then lightly scarified to loosen any imprint left by the compacting or shaping equipment.

The resulting surface shall be thoroughly rolled with a pneumatic tire roller and "clipped", "skinned" or "tight bladed" by a power grader to a depth of approximately 1/4 inch, removing all loosened soil and cement from the section.

The surface shall then be thoroughly compacted with the pneumatic tire roller, adding small increments of moisture as needed during rolling. If plus No. 4 aggregate is present in the mixture, one complete coverage of the section with the flat wheel roller shall be made immediately after the "clipping" operation. When directed by the Engineer, surface finishing methods may be varied from this procedure provided a dense, uniform

surface, free of surface compaction planes, is produced. The moisture content of the surface material must be maintained at its specified optimum during all finishing operations. Surface compaction and finishing shall proceed in such a manner as to produce, in not more than 2 hours, a smooth, closely knit surface, free of cracks, ridges or loose material conforming to the crown, grade and line shown on the plans.

272.5. **Curing.**

(1) **Protection and Cover.** After the portland cement treatment for base or subbase course has been finished as specified herein, the surface shall be protected against rapid drying by either of the following curing methods for a period as shown on plans but in no case less than 3 days or until the surface or an additional base course is placed:

(a) Maintain in a thorough and continuously moist condition by sprinkling.

(b) Apply a 2-inch layer of earth on the completed course and maintain in a moist condition.

(c) Apply an asphalt membrane to the course, immediately after same is completed. The quantity and type of asphalt approved for use by the Engineer shall be sufficient to completely cover and seal the total surface of the base and fill all voids. If the Contractor elects to use this method, it shall be his responsibility to protect the asphalt membrane from being picked up by traffic by either sanding or dusting the surface of same. The asphalt membrane may remain in place when the proposed surface or other base courses are placed.

(2) **Surface.** The surface or other base courses may be applied on the finished section as soon after completion as operations will permit.

272.6. **Construction Joints.** At the end of each day's construction a straight transverse construction joint shall be formed by cutting back into the total width of completed work to form a true vertical face free of loose and shattered material.

Portland cement treatment for base or subbase for large, wide areas shall be built in a series of parallel lanes of convenient length and width meeting the approval of the Engineer.

272.7. **Traffic.** Completed sections of portland cement treatment may be opened immediately to local traffic and to construction equipment, and to all traffic after the curing period, provided the mixture has hardened sufficiently to prevent marring or distorting the surface by equipment or traffic.

272.8. **Maintenance.** The Contractor shall be required, within the limits of his contract, to maintain the portland cement treatment in good condition until all work has been completed and accepted. Maintenance shall include

immediate repairs of any defects that may occur. This work shall be done by the Contractor at his own expense and repeated as often as may be necessary to keep the area continuously intact. Faulty work shall be replaced for the full depth of treatment. It is the intent of this specification that the Contractor construct the plan depth of cement treated base in one homogeneous mass. The addition of thin stabilized layers will not be permitted in order to provide the minimum specified depth.

272.9. Measurement. When portland cement is added to the base or subbase materials provided under pertinent specifications, the specification applicable to that item shall govern except that manipulation of the materials and application, mixing, measurement and payment for portland cement shall be as required herein.

Portland cement specified by the Engineer for treatment for base or subbase courses will be measured by the barrel of 376 pounds of cement.

272.10. Payment. Work performed and materials furnished as prescribed by this specification and measured as provided under "Measurement" will be paid for at the unit price bid per barrel of 376 pounds for "Portland Cement", which price shall be full compensation for supplying the portland cement, for all mixing, spreading, drying, application of the portland cement, mixing water, shaping and maintaining, for all manipulations required, for all hauling and freight involved, for all tools, equipment, labor and for all incidentals necessary to satisfactorily complete the work, except as hereinafter specified.

Payment for the preparation of the subgrade will be measured and paid for in accordance with the pertinent specification items.

Measurement and payment for all other items involved in constructing base or subbase courses, including sprinkling and rolling, will be as provided in the governing base or subbase item.

ITEM 274
CEMENT STABILIZED BASE

274.1. Description. This item shall consist of a foundation for surface course or for other base courses; shall be composed of a mixture of flexible base material, Portland Cement and water; and shall be constructed as herein specified and in conformity with the typical cross sections shown on the plans and to the lines and grades established by the Engineer.

274.2. Materials.

(1) Portland Cement. Cement shall be Type 1 of a standard brand of Portland Cement and shall conform to the requirements of ASTM Designation C 150. Bulk cement or sack cement may be used.

(2) Water. Water shall meet the requirements of water for the Item, "Concrete Pavement".

(3) Base Materials. The base material shall consist of durable coarse aggregate particles of shell, synthetic aggregate, bank-run gravel, processed

gravel, iron ore gravel, crushed stone or crushed blast furnace slag combined with approved binder material. Local material sources shall be approved prior to use. Material pits shall be opened up in such a manner as to expose the vertical faces of the various strata of acceptable material and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata in order that a uniformly mixed material is secured.

The base material when properly slaked and tested by Texas Highway Department standard laboratory test procedures shall meet the following requirements unless otherwise specified on the plans:

Type	A	B	C	D	E		F	G	H
Square Sieve	Sand Shell	Synthetic Aggregate	Iron Ore Gravel	Crushed Stone	Processed Gravel Gr.1	Processed Gravel Gr.2	Crushed Blast Furnace Slag	Bank-run Gravel	As Shown on Plans
PERCENTAGE RETAINED, SIEVES									
2-1/2"			0						
1-3/4"		0		0-10	0-5		0	0-5	
1-1/4"	0-10								
1/2"						0			
3/8"							25-45		
No. 4	30-65			45-75	30-75	15-35	45-65	30-75	
No. 40	50-75	60-80	45-65	55-80	60-85	55-85	70-85	65-85	

The material passing the No. 40 sieve shall be known as "Soil Binder" and unless otherwise shown on plans shall meet the following requirements when prepared in accordance with Test Method Tex-101-E Procedure:

The Plasticity Index shall not exceed 10.
The liquid limit shall not exceed 35.

Unless otherwise indicated on the plans, when the type of cement stabilized base is not specified, the Contractor may select any of the foregoing materials as aggregate for use in construction of cement stabilized base.

274.3. Equipment. Where materials are to be measured or proportioned by weight, equipment shall conform to the requirements of the item "Weighing and Measuring Equipment". Equipment necessary for the proper mixing and placing of the stabilized base shall be in first-class working condition and shall be approved by the Engineer both as to type and condition prior to the start of construction operations. The Contractor shall at all times provide sufficient equipment to allow continuous prosecution of the work and to insure that the mixing, placing and compaction operations are performed and completed within the time limit specified herein. All equipment shall be operated by experienced and capable workmen.

274.4. Proportioning of Mixes. Cement stabilized base mixture shall be proportioned as set out below under "Strength Design" or as set out below under "Cement Factor Design". Unless otherwise shown on the plans, the mixture shall be proportioned by "Cement Factor Design".

(1) Strength Design. The mix will be designed with the intention of producing a minimum average compressive strength of 650 pounds per square inch at the age of seven days using unconfined compression testing procedures unless otherwise specified on the plans. Cement stabilized base specimens shall be prepared, cured and tested as outlined in Test Method Tex-120-E.

(a) Preliminary Design. Prior to the beginning of cement stabilized base placement, the Contractor shall designate for the approval of the Engineer the source of base materials proposed for use and shall submit representative samples of the material therefrom for quality and gradation tests and for making design mixes. Three test cylinders will be made and tested for each of the following cement factors: 4%, 6% and 8%. From these preliminary tests, the cement content required to produce cement stabilized base of the specified strength will be selected by the Engineer. The cement content shall not be less than 4.5 percent of the dry weight of the cement-base material mixture.

(b) Test Specimens. The strength of the mix will be checked by tests of the mix as placed on the roadway. A minimum of three test specimens shall be made for each 1000 tons of material or fraction thereof placed each day. For these tests the material will be sampled prior to compaction. Changes in the mix design, including changes in the cement content, will be made when the average seven-day unconfined compressive strength of the cement stabilized base material, as indicated by the unconfined compressive strength values obtained from tests of the last three days' placement, departs from the intended strength by more than ten percent except that the cement rate shall not be reduced below 4.5 percent. In determining the average strength, the Engineer may, at his option, reject any test as non-representative that departs from this seven day average by more than 10 percent and compute the average from the values of the remaining tests.

(c) The Contractor may, at his option, after furnishing the materials for the preliminary tests outlined above, start construction of cement stabilized base using a cement factor from the following list:

Aggregate Material	Cement % by Dry Weight	Aggregate Material	Cement % by Dry Weight
Synthetic Aggregate	8.0	Iron Ore Gravel	5.9
Sand-Shell	7.0	Crushed Stone	4.7
Processed Gravel Gr 1 or 2	6.7	Crushed Blast Furnace Slag	4.7
Bank-run Gravel	5.9		

The Contractor will be allowed to construct cement stabilized base with the cement factor listed herein until the preliminary test results are available. Operation shall then continue under Section 274.4(1) (b) above.

(2) Cement Factor Design. Unless otherwise shown on the plans, the cement content shall be as follows for each type of aggregate:

Aggregate Material	Cement % by Dry Weight	Aggregate Material	Cement % by Dry Weight
Synthetic Aggregate	8.0	Iron Ore Gravel	6.0
Sand-Shell	7.0	Crushed Stone	5.0
Processed Gravel Gr 1 or 2	7.0	Crushed Blast Furnace Slag	5.0
Bank-run Gravel	6.0		

274.5. Sampling and Testing. Material for the preliminary tests described in the preceding sections of this specification shall be furnished by the Contractor at no cost to the State. The Engineer will perform all tests required at no cost to the Contractor. The Contractor may make such other tests as he desires at his own expense. In addition to tests mentioned above under Article 274.4., "Proportioning of Mixes", tests for moisture and density will be made on the material immediately following placement. As soon after placement as it is practical, the thickness of the material will be determined by coring. In addition to the above synthetic aggregate shall meet the wet ball mill, pressure slaking and loose unit weight requirements of and be sampled and tested as specified in the Item "Flexible Base (Delivered)" for Type F, Grade One, unless otherwise shown on the plans.

274.6. Construction Methods.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on the plans to the lines and grades established by the Engineer. All unstable or otherwise objectionable material or roots shall be removed from the subgrade and replaced with approved material. All holes, ruts and depressions shall be filled with approved material and, if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to lines and grades as established and shall be in conformity with the typical sections shown on the plans. A subgrade planer may be used. Any deviation in excess of one-half inch in cross section and in length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed.

(2) Mixing. The cement, base material and water shall be thoroughly mixed in an approved processing plant. The mixer shall be a stationary pugmill. Batch or continuous type mixers which will produce a uniform material will be allowed. The plant shall be equipped with feeding and metering devices which will add the base material, cement and water into the mixer in the specified quantities. Regardless of the type of mixer employed, the resulting mixture shall be homogeneous and uniform in appearance. The moisture content of the mixture shall be maintained between optimum moisture and two percentage points above optimum moisture or shall be maintained within the range established by the Engineer. The amounts of cement and moisture are expressed as percentages of dry weight of the combined base material and cement.

(3) Placing. The cement stabilized base shall be placed in uniform layers on the prepared subgrade to produce the depth specified on the plans. The depth of layers shall be as approved by the Engineer. To insure homogeneous distribution of the base material in each layer, the material shall be placed using an approved spreader. The spreading operations shall be done in such a manner as to eliminate nests or pockets of material of non-uniform gradation resulting from segregation in the hauling or dumping operations and in such a manner as to eliminate planes of weakness. Construction joints between new cement stabilized base and cement stabilized base that has been in place four hours or longer shall be approximately vertical. The plane of the joint may be formed by a header which shall be removed immediately prior to placing the subsequent base or the base placed first may be cut to an approximately vertical edge immediately prior to placing the new base.

Only one longitudinal joint will be permitted where cement stabilized base is placed underneath freeway main lanes and shoulders unless otherwise permitted by the Engineer. This joint shall normally be placed at the centerline of the highway. Longitudinal joints will not be permitted underneath frontage roads and ramps unless otherwise permitted by the Engineer.

Equipment permitted in the Item, "Concrete Pavement", may be used for placing cement stabilized base.

Cement stabilized base shall not be placed when the air temperature is below 40 F and is falling, but may be placed when the air temperature is above 35 F, and is rising, the temperature being taken in the shade and away from artificial heat and with the further provision that cement stabilized base shall be mixed or placed only when weather conditions in the opinion of the Engineer are suitable for such work.

(4) Compaction. Compaction shall be carried out under the controlled density method or under the ordinary compaction method as outlined below and as shown on the plans.

The optimum moisture content and desirable density shall be determined by Test Method Tex-114-E and shall be checked in the field by Test Method Tex-115-E. When the uncompacted cement stabilized base mixture is wetted by rain so that at the time of final compaction the average moisture content exceeds the range specified, the entire section shall be removed and

reconstructed in accordance with this specification at the expense of the Contractor.

(a) Density Control Method. Unless shown otherwise on the plans, the cement stabilized base shall be compacted to a density of not less than 95 percent of Compaction Ratio Density, Test Method Tex-114-E. The moisture content of the mixture during compaction operations shall be maintained within a range from optimum percentage to two percentage points above the optimum percentage or within the range directed by the Engineer.

(b) Ordinary Compaction Method. The cement stabilized base shall be rolled as directed by the Engineer until uniform compaction is obtained. Rollers used shall be as indicated on the plans. During this operation the shape of the course shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades.

(5) Finishing. After the final course of cement stabilized base, except the top mulch, is compacted, the surface shall be finished to grade and section by blading and shall be sealed with approved pneumatic tire or flat wheel rollers. When directed by the Engineer, surface finishing methods may be varied from this procedure provided a dense uniform surface is produced and further provided that the construction of compaction planes is avoided. Unless otherwise shown on plans, (1) not more than 60 minutes shall elapse between the start of mixing and the time of starting the compaction of the cement treated mixture on the prepared subgrade. (2) any mixture of aggregate, cement, and water that has not been compacted shall not be left undisturbed for more than 30 minutes, and (3) the compaction shall be completed within 2 hours of the time water is added to the mixture.

In that area where pavement or surface treatment is to be placed, any deviation from the plan surface in excess of one quarter inch in cross section and in length of 16 feet measured longitudinally shall be corrected immediately by loosening, adding or removing materials, reshaping and recompacting by sprinkling and rolling or high spots may be removed by grinding. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting.

(6) Curing. The cement stabilized base shall be kept wet for a period of 72 hours after completion of compaction. This may be done by sprinkling or by preventing the evaporation of water by placing an asphaltic membrane. The choice of curing method will belong to the Contractor unless a certain method of curing is required in the plans. If asphalt curing is required or if asphalt curing is used by the Contractor, the asphalt used shall be of the type and grade shown on the plans or as approved by the Engineer and shall be applied at the rate of approximately 0.1 gallon per square yard unless the plans require otherwise. Asphalt shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

(7) Traffic. The cement stabilized base shall be opened to traffic as specified on the plans or as directed by the Engineer, but in no case before being cured at least three days.

274.7. Maintenance. The Contractor will be required within the limits of his contract to maintain the cement stabilized base in good condition until all work has been completed and accepted. Maintenance shall include immediate repair of any defects that may occur. This work shall be done by the Contractor at his entire expense and shall be repeated as often as may be necessary to keep the area continuously intact. Repairs to cement stabilized base shall be effected by replacing the base for its full depth rather than by adding a thin layer of cement stabilized material to the layer of base in need of repair.

274.8. Penalty for Deficient Base Thickness. The adjustment in unit prices provided for in this article will apply only when measurement for payment is by the square yard.

It is the intent of this specification that the cement stabilized base be constructed in strict conformity with the thickness and typical sections shown on plans. Where any such base is found not so constructed, the following rules relative to adjustment of payment for acceptable stabilized base and to replacement of faulty stabilized base shall govern.

(1) The cement stabilized base will be core drilled by the Texas Highway Department prior to final acceptance. The thickness of the base will be determined by measurement of the cores in accordance with Test Method Tex-424-A.

For the purpose of establishing an adjusted unit price for cement stabilized base, units to be considered separately are defined as 1000 lineal feet of pavement in each traffic lane starting at the end of the base bearing the smaller station number. The last unit in each lane shall be 1000 feet plus the fractional part of 1000 feet remaining. Lane width shall be considered as the width between longitudinal construction joints or between the longitudinal construction joint and the edge of the cement stabilized base. For widening the width shall be considered as the average width placed of the widened section that is deficient in thickness. One core will be taken at random by the Department in each unit. When the measurement of the core from a unit is not deficient more than 0.5 inch from the plan thickness, full payment will be made. When such measurement is deficient more than 0.5 inch and not more than 1.50 inches from the plan thickness, two additional cores at intervals not less than 300 feet will be taken and used in the average thickness for that unit. An adjusted unit price as provided in Subarticle 274.8(2) will be paid for the unit represented.

Other areas such as intersections, entrances, crossovers, ramps, etc., will be considered as one unit, and the thickness of each unit will be determined separately. Small irregular unit areas may be included as part of another unit. At such points as the Engineer may select in each unit, one core will be taken for each 1000 square yards of cement stabilized base, or fraction thereof, in the unit. If the core so taken is not deficient more than 0.5 inch from the plan thickness, full payment will be made. If the core is deficient in thickness by more than 0.5 inch but not more than 1.50 inches from the plan thickness, two additional cores will be taken from the area represented and the average of the three cores determined. If the average measurement of

these three cores is not deficient more than 0.5 inch from the plan thickness, full payment will be made. If the average thickness of the three cores is deficient more than 0.5 inch but not more than 1.50 inches from the plan thickness, an adjusted unit price as provided in Subarticle 274.8(2) will be paid for the area represented by these cores.

In calculating the average thickness of the cement stabilized base, measurements which are in excess of the specified thickness by more than 0.2 inch will be considered as the specified thickness plus 0.2 inch, and measurements which are less than the specified thickness by more than 1.50 inches will not be included in the average.

When the measurement of any core is less than the specified thickness by more than 1.50 inches, the actual thickness of the cement stabilized base in this area will be determined by taking additional cores at (not less than) 10-foot intervals parallel to the center line in each direction from the affected location until in each direction a core is found which is not deficient by more than 1.50 inches. Areas found deficient in thickness by more than 1.50 inches shall be evaluated by the Engineer, and if in his judgment the deficient areas warrant removal, they shall be removed and replaced with stabilized base of the thickness shown on the plans.

Exploratory cores for deficient thickness will not be used in averages for adjusted unit price.

(2) Price Adjustments. Where the average thickness of cement stabilized base is deficient in thickness by more than 0.5 inch, but not more than 1.50 inches, payment will be made at an adjusted price as specified in the following table.

Cement Stabilized Base Deficiency

Deficiency in Thickness Determined by Cores Inches	Proportional Part of Contract Price Allowed
0.00 thru 0.50	100 percent
0.51 thru 0.75	80 percent
0.76 thru 1.00	70 percent
1.01 thru 1.25	60 percent
1.26 thru 1.50	50 percent

When the thickness of cement stabilized base is deficient by more than 1.50 inches and the judgment of the Engineer is that the area of such deficiency should not be removed and replaced, there will be no payment for the area retained.

(3) No additional payment over the contract unit price will be made for any cement stabilized base of a thickness exceeding that required by the plans.

274.9. Measurement. Work and acceptable materials as prescribed by this item will be measured for payment in accordance with the method indicated on the plans and in the proposal, the methods of measurement being as follows:

(1) When provided by the plans and the proposal, cement stabilized base will be measured by the square yard of completed and accepted work.

(2) When provided by the plans and the proposal, cement stabilized base will be measured by the ton of completed and accepted cement stabilized base. A ton will consist of 2,000 pounds of dry cement stabilized base mixture. Water in the mixture at time of weighing will be deducted.

(3) When provided by the plans and proposal, cement stabilized base will be measured by the cubic yard of completed and accepted cement stabilized base. Measurement will be made by the method of average end areas of authorized work.

274.10. Payment. The work performed and material furnished as prescribed by this item and measured in accordance with the method indicated on the plans and in the proposal and in accordance with the applicable provision of "Measurement" above will be paid for as follows:

(1) At the unit prices bid per square yard for "Cement Stabilized Base" of the type, grade, depth and compaction method specified or for "Cement Stabilized Base" of the depth and compaction method specified or at the adjusted unit price for base of deficient thickness as provided under Article 274.8, "Penalty for Deficient Base Thickness".

(2) At the unit price bid per ton for "Cement Stabilized Base" of the type, grade, depth and compaction method specified.

(3) At the unit price bid per cubic yard for "Cement Stabilized Base" of the type, grade, depth and compaction method specified or for "Cement Stabilized Base" of the depth and compaction method specified.

The unit price bid will be full compensation for securing and furnishing all materials; including all royalty, freight and storage involved; for all processing, crushing and loading; for all hauling, delivering, stockpiling, placing, spreading, blading, mixing, stripping, dragging, finishing, curing and maintaining; for all fine grading; for wetting and compacting and all manipulation, labor, tools, and incidentals necessary to complete the work, except as follows:

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly, but shall be subsidiary to other bid items, unless otherwise provided by the plans.

Unless otherwise indicated on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the

shoulders and slopes will be measured and paid for in accordance with the provisions governing the items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage will be measured and paid for once only regardless of the manipulations involved.

When shown on the plans, the excavation required in the preparation and shaping of the subgrade for the completion of shoulders and slopes and for finishing roadway shall be performed, measured and paid for in accordance with the provisions governing the items of "Blading", "Road Grader Work", or "Scraper Work". Payment under the item "Roadway Excavation" will not be allowed within the limits designated by the items "Blading", "Road Grader Work" and "Scraper Work".

ITEM 280

SOIL ASPHALT BASE
(Road Mix)

280.1. Description. This item shall consist of a foundation for surface course or for other base courses; shall be composed of a compacted mixture of soil and asphaltic material and shall be constructed as herein specified and in conformity with the typical cross sections shown on the plans and to the lines and grades established by the Engineer.

The soil and asphaltic material shall not be mixed when the air temperature is below 60 F and is falling, but they may be mixed when the air temperature is above 50 F and is rising, the temperature being taken in the shade and away from artificial heat, and with the further provision that the asphaltic mixture shall be mixed or placed only when weather conditions, in the opinion of the Engineer, are suitable.

280.2. Materials.

(1) Soil. Soil shall consist of approved soil, free from vegetation or other objectionable matter and may be either the material encountered in the existing roadbed; the material secured from sources shown on the plans or approved by the Engineer; or of a combination of existing material and additional soil from approved sources, all as shown on plans.

Where plans provide for the use of additional soil from approved sources, the pits utilized shall be cleaned of all grass, roots, vegetation or other objectionable matter; and overburden and any other material considered unacceptable by the Engineer shall be removed from the pits as directed and paid for as "Stripping". The pits shall be opened in such manner as to expose all the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

It is the intention of this specification to utilize materials existing on the roadbed where they are of such quality as to produce the results desired. Where satisfactory materials do not exist, material secured from approved sources shall be admixed with the existing soil or shall be furnished in sufficient quantity to construct the entire base course, all as shown on plans.

The Engineer may vary the proportions of the different types of soil to produce the most satisfactory material within the soil constant limits specified.

When the processed soil is properly tested by standard laboratory methods, the material shall meet the requirements indicated on plans.

(2) Asphaltic Material. The asphaltic material shall be of the type and grade shown on plans, and shall conform to requirements for the grade specified, as described in the Item, "Asphalts, Oils and Emulsions".

(3) If the minimum design strength of the soil asphalt mixture is specified on the plans, it will be determined by preliminary tests performed in accordance with Test Method Tex-119-E.

280.3. Equipment.

(1) General. Equipment necessary for the proper construction of the work shall be on the project, in first-class working condition, and shall be approved by the Engineer, both as to type and condition, prior to the beginning of construction operations. The Contractor shall at all times provide sufficient equipment to insure continuous prosecution of the work and its completion in the required number of working days. If in the opinion of the Engineer additional pieces of equipment of the type specified below are required for the mixing, aerating, compacting and finishing of the asphaltic mixture or to achieve a rate of progress which will insure completion of the work in the required number of working days, the Contractor shall, upon written request of the Engineer, immediately secure and place in operation the required equipment.

(2) Equipment. The following equipment, as required by the Contractor's method of operation, shall be provided by the Contractor and operated by experienced and capable workmen.

(a) Distributor. Asphalt distributors shall be of the self-propelled pressure type, equipped with pneumatic tires of ample size so as not to produce ruts in the subgrade or completed base, and shall be so designed and operated as to distribute the asphaltic material evenly and smoothly in the quantity specified. Distributors shall be equipped with the necessary facilities for determining the temperature and measuring the rate of application of the asphaltic material.

(b) Maintainers. Maintainers shall be self-propelled; shall have dual or 4-wheel drive; shall be equipped with pneumatic tires; shall have a blade of not less than 12 feet in length, and a wheel base length of not less than 16 feet; and shall be tight and in good operating condition. The Contractor shall furnish sufficient maintainers for continuous prosecution of work in a satisfactory manner and its completion in the required number of working days.

(c) Harrows. Harrows shall be of the offset disc-harrow type with 22-inch discs and not less than 10 feet in width.

(d) Pulverizer-Mixers. Pulverizer-mixers shall be of an approved type and be not less than 5 feet in width. They may be equipped with spray bars and asphaltic material, metering devices for applying the asphaltic material to the material being mixed.

(e) Water Sprinklers. Water sprinklers shall be equipped with positive and rapidly working cutoff valves, approved spray bars and shall be designed, equipped and operated so as to distribute the water uniformly in the quantity specified.

(f) Compaction Equipment. Suitable and sufficient compacting equipment shall be provided to complete compaction of the subgrade and the soil asphalt base in coordination with the other operations. Compaction equipment shall be of such types as are necessary to obtain the density and stability of soil asphalt base herein specified. Final Compaction of subgrade and base shall be obtained by the use of pneumatic tire roller meeting the requirements of the governing specifications and any special provisions for the Item, "Rolling".

(g) Tractors. Tractors of suitable type and of sufficient tractive power shall be furnished as required to draw any of the above equipment at an operating speed of not less than 3 miles per hour.

(3) Mixing Plants. The use of a traveling plant for the mixing of soils and/or the mixing of the asphaltic material with the soil will be permitted providing the Contractor makes a written request for the use of this type equipment and such request is approved in writing by the Engineer. The Contractor's request shall describe in full the equipment desired to be used, stating the make, type, size and capacity of such equipment and citing its successful use on similar work. Such an approval of change in type of equipment shall in no way modify the results required by this specification.

280.4. Heating Asphaltic Materials. Equipment used for the storage, heating or handling of asphalt shall be kept clean and in good operating condition at all times. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all heating operations. Cut-back asphalt shall not be heated to a temperature in excess of 190 F and road oil or cracked fuel oil shall not be heated to a temperature in excess of 250 F.

The temperature of the asphaltic material at the time of application will be selected by the Engineer, and the Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected. If cut-back asphalt is specified, it shall be applied at a temperature of not more than 175 F. If road oil or cracked fuel oil is specified, it shall be applied at a temperature of not more than 225 F.

280.5. Construction Methods. The roadbed shall be excavated and shaped as shown on the plans, and as required herein and in other pertinent specification items.

Where required by the plans or directed by the Engineer, additional soil shall be delivered on the road in the quantity ordered by the Engineer to provide a soil of the characteristics desired for the construction of the base. Such soil shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of material shall be delivered in each 100-foot station. The material shall be spread uniformly over the width of the roadbed. When the method of mixing requires the use of windrows, they shall be of uniform section.

The roadbed, composed either of material entirely from approved sources; a mixture of material from approved sources and the existing roadbed soil; or entirely of the existing roadbed soil; shall be loosened for the entire width and to a depth sufficient to produce a compacted base of the depth required by the plans. Unless otherwise specified on plans, the material so loosened shall be thoroughly mixed to provide a uniform material and shall be pulverized to the extent that 80 percent of the soil, by dry weight exclusive of gravel or stone, shall pass a No. 4 sieve. If the Contractor desires, sprinkling the soil to assist in pulverizing will be permissible. This loosening and mixing operation will not be required if a traveling plant as described herein is used for applying the asphaltic materials.

After completion of the mixing and pulverizing of the soil, sufficient material shall be removed to provide for the construction of the required section of base, and the subgrade shall be shaped to conform to the typical sections shown on plans and to the line and grade established by the Engineer. The subgrade shall be sprinkled and compacted to the extent necessary to provide a uniform, firmly compacted and stable surface at the time of the beginning of construction of the soil asphalt base. The stability of the subgrade shall be such as to support construction equipment without rutting.

Where shown on plans or directed by the Engineer, asphaltic material shall be applied on the prepared subgrade before beginning mixing operations. The soil asphalt base shall consist of a uniform mixture of soil, asphaltic material, and water and shall be constructed on the approved subgrade by blading the soil on to the subgrade, sprinkling as required, and applying the asphaltic material in approximately uniform applications at the rate directed by the Engineer, and in no case at a rate of more than 1 gallon per square yard in each application. The traveling plant method of mixing the soil, water and asphaltic material may be employed upon approval of the Engineer as stated above. The amount of asphaltic material in the mixture shall be such as to provide a weight of residual asphalt from 3 1/2 to 7 percent of the dry weight of the soil. The exact percentage of residual asphalt to be obtained in the mixture and the amount of asphaltic material shall be as directed by the Engineer.

Each course of soil asphalt base may be mixed as a whole, or the course may be constructed by mixing part width, or by mixing and compacting separate layers, in which case the upper layer of the course of soil asphalt base shall be not less than approximately 3 inches in depth. The maximum depth to be processed in one operation shall be as designated by the Engineer. The soil at the time of mixing with the asphaltic material shall contain

sufficient and uniformly distributed moisture to allow proper dispersion of the asphalt. The moisture shall in no case be sufficiently great to prevent proper dispersion of the asphaltic material, and if necessary the soil shall be dried before the asphaltic material is applied.

The soil may be sprinkled with water to assist in the proper dispersion of asphaltic material if the Contractor so desires.

Immediately after each application of the asphaltic material, the soil, water and asphaltic material shall be mixed by the use of the disc-harrow specified. Immediately following the application of all asphaltic material required for the soil asphalt base or that layer of the base, the entire amount of material shall be further mixed by the use of the disc-harrow and the pulverizer specified until thorough dispersion of the asphaltic material has been obtained and a homogeneous mixture results. Care shall be exercised to prevent incorporation of any material from the subgrade or shoulders in the soil asphalt mixture. The operations of mixing, aerating the mixture to reduce the amount of volatiles in the asphaltic material, spreading or placing in windrows, shall be continuous, with such deviations from this procedure as are authorized by the Engineer.

On the completion of mixing of the entire quantity of material required to produce the completed base or the layers of base as specified above, the mixed material shall be spread to the required section, shaped, compacted and finished in conformity with the typical sections shown on the plans and the line and grade established by the Engineer. The shaping and compacting operations shall be continued until the course is uniformly compacted to the extent that it will support loaded trucks and other construction equipment without appreciable displacement. Compaction shall be accomplished by blading and rolling the material at the moisture content, as indicated on the plans, to the end that a uniform mass without laminations or cleavage planes in the completed layer is obtained. The apparent dry density of the compacted base shall be not less than 95% of the laboratory density of the material at the moisture content as indicated on the plans. Materials for laboratory density shall be sampled from the roadway after the mixing operation and prior to the compaction operation. Laboratory density shall be obtained for the soil-asphalt road mixture using the compaction techniques in Test Method Tex-119-E.

Shaping and compaction of the soil asphalt base or of a layer of the soil asphalt base shall be continuous and the compaction and finishing of the base shall be completed within the daylight hours of that day on which such work is begun unless unforeseen conditions prevent such completion. Along curbs and at other places not accessible to the rollers, or in such positions that will not allow thorough compaction with the usual equipment, the mixture shall be compacted to the required density by use of lightly oiled hand tamps. Construction joints, formed at the end of each day's work or due to unavoidable interruptions of operations, shall be placed in such manner that a satisfactory riding surface shall be secured.

The completed course of soil asphalt base shall be allowed to dry as thoroughly as possible and to the satisfaction of the Engineer. During the

drying period, traffic shall be allowed to use the completed course. The course shall be sprinkled, bladed and rolled as directed and maintained true to the required sections and to the established lines and grades until a subsequent base or surface course is placed. Any portion of the base course which, after compaction, fails to meet the requirements for apparent dry density and stability, as specified above, shall be scarified and recompacted at the Contractor's entire expense.

The Contractor shall be required to maintain at his own expense the entire roadway within the limits of his contract in good condition satisfactory to the Engineer from the time he first starts work until all work shall have been completed. Maintenance shall include immediate repairs of any defects that may occur before or after the soil asphalt base has been compacted and finished, which work shall be done by the Contractor at his own expense and repeated as often as may be necessary to keep the roadway continuously intact. Repairs are to be made in a manner to insure restoration of a uniform surface and durability of the part repaired. Any low areas shall be remedied by replacing the material for the full depth of treatment rather than adding a thin layer of soil asphalt base to the completed work. Shoulders and slopes damaged by the Contractor during base construction shall be restored, bladed and shaped to the typical section shown on plans.

280.6. Measurement. Additional soil as required will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined at least one time each day and more often if conditions warrant. When the plans indicate that measurement is to be by the ton, the Contractor shall furnish a set of standard platform truck scales conforming to the applicable provisions of the Item, "Weighing and Measuring Equipment".

Measurement for hauling material into each quarter mile beyond the first quarter mile shall be based on the shortest practical haul route between the center of mass of the approved material source or sources and the point of delivery on the road.

Soil asphalt base will be measured by the square yard of surface area of completed and accepted work based on the width of the soil asphalt base as shown on the plans, or as established by the Engineer.

Asphaltic material of the type and grade shown on the plans may be measured in gallons at the applied temperature at the point of application on the road or by the ton as delivered to the project. If measurement is by the ton, the asphaltic material suppliers certificate of weights may be accepted provided the delivery is made in transports with seals unbroken. The Contractor shall furnish a set of standard platform truck scales conforming to the applicable provisions of Item "Weighing and Measuring Equipment" if the material is weighed on the project.

280.7. Payment. Work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Soil Asphalt Base" and "Additional Soil", which prices shall each be full compensation for cleaning the roadbed or the surface of the previously completed base course; for furnishing all materials; for all royalty and freight involved; for furnishing scales and labor involved in weighing the material; for loosening, excavating, loading, hauling the first one quarter mile and delivering additional soil on the road; for loosening, mixing and pulverizing of the soil; for shaping, sprinkling and compacting the subgrade; for all processing, mixing, drying, incorporation of asphaltic material, aerating and drying, spreading, sprinkling, shaping, compacting and finishing; for maintaining under traffic; and for all manipulations, labor, equipment, fuels, tools and incidentals necessary to complete the work except as hereinafter provided.

Hauling soil into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Asphaltic material measured as provided under "Measurement" will be paid for at the unit price bid for "Asphaltic Material" which price shall be full compensation for furnishing the material; for all freight involved; for all unloading, storing, heating, hauling and applying on the road; and for all labor, equipment, fuels, tools and incidentals necessary to complete the work.

All stripping performed as required will be measured and paid for in accordance with provisions governing the Item, "Stripping".

All earthwork involved in preparation of subgrade, other than that incidental to the specified fine grading, and manipulation necessary to reshape and compact the existing section and to compact the material added, will be measured and paid for in accordance with the provisions governing the pertinent roadway items. No direct payment will be made for blading, wetting or rolling, this being considered as subsidiary work pertaining to the construction of the stabilized base.

ITEM 290

SHELL CONCRETE BASE
(Water Cement Ratio)

290.1. Description. This item shall consist of a base of portland cement concrete, with or without reinforcement as shown on plans, with or without monolithic curbs, constructed as herein specified on the prepared subgrade or other base course in conformity with the thickness and typical cross sections shown on plans and to the lines and grades established by the Engineer. Concrete shall be considered of satisfactory quality provided it is made (a) of materials accepted for the job, (b) in the proportions established by the Engineer, and (c) mixed, placed, finished and cured in accordance with the requirements of this specification and meets the requirements herein specified.

290.2. Materials.

(1) Cement. The cement shall meet the requirements of subarticle 360.2(1) of the Item, "Concrete Pavement (Water Cement Ratio)".

(2) Admixtures. Admixtures specified or permitted for shell concrete base shall meet the requirements of subarticle 360.2(2) of the Item, "Concrete Pavement (Water Cement Ratio)".

(3) Coarse Aggregate. Coarse aggregate shall consist of durable particles of shell together with approved binding material, and when properly slaked and tested by Texas Highway Department laboratory methods shall meet the following grading requirements:

Retained on 3 inch sieve	0%
Retained on 3/4 inch sieve	12 to 37%
Retained on No. 4 sieve	95 to 100%
Passing No. 200 sieve	0 to 6%

The aggregate used shall be free from an excess of salt, alkali, vegetable matter or other objectionable materials, occurring either free or as adherent coatings. At the time of its use, the aggregate shall be free from frozen material and all foreign material such as wood, hay, burlap, paper or dirt, which may have become mixed with the aggregate in the stockpile.

(4) Fine Aggregate. Fine aggregate shall consist of sand, combination of sands and/or clean shell and shall be composed of clean, hard and durable uncoated particles and shall meet the requirements of subarticle 360.2(4) of the Item, "Concrete Pavement (Water Cement Ratio)".

(5) Water. Water shall meet the requirements of subarticle 360.2(5) of the Item, "Concrete Pavement (Water Cement Ratio)".

(6) Asphalt, Joint Filler, Joint Sealing Material and Asphalt Board. When required by the plans, asphalt, joint filler, joint sealing material and asphalt board shall conform to the pertinent provisions of subarticles 360.2(6), (7), (8) and (9) of the Item, "Concrete Pavement (Water Cement Ratio)".

(7) Load Transmission Devices for Expansion and Contraction Joints. Approved load transmission devices, if required, shall meet the requirements of subarticle 360.2(10) of the Item, "Concrete Pavement (Water Cement Ratio)".

(8) Metal Installing Devices for Joint Assembly. Such devices, where required, shall meet the requirements of subarticle 360.2(11) of the Item, "Concrete Pavement (Water Cement Ratio)".

(9) Steel Bar Reinforcement. Steel reinforcing bars, as required, shall meet the requirements of subarticle 360.2(12) of the Item, "Concrete Pavement (Water Cement Ratio)".

(10) Polyethylene Film, Membrane Curing Compound and Asphalt Curing Materials shall meet the requirements of subarticle 360.2(13), (14) and (15) respectively of the Item, "Concrete Pavement (Water Cement Ratio)".

290.3. Equipment. The equipment required for this work shall be as specified for and meet all the requirements of subarticle 360.3 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.4. Proportioning of Concrete.

(1) Proportions. Concrete shall be composed of portland cement, coarse aggregate, fine aggregate, mineral filler and/or admixtures if required, and water, mixed and proportioned as the Engineer determines in accordance with procedures outlined in Texas Highway Department Bulletin C-11 and with the requirements of this specification. On the basis of job and laboratory investigations of the proposed materials, the Engineer will fix the proportions by weight of water, coarse aggregate, fine aggregate, cement, admixtures and mineral filler where required, in order to produce concrete of the specified strength, workability and air content.

(2) Concrete Strength. The concrete mix will be designed with the intention of producing a minimum average flexural strength (modulus of rupture) of 400 pounds per square inch at the age of 7 days using a standard testing machine in which the load is applied at the center of the beam span. The coarse aggregate factor (dry, loose volume of coarse aggregate per unit volume of concrete) shall not exceed 0.92. The concrete shall contain not less than 4-1/2 sacks of cement per cubic yard of concrete. The water cement ratio (net gallons of water per sack or 94 pounds of cement) shall not exceed 11 gallons. Concrete specimens shall be prepared, cured and tested as outlined in THD Bulletin C-11.

(3) Workability of Concrete, Mix Design and Test Specimen shall meet the requirements of subarticle 360.4(4), (5) and (6), respectively, of the Item, "Concrete Pavement (Water Cement Ratio)".

290.5. Subgrade and Forms. Requirements for subgrade and forms shall meet the requirements of subarticle 360.5 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.6. Concrete Mixing and Placing. Concrete mixing and placing shall meet the requirements of subarticle 360.6 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.7. Joints. Joints shall meet the requirements of subarticle 360.7 of the Item, "Concrete Pavement (Water Cement Ratio)", except that the last sentence of this subarticle shall be replaced with the following: The mortar finish as required shall be subsidiary to the Item, "Shell Concrete Base".

290.8. Spreading and Finishing. Spreading and finishing shall meet the requirements of subarticle 360.8 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.9. Curing. Curing of shell concrete base shall meet the requirements of subarticle 360.9 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.10. Protection of Shell Concrete Base and Opening to Traffic. Provisions of subarticle 360.10 of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for the protection of shell concrete base and the opening to traffic.

290.11. Penalty for Deficient Shell Concrete Base Thickness. Penalty for deficient shell concrete base thickness shall be governed by the provisions of subarticle 360.11 of the Item, "Concrete Pavement (Water Cement Ratio)" where payment is specified to be by the square yard of surface area.

290.12. Measurement.

(1) When provided by plans and proposal, shell concrete base will be measured by the square yard of surface area of completed and accepted work. The surface area will be construed to also include that portion of the shell concrete base extending beneath the curb. When shell concrete base is to be measured by the square yard and monolithic curb is required, measurement for "Monolithic Curb" will be by linear foot complete in place.

(2) When provided by plans and proposal, shell concrete base, including monolithic curb when required, will be measured by the cubic yard of absolute volume of all materials entering the mixture as prescribed in THD Bulletin C-11.

290.13. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Shell Concrete Base", and "Monolithic Curb" (when base is measured by the square yard), as required, or the adjusted unit price for base of deficient thickness as provided under "Penalty for Deficient Shell Concrete Base Thickness", which price shall be full compensation for shaping and fine grading the roadbed, including furnishing and applying all water required; for finishing, loading and unloading, storing, hauling and handling all concrete ingredients, including all freight and royalty involved; for mixing, placing, finishing, sawing, cleaning and sealing joints and curing all concrete; for furnishing and installing all reinforcing steel; for furnishing all materials for sealing joints and placing longitudinal, expansion and weakened plane joints; including all steel dowel caps and load transmission devices required and wire and devices for placing, holding and supporting the steel bars, load transmission devices and joint filler material in proper position; for coating steel bars where required by plans and for all manipulations, labor, equipment, appliances, tools, traffic provisions and incidentals necessary to complete the work.

Excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage shall be measured and paid for once only, regardless of the manipulation involved; or, where shown on plans, such work will be measured and paid for in

accordance with the provisions governing the Item, "Blading". Measurement of subgrade excavation for payment shall be limited to a total width of that of the pavement plus 1 foot on each side. Payment under excavation items will not be allowed within the areas designated for "Blading".

Sprinkling and rolling required for the compaction of the rough subgrade in advance of fine grading will be measured and paid for as indicated in the governing items of excavation. Maintenance of a moist condition of the subgrade in advance of fine grading and concrete placing will not be paid for directly, but shall be considered subsidiary work, as provided above.

ITEM 292

ASPHALT STABILIZED BASE
(Plant Mix)

292.1. Description. This item shall consist of base courses, subbase courses or foundation courses to be composed of a compacted mixture of mineral aggregate and asphaltic material mixed hot in a mixing plant. The percent asphalt shall be determined in accordance with Test Method Tex-126-E or other established Texas Highway Department procedures as directed by the Engineer.

292.2. Materials.

(1) Asphaltic Materials.

(a) Mixture. Asphalt for the mixture shall be of the types of asphalt cement as determined by the Engineer and shall meet the requirements for the Item, "Asphalts, Oils and Emulsions". The grade of asphalt to be used will be determined by the Engineer after design tests have been made using the mineral aggregate approved for use in the construction of this Item. If more than one type of asphaltic concrete mixture is specified for the project, only one grade of asphalt will be required for all types of mixture unless otherwise shown on the plans. The Contractor shall notify the Engineer of the source of his asphaltic material prior to production of the asphaltic mixture and this source shall not be changed during the course of the project, except on written permission of the Engineer.

(b) Tack Coat. The asphaltic material for tack coat shall meet the requirements for emulsified asphalt EA-11M, cut-back asphalt RC-2, or shall be a cut-back asphalt made by combining 50 to 70 percent by volume of the asphaltic material as specified for the type of paving mixture with 30 to 50 percent by volume of gasoline and/or kerosene. If RC-2 cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of an approved grade of gasoline and/or kerosene, not to exceed 15 percent by volume. Asphaltic materials shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

(2) **Mineral Aggregate.**

(a) Description. The material shall be crushed or uncrushed and screened as necessary to meet the requirements hereinafter specified and shall consist of durable coarse aggregate particles mixed with approved binding materials.

(b) Grades. Unless otherwise specified, the grading of the mineral aggregate shall conform to the limitations as shown below:

	Percent by Weight
Grade 1:	
Retained on Sq. Sieve:	1-1/2" 0%
	1" ..... 0 - 10%
	3/8" .....30 - 55%
	No. 4 .....45 - 70%
	No. 40 ....70 - 85%
Grade 2:	
Retained on Sq. Sieve:	1-3/4" 0%
	1-1/2" .... 0 - 10%
	No. 4 .....45 - 75%
	No. 40 ....60 - 85%
Grade 3:	
Retained on Sq. Sieve:	1-3/4" 0%
	No. 40 ....60 - 85%
Grade 4:	
Retained on Sq. Sieve:	As Shown on Plans.

Unless otherwise specified on the plans, the mineral aggregate for grades 1, 2 and 3 shall meet the following physical requirements:

Wet Ball Mill	50 Max.
P.I.	15 Max.
L.L.	40 Max.

Sand equivalent value shall not be less than 40.

Mineral aggregate for Grade 4 shall meet the physical requirements shown on plans.

Testing of the mineral aggregate shall be in accordance with the following Texas Highway Department standard laboratory test procedures:

Preparation of Soil Constants and Sieve Analysis	Tex-101-E
Liquid Limit	Tex-104-E
Plastic Limit	Tex-105-E
Plasticity Index	Tex-106-E
Sieve Analysis	Tex-110-E
Wet Ball Mill	Tex-116-E
Sand Equivalent	Tex-203-F

Samples for testing the material shall be taken prior to the mixing operations. Where more than one material is used, tests will be on the combined materials unless otherwise shown on the plans.

Where pilot grading is required in the plans, the Engineer will designate the grading and allowable tolerances to govern during production. The mineral aggregate produced shall not vary from the designated pilot grading by more than the tolerances specified by the Engineer. The pilot grading may be varied by the Engineer as necessary to insure that the base material produced will meet the physical requirements specified.

The percent asphaltic material in the mixture shall be as determined by the Engineer using established methods.

(c) Material Sources. When material sources are not shown on the plans or in the specifications the material shall be obtained from sources secured by the Contractor and approved by the Engineer. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the available sources shown on plans or approved by the Engineer. The material shall be crushed or uncrushed and screened as necessary to meet the requirements hereinafter specified and/or shown on the plans and shall consist of durable particles of stone mixed with approved binding materials.

These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material and, unless otherwise directed by the Engineer, the material shall be secured in successive vertical cuts extending through all of the exposed strata in order that a uniformly mixed material will be secured.

Unless otherwise shown on plans, one or more types of mineral aggregate or binder may be used to produce the specified mixture.

292.3. Asphalt Stabilized Mixture.

(1) Paving Mixture. The mixture shall consist of a uniform mixture of mineral aggregate and asphaltic material. The mineral aggregate will conform to the gradation requirements as shown on the plans. The asphaltic material shall form from 4.0 to 9.0 percent of the mixture by weight unless otherwise shown on the plans.

(2) Tolerances. The Engineer will designate the asphalt content to be used in the mixture after design tests have been made with the aggregate to be used in the project. When tested as determined by the Engineer, samples of the mixture shall not vary from the asphalt content designated by the Engineer by more than 0.5 percent dry weight (based on total mixture).

292.4. Equipment.

(1) Mixing Plants. Mixing plants that will not consistently produce a mixture meeting all of the requirements of this specification will be condemned.

Mixing plants may be either the weight-batching type or the continuous mixing type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins and dust collectors and shall consist of the following essential pieces of equipment.

(a) Weight-Batching Type.

Cold Aggregate Bin and Proportioning Device. The number of compartments in the cold aggregate bin shall be equal to or greater than the number of stockpiles of individual materials to be used.

The bin shall be of sufficient size to store the amount of aggregate required to keep the plant in continuous operation and of proper design to prevent overflow of material of one bin to that of another bin. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each aggregate shall be proportioned in a separate compartment.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that aggregate will not be injured in the necessary drying and heating operations required to obtain a mixture of the specified temperature. The burner, or combination of burners, and type of fuel used shall be such that in the process of heating the aggregate to the desired or specified temperature, no residue from the fuel shall adhere to the heated aggregate. A continuous recording thermometer shall be provided which will indicate the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation.

Screening. The hot bin shall be provided with screens capable of eliminating oversize material. Separation of hot bin into compartments will not be required providing uniform grading and asphalt content are consistently produced in the completed mix.

Aggregate Weigh Box and Batching Scales. The aggregate weigh box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weigh box and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

Asphaltic Material Bucket and Scales. The asphaltic material bucket and scales shall be of sufficient capacity to hold and weigh the necessary asphaltic material for one batch. If the material is measured by weight, the bucket and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment". If a pressure type flow meter is used to measure the asphaltic material, the requirements of the Item, "Weighing and Measuring Equipment" shall apply.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 3000 pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the asphaltic material quickly and

uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the asphaltic material shall not be used. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type.

Cold Aggregate Bin and Proportioning Device. Same as for weight-batching type of plant.

Dryer. Same as for weight-batching type of plant.

Screening. Same as for weight-batching type of plant.

Hot Aggregate Proportioning Device. The hot aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Asphaltic Material Spray Bar. The asphaltic material spray bar shall be so designed that the asphalt will spray uniformly and continuously into the mixer.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than 40 tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used.

Truck Scales. A set of standard platform truck scales, conforming to the Item, "Weighing and Measuring Equipment" shall be placed at a location approved by the Engineer.

(2) Asphaltic Material Heating Equipment. Asphaltic material heating equipment shall be adequate to heat the amount of asphaltic material required to the desired temperature. Asphaltic material may be heated by steam coils which shall be absolutely tight. Direct fire heating of asphaltic materials will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the asphalt throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the asphaltic material at the highest temperature.

(3) Spreading and Finishing Machine. The spreading and finishing machine shall be of a type approved by the Engineer and shall be capable of producing a surface that will meet the requirements of the typical cross section and when the mixture is dumped directly into the finishing machine shall have adequate power to propel the delivery vehicles in a satisfactory manner. The finishing machine shall be equipped with a flexible spring and/or

hydraulic type hitch sufficient in design and capacity to maintain contact between the rear wheels of the hauling equipment and the pusher rollers of the finishing machine while the mixture is being unloaded. When indicated by the plans and/or the specifications, the spreading and finishing machine shall be equipped with an automatic screed control device of the type specified.

The use of any vehicle which requires dumping directly into the finishing machine and which the finishing machine cannot push or propel in such a manner as to obtain the desired lines and grades without resorting to hand finishing will not be allowed. Unless otherwise permitted by the plans, vehicles of the semi-trailer type will be specifically prohibited from dumping directly into the finishing machine while in contact with the finishing machine. Vehicles dumping directly or indirectly into the finishing machine shall be so designed and equipped that unloading into the finishing machine can be mechanically and/or automatically operated in such a manner that overloading the finishing machine being used cannot occur and the required lines and grades will be obtained without resorting to hand finishing.

Dumping of the asphaltic mixture in a windrow and then placing the mixture in the finishing machine will be permitted provided that the loading equipment is constructed and operated in such manner that substantially all of the mixture deposited on the roadbed is picked up and loaded in the finishing machine without contamination by foreign material of the mixture. The loading equipment will be so designed and operated that the finishing machine being loaded will obtain the required line, grade and surface without resorting to hand finishing. Any operation of the loading equipment resulting in the accumulation and subsequent shedding of this accumulated material into the asphaltic mixture will not be permitted.

(4) Motor Grader. The motor grader, if used, shall be a self-propelled power motor grader; it shall be equipped with smooth tread pneumatic tired wheels; shall have a blade length of not less than 12 feet; shall have a wheel base of not less than 16 feet; and shall be tight and in good operating condition and approved by the Engineer.

(5) Pneumatic Tire Rollers. The rollers shall be acceptable medium pneumatic tire rollers conforming to the requirements of the Item "Rolling (Pneumatic Tire)", Type B, unless otherwise specified on the plans.

The tire pressure of each tire shall be adjusted as directed by the Engineer and this pressure shall not vary by more than 5 pounds per square inch.

(6) Two Axle Tandem Roller. This roller shall be an acceptable power driven tandem roller weighing not less than 8 tons.

(7) Three Wheel Roller. This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(8) Three Axle Tandem Roller. This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(9) Trench Roller. This roller shall be an acceptable power driven trench roller equipped with sprinkler for keeping the wheels wet and adjustable road wheel so that the roller may be kept level during rolling. The drive wheel shall be not less than 20 inches wide.

(10) All Equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

(11) Alternate Equipment. When permitted by the Engineer in writing, equipment other than that specified which will consistently produce satisfactory results may be used.

292.5. Stockpiling, Storage, Proportioning and Mixing.

(1) Stockpiling of Aggregates. Prior to mixing operations with asphaltic material, processed mineral aggregate shall be stockpiled on an area previously cleared of trash, weeds and grass and smoothed as directed by the Engineer. Unless otherwise shown on plans, the stockpile shall be not less than ten (10) feet in height and constructed in layers not exceeding eighteen (18) inches in depth. Material shall be stockpiled in such a manner as to prevent segregation of aggregate and mixing of aggregates from different stockpiles and/or sources. More than one stockpile will be permitted unless otherwise shown on plans.

(2) Storage and Heating of Asphaltic Materials. The asphaltic material storage shall be ample to meet the requirements of the plans. Asphalt shall not be heated to a temperature in excess of 400 F. All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such manner that there will be no contamination with foreign matter.

(3) Feeding and Drying of Aggregate. The feedings of various sizes of aggregate to the dryers shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature. In no case shall the aggregate be introduced into the mixing unit at a temperature more than 350 F.

(4) Proportioning. The proportioning of the various materials entering into the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weight-batching type of plant is used and by volume using the hot aggregate proportioning device when the continuous mixing type of plant is used. The asphaltic material shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) **Mixing.**

(a) **Batch Type Mixer.**

1. Where only one hot bin compartment is used, such methods or devices shall be used in the charging of the weigh box and in the charging of the mixer from the weigh box as are necessary to secure a uniform asphaltic mixture. All mineral aggregate and asphaltic material may be introduced into the mixer together and mixed for a total period of not less than 30 seconds. This mixing may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

2. Where more than one hot bin compartment is used, such methods or devices shall be used in the charging of the weigh box and in the charging of the mixer from the weigh box as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of 5 to 20 seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than 30 seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

(b) Continuous Type Mixer. The amount of aggregate and asphaltic material entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and asphalt content will be produced.

(c) The asphaltic mixture shall be at a temperature between 225 F and 350 F when dumped from the mixer. The Engineer will determine the temperature, within the above limitations, and the mixture when dumped from the mixer shall not vary from this selected temperature more than 25 F.

(d) A Surge-Storage System may be used during the normal day's operation. Overnight storage will not be permitted unless authorized in the plans or in writing by the Engineer. The mix coming out of the surge-storage bin must be of equal quality to that coming out of the mixer.

292.6. Construction Methods. When specified on the plans, the mixture shall be placed with a spreading and finishing machine and shall not be placed when the air temperature is below 50 F and falling, but it may be placed when the air temperature is above 40 F and rising. The mixture when placed with a motor grader shall not be placed when the air temperature is below 60 F and is falling, but may be placed when the air temperature is above 50 F and is rising. The air temperature shall be taken in the shade away from artificial heat. It is further provided that the prime coat, tack coat or asphalt stabilized base shall be placed only when the humidity, general weather conditions and temperature and moisture condition of the subbase or subgrade, in the opinion of the Engineer, are suitable.

If the temperature of a load of the asphaltic mixture or any part of a load becomes 50 F or more, less than the mixing temperature selected by the Engineer as provided in this specification after being dumped from the mixer and prior to placing, all or any part of the load may be rejected and payment will not be made for the rejected material.

(1) **Prime Coat.** If a prime coat is required, it shall be applied and paid for as a separate item conforming to the requirements of the Item, "Prime Coat" except the air temperature for application shall be as provided above for asphaltic mixture to be laid by a spreading and finishing machine. The tack coat or asphalt stabilized base shall not be applied on a previously primed course until the prime coat has completely cured to the satisfaction of the Engineer.

(2) **Tack Coat.** Before the asphaltic mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat under asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat. The tack coat shall be rolled with a pneumatic tire roller as directed by the Engineer.

(3) **Transporting.** The asphaltic mixture, prepared as specified above, shall be hauled to the work in tight vehicles previously cleaned of all foreign material. The dispatching of the vehicles shall be arranged so that all material delivered may be placed, and all rolling shall be completed during daylight hours. In cool weather or for long hauls, canvas covers and insulating of the truck bodies will be required. The inside of the truck body may be given a light coat of oil, lime slurry or other material satisfactory to the engineer, if necessary, to prevent mixture from adhering to the body.

(4) **Placing.**

(a) **Generally,** the asphaltic mixture shall be dumped and spread on the approved prepared surface with the specified spreading and finishing machine, in such a manner that when properly compacted, the finished course will be smooth, of uniform density, and will conform with the typical sections shown on the plans and to the lines and grades established by the Engineer. During the application of asphaltic material, care shall be taken to prevent splattering of adjacent pavement, curb and gutter and structures.

(b) **The mixture** shall be spread and compacted in layers or lifts as specified on the plans or as directed by the Engineer. The sequence of compacting shall be such that undue displacement of the edge of the course does not occur. On deep lifts, the edge of the course may be rolled with a motor grader wheel or similar equipment or supported by blading a roll of earth against the edge of the course prior to compacting the surface.

(c) When the asphaltic mixture is placed in a narrow strip along the edge of an existing pavement, or used to level up small areas of an existing pavement or placed in small irregular areas where the use of a finishing machine is not practical, the finishing machine may be eliminated when authorized by the Engineer, provided a satisfactory surface can be obtained by other approved methods.

(5) Compacting.

(a) As directed by the Engineer, the asphalt stabilized base shall be compressed thoroughly and uniformly with the specified rollers. In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued. When directed by the Engineer, the initial compaction shall be accomplished with the pneumatic tire roller.

(b) Rolling with the three wheel and tandem rollers shall be done longitudinally, overlapping on successive trips by at least half the width of the rear wheel unless otherwise directed by the Engineer. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side unless otherwise directed by the Engineer. Rolling with the pneumatic-tired roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller, one pneumatic-tired roller and at least one three wheel roller, as specified above shall be provided for each job. If the Contractor elects, he may substitute the three-axle tandem roller for the two-axle tandem roller and/or the three wheel rollers; but three rollers shall be in use on each job unless otherwise permitted by the Engineer in writing. Additional rollers shall be provided if needed. The motion of the rollers shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and fresh mixture where required. The roller shall not be allowed to stand on any portion of the mixture which has not been fully compacted. To prevent adhesion of the mixture to the roller unless otherwise directed by the Engineer, the roller wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease or other foreign matter on the roadway, either when the rollers are in operation or when standing.

(c) Hand Tamping. In locations not accessible to the roller or in locations where thorough compaction cannot be obtained with the roller, compaction shall be accomplished by the use of lightly oiled tamps.

(d) Rolling with the trench type roller will be required on widening areas in trenches and other limited areas where satisfactory compaction cannot be obtained with the three wheel and tandem rollers.

(6) Surface Finish. The compacted material shall conform to the typical cross sections, lines and grades as shown on plans and directed by the Engineer and shall have a smooth surface with a reasonably uniform texture acceptable to the Engineer. Unacceptable finished surfaces may be corrected by the placement of additional mixture, all at the expense of the Contractor.

(7) Protection of the Work and Opening to Traffic. The completed asphalt stabilized base course shall be opened to traffic as provided by the plans and as directed by the Engineer. All construction traffic allowed on the base course shall comply with the State laws governing traffic on highways unless otherwise authorized by the Engineer. When another roadway surface is provided for the traveling public and construction traffic through the project, the Engineer may prohibit traffic on the completed base course.

292.7. In Place Density. When in place density is required, it is the intent of this specification that the material be placed and compacted to the percent of the maximum molded gyrated density as determined by Test Method Tex-126-E or as specified on the plans. The maximum molded gyrated density shall be determined from material sampled from the mixing plant and molded in accordance with Test Method Tex-126-E. Procedures and methods outlined in Test Method Tex-126-E shall also be used in determining the in place density unless determined otherwise by the Engineer. The field specimens utilized for the in place density testing may be either cores or sections of asphalt stabilized base. Other methods of determining in place density which correlate satisfactorily with those results obtained through use of Test Method Tex-126-E may be used. In place density tests are intended for control tests. If the in place density of the mixture produced has a value lower than that specified and in the opinion of the Engineer is not due to a change in the quality of the material, production may proceed with subsequent changes in the mix and/or construction operations until the in place density equals or exceeds the specified density. Requirements specifying air temperature limitations for placing and types of rollers to be furnished are not applicable when in place density is specified.

292.8. Measurement. Asphalt stabilized base will be measured separately by the ton of 2000 pounds of "Asphalt" and "Aggregate" of the type and grade actually used in the completed and accepted work in accordance with the plans and specifications for the project. Measurement, if mixing is done by a continuous mixer, will be made on truck scales. Measurement, if batched by weight, may be made on the batch scales and records of the number of batches, batch designs and weight of "Asphalt" and "Aggregate" shall be kept. Where surge-storage is used measurement of material taken from the surge-storage bin will be made on truck scales.

292.9. Payment.

(1) The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt" and "Aggregate", of the types and/or grade specified, which prices shall each be full compensation for quarrying, furnishing all materials, including royalty payments on mineral aggregate

where applicable, tack coat, all stripping unless specifically stated otherwise on the plans, and freight involved; for all heating, mixing, hauling, shaping and fine grading the subgrade or cleaning the existing base course or pavement, placing asphalt stabilized base, rolling and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except prime coat when required.

(2) **The prime coat**, performed where required, will be measured and paid for in accordance with the provisions governing the Item "Prime Coat".

(3) **All scales** and other weighing and measuring devices necessary for the proper construction, measuring and checking of the work shall be furnished, operated and maintained by the Contractor at his expense.

PART II. CONSTRUCTION DETAILS

DIVISION III
SURFACE COURSES OR PAVEMENT

ITEM 300

ASPHALTS, OILS AND EMULSIONS

300.1. Description. This item establishes the requirements for oil asphalts, cut-back asphalts, road oils, emulsified asphalts, asphalt cement and other miscellaneous asphaltic materials and asbestos and latex additives.

300.2. Materials. When tested according to Texas Highway Department Test Methods, the various materials shall meet the applicable requirements of this specification.

(1) Oil Asphalt. The material shall be homogeneous, shall be free from water, shall not foam when heated to 347 F and shall meet the following requirements:

TYPE-GRADE	OA-30		OA-175**		OA-400	
	Min.	Max.	Min.	Max.	Min.	Max.
Penetration at 32 F, 200g., 60 sec	15	–	–	–	–	–
Penetration at 77 F, 100g., 5 sec	25	35	150	200	–	–
Penetration at 115 F, 50g., 5 sec	–	65	–	–	–	–
Ductility at 77 F, 5 cm/min., cms: Original OA	2	–	70	–	–	–
Flash Point C.O.C., F	450	–	425	–	425	–
Softening Point, R. & B., F	185	–	95	130	–	–
Thin Film Oven Test, 1/8 in. Film, 50 g., 5 hrs., 325 F, % Loss by wt	–	0.4	–	1.4	–	2.0
Penetration of Residue, at 77 F, 100g., 5 sec. % of Original Pen	–	–	40	–	–	–
Ductility of Residue at 77 F, 5 cm/min., cms	–	–	100	–	–	–
Solubility in Trichloroethylene, %	99.0	–	99.0	–	99.0	–
Spot Test on Original OA	Neg.		Neg.		Neg.	
Float Test at 122 F, sec	–	–	–	–	120	150
Tests on 85 to 115 Pen. Residue*						
Residue by Wt., %	–	–	–	–	75	–
Ductility, 77 F, 5 cm/min.:						
Original Res., cms	–	–	–	–	100	–
Subjected to Thin Film Test, cms	–	–	–	–	100	–

*Determined by Vacuum Distillation (by evaporation if unable to reduce by vacuum).

**For use with Latex Additive only.

(2) Asphalt Cement. The material shall be homogeneous, shall be free from water, shall not foam when heated to 347 F and shall meet the following requirements:

Test	VISCOSITY GRADE									
	AC-3		AC-5		AC-10		AC-20		AC-40	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity, 140 F stokes	300±50		500±100		1000±200		2000±400		4000±800	
Viscosity, 275 F stokes	1.1	–	1.4	–	1.9	–	2.5	–	3.5	–
Penetration, 77 F, 100g, 5 sec.	210	–	135	–	85	–	55	–	35	–
Flash Point, C.O.C. F	425	–	425	–	450	–	450	–	450	–
Solubility in trichloroethylene, percent	99.0	–	99.0	–	99.0	–	99.0	–	99.0	–
Tests on residues from thin film oven test: Viscosity, 140 F stokes	–	900	–	1500	–	3000	–	6000	–	12000
Ductility, 77 F 5 cms per min, cms.	100	–	100	–	70	–	50	–	30	–
Spot test	Negative for all grades									

(3) Latex Additive. A minimum of two percent, by weight, latex additive (solids basis) shall be added to the OA-175 Asphalt or to AC-5 Asphalt when specified on the plans or in other specifications in the contract. The latex additive shall be governed by the following specifications:

The latex is to be an anionic emulsion of butadiene-styrene low-temperature copolymer in water, stabilized with fatty-acid soap so as to have good storage stability, and possessing the following properties:

Monomer ratio, B/S	70/30
Minimum solids content	67%
Solids content per gal. @67%	5.3 lbs.
Coagulum on 80-mesh screen	0.1% max.
Type Anti-oxidant	staining
Mooney Viscosity of Polymer (M/L 4 @ 212 F)	100 min.
pH of Latex	9.4 - 10.5
Surface tension	28-42 dynes/cm^2
Brookfield Viscosity of Latex	1200 ps max. @ 67% solids

The finished latex-asphalt blend shall meet the following requirements:

Viscosity at 140 F, stokes	1500 max.
Ductility at 39.2 F. 1 cm. per min., cm . .	100 min.

(4) Cut-back Asphalt. The material shall meet the requirements shown in the following table:

TYPE-GRADE	RC-1		RC-2		RC-250		RC-3		RC-4		RC-5	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Water, %	–	0.2	–	0.2	–	0.2	–	0.2	–	0.2	–	0.2
Flash Point, T.O.C., F	80	–	80	–	80	–	80	–	80	–	80	–
Furol Viscosity, sec..												
At 122 F	100	160	200	300	–	–	–	–	–	–	–	–
At 140 F . . .	–	–	–	–	125	250	250	400	–	–	–	–
At 180 F	–	–	–	–	–	–	–	–	125	250	350	500
The Distillate, expressed as precent by volume of total distillate to 680 F, shall be as follows:												
Off at 437 F	55	80	50	75	35	–	50	70	35	60	20	55
Off at 500 F	70	90	70	90	60	–	65	85	60	80	55	75
Off at 600 F	90	–	90	–	80	–	85	–	80	–	75	–
Residue from 680 F Distillation, Volume, %	50	–	70	–	65	–	73	–	78	–	82	–
Tests on Distillation Residue:												
Penetration at 77 F, 100G., 5 sec	70	100	110	150	80	120	110	150	110	150	110	150
Ductility at 77 F, 5 cm/min., cms	100	–	100	–	100	–	100	–	100	–	100	–
Solubility in Trichloroethylene, %	99.0	–	99.0	–	99.0	–	99.0	–	99.0	–	99.0	–
Spot Test	Neg.		Neg.		Neg.		Neg.		Neg.		Neg.	

TYPE-GRADE	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Water, %	–	0.2	–	0.2	–	0.2	–	0.2	–	0.2
Flash Point, T.O.C., F	100	–	100	–	150	–	150	–	150	–
Kinematic Viscosity At 140 F, C St . . .	30	60	70	140	250	500	800	1600	3000	6000
The Distillate, expressed as percent by volume of total distillate to 680 F, shall be as follows:										
Off at 437 F	–	25	–	20	–	10	–	–	–	–
Off at 500 F	40	70	20	60	15	55	–	35	–	15
Off at 600 F	75	93	65	90	60	87	45	80	15	75
Residue from 680 F Distillation, Volume, %	50	–	55	–	67	–	75	–	80	–
Tests on Distillation Residue:										
Penetration at 77 F, 100g, 5 sec	120	250	120	250	120	250	120	250	120	250
Ductility at 77 F, 5 cm/min., cms . . .	100*	–	100*	–	100*	–	100*	–	100*	–
Solubility in Trichloroethylene, % . . .	99.0	–	99.0	–	99.0	–	99.0	–	99.0	–
Spot Test	Neg.		Neg.		Neg.		Neg.		Neg.	

*If penetration of residue is more than 200 and ductility at 77 F is less than 100 cm., the material will be acceptable if its ductility at 60 F is more than 100.

(5) Road Oils. The material shall meet the following requirements:

TYPE-GRADE	RO-3		RO-4		RO-95		RO-Special	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Water, %	–	0.2	–	0.2	–	0.2	–	–
Asphalt content of 85 to 115 penetration by vacuum distillation	60	–	55	–	80	–	55	–
Flash Point, C.O.C., F	225	–	175	–	250	–	225	–
Furol Viscosity: At 122 F, sec	–	–	100	160	–	–	–	500
At 140 F, sec	200	320	–	–	–	–	–	–
Loss at 212 F, 20g., 5 hrs., %	–	6.0	–	6.0	–	–	–	6.0
Loss at 325 F, 50g., 7 hrs., %	–	–	–	–	2.0	6.0	–	–
Water and Sediment, %	–	–	–	–	–	–	–	2.0
Penetration of residue after evaporation loss, 100 g., 5 sec	–	–	–	–	175	250	–	–
Ductility of residue at 77 F, 5 cm/min., cms	100	–	100	–	–	–	–	–
Solubility in Trichloroethylene, %	99.0	–	99.0	–	99.0	–	–	–
Float Test at 122 F, sec	–	–	–	–	140	175	–	–
Spot Test	Neg.		Neg.		Neg.		–	
Tests on 85 to 115 penetration residue by vacuum distillation								
Residue by weight, %	–	–	–	–	80	–	–	–
Ductility, 77 F, 5 cms/min., Original Residue, cms	–	–	–	–	100	–	–	–
Subjected to Thin Film Test, cms	–	–	–	–	100	–	–	–

(6) **Cracked Fuel Oils and Crude Oils.** These materials shall meet the following requirements:

	CRACKED FUEL OIL		CRUDE OIL	
	Min.	Max.	Min.	Max.
Asphalt Content of 100 Penetration at 77 F, %	65	80	–	–
Asphalt Content of 260 Penetration at 77 F, %	–	–	65	80
Flash Point T.O.C., F	–	–	80	–
Flash Point C.O.C., F	250	–	–	–
Furol Viscosity at 77 F, Sec	–	–	–	500
Furol Viscosity at 122 F, Sec	–	500	–	–
Loss at 212 F, 20g., 5 hrs., %	–	3.0	–	–
Loss at 325 F, 50g., 7 hrs., %	–	–	–	3.0
Water and Sediment, %	–	2.0	–	2.0
Penetration of Residue after Evaporation Loss	–	–	–	300

(7) **Emulsions.** The material shall be homogeneous. It shall show no separation of asphalt after thorough mixing and shall meet the viscosity requirements at any time within 30 days after delivery.

ANIONIC EMULSIONS:

TYPE	Rapid Setting				Medium Setting				Slow Setting			
GRADE:	EA-HVRS		EA-HVRS-90		EA-HVMS		EA-HVMS-90		EA-11M		EA-10S	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Furol Viscosity at 77 F, sec.	–	–	–	–	–	–	–	–	30	100	30	100
Furol Viscosity at 122 F, sec.	100	300	100	300	100	300	100	300	–	–	–	–
Residue by Distillation, %	63	–	63	–	63	–	63	–	60	–	60	–
Oil Portion of Distillate, %	–	2.0	–	2.0	–	2.0	–	2.0	–	2.0	–	2.0
Sieve Test, %	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Miscibility (Standard Test)	–	–	–	–	–	–	–	–	Passing		Passing	
Coating	–	–	–	–	–	–	–	–	Passing		–	–
Cement Mixing, %	–	–	–	–	–	–	–	–	–	–	–	2.0
Demulsibility 50 cc of N/10 $CaCl_2$, %	–	–	–	–	–	–	–	–	–	70	–	–
Demulsibility 35 cc of N/50 $CaCl_2$, %	60	–	60	–	–	30	–	30	–	–	–	–
Settlement, 5 days, %	–	5.0	–	5.0	–	5.0	–	5.0	–	5.0	–	5.0
Freezing Test 3 Cycles (*)	–	–	–	–	Passing*		Passing*		Passing*		Passing*	
Tests on Residue:												
Penetration at 77 F, 100g., 5 sec.	120	160	80	110	120	160	80	110	120	160	120	160
Solubility in Trichloroethylene, %	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–
Ductility at 77 F, 5 cm/min., cms.	100	–	100	–	100	–	100	–	100	–	100	–

*Applies only when Engineer designates material for winter use.

CATIONIC EMULSIONS:

TYPE	Rapid Setting				Medium Setting				Slow Setting			
GRADE	EA-CRS-2		EA-CRS-2h		EA-CMS-2		EA-CMS-2h		EA-CSS-1		EA-CSS-1h	
Tests on Emulsions:	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity, Saybolt Furol at 77 F, sec.	–	–	–	–	–	–	–	–	20	100	20	100
Viscosity, Saybolt Furol at 122 F, sec.	100	300	100	300	100	300	100	300	–	–	–	–
Settlement, [a] 5 days, %	–	5	–	5	–	5	–	5	–	5	–	5
Storage stability test, [b] 1 day, %	–	1	–	1	–	1	–	1	–	1	–	1
Demulsibility, [c] 35 ml 0.8 percent sodium dioctyl sulfosuccinate, %	40	–	40	–	–	–	–	–	–	–	–	–
Coating, ability and water resistance:												
Coating, dry aggregate	–	–	–	–	good		good		–	–	–	–
Coating, after spraying	–	–	–	–	fair		fair		–	–	–	–
Coating, wet aggregate	–	–	–	–	fair		fair		–	–	–	–
Coating, after spraying	–	–	–	–	fair		fair		–	–	–	–
Particle charge test	positive		positive		positive		positive		positive		positive	
Sieve Test, %	–	0.10	–	0.10	–	0.10	–	0.10	–	0.10	–	0.10
Cement mixing test, %	–	–	–	–	–	–	–	–	–	2.0	–	2.0
Distillation:												
Oil distillate, by volume of emulsion, %	–	3	–	3	–	12	–	12	–	–	–	–
Residue, percent	60	–	65	–	65	–	65	–	60	–	60	–
Tests on Residue from Distillation Test:												
Penetration, 77 F, 100g, 5 sec.	120	160	80	110	120	160	80	110	120	160	80	110
Ductility, 77 F, 5 cm/min., cm	100	–	100	–	100	–	100	–	100	–	100	–
Solubility in trichloroethylene, %	98	–	98	–	97.5	–	97.5	–	97.5	–	97.5	–
Ash, %	–	–	–	–	–	2.0	–	2.0	–	2.0	–	2.0

[a]The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the Engineer may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.

[b]The 24-h (1-day) storage stability test may be used instead of the 5-day settlement test.

[c]The demulsibility test shall be made within 30 days from date of shipment.

(8) Flux Oil. Fluxing material shall be free from foreign matter and shall meet the following requirements:

Type	Flux Oil Min.	Flux Oil Max.
Water, %	–	0.2
Furol Viscosity at 122 F, sec	50	100
Flash Point, C.O.C., F	250	–
Loss on Heating, 50g, 5 hrs. at 325 F, %	–	5
Asphalt Content of 85 to 115 Penetration by vacuum distillation, weight %	25	–

(9) Precoat Material. Precoat material may consist of any one of the various types of asphaltic materials listed in this specification, approved by the Engineer, including "Special Precoat Material".

Type	Special Precoat Material Min.	Special Precoat Material Max.
Water, %	–	0.2
Flash, C.O.C., F	200	–
Furol Viscosity at 140 F, sec	150	250
Distillation to 680 F:		
Initial Boiling Point, F	500	–
Residue by weight, %	70	–
Penetration residue, 77 F, 100g., 5 sec	200	300

(10) Catalytically-Blown Asphalt Joint and Crack Sealer. Catalytically-blown asphalt shall be uniformly blended with 10 percent diatomaceous earth filler which passes the No. 325 sieve. It shall form a suitable joint and crack sealer which may be melted to pouring consistency in the regular asphalt kettle at a temperature of approximately 450 to 475 F. The material shall

meet the following requirements:

TYPE-GRADE	68-88 Pen.		38-45 Pen.	
	Min.	Max.	Min.	Max.
Penetration, 77 F, 100g., 5 sec	68	88	38	45
Penetration, 32 F, 200g., 60 sec	38	–	–	–
Penetration, 115 F, 50g., 5 sec	–	160	–	–
Softening Point, R. & B., F	175	200	185	200
Flash, C.O.C., F	500	–	500	–
Ductility, 77 F, 5 cm/min., cms	5	–	3	–
Flow, 140 F, cm	–	0.5	–	0.5
Ash, Weight, %	8	–	8	–
Settlement Ratio	–	1.02	–	1.02
Brittleness Test, 32 F	No Cracking		No Cracking	

(11) Asbestos Additive. Asbestos fiber shall be used only when specified on the plans or in other specifications in the contract. Asbestos fiber shall be Chrysettle Asbestos. Asbestos fiber shall be 7M grade by Quebec Standard Screen Test.

GUARANTEED MINIMUM TEST

ROTAP (3-minute procedure)	35% minimum retained on No. 20 mesh sieve
WET WASH (QAMA Procedure)	20% minimum retained on No. 200 mesh sieve
PENETRATION-EFFICIENCY TEST	70-105%

The manufacturer will furnish a notarized certification that the asbestos meets the above requirements.

Storing and Handling. While stored at the site of the batch plant, the asbestos shall be given suitable protection from moisture. Any asbestos which is wet or damp shall be rejected for use.

300.3. Storage, Heating And Application Temperatures. Asphaltic materials should be applied at the temperature which provides proper and uniform distribution and within practical limits avoiding higher temperatures than necessary. Satisfactory application usually should be obtained within the

recommended ranges shown below. No material shall be heated above the following maximum temperatures:

TYPE-GRADE	Application and Mixing		Heating and Storage Maximum, F
	Recommended Range, F	Maximum Allowable, F	
AC-3, 5, 10, 20, 40, OA-175	275-325	350	400
OA-30	400-500	500	500
OA-400	220-300	350	350
RC-1	100-150	175	175
RC-2	125-180	200	200
RC-250	150-200	210	210
RC-3	160-210	230	230
RC-4	180-240	270	270
RC-5	215-270	285	285
MC-30	70-150	175	175
MC-70	125-175	200	200
MC-250	125-210	240	240
MC-800	175-260	275	275
MC-3000	225-275	290	290
RO-3	160-210	250	250
RO-4	100-150	200	200
RO-95	230-300	325	325
RO-Special	160-220	260	260
Cracked Fuel Oil	160-220	260	260
Crude Oil	100-150	175	175
EA-10S, EA-11M, EA-CSS-1, EA-CSS-1h	50-130	140	140
EA-HVRS, EA-HVMS, EA-HVRS-90, EA-HVMS-90, EA-CRS-2, EA-CRS-2h, EA-CMS-2, EA-CMS-2h	110-150	160	160
Cat. Blown Asph	425-475	500	500
Special Precoat Material	125-250	275	275

Note: Heating of asphaltic materials (except emulsions) constitutes a fire hazard to various degrees. Proper precautions should be used in all cases and especially with RC cut-backs.

Warning to Contractors: Attention is called to the fact that asphaltic materials are very flammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic material or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

300.4. Measurement And Payment. All asphaltic materials included in this specification will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

ITEM 301

AGGREGATE FOR SURFACE TREATMENTS (Class A)

301.1. Description. This item establishes the requirements for aggregate to be used in the construction of surface treatments.

301.2. Materials. Aggregates shall be composed of clean, tough and durable particles of gravel, crushed gravel, crushed stone, crushed slag or natural limestone rock asphalt. These materials shall not contain more than 5 percent by weight of soft particles and other deleterious materials as determined by Test Method Tex-217-F, Part I.

The natural limestone rock asphalt aggregate furnished shall have an average bitumen content from 4 to 8 percent by weight of naturally impregnated asphalt, as determined by Test Method Tex-215-F, and shall contain not more than 2 percent by weight of any one of or combination of iron pyrites, or other objectionable matter, as determined by Test Method Tex-217-F, Part I.

No aggregate shall contain a total of more than 5 percent by weight of impurities or objectionable matter listed above.

The percent of wear, as determined by Test Method Tex-410-A, for each of the materials shall not exceed 35 percent.

The percent of wear on natural limestone rock asphalt aggregate as determined by Test Method Tex-410-A shall be made on that portion of the material retained on the No. 4 sieve, having a naturally impregnated asphalt content of less than 1 percent.

Crushed gravel shall have a minimum of 85 percent of the particles retained on the No. 4 sieve with at least one crushed face, as determined by Test Method Tex-413-A.

301.3. Types. The various types of aggregates are identified as follows:

Type A. Type A aggregate shall consist of gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type B. Type B aggregate shall consist of crushed gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type C. Type C aggregate shall consist of gravel, crushed slag or crushed stone.

Type D. Type D aggregate shall consist of crushed gravel, crushed slag or crushed stone.

Type E. Type E aggregate shall consist of natural limestone rock asphalt.

301.4. Grades. When tested by Test Method Tex-200-F, Part I, the gradation requirements for the several grades of aggregate shall be as follows:

		Percent by Weight
Grade 1:	Retained on 7/8" sieve	0
	Retained on 3/4" sieve	0-5
	Retained on 5/8" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 2:	Retained on 3/4" sieve	0
	Retained on 5/8" sieve	0-5
	Retained on 1/2" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 3:	Retained on 5/8" sieve	0
	Retained on 1/2" sieve	0-5
	Retained on 3/8" sieve	85-100
	Retained on 1/4" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 4:	Retained on 1/2" sieve	0
	Retained on 3/8" sieve	0-5
	Retained on 1/4" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 5:	Retained on 3/8" sieve	0
	Retained on 1/4" sieve	0-5
	Retained on No. 4 sieve	50-100
	Retained on No. 10 sieve	99-100

The aggregate shall not contain more than 1.0 percent by weight of fine dust, clay-like particles and/or silt present when tested in accordance with Test Method Tex-217-F, Part II.

301.5. Measurement And Payment. Aggregates will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

ITEM 302

AGGREGATE FOR SURFACE TREATMENTS (Class B)

302.1. Description. This item establishes the requirements for aggregate to be used in the construction of surface treatments.

302.2. Materials. Aggregates shall be composed of clean, tough and durable particles of gravel, crushed gravel, crushed stone, crushed slag or natural limestone rock asphalt. These materials shall not contain more than 5 percent by weight of soft particles and other deleterious material as determined by Test Method Tex-217-F, Part I.

The natural limestone rock asphalt aggregate furnished shall have an average bitumen content from 4 to 8 percent by weight of naturally impregnated asphalt, as determined by Test Method Tex-215-F, and shall contain not more than 2 percent by weight of any one of or combination of iron pyrites, or other objectionable matter, as determined by Test Method Tex-217-F, Part I.

No aggregate shall contain a total of more than 5 percent by weight of impurities or objectionable matter listed above.

The percent of wear, as determined by test Method Tex-410-A, for each of the materials shall not exceed 35 percent.

The percent of wear on natural limestone rock asphalt aggregate as determined by Test Method Tex-410-A shall be made on that portion of the material retained on the No. 4 sieve, having a naturally impregnated asphalt content of less than 1 percent.

Crushed gravel shall have a minimum of 85 percent of the particles retained on the No. 4 sieve with at least one crushed face, as determined by Test Method Tex-413-A.

302.3. Types. The various types of aggregates are identified as follows:

Type A. Type A aggregate shall consist of gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type B. Type B aggregate shall consist of crushed gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type C. Type C aggregate shall consist of gravel, crushed slag or crushed stone.

Type D. Type D aggregate shall consist of crushed gravel, crushed slag or crushed stone.

Type E. Type E aggregate shall consist of natural limestone rock asphalt.

302.4. Grades. When tested by Test Method Tex-200-F, Part I, the gradation requirements for the several grades of aggregate shall be as follows:

		Percent by Weight
Grade 1:	Retained on 1" sieve	0
	Retained on 7/8" sieve	0-2
	Retained on 3/4" sieve	20-35
	Retained on 5/8" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100

		Percent by Weight
Grade 2:	Retained on 7/8" sieve	0
	Retained on 3/4" sieve	0-2
	Retained on 5/8" sieve	20-35
	Retained on 1/2" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 3:	Retained on 3/4" sieve	0
	Retained on 5/8" sieve	0-2
	Retained on 1/2" sieve	20-35
	Retained on 3/8" sieve	85-100
	Retained on 1/4" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 4:	Retained on 5/8" sieve	0
	Retained on 1/2" sieve	0-2
	Retained on 3/8" sieve	20-35
	Retained on No. 4 sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 5:	Retained on 3/8" sieve	0
	Retained on 1/4" sieve	0-5
	Retained on No. 10 sieve	99-100

The aggregate shall not contain more than 1.0 percent by weight of fine dust, clay-like particles and/or silt present when tested in accordance with Test Method Tex-217-F, Part II.

302.5. Measurement And Payment. Aggregates will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

ITEM 303

AGGREGATE FOR SURFACE TREATMENTS (Lightweight)

303.1. Description. This item establishes the requirements for lightweight aggregates to be used in the construction of surface treatments.

303.2. Materials. Aggregates shall be composed predominantly of lightweight cellular and granular inorganic material produced by fuzing raw shale or clay in a rotary kiln under intense heat into predominantly amorphous silicate. All aggregate for use on this project shall be produced from the same plant and source.

The dry loose unit weight of coarse lightweight aggregates shall not be less than 35 and shall not exceed 55 pounds per cubic foot unless otherwise specified on the plans. If the unit weight of any shipment of lightweight aggregate differs by more than 4 percent from that of the sample submitted

for acceptance tests, the aggregates in the shipment may be rejected. Tests shall be in accordance with Test Method Tex-404-A, Part C. The percent of wear, as determined by Test Method Tex-410-A shall not exceed 35 percent.

The Aggregate Freeze Thaw Loss shall not exceed 7 percent when tested in accordance with Texas Test Method Tex-432-A (Tentative).

The Pressure Slaking Value shall not exceed 4 percent when tested in accordance with Test Method Tex-431-A, (Tentative).

303.3. Grades. When tested by Test Method Tex-200-F, Part I, the gradation requirements for the several grades of aggregate shall be as follows:

		Percent by Weight
Grade 3:	Retained on 3/4" sieve	0
	Retained on 5/8" sieve	0-5
	Retained on 1/2" sieve	30-50
	Retained on 3/8" sieve	85-100
	Retained on 1/4" sieve	95-100
	Retained on No. 10 sieve	98-100
Grade 4:	Retained on 5/8" sieve	0
	Retained on 1/2" sieve	0-5
	Retained on 3/8" sieve	20-40
	Retained on No. 4 sieve	95-100
	Retained on No. 10 sieve	98-100
Grade 5:	Retained on 1/2" sieve	0
	Retained on 3/8" sieve	0-2
	Retained on No. 4 sieve	60-80
	Retained on No. 10 sieve	98-100

The aggregate shall not contain more than 1.0 percent by weight of fine dust, clay-like particles and/or silt present when tested in accordance with Test Method Tex-217-F, Part II.

303.4. Measurement And Payment. Aggregates will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

ITEM 304

AGGREGATE FOR SURFACE TREATMENTS
(Precoated)
(Class B)

304.1. Description. This item establishes the requirements for precoated aggregate to be used in the construction of surface treatments.

304.2. Materials. Aggregates shall be composed of clean, tough and durable particles of gravel, crushed gravel, crushed stone, crushed slag or natural limestone rock asphalt. These materials shall not contain more than 5

percent by weight of soft particles and other deleterious material as determined by Test Method Tex-217-F, Part I.

The natural limestone rock asphalt aggregate furnished shall have an average bitumen content from 4 to 8 percent by weight of naturally impregnated asphalt, as determined by Test Method Tex-215-F, and shall contain not more than 2 percent by weight of any one of or combination of iron pyrites or other objectionable matter, as determined by Test Method Tex-217-F, Part I.

No aggregate shall contain a total of more than 5 percent by weight of impurities or objectionable matter listed above.

The percent of wear, as determined by Test Method Tex-410-A, for each of the materials shall not exceed 35 percent.

The percent of wear on natural limestone rock asphalt aggregate as determined by Test Method Tex-410-A shall be made on that portion of the material retained on the No. 4 sieve, having a naturally impregnated asphalt content of less than 1 percent.

Crushed gravel shall have a minimum of 85 percent of the particles retained on the No. 4 sieve with at least one crushed face, as determined by Test Method Tex-413-A.

The precoat material shall meet the requirements for "Precoat Materials" as specified in the Item, "Asphalts, Oils and Emulsions".

The flux oil shall meet the requirements for "Flux Oil" as specified in the Item, "Asphalts, Oils and Emulsions".

304.3. Types. The various types of precoated aggregates are identified as follows:

Type PA. Type PA shall be precoated aggregate consisting of gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type PB. Type PB shall be precoated aggregate consisting of crushed gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type PC. Type PC shall be precoated aggregate consisting of gravel, crushed slag or crushed stone.

Type PD. Type PD shall be precoated aggregate consisting of crushed gravel, crushed slag or crushed stone.

Type PE. Type PE shall be precoated aggregate consisting of natural limestone rock asphalt.

304.4. Grades. When tested by Test Method Tex-200-F, Part I, the gradation requirements for the several grades of aggregate shall be as follows:

		Percent by Weight
Grade 1:	Retained on 1" sieve	0
	Retained on 7/8" sieve	0-2
	Retained on 3/4" sieve	20-35
	Retained on 5/8" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 2:	Retained on 7/8" sieve	0
	Retained on 3/4" sieve	0-2
	Retained on 5/8" sieve	20-35
	Retained on 1/2" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 3:	Retained on 3/4" sieve	0
	Retained on 5/8" sieve	0-2
	Retained on 1/2" sieve	20-35
	Retained on 3/8" sieve	85-100
	Retained on 1/4" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 4:	Retained on 5/8" sieve	0
	Retained on 1/2" sieve	0-2
	Retained on 3/8" sieve	20-35
	Retained on No. 4 sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 5:	Retained on 3/8" sieve	0
	Retained on 1/4" sieve	0-5
	Retained on No. 10 sieve	99-100

The aggregate shall not contain more than 1.0 percent by weight of fine dust, clay-like particles and/or silt present when tested in accordance with Test Method Tex-217-F, Part II.

304.5. Precoated Aggregates. Precoated aggregates shall be aggregates of the type specified, treated (coated or fluxed) with 0.5 to 1.5 percent by weight of precoat material or flux oil meeting the requirements of this specification and the approval of the Engineer. The particular grade of precoated aggregate specified shall meet all requirements of Article 304.4. prior to the application of the precoat material or flux oil.

(1) Water. Water in an amount not to exceed 3 percent by weight of the mixture may be used in preparing the mixture. The water shall be added as directed by the Engineer during the mixing. In the event water is used in the mixing operation adequate measuring devices shall be used and the water shall be administered to the mix through an approved spray bar.

(2) Physical Properties of the Mixture. The materials may be mixed on the job or at some central mixing plant and shipped ready for use. Mixes that do not remain workable a sufficient period of time or maintain flow qualities such that the precoated aggregate may be satisfactorily spread by normal approved mechanical spreading devices will not be acceptable.

Materials that are not uniformly and/or properly coated or fluxed, as determined by the Department's standard testing procedures or in the opinion of the Engineer, will not be accepted for use.

304.6. Equipment.

(1) Mixing Plants. Mixing plants that will not continuously meet all the requirements of this specification shall be condemned.

Mixing plants may be either the weight-batching type or the continuous mixing type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, aggregate screens and bins and shall consist of the following essential pieces of equipment:

(a) Weight-batching Type.

Cold Aggregate Bin and Proportioning Device. The cold aggregate bins or aggregate stockpiles shall be of sufficient number and size to supply the amount of aggregate required to keep the plant in continuous operation. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the plant.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that aggregate will not be injured in the necessary drying and heating operations required to obtain a mixture of the specified temperature.

The burner, or combination of burners, and type of fuel used shall be such that in the process of heating the aggregate to the desired or specified temperatures, no residue from the fuel shall adhere to the heated aggregate. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation. The dryer will not be required for precoating natural limestone rock asphalt.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. Proper provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where accurate representative samples of aggregate may be taken from the bins for testing.

Weighing and Measuring Equipment. The weighing and measuring equipment shall be of sufficient capacity and of adequate design for proper batching. The following equipment, conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished:

1. Aggregate weigh box and batching scales.

2. Bucket and scales for precoat material or flux oil.

A pressure type flow meter may be used to measure the precoat material or flux oil for each batch.

Mixer. The mixer shall be of the pug mill type, and shall have a capacity of not less than 3000 pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the precoat material or flux oil quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the precoat material or flux oil shall not be used. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type.

Cold Aggregate Bin and Proportioning Device. Same as for weight-batching type of plant.

Dryer. Same as for weight-batching type of plant.

Screening and Proportioning. Same as for weight-batching type of plant. These requirements shall also apply to materials that are stockpiled and that are proposed for direct use by a continuous mixing plant without the use of plant bins.

Aggregate Proportioning Device. The aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Spray Bar for Precoat Material and Flux Oil. The spray bar for the precoat material or flux oil shall be so designed that the material will spray uniformly and continuously into the mixer.

Meter for Precoat Material or Flux Oil. An accurate recording meter for precoat material or flux oil shall be placed in the line leading to the spray bar so that the accumulative amount of precoat material or flux oil being used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of the meter output.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than 40 tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the precoat material or flux oil shall not be used.

Heating Equipment for Precoat Material and Flux Oil. Heating equipment for precoat material and flux oil shall be adequate to heat the amount of material required to the desired temperature. The material may be heated by steam coils which shall be absolutely tight. Direct fire heating will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the liquid throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the precoat material or flux oil where it is at the highest temperature.

304.7. **Storage, Proportions and Mixing.**

(1) **Aggregate Storage.** If the mineral aggregates are stored or stockpiled, they shall be handled in such a manner as to prevent segregation, the mixing of the various materials or sizes, and the contamination with foreign materials. The grading of aggregates proposed for use and as supplied to the mixing plant shall be uniform.

The use of limestone rock asphalt aggregate containing moisture in excess of the saturated surface-dry condition will not be permitted. Excess moisture will be evidenced by visual surface moisture on the aggregate or any unusual quantities of fines clinging to the aggregate.

(2) **Storage and Heating of Precoat or Flux Oil.** The precoating or fluxing material storage shall be ample to meet the requirements of the plant. The materials shall not be heated to a temperature in excess of 250 F. All equipment used in the storage and handling of precoat material or flux oil shall be kept in a clean condition at all times and shall be operated in such manner that there will be no contamination with foreign matter.

(3) **Feeding and Drying of Aggregate.** The feeding of various sizes of aggregate, other than natural limestone rock asphalt, to the dryer shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of material in the required proportions will be maintained. The aggregate shall be heated to the temperature necessary to produce a mixture meeting the requirements of Subarticle 304.5(2), "Physical Properties of the Mixture".

(4) **Proportioning.** The proportioning of the various materials entering into the mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weight-batch type of plant is used and by volume using the aggregate proportioning device when the continuous mixer type of plant is used. The precoat material or flux oil shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) Mixing.

(a) Batch Type Mixer. In the charging of the weigh box and in the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform mixture. In introducing the batch into the mixer, the mineral aggregate shall be introduced first; shall be mixed thoroughly, as directed, to uniformly distribute the various sizes throughout the batch before the precoat material or flux oil is added; the precoat material or flux oil shall then be added and the mixing continued until such time that the aggregate is properly coated. This mixing period may be varied, if, in the opinion of the Engineer, the mixture is not uniform.

(b) Continuous Type Mixer. The amount of aggregate and precoat material or flux oil entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and percent by weight of precoat material or flux oil will be produced.

304.8. Measurement And Payment. Aggregates will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

ITEM 305

AGGREGATE FOR SURFACE TREATMENTS
(Precoated)
(Class A)

305.1. Description. This item establishes the requirements for precoated aggregate to be used in the construction of surface treatments.

305.2. Materials. Aggregates shall be composed of clean, tough and durable particles of gravel, crushed gravel, crushed stone, crushed slag or natural limestone rock asphalt. These materials shall not contain more than 5 percent by weight of soft particles and other deleterious material as determined by Test Method Tex-217-F, Part I.

The natural limestone rock asphalt aggregate furnished shall have an average bitumen content from 4 to 8 percent by weight of naturally impregnated asphalt, as determined by Test Method Tex-215-F, and shall contain not more than 2 percent by weight of any one of or combination of iron pyrites or other objectionable matter, as determined by Test Method Tex-217-F, Part I.

No aggregate shall contain a total of more than 5 percent by weight of impurities or objectionable matter listed above.

The percent of wear, as determined by Test Method Tex-410-A, for each of the materials shall not exceed 35 percent.

The percent of wear on natural limestone rock asphalt aggregate as determined by Test Method Tex-410-A shall be made on that portion of the material retained on the No. 4 sieve, having a naturally impregnated asphalt content of less than 1 percent.

Crushed gravel shall have a minimum of 85 percent of the particles retained on the No. 4 sieve with at least one crushed face, as determined by Test Method Tex-413-A.

The precoat material shall meet the requirements for "Precoat Materials" as specified in the Item, "Asphalts, Oils and Emulsions".

The flux oil shall meet the requirements for "Flux Oil" as specified in the Item, "Asphalts, Oils and Emulsions".

305.3. Types. The various types of precoated aggregates are identified as follows:

Type PA. Type PA shall be precoated aggregate consisting of gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type PB. Type PB shall be precoated aggregate consisting of crushed gravel, crushed slag, crushed stone or natural limestone rock asphalt.

Type PC. Type PC shall be precoated aggregate consisting of gravel, crushed slag or crushed stone.

Type PD. Type PD shall be precoated aggregate consisting of crushed gravel, crushed slag or crushed stone.

Type PE. Type PE shall be precoated aggregate consisting of natural limestone rock asphalt.

305.4. Grades. When tested by Test Method Tex-200-F, Part I, the gradation requirements for the several grades of aggregate shall be as follows:

		Percent by Weight
Grade 1:	Retained on 7/8" sieve	0
	Retained on 3/4" sieve	0-5
	Retained on 5/8" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 2:	Retained on 3/4" sieve	0
	Retained on 5/8" sieve	0-5
	Retained on 1/2" sieve	85-100
	Retained on 3/8" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 3:	Retained on 5/8" sieve	0
	Retained on 1/2" sieve	0-5
	Retained on 3/8" sieve	85-100
	Retained on 1/4" sieve	95-100
	Retained on No. 10 sieve	99-100

		Percent by Weight
Grade 4:	Retained on 1/2" sieve	0
	Retained on 3/8" sieve	0-5
	Retained on 1/4" sieve	95-100
	Retained on No. 10 sieve	99-100
Grade 5:	Retained on 3/8" sieve	0
	Retained on 1/4" sieve	0-5
	Retained on No. 4 sieve	50-100
	Retained on No. 10 sieve	99-100

The aggregate shall not contain more than 1.0 percent by weight of fine dust, clay-like particles and/or silt present when tested in accordance with Test Method Tex-217-F, Part II.

305.5. Precoated Aggregates. Precoated aggregates shall be aggregates of the type specified, treated (coated or fluxed) with 0.5 to 1.5 percent by weight of precoat material or flux oil meeting the requirements of this specification and the approval of the Engineer. The particular grade of precoated aggregate specified shall meet all requirements of Article 305.4. prior to the application of the precoat material or flux oil.

(1) Water. Water in an amount not to exceed 3 percent by weight of the mixture may be used in preparing the mixture. The water shall be added as directed by the Engineer during the mixing. In the event water is used in the mixing operation adequate measuring devices shall be used and the water shall be administered to the mix through an approved spray bar.

(2) Physical Properties of the Mixture. The materials may be mixed on the job or at some central mixing plant and shipped ready for use. Mixes that do not remain workable a sufficient period of time or maintain flow qualities such that the precoated aggregate may be satisfactorily spread by normal approved mechanical spreading devices will not be acceptable.

Materials that are not uniformly and/or properly coated or fluxed, as determined by the Department's standard testing procedures or in the opinion of the Engineer, will not be accepted for use.

305.6. Equipment.

(1) Mixing Plants. Mixing plants that will not continuously meet all the requirements of this specification shall be condemned.

Mixing plants may be either the weight-batching type or the continuous mixing type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, aggregate screens and bins and shall consist of the following essential pieces of equipment:

(a) Weight-batching Type.

Cold Aggregate Bin and Proportioning Device. The cold aggregate bins or aggregate stockpiles shall be of sufficient number and size to supply the amount of aggregate required to keep the plant in continuous operation. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the plant.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that aggregate will not be injured in the necessary drying and heating operations required to obtain a mixture of the specified temperature.

The burner, or combination of burners, and type of fuel used shall be such that in the process of heating the aggregate to the desired or specified temperatures, no residue from the fuel shall adhere to the heated aggregate. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation. The dryer will not be required for precoating natural limestone rock asphalt.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. Proper provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where accurate representative samples of aggregate may be taken from the bins for testing.

Weighing and Measuring Equipment. The weighing and measuring equipment shall be of sufficient capacity and of adequate design for proper batching. The following equipment, conforming to the requirements of the Item, "Weighing and Measuring Equipment", shall be furnished:

1. Aggregate weigh box and batching scales.
2. Bucket and scales for precoat material or flux oil.

A pressure type flow meter may be used to measure the precoat material or flux oil for each batch.

Mixer. The mixer shall be of the pug mill type, and shall have a capacity of not less than 3000 pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the precoat material or flux oil quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the precoat material or flux oil shall not be used. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pug mill.

(b) **Continuous Mixing Type.**

Cold Aggregate Bin and Proportioning Device. Same as for weight-batching type of plant.

Dryer. Same as for weight-batching type of plant.

Screening and Proportioning. Same as for weight-batching type of plant. These requirements shall also apply to materials that are stockpiled and that are proposed for direct use by a continuous mixing plant without the use of plant bins.

Aggregate Proportioning Device. The aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Spray Bar for Precoat Material and Flux Oil. The spray bar for the precoat material or flux oil shall be so designed that the material will spray uniformly and continuously into the mixer.

Meter for Precoat Material or Flux Oil. An accurate recording meter for precoat material or flux oil shall be placed in the line leading to the spray bar so that the accumulative amount of precoat material or flux oil being used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of the meter output.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than 40 tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the precoat material or flux oil shall not be used.

Heating Equipment for Precoat Material and Flux Oil. Heating equipment for precoat material and flux oil shall be adequate to heat the amount of material required to the desired temperature. The material may be heated by steam coils which shall be absolutely tight. Direct fire heating will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the liquid throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the precoat material or flux oil where it is at the highest temperature.

305.7. Storage, Proportioning And Mixing.

(1) Aggregate Storage. If the mineral aggregates are stored or stockpiled, they shall be handled in such a manner as to prevent segregation, the mixing of the various materials or sizes, and the contamination with foreign materials. The grading of aggregates proposed for use and as supplied to the mixing plant shall be uniform.

The use of limestone rock asphalt aggregate containing moisture in excess of the saturated surface-dry condition will not be permitted. Excess moisture will be evidenced by visual surface moisture on the aggregate or any unusual quantities of fines clinging to the aggregate.

(2) Storage and Heating of Precoat or Flux Oil. The precoating or fluxing material storage shall be ample to meet the requirements of the plant. The materials shall not be heated to a temperature in excess of 250 F. All equipment used in the storage and handling of precoat material or flux oil shall be kept in a clean condition at all times and shall be operated in such manner that there will be no contamination with foreign matter.

(3) Feeding and Drying of Aggregate. The feeding of various sizes of aggregate, other than natural limestone rock asphalt, to the dryer shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of material in the required proportions will be maintained. The aggregate shall be heated to the temperature necessary to produce a mixture meeting the requirements of Subarticle 305.5(2), "Physical Properties of the Mixture".

(4) Proportioning. The proportioning of the various materials entering into the mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weight-batch type of plant is used and by volume using the aggregate proportioning device when the continuous mixer type of plant is used. The precoat material or flux oil shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) Mixing.

(a) Batch Type Mixer. In the charging of the weigh box and in the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform mixture. In introducing the batch into the mixer, the mineral aggregate shall be introduced first; shall be mixed thoroughly, as directed, to uniformly distribute the various sizes throughout the batch before the precoat material or flux oil is added; the precoat material or flux oil shall then be added and the mixing continued until such time that the aggregate is properly coated. This mixing period may be varied, if, in the opinion of the Engineer, the mixture is not uniform.

(b) Continuous Type Mixer. The amount of aggregate and precoat material or flux oil entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and precent by weight of precoat material or flux oil will be produced.

305.8. Measurement And Payment. Aggregates will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

ITEM 310

PRIME COAT
(Asphaltic Material Only)

310.1. Description. This item shall consist of an application of asphaltic material on the completed base course and/or other approved area in accordance with these specifications.

Prime Coat shall not be applied when the air temperature is below 60 F and falling, but it may be applied when the air temperature is above 50 F and is rising, the air temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

310.2. Materials. The asphaltic material used for the prime coat shall be of the type and grade shown on plans and when tested by approved laboratory methods shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

The asphaltic material used for the prime coat may, upon instructions from the Engineer, be further cut back by the addition of a maximum of fifteen (15) percent of an approved grade of gasoline and/or kerosene, by volume.

310.3. Construction Methods. When in the opinion of the Engineer, the area and/or base is satisfactory to receive the prime coat, the surface may be cleaned by sweeping or other approved methods. If found necessary by the Engineer, the surface shall be lightly sprinkled just prior to application of the asphaltic material. The asphaltic material shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads.

All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphaltic material shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning of the work, should the yield on the asphaltic material applied appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

The Engineer will select the temperature of application based on the temperature-viscosity relationship that will permit application of the asphalt within the limits recommended in the Item, "Asphalts, Oils and Emulsions". The recommended range for the viscosity of the asphalt is 50 seconds to 60 seconds, Saybolt Furol. The Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected.

The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer.

No traffic, hauling or placement of any subsequent courses shall be permitted over the freshly applied prime coat until authorized by the Engineer.

310.4. Measurement. The asphaltic material for prime coat will be measured at point of delivery on the road in gallons at the applied temperature. The quantity to be paid for shall be the number of gallons used, as directed, in the accepted prime coat.

310.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Asphaltic Material", of the type and grade specified, which price shall be full compensation for cleaning the area and/or base; for furnishing, heating, hauling and distributing the asphaltic material as specified; for all freight involved; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 312

PRIME COAT
(Asphaltic Material and Sand)

312.1. Description. This item shall consist of an application of asphaltic material on the completed base course and/or other approved area covered with sweepings from the base and native sand, and constructed in accordance with these specifications.

Prime Coat shall not be applied when the air temperature is below 60 F and falling, but may be applied when the air temperature is above 50 F and is rising, the air temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

312.2. Materials. The asphaltic material used for the prime coat shall be of the type and grade shown on plans and when tested by approved laboratory methods shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

Base course sweepings shall be those sweepings obtained from cleaning the base.

Native sand shall be local material obtained from approved sources and subject to the approval of the Engineer.

312.3. Construction Methods. Native sand, as specified above, shall be hauled in vehicles of uniform capacity. When, in the opinion of the Engineer, the area and/or base is satisfactory to receive the prime coat, the surface shall be cleaned by sweeping or other approved methods. If found necessary by the Engineer, the surface shall be lightly sprinkled just prior to application of the asphaltic material. Asphaltic material shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the

Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

The surface shall then be covered with base sweepings and/or native sand as directed by the Engineer. The surface shall then be dragged with an approved type of drag broom so as to evenly and smoothly distribute the cover material. This brooming or dragging shall continue until, in the opinion of the Engineer, the course has properly cured under traffic.

No traffic, hauling or placing of subsequent courses shall be permitted over the freshly applied prime coat until authorized by the Engineer.

All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphalt shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

The Engineer will select the temperature of application based on the temperature-viscosity relationship that will permit application of the asphalt within the limits recommended in the Item, "Asphalts, Oils and Emulsions". The recommended range for the viscosity of the asphalt is 50 seconds to 60 seconds, Saybolt Furol. The Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected.

312.4. Measurement. The asphaltic material for prime coat will be measured at point of delivery on the road in gallons at the applied temperature. The quantity to be paid for shall be the number of gallons used, as directed, in the accepted prime coat.

Native Sand will be measured by the cubic yard in vehicles as applied on the road.

312.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphaltic Material", of the type and grade specified, and for "Native Sand", which prices shall each be full compensation for cleaning the base; for furnishing, preparing, hauling and placing all materials (including application of base sweepings); for all freight involved; for spreading, dragging, brooming, finishing and maintaining under traffic until accepted; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 314

EMULSIFIED ASPHALT TREATMENT

314.1. Description. "Emulsified Asphalt Treatment" shall consist of one or more applications of a mixture of emulsified asphalt of the type specified on the plans and water to be used as a base treatment, earthwork seal, prime

coat or dust preventative. This mixture may be applied to the base course, subgrade, shoulders or detours at the locations and to the extent shown on plans or as directed by the Engineer.

314.2. Materials. The amount of emulsified asphalt in the mixture expressed as a percent by volume of the total mixture, shall be within the limits specified on the plans. When tested by approved laboratory methods, the emulsified asphalt used shall meet the requirements of the Item, "Asphalts, Oils and Emulsions". The water used shall meet the requirements of the Item, "Sprinkling".

314.3. Construction Methods. The emulsified asphalt and water mixture shall be applied by a self-propelled sprinkler meeting requirements of the Item, "Sprinkling" so operated as to uniformly distribute the mixture in the quantity determined by the Engineer.

The emulsion and water may be mixed in the sprinkler tank. The Contractor shall make suitable provisions for agitating the two materials sufficiently to produce a uniform blend. The sprinkler tank shall have been recently calibrated, and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield of the emulsion applied appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Where indicated on the plans or directed by the Engineer, "Emulsified Asphalt Treatment" shall be mixed with the base or subbase material. The emulsified asphalt and water mixture shall be applied and incorporated into the top portion of subbase or base course layers to the depth and width shown on plans or directed by the Engineer. Successive applications of a mixture of emulsified asphalt and water shall be applied to the area to be treated with either a pressure distributor or an approved sprinkler and shall be continued until all of the specified amount of emulsified asphalt has been incorporated into the material or as directed by the Engineer.

The percentage of emulsified asphalt in the mixture shall be regulated to insure that the specified amount of emulsified asphalt is incorporated into the material, while maintaining the proper moisture content.

The treated material shall be mixed by blading then shaped and compacted by rolling and blading, as required by the pertinent specification for the particular course, to the lines, grades and typical sections shown on plans. The surface shall be maintained with light applications of emulsified asphalt and water or raw water, as directed by the Engineer, during curing of the course.

314.4. Measurement. Emulsified asphalt will be measured by the gallon of emulsified asphalt used in the emulsified asphalt and water mixture.

Water used in the emulsified asphalt and water mixture will be measured as provided in the Item, "Sprinkling".

314.5. Payment. The work performed and the emulsified asphalt furnished as prescribed by this item and measured as provided under

"Measurement" will be paid for at the unit price bid for "Emulsified Asphalt" of the type specified, which price shall be full compensation for furnishing all required materials, except mixing water, for application; for all freight involved; for all hauling, mixing and distributing the mixture as specified; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

Water for mixing used in the emulsified asphalt and water mixture will be paid for in accordance with the provisions governing the Item, "Sprinkling".

ITEM 316
SEAL COAT

316.1. Description. This item shall consist of a surface treatment composed of a single application of asphalt covered with aggregate for the sealing of existing pavements in accordance with these specifications.

Seal coats shall not be applied when the air temperature is below 60 F and is falling, but may be applied when the air temperature is above 50 F and is rising, the air temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

316.2. Materials.

(1) Asphaltic Materials. The asphaltic materials used shall be one or more of the materials prescribed in the Item, "Asphalts, Oils and Emulsions", whichever are called for on the plans.

(2) Aggregate. The aggregate used shall be of the type and grade or types and grades as noted on the plans and selected from those prescribed in the Items, "Aggregate for Surface Treatments", "Aggregate for Surface Treatments (Precoated)", or in the Item, "Aggregate for Surface Treatments (Lightweight)".

(3) Aggregate (Stockpiled). When plans include the Item, "Aggregate (Stockpiled)", aggregate of the type and grade specified for the seal coat shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled if required and prepared as specified herein.

316.3. Construction Methods. The area to be treated shall be cleaned of dirt, dust or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer, the surface shall be lightly sprinkled just prior to the application of asphaltic material. Asphaltic material shall be applied on the cleaned surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in

error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material may be applied for the full width of the seal coat in one application unless the width exceeds 26 feet. Asphaltic material shall not be applied until immediate covering with aggregate is assured.

Aggregate shall be immediately and uniformly applied and spread by an approved self-propelled continuous feed aggregate spreader, unless otherwise shown on the plans or authorized by the Engineer in writing. The aggregate shall be applied at the approximate rates indicated on the plans and as directed by the Engineer.

The entire surface shall be broomed, bladed or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment shall meet the governing specifications for the Item, "Rolling".

The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer. All holes or failures in the seal coat surface shall be repaired by use of additional asphalt and aggregate and all fat or bleeding surfaces shall be covered with approved cover material in such manner that the asphaltic material will not adhere to or be picked up on the wheels of vehicles.

Temporary stockpiling of aggregates on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of all stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphaltic material shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphalt with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

The Engineer will select the temperature of application based on the temperature-viscosity relationship that will permit application of the asphalt within the limits recommended in the Item, "Asphalts, Oils and Emulsions". The recommended range for the viscosity of the asphalt is 50 seconds to 60 seconds, Saybolt Furol. The Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected.

When shown on the plans, the Texas Highway Department will furnish satisfactory aggregate to the Contractor for designated sections of the project free of charge in stockpiles at locations shown on the plans. The Contractor shall load, haul, distribute and apply the stockpiled aggregate and clean up all stockpiles in accordance with specification requirements governing for this item.

316.4. Measurement. Asphaltic material will be measured at point of application on the road in gallons at the applied temperature. The quantity to

be paid for shall be the number of gallons used, as directed, in the accepted seal coat.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

When "Loading, Hauling and Distributing Aggregate" is a bid item, it will be measured by the cubic yard in vehicles as applied on the road.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

316.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate" and "Aggregate (Stockpiled)", if required, of the class, type and grade specified, which prices shall each be full compensation for cleaning and sprinkling the existing surface; for furnishing, preparing, hauling, and placing all materials; for all freight involved; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work, except rolling.

When "Loading, Hauling and Distributing Aggregate" is a bid item, the work performed and measured as provided for herein above will be paid for at the unit price bid for "Load, Haul and Distribute Aggregate", which price shall be full compensation for loading, hauling, applying and distributing aggregate and cleaning up stockpiles, and all manipulation, labor, tools, equipment and incidentals necessary to complete the work except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Rolling".

ITEM 320
ONE COURSE SURFACE TREATMENT

320.1. Description. This item shall consist of a wearing surface composed of a single application of asphaltic material covered with aggregate, constructed on the prepared base course or surface in accordance with these specifications.

One course surface treatment shall not be applied when the air temperature is below 60 F and is falling, but it may be applied when the air temperature is above 50 F and is rising, the air temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

320.2. Materials.

(1) Asphaltic Materials. The asphaltic materials used shall be one or more of the materials prescribed in the Item, "Asphalts, Oils and Emulsions", whichever are called for on the plans.

(2) Aggregate. The aggregate used shall be of the type and grade or types and grades as noted on the plans and selected from those prescribed in the Items, "Aggregate for Surface Treatments", "Aggregate for Surface Treat-

ments (Precoated)", or in the Item, "Aggregate for Surface Treatments (Lightweight)".

(3) Aggregate (Stockpiled). When plans include the Item, "Aggregate (Stockpiled)", aggregate of the type and grade specified for the surface treatment shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled if required and prepared as specified herein.

320.3. Construction Methods. The area to be treated shall be cleaned of dirt, dust, or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer the surface shall be lightly sprinkled just prior to the application of the asphaltic material.

Asphaltic material shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material may be applied for the full width of the surface treatment in one application, unless the width exceeds 26 feet. No traffic or hauling will be permitted over the freshly applied asphaltic material. Asphaltic material shall not be applied until immediate covering is assured.

Aggregate shall be immediately and uniformly applied and spread by an approved self-propelled continuous feed aggregate spreader, unless otherwise shown on the plans or authorized by the Engineer in writing. The aggregate shall be applied at the approximate rates indicated on the plans and as directed by the Engineer.

The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer.

The entire surface shall be broomed, bladed or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment shall meet the governing specifications for the Item, "Rolling".

Temporary stockpiling of the aggregate on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of all stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks and distributors used in

storing or handling asphaltic materials shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic materials with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times. The Engineer will select the temperature of application based on the temperature-viscosity relationship that will permit application of the asphalt within the limits recommended in the Item, "Asphalts, Oils and Emulsions". The recommended range for the viscosity of the asphalt is 50 seconds to 60 seconds, Saybolt Furol. The Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected.

320.4. Measurement. Asphaltic material will be measured at point of application on the road in gallons at the applied temperature. The quantity to be paid for shall be the number of gallons used, as directed, in the accepted surface treatment.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

320.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate"and "Aggregate (Stockpiled)", if required, of the class, type and grade specified, which prices shall each be full compensation for cleaning and sprinkling the base; for furnishing, preparing, hauling and placing all materials; for all freight involved; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Rolling".

ITEM 322
TWO COURSE SURFACE TREATMENT

322.1. Description. This item shall consist of a wearing surface composed of two applications of asphaltic material, each covered with aggregate, constructed on the prepared base course or surface in accordance with these specifications.

Two course surface treatment shall not be applied when the air temperature is below 60 F and is falling, but it may be applied when the air temperature is above 50 F and is rising. Air temperature shall be taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

322.2. Materials.

(1) Asphaltic Materials. The asphaltic materials used shall be one or

more of the materials prescribed in the Item, "Asphalts, Oils and Emulsions", whichever are called for on the plans.

(2) **Aggregate.** The aggregate used shall be of the type and grade or types and grades as noted on the plans and selected from those prescribed in the Items, "Aggregate for Surface Treatments", "Aggregate for Surface Treatments (Precoated)", or in the Item, "Aggregate for Surface Treatments (Lightweight)".

(3) **Aggregate (Stockpiled).** When plans include the Item, "Aggregate (Stockpiled)", aggregate of the type and grade specified for the surface treatment shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled, if required, and prepared as specified herein.

322.3. **Construction Methods.** The area to be treated shall be cleaned of dirt, dust, or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer, the surface shall be lightly sprinkled just prior to the first application of asphaltic material.

Asphaltic material of the type and grade shown on the plans for the first course shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determing the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satifactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material for each course may be applied for the full width of the surface treatment in one application, unless the width exceeds 26 feet. No traffic or hauling will be permitted over the freshly applied asphaltic material. Asphaltic material shall not be applied until immediate covering is assured.

Aggregate, of the type and grade shown on the plans for the first course, shall be immediately and uniformly applied and spread by an approved self-propelled continuous feed aggregate spreader, unless otherwise shown on the plans or authorized by the Engineer in writing. The aggregate shall be applied at the approximate rates indicated on the plans and as directed by the Engineer. The Contractor shall be responsible for the maintenance of the surface of the first course until the second course is applied.

The entire surface shall then be broomed, bladed or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment used shall meet the governing specifications for the Item, "Rolling".

The second course shall consist of asphaltic material and aggregate of the type and grade indicated on the plans for the second course. The asphaltic

material and aggregate for this second course shall be applied and covered in the manner specified for the first application. The surface shall then be broomed, bladed or raked as required by the Engineer and thoroughly rolled as specified for the first course. Asphaltic materials and aggregates for both courses shall be applied at the approximate rates indicated on the plans and as directed by the Engineer.

The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer.

Temporary stockpiling of aggregates on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of all stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphaltic materials shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

The Engineer will select the temperature of application based on the temperature-viscosity relationship that will permit application of the asphalt within the limits recommended in the Item, "Asphalts, Oils and Emulsions". The recommended range for the viscosity of the asphalt is 50 seconds to 60 seconds, Saybolt Furol. The Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected.

322.4. Measurement. Asphaltic material will be measured at point of application on the road in gallons at the applied temperature. The quantity to be paid for shall be the number of gallons used, as directed, in the accepted surface treatment.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

322.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate" and "Aggregate (Stockpiled)", if required, of the class, type and grade specified, which prices shall each be full compensation for cleaning and sprinkling the base; for furnishing, preparing, hauling and placing all materials; for all freight involved; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work; except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Rolling".

ITEM 324

THREE COURSE SURFACE TREATMENT

324.1. Description. This item shall consist of a wearing surface composed of three applications of asphaltic material, each covered with aggregate, constucted on the prepared base course or surface in accordance with these specifications.

Three course surface treatment shall not be applied when the air temperature is below 60 F and is falling, but it may be applied when the air temperature is above 50 F and is rising. Air temperature shall be taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

324.2. Materials.

(1) Asphaltic Materials. The asphaltic materials used shall be one or more of the materials prescribed in the Item, "Asphalts, Oils and Emulsions", whichever are called for on the plans.

(2) Aggregate. The aggregate used shall be of the type and grade or types and grades as noted on the plans and selected from those prescribed in the Items, "Aggregate for Surface Treatments", "Aggregate for Surface Treatments (Precoated)", or in the Item, "Aggregate for Surface Treatments (Lightweight)".

(3) Aggregate (Stockpiled). When plans include the Item, "Aggregate (Stockpiled)", aggregate of the type and grade specified for the surface treatment shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled if required and prepared as specified herein.

324.3. Construction Methods. The area to be treated shall be cleaned of dirt, dust or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer, the surface shall be lightly sprinkled just prior to the first application of asphaltic material.

Asphaltic material of the type and grade shown on the plans for the first course shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material for each course may be applied for the full width of the surface treatment in one application, unless the width exceeds 26 feet. No

traffic or hauling will be permitted over the freshly applied asphaltic material. No asphaltic material shall be applied until immediate covering is assured.

Aggregates, of the type and grade shown on the plans for the first course, shall be immediately and uniformly applied and spread by an approved self-propelled continuous feed aggregate spreader, unless otherwise shown on the plans or authorized by the Engineer in writing. The aggregate shall be applied at the approximate rates indicated on the plans and as directed by the Engineer.

The entire first course shall then be broomed, bladed or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment used shall meet the governing specifications for the Item, "Rolling".

The Contractor shall be responsible for the maintenance of the first course until the second course is applied.

The second course shall consist of asphaltic material and aggregate of the type and grade indicated on the plans for the second course. The asphaltic material for this second course shall be applied and covered with aggregate in the manner specified for the first application. The surface shall then be broomed, bladed or raked as required by the Engineer and thoroughly rolled as specified for the first course. Asphaltic material and aggregate for the second course shall be applied at the approximate rate indicated on the plans and as directed by the Engineer.

The Contractor shall be responsible for the maintenance of the surface of the second course until the third course is applied.

The third course shall consist of asphaltic material and aggregate of the type and grade indicated on the plans for the third course. The asphaltic material for this third course shall be applied and covered with aggregate in the manner specified for the first application. The surface shall then be broomed, bladed or raked as required by the Engineer and thoroughly rolled as specified for the first course. Asphaltic material and aggregate for the third course shall be applied at the approximate rate indicated on the plans and as directed by the Engineer.

The contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer.

Temporary stockpiling of aggregates on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of all stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphaltic material shall be kept clean and in good operating condition at all times, and they shall be operated in such matter that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

The Engineer will select the temperature of application based on the temperature-viscosity relationship that will permit application of the asphalt within the limits recommended in the Item, "Asphalts, Oils and Emulsions". The recommended range for the viscosity of the asphalt is 50 seconds to 60 seconds, Saybolt Furol. The Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected.

324.4. Measurement. Asphaltic material will be measured at point of application on the road in gallons at the applied temperature. The quantity to be paid for shall be the number of gallons used, as directed, in the accepted surface treatment.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

324.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate" and "Aggregate (Stockpiled)", if required, of the class, type and grade specified, which prices shall be full compensation for cleaning and sprinkling the base; for furnishing, preparing, hauling, and placing all materials; for all freight involved; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work, except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item, "Rolling".

ITEM 330

COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT (Class A)

330.1. Description. This item shall consist of a surface course, a leveling-up course, or a combination of these courses as shown on plans, composed of a compacted layer of natural limestone rock asphalt, cold mixed with a prescribed flux and shall be constructed on the completed and approved base course, existing pavement or floor slab, all in accordance with these specifications and in conformity with the lines, grades, quantities and typical cross section shown on plans. The mixture when designed and tested in accordance with these specifications shall have a laboratory stability of not less than 30 percent unless otherwise shown on the plans.

330.2. Materials.

(1) Rock Asphalt. This material shall be composed of natural limestone rock asphalt. This material shall contain not more than 1 percent by weight of organic matter (other than native bitumen), clays, loam or pebbles coated therewith and shall contain not more than 5 percent by weight of any one of

or combination of slate, shale, schist, soft particles or other undesirable materials when tested in accordance with Test Method Tex-217-F.

The rock asphalt mixture shall be uniform and well graded and shall contain natural limestone rock asphalt aggregate with an average bitumen content of 5 to 9 percent by weight of naturally impregnated asphalt as determined by Test Method Tex-215-F, and shall contain not more than 2 percent by weight of any one of or combination of iron pyrites, or other objectionable matter, as determined by Test Method Tex-217-F.

No aggregate shall contain a total of more than 5 percent by weight of impurities or objectionable matter listed above.

The portion of the material passing the No. 10 sieve shall have by weight not more than 8.5 percent nor less than 5 percent of naturally impregnated asphalt.

Except for Type D Paving Mixture, the portion of the material retained on the No. 4 sieve shall contain by weight from 20 percent to 35 percent of material with a naturally impregnated asphalt content of less than 1 percent. The portion of the material retained on the No. 4 sieve for Type D Paving Mixture shall contain by weight from 15 percent to 35 percent of the material with a naturally impregnated asphalt content of less than 1 percent. This percentage shall be adjusted within the grading limits to obtain an acceptable mixture.

The percent of wear on limestone rock asphalt aggregate shall be no more than 40 as determined by Test Method Tex-410-A and shall be made on that portion of the material retained on the No. 4 sieve having a naturally impregnated asphalt content of less than 1 percent.

No material shall be used before the source has been approved and the material has been sampled, tested and approved by the Engineer. The Contractor shall notify the Engineer in advance if change in source of any material is desired, and both the new source and material shall be approved by the Engineer prior to use.

(2) Asphaltic Material.

(a) Flux. The fluxing material shall meet the Flux Oil requirements of the Item, "Asphalts, Oils and Emulsions".

(b) Tack Coat. The asphalt material for tack coat shall meet the requirements for emulsified asphalt, EA-11M, or cut-back asphalt, RC-2. If RC-2 cut-back asphalt is used it may, upon instruction from the Engineer, be diluted by the addition of an approved grade of gasoline and/or kerosene, not to exceed 15 percent by volume. Asphaltic materials shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

330.3. Paving Mixtures.

(1) Types. The paving mixture shall consist of a uniform mixture of crushed limestone rock asphalt aggregate, flux and water if needed. The grading shall be such as to produce, when properly proportioned, a mixture which, when tested in accordance with Test Method Tex-200-F, will conform to the limitations for grading given below for the type specified prior to the

application of the fluxing material to the limestone rock asphalt aggregate. The grading to be used in these mixtures, within the limits specified, shall be approximately as designated by the Engineer, and the mixture produced shall be uniform.

	Percent by Weight
Type "A":	
Retained on 1" sieve	0
Retained on 7/8" sieve	0 to 2
Retained on 5/8" sieve	5 to 15
Retained on 3/8" sieve	25 to 35
Retained on No. 4 sieve	50 to 60
Passing No. 10 sieve	25 to 35
Type "B":	
Retained on 5/8" sieve	0
Retained on 1/2" sieve	0 to 2
Retained on 3/8" sieve	5 to 15
Retained on No. 4 sieve	45 to 60
Passing No. 10 sieve	25 to 35
Type "C":	
Retained on 1/2" sieve	0
Retained on 3/8" sieve	0 to 2
Retained on No. 4 sieve	40 to 55
Passing No. 10 sieve	20 to 35
Type "CC":	
Retained on 1/2" sieve	0
Retained on 3/8" sieve	0 to 2
Retained on No. 4 sieve	40 to 55
Passing No. 10 sieve	35 to 50
Type "D":	
Retained on 3/8" sieve	0
Retained on 1/4" sieve	0 to 2
Retained on No. 4 sieve	5 to 15
Passing No. 10 sieve	35 to 50

(2) Sampling and Testing. The mixture shall be tested in accordance with Texas Test Methods to determine whether it complies with the governing specification requirements.

Stability is a control requirement. If the stability of the mixture produced has a value 10 percent lower than that specified, corrective measures shall be taken to bring the mixture within the specified requirements.

(3) Tolerances. The designated grading and fluxing material content shall be such that when the tolerances listed below are allowed, the grading and the fluxing material content will be within the grading limits specified. The respective tolerances, based on the percent by weight of the mixture, are listed as follows:

	Percent by Weight
Retained on 7/8" sieve	plus or minus 4
Retained on 5/8" sieve	plus or minus 4
Retained on 1/2" sieve	plus or minus 4
Retained on 3/8" sieve	plus or minus 4
Retained on 1/4" sieve	plus or minus 4
Retained on No. 4 sieve	plus or minus 4
Total Retained on No. 10 sieve	plus or minus 3
Fluxing Material	plus or minus 0.2

(4) Material Produced for Maintenance Requisition. The limestone rock asphalt aggregate grading and flux content of the mixture shall be within the limits specified. The designated grading and flux content shall be selected from the first shipment for material on each shipment or partial shipment where requested by the Engineer, and the mixture produced shall conform to this designated grading and flux content throughout each shipment or partial shipment, respectively, within the tolerances specified above.

(5) Water Content. If the rock asphalt mixture is prepared at some central point and shipped to the work, water may be added to prevent setting-up in transit. If water is added, the total water so added shall not exceed 4 percent by weight and shall be administered to the mixture through an approved spray bar. If the rock asphalt mixture is prepared on or adjacent to the project, the addition of water will not be permitted unless authorized by the Engineer. The amount of water that may be added shall be as designated by the Engineer but shall not exceed 4 percent by weight. In order to insure uniformity of the rock asphalt mixture a suitable measuring device, subject to approval of the Engineer, shall be used to accurately measure the amount of water to be incorporated into each batch. All water in the mixture in excess of 4 percent by weight at the time of weighing the mixture on the truck scales shall be deducted in determining the tonnage of mixture for payment. The method of determining the water content of the mixture shall be in accordance with Test Method Tex-212-F. The water content shall be measured on representative samples, each representing approximately 200 tons. Not less than one sample shall be taken on each day's run.

(6) Physical Properties of the Mixture. The materials may be mixed on the job or at some central mixing plant and shipped ready to use. Mixtures that do not remain workable a sufficient period of time to permit unloading by normal means, proper spreading, blading and rolling will not be acceptable.

The type and amount of the mixture used shall be as specified on the plans.

330.4. Equipment.

(1) Mixing Plants. Mixing plants that will not continuously produce a mixture meeting all of the above requirements will be condemned.

Mixing plants may be either the weight-batching type or the continuous mixing type. Both types of plant shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, aggregate screens and bins and shall consist of the following essential pieces of equipment:

(a) **Weight-batching Type.**

Cold Aggregate Bin and Proportioning Device. The cold aggregate bins or aggregate stockpiles shall be of sufficient number and shall be of sufficient size to supply the amount of aggregate required to keep the plant in continuous operation. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the plant.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. Proper provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where accurate representative samples of aggregate may be taken from the bins for testing. The aggregate shall be separated into at least four bins when producing Type "A" mixtures, at least three bins when producing Type "B" and at least two bins when producing Types "C" and "D".

Type "A":

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1/2 inch sieve and be retained on the 1/4 inch sieve.

Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 7/8 inch sieve and be retained on the 3/8 inch sieve.

Type "B":

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1/2 inch sieve and be retained on the 1/4 inch sieve.

Type "C", Type "CC" and Type "D":

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 10 sieve.

Aggregate Weigh Box and Batching Scales. The aggregate weigh box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weigh box and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

Flux Oil Bucket and Scales. The flux oil bucket and scales shall be of sufficient capacity to hold and weigh the necessary material for one batch. If the flux oil is measured by weight, the bucket and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

If a pressure type flow meter is used to measure the flux oil, the requirements of the Item, "Weighing and Measuring Equipment" shall apply.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 3,000 pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the fluxing material quickly and uniformly throughout the mixer. If, in the opinion of the Engineer, any mixer has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the fluxing material, it shall not be used. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type.

Cold Aggregate Bin and Proportioning Device. Same as for weight-batching type of plant.

Screening and Proportioning. Same requirements as specified under weight-batching plants. These requirements shall also apply to materials that are stockpiled and that are proposed for direct use by a continuous mixing plant without the use of plant bins.

Fluxing Material Spray Bar. The fluxing material spray bar shall be so designed that the fluxing material will spray uniformly and continuously into the mixer.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than 40 tons of mixture per hour. If, in the opinion of the Engineer, any mixer has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the fluxing material, it shall not be used.

(2) Spreading and Finishing Machine. The spreading and finishing machine, when permitted in subarticle 330.6(3), shall be a type approved by the Engineer and shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test.

Automatic Screed Controls, if required, shall meet the requirements of the Item, "Automatic Screed Controls for Asphaltic Concrete Spreading and Finishing Machines".

(3) Motor Grader. The motor grader shall be a self-propelled power-grader; it shall be equipped with smooth tread pneumatic tired wheels; shall have a blade length of not less than 12 feet; shall have a wheel base of not less than 16 feet; and shall be tight and in good operating condition and approved by the Engineer.

(4) Pneumatic Tire Rollers. The pneumatic tire roller shall be an acceptable medium pneumatic tire roller conforming to the requirements of the Item, "Rolling (Pneumatic Tire)", Type B, unless otherwise specified on the plans.

The tire pressure of each tire shall be adjusted as directed by the Engineer and this pressure shall not vary by more than 5 pounds per square inch.

(5) Two Axle Tandem Roller. This roller shall be an acceptable power drive tandem roller weighing not less than 8 tons.

(6) Three Wheel Roller. This roller shall be an acceptable power driven three wheel roller, weighing not less than 10 tons.

(7) Three Axle Tandem Roller. This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(8) Straightedges and Templates. The Contractor shall provide acceptable 10-foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(9) Truck Scales. A set of standard platform truck scales, conforming to the Item, "Weighing and Measuring Equipment", shall be placed at a location approved by the Engineer.

(10) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

(11) Alternate Equipment. When permitted by the Engineer in writing, equipment other than that specified which will consistently produce satisfactory results may be used.

330.5. Storage, Proportions and Mixing.

(1) Storage of Rock Asphalt.

Central Mixing Plants. Sufficient material shall be stored, stockpiled or produced to permit continuous operation throughout any working period

without shutdowns due to material shortages. If the natural limestone rock asphalt aggregates are stored or stockpiled, they shall be handled in such a manner as to prevent segregation, the mixing of various materials or sizes and the contamination with foreign materials.

Storage of the crushed limestone rock asphalt mixture upon the ground will not be permitted at the plant site. Material that comes in contact with earth or other objectionable foreign matter shall be rejected. Mixtures that do not remain workable a sufficient period of time to permit proper spreading, blading and rolling will not be acceptable. Storage, handling or loading of the rock asphalt mixture shall be in such manner as to prevent undue segregation.

(2) Storage and Heating of Flux. The flux storage shall be ample to meet the requirements of the plant. The flux may be heated by steam coil or direct fire to a temperature not to exceed 250 F. Agitation by steam or air will not be permitted. If direct fire heating is used, the heating equipment shall be such that it will insure positive circulation of the flux while being heated and shall be approved by the Engineer. Care shall be taken not to injure the flux by subjecting it to undue continuous heat. The heating apparatus shall be equipped with a recording thermometer with a 24 hour chart that will record the temperature of the fluxing material where it is at the highest temperature.

(3) Proportioning. The proportioning of the various materials entering into the mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales when the weight-batch type of plant is used and by volume using the aggregate proportioning device when the continuous mixer type of plant is used. The fluxing material shall be proportioned by weight or by volume based on weight using the specified equipment. The proportions of each constituent by weight of the paving mixture shall be within the following limits:

Crushed Limestone Rock Asphalt, 96 to 97.5 percent by weight.

Flux Material, 2.5 to 4 percent by weight.

(4) Mixing. In introducing the batch into the mixer, the sequence of addition of aggregate and flux oil and the amount of mixing shall be determined by the Engineer, and shall be done in a manner to minimize formation of "flux balls" and produce optimum conditions for a homogeneous mix. The mixer shall be equipped with an approved spray bar that will distribute the flux oil quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the rock asphalt aggregate or fails to secure a thorough and uniform mixing with the flux oil shall not be used.

Mixtures produced when the limestone rock asphalt aggregates contain moisture in excess of saturated surface dry condition will not be accepted. Excess moisture will be evidenced by visual surface moisture on the aggregates or any unusual quantities of fines clinging to the coarse aggregate.

In order to observe plant operations and the rock asphalt mixtures, adequate lighting shall be provided or mixing shall be confined to the daylight hours.

All limestone rock asphalt mixtures shipped on any one particular requisition or project shall be produced out of the same mixing plant, unless if in the opinion of the Engineer there is no difference in the quality of the rock asphalt mixture when produced by two different mixing plants. Materials produced by a weight-batching plant shall not be mixed with material produced from a continuous mixing plant.

330.6. Construction Methods. The rock asphalt mixture, tack coat or prime coat shall not be placed when the air temperature is below 60 F and is falling, but it may be placed when the air temperature is above 50 F and is rising, the temperature being taken in the shade away from artificial heat, with the further provision that asphaltic mixture or tack coat shall only be placed when the humidity and general weather conditions, in the opinion of the Engineer, are suitable.

(1) Prime Coat. If a prime coat is required, it will be applied and paid for as a separate item. The tack coat or rock asphalt mixture shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat. Before the rock asphalt mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat meeting the requirements for tack coat under asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate of not to exceed 0.05 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be elimated by the Engineer. The tack coat shall be rolled with a pneumatic tire roller as directed by the Engineer.

(3) Placing. If the mixtures are shipped to the job, the railroad cars shall first be cleaned of all foreign matter, and the material shall be loaded in such a manner as to prevent segregation. The rock asphalt mixture, prepared as specified, shall be hauled to the work in tight vehicles previously cleaned of all foreign materials. The dispatching of the vehicles shall be so that all material delivered may be placed and shall have received its initial rolling in daylight. The mixture shall be laid only on an approved base course or pavement which has been tack-coated as previously specified and shall be free of all foreign materials. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coating of cut-back or emulsified asphalt as required for tack-coating the base. The mixture shall be thoroughly aerated and then spread into place with a motor grader, in a uniform layer of such depth that after receiving ultimate compaction by rolling, the requirements of the typical cross sections will have been fulfilled. Hand spreading will be permitted where the mixture is placed on narrow strips or small irregular areas.

Adjacent to flush curbs, gutters, liners and structures, the surface mixture shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb or flush structure. During the application

of asphaltic material, care shall be taken to prevent splattering of adjacent pavement, curb and gutters or structures.

Where more than one course of pavement is to be placed, no succeeding course shall be placed until the preceding course has cured to the satisfaction of the Engineer, but shall contain not more than a maximum of 3 percent moisture and 0.2 percent hydrocarbon volatile content of the mixture by weight as determined by Test Method Tex-212-F and 213-F or test methods included in THD Bulletin C-14.

Alternate Method of Placing. When indicated on the plans or directed by the Engineer in writing, the mixture may be spread with the specified spreading and finishing machine. In placing the material with a spreading and finishing machine, rolling shall be deferred for a period of time, as directed by the Engineer, to allow for volatilization. Where more than one course of pavement is to be placed, no succeeding course shall be placed until the preceding course has cured to the satisfaction of the Engineer, but shall contain not more than a maximum of 3 percent moisture and 0.2 percent hydrocarbon volatile content of the mixture by weight as determined by Test Method Tex-212-F and 213-F.

(4) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers and/or other approved rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. On superelevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with pneumatic tire roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller, one pneumatic tire roller and at least one three wheel roller as specified above shall be provided for each job. If the Contractor elects he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller; but in no case shall less than three rollers be in use on each job. Additional rollers shall be provided if needed. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease or other foreign matter on the pavement, either when the rollers are in operation or when standing. When permitted by the Engineer in writing, equipment other than that specified which will consistently produce satisfactory results may be used.

(c) Pavement Compaction. When a pavement compaction requirement is specified, it is the intent of this specification that the material be

placed and compacted such that the actual specific gravity of the pavement after compaction is equal to or greater than the minimum percent, indicated on the plans, of the laboratory actual specific gravity. The method of determining the in-place actual specific gravity shall be as designated by the Engineer, each method correlating satisfactorily with results obtained from standard tests as described in Test Method Tex-207-F. In-place percent compaction tests are intended for compaction control. If the in-place percent compaction is lower than that specified, work may proceed with changes in the construction operations, rolling procedure and/or, rolling sequence until the in-place percent compaction equals or exceeds that specified.

(d) Hand Tamping. The edges of the pavement along curbs, headers and similar structures, and pavement mixture at all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(5) Surface Tests. The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross section, and when tested with a 10-foot straightedge placed parallel to the centerline of the roadway, it shall have no deviation in excess of 1/16 inch per foot from the nearest point of contact. The maximum ordinate measured from the face of the straightedge shall not exceed 1/4 inch at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(6) Opening to Traffic. The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

330.7. Measurement. The rock asphalt mixture will be measured by the ton of 2,000 pounds as actually used in the completed and accepted work in accordance with the plans and specifications for the project. Measurement by weight will be made on the truck scales as provided in this specification. Records will be kept on tare load, total load and net load of rock asphalt mixture for each load of same. All water in excess of 4 percent by weight in the mixture at the time of weighing shall be deducted from the net weight to determine the quantity for which payment is made.

330.8. Payment.

(1) Work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Cold Mix Limestone Rock Asphalt Pavement" of the types specified, which prices shall each be full compensation for furnishing all materials; for all heating, mixing, hauling, cleaning base course, tack coat, placing rock asphalt mixture; all blading, rolling and finishing; and for all labor, tools, equipment and incidentals necessary to complete the work except prime coat when required.

(2) Prime Coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(3) All templates, straightedges, scales and other weighing and measuring devices necessary for the proper construction and checking of the work shall be furnished, operated and maintained by the Contractor at his expense.

ITEM 340

HOT MIX ASPHALTIC CONCRETE PAVEMENT
(Class A)

340.1. Description. This item shall consist of a base course, a leveling-up course, a surface course or any combination of these courses as shown on the plans, each to be composed of a compacted mixture of mineral aggregate and asphaltic material.

The pavement shall be constructed on the previously completed and approved subgrade, base, existing pavement, bituminous surface or in the case of a bridge, on the prepared slab as herein specified and in accordance with the details shown on the plans.

340.2. Materials.

(1) Mineral Aggregate. The mineral aggregate shall be composed of a coarse aggregate, a fine aggregate, and if required, a mineral filler. Samples of coarse aggregate, fine aggregate and mineral filler shall be submitted in accordance with the methods prescribed in the Item "Control of Materials" of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery.

Except where iron ore topsoil is used, combined mineral aggregate, after final processing by the mixing plant and prior to addition of asphalt and mineral filler, shall have a sand equivalent value of not less than 45, unless otherwise shown on plans when tested in accordance with Test Method Tex-203-F. Mineral aggregate from each source will meet the quality tests specified hereafter unless otherwise specified on the plans.

Mineral aggregate for iron ore topsoil mixture shall be composed of iron ore topsoil from pits or other sources approved by the Engineer. The material shall be from those parts of the pit designated by the Engineer and shall be free from organic or other injurious matter. All trees, brush, weeds, grass or other undesirable material shall be removed from the pits and the exposed material thoroughly mixed before any of the mineral aggregate is secured.

(a) Coarse Aggregate. Coarse aggregate shall be that part of the aggregate retained on the No. 10 sieve; shall consist of clean, tough, durable fragments of stone, crushed blast furnace slag, crushed gravel, gravel, iron ore topsoil, oyster shell, cinder aggregate (produced by burning lignite or coal), crushed limestone rock asphalt or combination thereof as hereinafter specified and/or as shown on the plans, of uniform quality throughout. When specified on the plans, other coarse aggregate material may be permitted or required.

The point of sampling for tests, Test Method Tex-217-F (Part I and Part II) will be as shown on the plans.

Except for mixtures containing iron ore topsoil or oyster shell unless otherwise shown on the plans, when the coarse aggregate is tested in accordance with Test Method Tex-217-F (Part I, Separation of Deleterious Material), the amount of organic matter, clay, loam or particles coated therewith or other undesirable materials shown in the plans shall not exceed

two percent and when the remaining part of the sample is further tested in accordance with Test Method Tex-217-F (Part II, Decantation), the amount of material removed shall not be more than two percent.

When it is specified that the coarse aggregate be sampled from the hot bins and tested in accordance with Test Method Tex-217-F (Part II, Decantation), the amount of material removed shall not exceed 1 percent.

When it is specified that the coarse aggregate be sampled during delivery to the plant, from the stockpile, or from the cold bin, the material removed when tested in accordance with Test Method Tex-217-F (Part II, Decantation), shall not exceed two percent.

When oyster shell is used in combination with aggregates other than iron ore topsoil, the coarse aggregate shall be tested in accordance with Test Method Tex-217-F (Part II, Decantation), and unless otherwise shown on the plans the amount of the material removed shall not exceed three percent by weight when the plasticity index of the material passing the No. 40 sieve from all of the aggregates used in the combined mixture does not exceed six.

For mixtures containing iron ore topsoil, the plasticity index of the material passing the No. 40 sieve shall not be more than six unless otherwise shown on the plans.

When the coarse aggregate is oyster shell and is tested in accordance with Test Method Tex-217-F (Part II, Decantation), the amount of material removed unless otherwise shown on the plans shall not be more than four percent, except that, when the plasticity index of the material passing the No. 40 sieve contained in the coarse aggregate stockpile is not more than six, the amount removed may be as much as five percent. The coarse aggregate unless otherwise shown on the plans shall have an abrasion loss of not more than fifty-five percent when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A.

The coarse aggregate, except iron ore topsoil, (each coarse aggregate when a combination of materials is used) shall have an abrasion of not more than forty percent loss by weight when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A unless otherwise shown on the plans.

Unless otherwise indicated on the plans, the abrasion test requirements for iron ore topsoil shall be omitted.

Unless specified otherwise, gravel shall be so crushed that the percent as shown on the plans of the particles retained on the No. 4 sieve shall have more than one crushed face when tested in accordance with Test Method Tex-413-A (Particle Count).

(b) Fine Aggregate. The fine aggregate shall be that part of the aggregate passing the No. 10 sieve and shall consist of sand, screenings, fine particles of shell or combination thereof as hereinafter specified and/or as shown on the plans of uniform quality throughout. When specified on the plans, other fine aggregate material may be permitted or required.

Fine aggregate shall consist of durable particles, free from injurious foreign matter. Screenings shall be of the same or similar material as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6 when tested in accordance

with Test Method Tex-106-E. Fine aggregate from each source shall meet plasticity requirements.

Where stone screenings are specified for use, the stone screenings shall meet the following grading requirements unless otherwise shown on plans:

	Percent by Weight
Passing the 3/8" Sieve	100
Passing the No. 200 Sieve	10 - 30

When authorized by the Engineer, stone screenings containing particles larger than 3/8" may be used but only that portion of the material passing the 3/8" sieve shall be considered as fulfilling the requirements for screenings when a minimum percentage of screenings is specified for a particular mixture.

Where limestone rock asphalt screenings are specified for use, they shall be screenings resulting from a crushing operation.

(c) Mineral Filler. Mineral filler shall consist of thoroughly dry stone dust, slate dust, portland cement, fly ash or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter.

When tested by Test Method Tex-200-F (Dry Sieve Analysis), it shall meet the following grading requirements, unless otherwise shown on the plans:

	Percent by Weight
Passing a No. 30 Sieve	95 to 100
Passing a No. 80 Sieve, not less than	75
Passing a No. 200 Sieve, not less than	55

(2) Asphaltic Material.

(a) Paving Mixture. Asphalt for the paving mixture shall be of the types of asphalt cement or oil asphalt as determined by the Engineer and shall meet the requirements of the Item, "Asphalts, Oils and Emulsions". The grade of asphalt used shall be as designated by the Engineer after design tests have been made using the mineral aggregates that are to be used in the project. If more than one type of asphaltic concrete mixture is specified for the project, only one grade of asphalt will be required for all types of mixtures, unless otherwise shown on plans. The Contractor shall notify the Engineer of the source of his asphaltic material prior to design or production of the asphaltic mixture and this source shall not be changed during the course of the project except on written permission of the Engineer.

(b) Tack Coat. The asphaltic material for tack coat shall meet the requirements for emulsified asphalt EA-11M, cut-back asphalt RC-2, or shall be a cut-back asphalt made by combining 50 to 70 percent by volume of the asphaltic material as specified for the type of paving mixture with 30 to 50 percent by volume of gasoline and/or kerosene. If RC-2 cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of an approved grade of gasoline and/or kerosene, not to exceed 15 percent by volume. Asphaltic materials shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

340.3. Paving Mixtures.

(1) Types. The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate, asphaltic material and mineral filler, if required.

The grading of each constituent of the mineral aggregate shall be such as to produce, when properly proportioned, a mixture which, when tested in accordance with Test Method Tex-200-F (Dry Sieve Analysis), will conform to the limitations for master grading given below for the type specified unless otherwise shown on plans.

Type "B" (Fine Graded Base or Leveling-Up Course):	**Percent by Weight**
Passing 1" sieve	100
Passing 7/8" sieve	95 to 100
Passing 7/8" sieve, retained on 3/8" sieve	20 to 50
Passing 3/8" sieve, retained on No. 4 sieve	10 to 40
Passing No. 4 sieve, retained on No. 10 sieve	5 to 25
Total retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 20
Passing No. 80 sieve, retained on No. 200 sieve	3 to 20
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight unless specified otherwise on the plans.

Type "C" (Coarse Graded Surface Course):	
Passing 7/8" sieve	100
Passing 5/8" sieve	95 to 100
Passing 5/8" sieve, retained on 3/8" sieve	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve	10 to 35
Passing No. 4 sieve, retained on No. 10 sieve	10 to 30
Total retained on No. 10 sieve	50 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 25
Passing No. 80 sieve, retained on No. 200 sieve	3 to 25
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight unless specified otherwise on the plans.

Type "D" (Fine Graded Surface Course):	
Passing 1/2" sieve	100
Passing 3/8" sieve	95 to 100
Passing 3/8" sieve, retained on No. 4 sieve	20 to 50
Passing No. 4 sieve, retained on No. 10 sieve	10 to 30
Total retained on No. 10 sieve	50 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 25
Passing No. 80 sieve, retained on No. 200 sieve	3 to 25
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 4.0 to 8.0 percent of the mixture by weight unless specified otherwise on the plans.

Type "E" (Sheet Asphalt Surface Course):

Passing No. 4 sieve	100
Passing No. 4 sieve, retained on No. 10 sieve	0 to 5
Passing No. 10 sieve, retained on No. 40 sieve	15 to 40
Passing No. 40 sieve, retained on No. 80 sieve	20 to 45
Passing No. 80 sieve, retained on No. 200 sieve	12 to 32
Passing No. 200 sieve	7 to 20

The asphaltic material shall form from 7.5 to 12 percent of the mixture by weight unless specified otherwise on the plans.

Type "F" (Fine Graded Surface Course):

Passing 3/8" sieve	100
Passing No. 4 sieve	95 to 100
Passing No. 4 sieve, retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 25
Passing No. 40 sieve, retained on No. 80 sieve	3 to 12
Passing No. 80 sieve, retained on No. 200 sieve	2 to 10
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 3.5 to 6.5 percent of the mixture by weight unless specified otherwise on the plans.

Type "G":

Grading requirements and asphalt content shall be as shown on the plans.

(2) Tolerances. The Engineer will designate the exact grading of the aggregate and asphalt content, within the above limits, to be used in the mixture. The paving mixture produced should not vary from the designated grading and asphalt content by more than the tolerances allowed herein; however, the mixture produced shall conform to the limitations for master grading specified above.

	Percent by Weight
Passing 7/8" sieve, retained on 3/8" sieve	Plus or minus 5
Passing 5/8" sieve, retained on 3/8" sieve	Plus or minus 5
Passing 3/8" sieve, retained on No. 4 sieve	Plus or minus 5
Passing No. 4 sieve, retained on No. 10 sieve	Plus or minus 5
Total retained on No. 10 sieve	Plus or minus 5
Passing No. 10 sieve, retained on No. 40 sieve	Plus or minus 3
Passing No. 40 sieve, retained on No. 80 sieve	Plus or minus 3
Passing No. 80 sieve, retained on No. 200 sieve	Plus or minus 3
Passing No. 200 sieve	Plus or minus 3
Asphalt Material	Plus or minus 0.5

Should the paving mixture produced vary from the designated grading and asphalt content by more than the above tolerances, proper changes are to be made until it is within these tolerances.

(3) Extraction Test. Samples of the mixture when tested in accordance with Test Method Tex-210-F shall not vary from the grading proportions of the aggregate and the asphalt content designated by the Engineer by more than the respective tolerances specified above and shall be within the limits specified for master grading.

When limestone rock asphalt screenings are used, the extraction requirements relative to asphalt content are waived.

(4) Sampling and Testing. It is the intent of this specification to produce a mixture which when designed and tested in accordance with these specifications and methods outlined in THD Bulletin C-14, will have the following laboratory density and stability unless otherwise shown on the plans.

Density,		Percent	Stability, Percent
Min	Max	Optimum	Not less than 30 unless
95	99	97	otherwise shown on plans

Stability and density are control tests. If the laboratory stability and/or density of the mixture produced has a value lower than that specified, and in the opinion of the Engineer is not due to change in source or quality of materials, production may proceed, and the mix shall be changed until the laboratory stability and density falls within the specified limits and as near the optimum value as is practicable. If there is, in the opinion of the Engineer, a fundamental change in any material from that used in the design mixtures, production will be discontinued until a new design mixture is determined by trial mixes. It is the intent of this specification that the mixture will be designed to produce a mixture of optimum density.

340.4. Equipment.

(1) Mixing Plants. Mixing plants that will not continuously produce a mixture meeting all of the requirements of this specification will be condemned.

Mixing plants may be either the weight-batching type or the continuous mixing type (See Article 340.5 also). Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins and dust collectors and shall consist of the following essential pieces of equipment.

When shown on plans, mixing plants shall be equipped with automatic proportioning and recording devices in accordance with the Item, "Weighing and Measuring Equipment"

(a) Weight-batching Type.

Cold Aggregate Bin and Proportioning Device. The aggregate bin shall have at least four compartments of sufficient size to store the amount of aggregate required to keep the plant in continuous operation and of proper

design to prevent overflow of material of one bin to that of another bin. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each aggregate shall be proportioned in a separate compartment.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that aggregate will not be injured in the necessary drying and heating operations required to obtain a mixture of the specified temperature. The burner, or combination of burners, and type of fuel used shall be such that in the process of heating the aggregate to the desired or specified temperature, no residue from the fuel shall adhere to the heated aggregate. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. Provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where representative samples may be taken from the hot bins for testing. The aggregate shall be separated into at least four bins when producing Type "B" and Type "C" mixtures, at least three bins when producing Type "D" mixtures and at least two bins when producing Type "E" and Type "F". If mineral filler is used, an additional bin shall be provided. These bins shall contain the following sizes of aggregates:

Type "B" (Fine Graded Base or Leveling-Up Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 70 percent by weight will be of such size as to pass the No. 4 sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 1 inch sieve and be retained on the 3/8 inch sieve.

Type "C" (Coarse Graded Surface Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 70 percent by weight will be of such size as to pass the No. 4 sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 7/8 inch sieve and be retained on the 3/8 inch sieve.

Type "D" (Fine Graded Surface Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 70 percent by weight will be of such size as to pass the No. 4 sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 1/2 inch sieve and be retained on the No. 4 sieve.

Type "E" (Sheet Asphalt Surface Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 70 percent by weight will be of such size as to pass the No. 4 sieve and be retained on the No. 10 sieve.

Type "F" (Fine Graded Surface Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 10 sieve.

Aggregate Weigh Box and Batching Scales. The aggregate weigh box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weigh box and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

Asphaltic Material Bucket and Scales. The asphaltic material bucket and scales shall be of sufficient capacity to hold and weigh the necessary asphaltic material for one batch. If the material is measured by weight, the bucket and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

If a pressure type flow meter is used to measure the asphaltic material, the requirements of the Item, "Weighing and Measuring Equipment" shall apply.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 3,000 pounds in a single batch unless otherwise shown on the plans. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the asphaltic material quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure

a thorough and uniform mixing with the asphaltic material shall not be used. This shall be determined by mixing the standard batch for the required time, then dumping the mixture and taking samples from its different parts. This will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type.

Cold Aggregate Bin and Proportioning Device. Same as for weight-batching type of plant.

Dryer. Same as for weight-batching type of plant.

Screening and Proportioning. Same as for weight-batching type of plant.

Hot Aggregate Bin. The hot bins shall be so constructed that oversize and overloaded material will be discarded through a discharge chute. Hot bins that become deficient in material shall activate a switch that automatically stops the plant until the proper adjustments are made in the aggregate gates.

Hot Aggregate Proportioning Device. The hot aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Asphaltic Material Spray Bar. The asphaltic material spray bar shall be so designed that the asphalt will spray uniformly and continuously into the mixer.

Asphaltic Material Meter. An accurate asphaltic material recording meter shall be placed in the asphalt line leading to the spray bar so that the cumulative amount of asphalt used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of the meter output. The asphalt meter and line to the meter shall be protected with a jacket of hot oil or other approved means to maintain the temperature of the line and meter at near that temperature specified for the asphaltic material. Unless otherwise shown on the plans the temperature of the asphaltic material entering the recording meter shall be maintained at ± 10 F of the temperature at which the asphalt metering pump was calibrated and set. Inability to maintain this tolerance in temperature shall result in an adjustment of the pay quantity for the asphaltic material.

If a pressure type flow meter is used to measure the asphaltic material, the requirements of the Item "Weighing and Measuring Equipment" shall apply.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than 40 tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used. The dam gate at the discharge end of the pug mixer and/or pitch of the mixing paddles shall be so adjusted to maintain a level of mixture in the pug mixer between the paddle shaft and the paddle tips (except at the discharge end).

Truck Scales. A set of standard platform truck scales, conforming to the Item, "Weighing and Measuring Equipment", shall be placed at a location approved by the Engineer.

(2) Asphaltic Material Heating Equipment. Asphaltic material heating equipment shall be adequate to heat the amount of asphaltic material required to the desired temperature. Asphaltic material may be heated by steam coils which shall be absolutely tight. Direct fire heating of asphaltic materials will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the asphalt throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the asphaltic material at the highest temperature.

(3) Spreading and Finishing Machine. The spreading and finishing machine shall be of a type approved by the Engineer, shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test, when required, and when the mixture is dumped directly into the finishing machine shall have adequate power to propel the delivery vehicles in a satisfactory manner. The finishing machine shall be equipped with a flexible spring and/or hydraulic type hitch sufficient in design and capacity to maintain contact between the rear wheels of the hauling equipment and the pusher rollers of the finishing machine while the mixture is being unloaded.

The use of any vehicle which requires dumping directly into the finishing machine and which the finishing machine cannot push or propel in such a manner as to obtain the desired lines and grades without resorting to hand finishing will not be allowed. Unless otherwise permitted by the plans, vehicles of the semi-trailer type are specifically prohibited from dumping directly into the finishing machine while in contact with the finishing machine. Vehicles dumping directly or indirectly into the finishing machine shall be so designed and equipped that unloading into the finishing machine can be mechanically and/or automatically operated in such a manner that overloading the finishing machine being used cannot occur and the required lines and grades will be obtained without resorting to hand finishing.

Dumping of the asphaltic mixture in a windrow and then placing the mixture in the finishing machine with loading equipment will be permitted provided that the loading equipment is constructed and operated in such manner that substantially all of the mixture deposited on the roadbed is picked up and loaded in the finishing machine without contamination by foreign material of the mixture and excessive temperature loss is not encountered. The loading equipment will be so designed and operated that the finishing machine being loaded will obtain the required line, grade and surface without resorting to hand finishing. Any operation of the loading equipment resulting in the accumulation and subsequent shedding of this accumulated material into the asphaltic mixture will not be permitted.

Automatic screed controls, if required, shall meet the requirements of the Item, "Automatic Screed Controls for Asphaltic Concrete Spreading and Finishing Machines".

(4) Motor Grader. The motor grader, if used, shall be a self-propelled power motor grader; it shall be equipped with smooth tread pneumatic tired wheels; shall have a blade length of not less than 12 feet; shall have a wheel base of not less than 16 feet; and shall be tight and in good operating condition and approved by the Engineer.

(5) Pneumatic Tire Rollers. The rollers shall be acceptable medium pneumatic tire rollers conforming to the requirements of the Item "Rolling (Pneumatic Tire)", Type B, unless otherwise specified on plans.

The tire pressure of each tire shall be adjusted as directed by the Engineer and this pressure shall not vary by more than 5 pounds per square inch.

(6) Two Axle Tandem Roller. This roller shall be an acceptable power driven tandem roller weighing not less than 8 tons.

(7) Three Wheel Roller. This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(8) Three Axle Tandem Roller. This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(9) Trench Roller. This roller shall be an acceptable power driven trench roller equipped with sprinkler for keeping the wheels wet and adjustable road wheel so that the roller may be kept level during rolling. The drive wheel shall be not less than 20 inches wide.

The roller under working conditions shall produce 325 pounds per linear inch of roller width and be so geared that a speed of 1.8 miles per hour is obtained in low gear.

(10) Straightedges and Templates. When directed by the Engineer, the Contractor shall provide acceptable 10 foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(11) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

(12) Alternate Equipment. When permitted by the Engineer in writing, equipment other than that specified which will consistently produce satisfactory results may be used.

340.5. Stockpiling, Storage, Proportioning and Mixing.

(1) Stockpiling of Aggregates. Prior to stockpiling of aggregates, the area shall be cleaned of trash, weeds and grass and be relatively smooth. Aggregates shall be stockpiled in such a manner as to prevent mixing of one aggregate with another. Coarse aggregates for "B" and "C" shall be separated into at least two stockpiles of different gradation, such as a large coarse aggregate and a small coarse aggregate stockpile and such that the grading requirements of the specified type will be met when the piles are combined in the asphaltic mixture. No coarse aggregate stockpile shall contain more than 15 percent by weight of material that will pass a No. 10 sieve except as noted

on the plans. Fine aggregate stockpiles may contain coarse aggregate in the amount of up to 20 percent by weight, however, the coarse aggregate shall meet the quality tests specified herein for "Coarse Aggregates". Suitable equipment of acceptable size shall be furnished by the Contractor to work the stockpiles and prevent segregation of the aggregates.

(2) Storage and Heating of Asphaltic Materials. The asphaltic material storage shall be ample to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of that specified in the Item, "Asphalts, Oils and Emulsions". All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such manner that there will be no contamination with foreign matter.

(3) Feeding and Drying of Aggregate. The feeding of various sizes of aggregate to the dryer shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. When specified on the plans, the cold aggregate bins shall be charged by use of a clamshell, dragline, shovel or front end loader. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature. In no case shall the aggregate be introduced into the mixing unit at a temperature more than 400 F.

(4) Proportioning. The proportioning of the various materials entering into the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weight-batch type of plant is used and by volume using the hot aggregate proportioning device when the continuous mixer type of plant is used. The asphaltic material shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) Mixing.

(a) Batch Type Mixer. In the charging of the weigh box and in the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of 5 to 20 seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than 30 seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

(b) Continuous Type Mixer. The amount of aggregate and asphaltic material entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and asphalt content will be produced. The differential in temperature of the aggregates and the asphalt as they enter the pug mixer shall not exceed 25 F.

Checks on asphalt used shall be made at least twice daily by comparing the asphalt used in ten loads of completed mix as shown on the asphalt recording meter and the design amount for these ten loads. The acceptable percent of variation between the asphalt used and the design amount will be as shown on the plans or as determined by the Engineer.

(c) The mixture produced from each type of mixer shall not vary from the specified mixture by more than the tolerances herein specified.

(d) The asphaltic mixture from each type of mixer shall be at a temperature between 225 F and 350 F when discharged from the mixer. The Engineer will determine the temperature, within the above limitations, and the mixture when discharged from the mixer shall not vary from this selected temperature more than 25 F.

(e) A Surge-Storage System may be used during the normal day's operation. Overnight storage will not be permitted unless authorized in the plans or in writing by the Engineer. The mixture coming out of the surge-storage bin must be of equal quality to that coming out of the mixer.

340.6. Construction Methods. The prime coat, tack coat or the asphaltic mixture when placed with a spreading and finishing machine, shall not be placed when the air temperature is below 50 F and is falling, but it may be placed when the air temperature is above 40 F and is rising. The asphaltic mixture when placed with a motor grader, shall not be placed when the air temperature is below 60 F and is falling, but may be placed when the air temperature is above 50 F and is rising. The air temperature shall be taken in the shade away from artificial heat. It is further provided that the prime coat, tack coat or asphaltic mixture shall be placed only when the humidity, general weather conditions and temperature and moisture condition of the base, in the opinion of the Engineer, are suitable.

If the temperature of the asphaltic mixture of a load or any part of a load becomes 50 F or more less than the temperature selected by the Engineer under subarticle 340.5(5) of this specification after being dumped from the mixer and prior to placing while passing through the lay-down machine, all or any part of the load may be rejected and payment will not be made for the rejected material.

(1) Prime Coat. If a prime coat is required, it shall be applied and paid for as a separate item conforming to the requirements of the Item, "Prime Coat", except the application temperature shall be as provided above. The tack coat or asphaltic concrete shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat. Before the asphaltic mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat using asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate

not to exceed 0.05 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material meeting the requirements for tack coat. The tack coat shall be rolled with a pneumatic tire roller when directed by the Engineer.

(3) Transporting Asphaltic Concrete. The asphaltic mixture, prepared as specified above, shall be hauled to the work in tight vehicles previously cleaned of all foreign material. The dispatching of the vehicles shall be arranged so that all material delivered may be placed, and all rolling shall be completed during daylight hours. In cool weather or for long hauls, canvas covers and insulating of the truck bodies may be required. The inside of the truck body may be given a light coating of oil, lime slurry or other material satisfactory to the Engineer, if necessary, to prevent mixture from adhering to the body.

(4) Placing.

(a) Generally the asphaltic mixture shall be dumped and spread on the approved prepared surface with the specified spreading and finishing machine, in such manner that when properly compacted the finished pavement will be smooth, of uniform density and will meet the requirements of the typical cross sections and the surface tests. During the application of asphaltic material, care shall be taken to prevent splattering of adjacent pavement, curb and gutter and structures.

(b) In placing a level-up course with the spreading and finishing machine, binder twine or cord shall be set to line and grade established by the Engineer. When directed by the Engineer, level-up courses shall be spread with the specified motor grader.

(c) When the asphaltic mixture is placed in a narrow strip along the edge of an existing pavement, or used to level up small areas of an existing pavement or placed in small irregular areas where the use of a finishing machine is not practical, the finishing machine may be elimated when authorized by the Engineer, provided a satisfactory surface can be obtained by other approved methods.

(d) Flush Structures. Adjacent to flush curbs, gutters, liners and structures, the surface shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb and flush structure.

(5) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers and/or other approved rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheel unless otherwise directed by the Engineer. Alternate trips of the roller shall

be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side unless otherwise directed by the Engineer. Rolling with pneumatic-tire roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller, one pneumatic-tire roller and at least one three wheel roller, as specified above shall be provided for each job. If the Contractor elects, he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller; but in no case shall less than three rollers be in use on each job. Additional rollers shall be provided if needed. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixtures where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease or other foreign matter on the pavement, either when the rollers are in operation or when standing.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

(c) In Place Density. When in place density is required, it is the intent of this specification that the material be placed and compacted to the percent density shown on the plans and determined by the test method specified on the plans. The field specimens utilized for the in place density testing may be either cores or sections of asphaltic pavement. Other methods of determining in place density which correlate satisfactorily with those results obtained through use of the test method shown on the plans may be used. In place density tests are intended for compaction control tests. If the in place density of the mixture produced has a value lower than that specified and in the opinion of the Engineer is not due to a change in the quality of the material, production may proceed with subsequent changes in the mix and/or construction operations until the in place density equals or exceeds the specified density. Requirements specifying air temperature limitations for placing and types of rollers to be furnished are not applicable when in place density is specified. Rolling procedures and rolling sequence shall be satisfactory to the Engineer.

(d) Hand Tamping. The edges of the pavement along curbs, headers and similar structures, and all places not accessible to the roller, or in such positions as will not allow thorough compaction with the rollers, shall be thoroughly compacted with lightly oiled tamps.

(e) Rolling with the trench type roller will be required on widening areas in trenches and other limited areas where satisfactory compaction cannot be obtained with the rollers specified or approved.

(6) Surface Tests. The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross section, and when tested with a 10 foot straightedge placed parallel to the centerline of the roadway or tested by other equivalent and acceptable means, except as provided herein, the maximum deviation shall not exceed 1/8 inch in 10 feet, and any point in the surface not meeting this requirement shall be corrected as directed by the Engineer. When placed on existing surfaces, the 1/8 inch deviation in 10 feet requirement may be waived by the Engineer.

(7) Opening to Traffic. The pavement shall be opened to traffic when directed by the Engineer. The Contractor's attention is directed to the fact that all construction traffic allowed on pavement open to the public will be subject to the State laws governing traffic on highways.

If the surface ravels, it will be the Contractor's responsibility to correct this condition at his expense.

340.7. Measurement.

Asphaltic concrete will be measured separately by the ton of 2,000 pounds of "Asphalt" and "Aggregate" of the type actually used in the completed and accepted work in accordance with the plans and specifications for the project. Measurement, if mixing is done by a continuous mixer, will be made on truck scales adjusted as specified in subarticle 340.4(1)(b). Measurement, if batched by weight, may be made on the batch scales and records of the number of batches, batch designs and weight of "Asphalt" and "Aggregate" shall be kept. Where surge-storage is used, measurement of material taken from the surge-storage bin will be made on truck scales.

340.8. Payment.

(1) The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt" and "Aggregate", of the types specified, which prices shall be full compensation for quarrying, furnishing all materials, freight involved; for all heating, mixing, hauling, cleaning the existing base course or pavement, tack coat, placing asphaltic concrete mixture, rolling and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except prime coat when required.

(2) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(3) All templates, straightedges, scales and other weighing and measuring devices necessary for the proper construction, measuring and checking of the work shall be furnished, operated and maintained by the Contractor at his expense.

ITEM 350

HOT MIX-COLD LAID ASPHALTIC CONCRETE PAVEMENT (Class A)

350.1. Description. This item shall consist of a base course, a leveling-up course, a surface course or any combination of these courses as shown on the plans, each to be composed of a compacted mixture of mineral aggregate and asphaltic material.

The pavement shall be constructed on the previously completed and approved subgrade, base, existing pavement, bituminous surface or in the case of a bridge, on the prepared slab as herein specified and in accordance with the details shown on the plans.

350.2. Materials.

(1) Mineral Aggregate. The mineral aggregate shall be composed of a coarse aggregate, a fine aggregate, and if required, a mineral filler. Samples of coarse aggregate, fine aggregate and mineral filler shall be submitted in accordance with the methods prescribed in the Item "Control of Materials" of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery.

The combined mineral aggregate, after final processing by the mixing plant and prior to addition of asphalt and mineral filler, shall have a sand equivalent value of not less than 45, unless otherwise shown on plans when tested in accordance with Test Method Tex-203-F. Mineral aggregate from each source will meet the quality tests specified hereafter unless otherwise specified on the plans.

(a) Coarse Aggregate. Coarse aggregate shall be that part of the aggregate retained on the No. 10 sieve; shall consist of clean, tough, durable fragments of stone, crushed blast furnace slag, crushed gravel, gravel, cinder aggregate (produced by burning lignite or coal), crushed limestone rock asphalt or combination thereof as hereinafter specified and/or as shown on the plans, of uniform quality throughout. When specified on the plans, other coarse aggregate material may be permitted or required.

The point of sampling for tests, Test Method Tex-217-F (Part I and Part II) will be as shown on the plans.

When the coarse aggregate is tested in accordance with Test Method Tex-217-F (Part I, Separation of Deleterious Material), the amount of organic matter, clay, loam or particles coated therewith or other undesirable materials shown in the plans shall not exceed two percent and when the remaining part of the sample is further tested in accordance with Test Method Tex-217-F (Part II, Decantation), the amount of material removed shall not be more than two percent.

When it is specified that the coarse aggregate be sampled from the hot bins and tested in accordance with Test Method Tex-217-F (Part II, Decantation), the amount of material removed shall not exceed 1 percent.

When it is specified that the coarse aggregate be sampled during delivery to the plant, from the stockpile, or from the cold bin, the material removed

when tested in accordance with Test Method Tex-217-F (Part II, Decantation), shall not exceed two percent.

The coarse aggregate (each coarse aggregate when a combination of materials is used) shall have an abrasion of not more than forty percent loss by weight when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A unless otherwise shown on the plans.

Unless specified otherwise, gravel shall be so crushed that the percent as shown on the plans of the particles retained on the No. 4 sieve shall have more than one crushed face when tested in accordance with Test Method Tex-413-A (Particle Count).

(b) Fine Aggregate. The fine aggregate shall be that part of the aggregate passing the No. 10 sieve and shall consist of sand, screenings or combination thereof as hereinafter specified and/or as shown on the plans of uniform quality throughout. When specified on the plans, other fine aggregate material may be permitted or required.

Fine aggregate shall consist of durable particles, free from injurious foreign matter. Screenings shall be of the same or similar material as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6 when tested in accordance with Test Method Tex-106-E. Fine aggregate from each source shall meet plasticity requirements.

Where stone screenings are specified for use, the stone screenings shall meet the following grading requirements unless otherwise shown on plans:

	Percent by Weight
Passing the 3/8" Sieve	100
Passing the No. 200 Sieve	10 - 30

When authorized by the Engineer, stone screenings containing particles larger than 3/8" may be used but only that portion of the material passing the 3/8" sieve shall be considered as fulfilling the requirements for screenings when a minimum percentage of screenings is specified for a particular mixture.

Where limestone rock asphalt screenings are specified for use, they shall be screenings resulting from a crushing operation.

(c) Mineral Filler. Mineral filler shall consist of thoroughly dry stone dust, slate dust, portland cement, fly ash or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter.

When tested by Test Method Tex-200-F (Dry Sieve Analysis), it shall meet the following grading requirements, unless otherwise shown on the plans:

	Percent by Weight
Passing a No. 30 Sieve	95 - 100
Passing a No. 80 Sieve, not less than	75
Passing a No. 200 Sieve, not less than	55

(2) **Asphaltic Material.**

(a) Paving Mixture. Asphalt for the paving mixture shall be of the types of asphalt cement or oil asphalt as determined by the Engineer and shall meet the requirements of the Item, "Asphalts, Oils and Emulsions". The grade of asphalt used shall be as designated by the Engineer after design tests have been made using the mineral aggregates that are to be used in the project. If more than one type of asphaltic concrete mixture is specified for the project, only one grade of asphalt will be required for all types of mixtures, unless otherwise shown on plans. The Contractor shall notify the Engineer of the source of his asphaltic material prior to design or production of the asphaltic mixture and this source shall not be changed during the course of the project except on written permission of the Engineer.

(b) Tack Coat. The asphaltic material for tack coat shall meet the requirements for emulsified asphalt EA-11M, cut-back asphalt RC-2, or shall be a cut-back asphalt made by combining 50 to 70 percent by volume of the asphaltic material as specified for the type of paving mixture with 30 to 50 percent by volume of gasoline and/or kerosene. If RC-2 cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of an approved grade of gasoline and/or kerosene, not to exceed 15 percent by volume. Asphaltic materials shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

350.3. Paving Mixtures.

(1) Types. The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate, asphaltic material and mineral filler, if required.

The grading of each constituent of the mineral aggregate shall be such as to produce when properly proportioned, a mixture which, when tested in accordance with Test Method Tex-200-F (Dry Sieve Analysis), will conform to the limitations for master grading given below for the type specified unless otherwise shown on plans.

Type "B" (Fine Graded Base or Leveling-up Course):	**Percent by Weight**
Passing 1" sieve	100
Passing 7/8" sieve	95 to 100
Passing 7/8" sieve, retained on 3/8" sieve	20 to 50
Passing 3/8" sieve, retained on No. 4 sieve	10 to 40
Passing No. 4 sieve, retained on No. 10 sieve	5 to 25
Total retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 20
Passing No. 80 sieve, retained on No. 200 sieve	3 to 20
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "C" (Coarse Graded Surface Course):

Passing 7/8" sieve	100
Passing 5/8" sieve	95 to 100
Passing 5/8" sieve, retained on 3/8" sieve	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve	10 to 35
Passing No. 4 sieve, retained on No. 10 sieve	10 to 30
Total retained on No. 10 sieve	50 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 25
Passing No. 80 sieve, retained on No. 200 sieve	3 to 25
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "D" (Fine Graded Surface Course):

Passing 1/2" sieve	100
Passing 3/8" sieve	95 to 100
Passing 3/8" sieve, retained on No. 4 sieve	20 to 50
Passing No. 4 sieve, retained on No. 10 sieve	10 to 30
Total retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 25
Passing No. 80 sieve, retained on No. 200 sieve	3 to 25
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 4.0 to 7.5 percent of the mixture by weight.

Type "DD" (Fine Graded Surface Course):

Passing 3/8" sieve	100
Passing 1/4" sieve	80 to 100
Passing 1/4" sieve, retained on No. 10 sieve	25 to 55
Total retained on No. 10 sieve	40 to 55
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 30
Passing No. 80 sieve, retained on No. 200 sieve	3 to 30
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 4.0 to 7.5 percent of the mixture by weight.

Type "F" (Fine Graded Surface Course):

Passing 1/2" sieve	100
Passing 3/8" sieve	95 to 100
Passing 3/8" sieve, retained on No. 4 sieve	10 to 35
Passing No. 4 sieve, retained on No. 10 sieve	15 to 45
Total retained on No. 10 sieve	60 to 75
Passing No. 10 sieve, retained on No. 40 sieve	0 to 25
Passing No. 40 sieve, retained on No. 80 sieve	3 to 12
Passing No. 80 sieve, retained on No. 200 sieve	2 to 10
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 3.5 to 5.5 percent of the mixture by weight.

Type "FF" (Fine Graded Surface Course):

Passing 3/8" sieve	100
Passing 1/4" sieve	95 to 100
Passing 1/4" sieve, retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 25
Passing No. 40 sieve, retained on No. 80 sieve	3 to 12
Passing No. 80 sieve, retained on No. 200 sieve	2 to 10
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 3.5 to 5.5 percent of the mixture by weight.

Type "G":

Grading requirements and asphalt content shall be as shown on the plans.

(2) **Tolerances.** The Engineer will designate the exact grading of the aggregate and asphalt content, within the above limits, to be used in the mixture. The paving mixture produced should not vary from the designated grading and asphalt content by more than the tolerances allowed herein; however, the mixture produced shall conform to the limitations for master grading specified above.

	Percent by Weight
Passing 7/8" sieve, retained on 5/8" sieve	Plus or minus 5
Passing 5/8" sieve, retained on 3/8" sieve	Plus or minus 5
Passing 3/8" sieve, retained on No. 4 sieve	Plus or minus 5
Passing 1/4" sieve, retained on No. 10 sieve	Plus or minus 5
Passing No. 4 sieve, retained on No. 10 sieve	Plus or minus 5
Total retained on No. 10 sieve	Plus or minus 5
Passing No. 10 sieve, retained on No. 40 sieve	Plus or minus 3
Passing No. 40 sieve, retained on No. 80 sieve	Plus or minus 3
Passing No. 80 sieve, retained on No. 200 sieve	Plus or minus 3
Passing No. 200 sieve	Plus or minus 3
Asphalt Material	Plus or minus 0.5

Should the paving mixture produced vary from the designated grading and asphalt content by more than the above tolerances, proper changes are to be made until it is within these tolerances.

(3) Primer. The use of an asphaltic primer when approved by the Engineer, will be permitted. In the event the asphalt primer is used, the hydrocarbon volatile content of the asphaltic concrete, as determined by Test Method Tex-213-F, shall not exceed 0.6 percent of the mixture by weight. The asphalt content of the primer shall be included in the total asphalt content of the paving mixture.

(4) Water. Water in an amount not to exceed 3 percent by weight of the mixture, as determined by Test Method Tex-212-F may be used in preparing the mixture. In the event water is used in the mixing operation, adequate measuring devices as approved by the Engineer shall be used, and the water shall be administered to the mix through an approved spray bar.

The primer and/or water shall be added as directed by the Engineer during the mixing.

(5) Physical Properties of the Mixture. The materials may be mixed on the job or at some central mixing plant and shipped ready for use. Mixtures that do not remain workable a sufficient period of time to permit unloading by normal means, proper spreading, blading and rolling will not be acceptable.

(6) Extraction Test. Samples of the mixture when tested in accordance with Test Method Tex-210-F shall not vary from the grading proportions of the aggregate and the asphalt content designated by the Engineer by more than the respective tolerances specified above and shall be within the limits specified for master grading.

(7) Sampling and Testing. It is the intent of this specification to produce a mixture which when designed and tested in accordance with these specifications and methods outlined in THD Bulletin C-14, will have the following laboratory density and stability:

Density, Percent			**Stability, Percent**
Min.	Max.	Optimum	
93	96	95	
95	99	97 (Applicable when placing hot is specified or permitted)	Not less than 30 unless otherwise shown on plans.

Stability and density tests are control tests. If the laboratory stability and/or density of the mixture produced has a value lower than that specified, and in the opinion of the Engineer is not due to change in source or quality of materials, production may proceed, and the mix shall be changed until the laboratory stability and density equals or exceeds the specified values. If there is, in the opinion of the Engineer, an apparent change in any material from that used in the design mixtures, production will be discontinued until a new design mixture is determined by trial mixes.

350.4. Equipment.

(1) Mixing Plants. Mixing plants that will not continuously produce a mixture meeting all of the requirements of this specification will be condemned.

Mixing plants may be either the weight-batching type or the continuous mixing type. (See Article 350.5 also) Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins and dust collectors and shall consist of the following essential pieces of equipment:

(a) Weight-batching Type.

Cold Aggregate Bin and Proportioning Device. The cold aggregate bin shall have at least four compartments of sufficient size to store the amount of aggregate required to keep the plant in continuous operation and of proper design to prevent overflow of material of one bin to that of another bin. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each aggregate shall be proportioned in a separate compartment.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that aggregate will not be injured in the necessary drying and heating operations required to obtain a mixture of the specified temperature. The burner, or combination of burners, and type of fuel used shall be such that in the process of heating the aggregate to the desired or specified temperature, no residue from the fuel shall adhere to the heated aggregate. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. Provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where representative samples may be taken from the hot bins for testing. The aggregate shall be separated into at least four bins when producing Type "B" and Type "C" mixtures and at least three bins when producing Type "D" and Type "F" mixtures, and at least two bins when producing the other type mixtures. If mineral filler is used, an additional bin shall be provided. These bins shall contain the following sizes of aggregates.

Type "B" (Fine Graded Base or Leveling-up Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 70 percent by weight will be of such size as to pass the No. 4 sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 1 inch sieve and be retained on the 3/8 inch sieve.

Type "C" (Coarse Graded Surface Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 70 percent by weight will be of such size as to pass the No. 4 sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 7/8 inch sieve and be retained on the 3/8 inch sieve.

Type "D" (Fine Graded Surface Course): and
Type "F" (Fine Graded Surface Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 70 percent by weight will be of such size as to pass the No. 4 sieve and be retained on the No. 10 sieve.

Bin No. 3—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 1/2 inch sieve and be retained on the No. 4 sieve.

Type "DD" (Fine Graded Surface Course): and
Type "FF" (Fine Graded Surface Course):

Bin No. 1—will contain aggregates of which 85 to 100 percent by weight will pass the No. 10 sieve.

Bin No. 2—will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 3/8 inch sieve and be retained on the No. 10 sieve.

Aggregate Weigh Box and Batching Scales. The aggregate weigh box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weigh box and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

Asphaltic Material Bucket and Scales. The asphaltic material bucket and scales shall be of sufficient capacity to hold and weigh the necessary asphaltic material for one batch. If the material is measured by weight, the bucket and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

If a pressure type flow meter is used to measure the asphaltic material, the requirements of the Item "Weighing and Measuring Equipment" shall apply.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 3,000 pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the asphaltic material quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the asphaltic material shall not be used. This shall be determined by mixing the standard batch for the required time, then dumping the mixture and taking samples from its different parts. This will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type.

Cold Aggregate Bin and Proportioning Device. Same as for the weight-batching type of plant.

Dryer. Same as for weight-batching type of plant.

Screening and Proportioning. Same as for weight-batching type of plant.

Hot Aggregate Proportioning Device. The hot aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Asphaltic Material Spray Bar. The asphaltic material spray bar shall be so designed that the asphalt will spray uniformly and continuously into the mixer.

Asphaltic Material Meter. An accurate asphaltic material recording meter shall be placed in the asphalt line leading to the spray bar so that the accumulative amount of asphalt used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of the meter output.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than 40 tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used.

Truck Scales. A set of standard platform truck scales, conforming to the Item, "Weighing and Measuring Equipment", shall be placed at a location approved by the Engineer.

(2) Asphaltic Material Heating Equipment. Asphaltic material heating equipment shall be adequate to heat the amount of asphaltic material required to the desired temperature. Asphaltic material may be heated by steam coils which shall be absolutely tight. Direct fire heating of asphaltic

materials will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the asphalt throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24 hour chart that will record the temperature of the asphaltic material where it is at the highest temperature.

(3) Spreading and Finishing Machine. The spreading and finishing machine shall be of a type approved by the Engineer, shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test, when required, and shall have adequate power to propel the delivery vehicles in a satisfactory manner when the mixture is dumped into the finishing machine. The finishing machine shall be equipped with a flexible spring and/or hydraulic type hitch sufficient in design and capacity to maintain contact between the rear wheels of the hauling equipment and the pusher rollers of the finishing machine while the mixture is being unloaded.

Any vehicle which the finishing machine cannot push or propel in such a manner as to obtain the desired lines and grade without resorting to hand finishing will not be allowed to dump directly into the finishing machine. Unless otherwise permitted by the plans, vehicles of the semi-trailer type are specifically prohibited from dumping directly into the finishing machine. Vehicles dumping into the finishing machine shall be so designed and equipped that unloading into the finishing machine can be mechanically and/or automatically operated in such a manner that overloading the finishing machine being used cannot occur and the required line and grade will be obtained without resorting to hand finishing.

Dumping of the asphaltic mixture in a windrow and then placing the mixture in the finishing machine with loading equipment will be permitted provided that the loading equipment is constructed and operated in such manner that substantially all of the mixture deposited on the roadbed is picked up and placed in the finishing machine without contamination by foreign material of the mixture. The loading equipment will be so designed and operated that the finishing machine being loaded will obtain the required line, grade and surface without resorting to hand finishing. Any operation of the loading equipment resulting in the accumulation and subsequent shedding of this accumulated material into the asphaltic mixture will not be permitted.

Automatic screed controls, if required, shall meet the requirements of the Item, "Automatic Screed Controls for Asphaltic Concrete Spreading and Finishing Machines".

(4) Motor Grader. The motor grader, if used, shall be a self-propelled power motor grader; it shall be equipped with smooth tread pneumatic tired wheels; shall have a blade length of not less than 12 feet; shall have a wheel base of not less than 16 feet; and shall be tight and in good operating condition and approved by the Engineer.

On courses applied with a blade, a motor grader shall be provided. A windrow evener box may be required for quantity control on level up courses when directed by the Engineer in writing.

(5) Pneumatic Tire Rollers. The roller shall be an acceptable medium pneumatic tire roller conforming to the requirements of the Item, "Rolling (Pneumatic Tire)", Type B, unless otherwise specified on plans.

The tire pressure of each tire shall be adjusted as directed by the Engineer and this pressure shall not vary by more than 5 pounds per square inch.

(6) Two Axle Tandem Roller. This roller shall be an acceptable power driven tandem roller weighing not less than 8 tons.

(7) Three Wheel Roller. This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(8) Three Axle Tandem Roller. This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(9) Trench Roller. This roller shall be an acceptable power driven trench roller equipped with sprinkler for keeping the wheels wet and adjustable road wheel so that the roller may be kept level during rolling. The drive wheel shall be not less than 20 inches wide.

The roller under working conditions shall produce 325 pounds per linear inch of roller width and be so geared that a speed of 1.8 miles per hour is obtained in low gear.

(10) Straightedges and Templates. When directed by the Engineer, the Contractor shall provide acceptable 10-foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(11) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

(12) When permitted by the Engineer in writing, equipment other than that specified which will consistently produce satisfactory results may be used.

350.5. Stockpiling, Storage, Proportioning And Mixing.

(1) Stockpiling of Aggregates. Prior to stockpiling of aggregates, the area shall be cleaned of trash, weeds and grass and be relatively smooth. Aggregates shall be stockpiled in such a manner as to prevent mixing of one aggregate with another. Coarse aggregates for Types "B" and "C" shall be separated into at least two stockpiles of different gradation, such as a large coarse aggregate, and small coarse aggregate stockpile and such that the grading requirements of the specified type will be met when the piles are combined in the asphaltic mixture. No coarse aggregate stockpile shall contain more than 15 percent by weight of material that will pass a No. 10 sieve except as noted on the plans. Fine aggregate stockpiles may contain coarse aggregate in the amount of up to 20 percent by weight; however, the coarse aggregate shall meet the quality tests specified herein for "Coarse Aggregates". Suitable equipment of acceptable size shall be furnished by the Contractor to work the stockpiles and prevent segregation of the aggregates. When required by the plans, the cold bins shall be charged by the use of a clamshell, dragline, shovel or front-end loader.

(2) **Storage and Heating of Asphaltic Materials.** The asphaltic material storage shall be ample to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of that specified in the Item, "Asphalts, Oils and Emulsions". All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such a manner that there will be no contamination with foreign matter.

(3) **Feeding and Drying of Aggregate.** The feeding of various sizes of aggregate to the dryer shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature. In no case shall the aggregate be introduced into the mixing unit at a temperature more than 400 F.

(4) **Proportioning.** The proportioning of the various materials entering into the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weight-batch type of plant is used and by volume using the hot aggregate proportioning device when the continuous mixer type of plant is used. The asphaltic material shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) **Mixing.**

(a) **Batch Type Mixer.** In the charging of the weigh box and in the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of 5 to 20 seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than 30 seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

(b) **Continuous Type Mixer.** The amount of aggregate and asphaltic material entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and asphalt content will be produced.

(c) **The mixture produced** from each type of mixer shall not vary from the specified mixture more than the tolerances herein specified.

(d) **The asphaltic mixture** when placed cold shall be at a temperature between 145 F and 275 F when dumped from the mixer. The Engineer will determine the temperature within the above limitations that the mixture should be produced.

The asphaltic mixture when placed hot shall be at a temperature between 225 F and 350 F when dumped from the mixer. The Engineer will determine the temperature within the above limitations and the mixture when dumped from the mixer shall not vary from this selected temperature more than 25 F.

350.6. Construction Methods. The prime coat, tack coat or the asphaltic mixture when placed hot with a spreading and finishing machine, shall not be placed when the air temperature is below 50 F and is falling, but it may be placed when the air temperature is above 40 F and is rising. The asphaltic mixture when placed cold or placed with a motor grader, shall not be placed when the air temperature is below 60 F and is falling, but may be placed when the air temperature is above 50 F and is rising. The air temperature shall be taken in the shade away from artificial heat. It is further provided that the prime coat, tack coat or asphaltic mixture shall be placed only when the humidity, general weather conditions and temperature and moisture condition of the base, in the opinion of the Engineer, are sutiable.

If the temperature of the asphaltic mixture of a load or any part of a load where the mixture is to be placed hot becomes 50 F or more, or as shown on the plans, less than the temperature selected by the Engineer under Subarticle 350.5(5) of this specification after being dumped from the mixer and prior to placing or passing through the laydown machine, all or any part of the load may be rejected and payment will not be made for the rejected material.

(1) Prime Coat. If a prime coat is required, it will be applied and paid for as a separate item conforming to the requirements of the Item, "Prime Coat", except the application temperature shall be as provided above. The tack coat or asphaltic concrete shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat. Before the asphaltic mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat using asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate not to exceed 0.05 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material meeting the requirements for tack coat. The tack coat shall be rolled with a pneumatic tire roller as directed by the Engineer.

(3) Placing. If the mixtures are shipped to the job, the railroad cars shall first be cleaned of all foreign matter, and the material shall be loaded in such a manner as to prevent segregation. The asphaltic concrete mixture, prepared as specified, shall be hauled to the work in tight vehicles previously cleaned of all foreign materials. The dispatching of the vehicles shall be so that all material delivered may be placed and shall have received its initial rolling in daylight. The mixture shall be laid only on an approved base course or pavement which has been tack-coated as previously specified and shall be free

of all foreign materials. All contact surfaces of curbs and structures and all joints shall be painted with a thin, uniform coating of cut-back or emulsified asphalt as required for tack-coating the base. The mixture shall be thoroughly aerated and then spread into place with a power motor grader in a uniform layer of such depth that after receiving ultimate compaction by rolling, the requirements of the typical cross sections will have been fulfilled. Hand spreading will be permitted where the mixture is placed on narrow strips or small irregular areas. During the application of asphaltic material, care shall be taken to prevent splattering of adjacent pavement, curb and gutter and structures.

Where more than one course of pavement is to be placed and the material is to be laid cold, no succeeding course shall be placed until the preceding course has been in place for a sufficient period of time for the preceding course to dry and cure out. The drying and curing period shall be not less than 45 days in any case, unless a variation is authorized by the Engineer in writing.

Alternate Method of Placing. When shown on the plans or directed by the Engineer in writing, the mixture may be spread with the specified spreading and finishing machine. In placing the material with a spreading and finishing machine, rolling shall be deferred for a period of time, as directed by the Engineer, to allow for volatilization. Where more than one course of pavement is to be placed and the material to be laid cold, no succeeding course shall be placed until the preceding course has been in place for a sufficient period of time for the preceding course to dry and cure out. The drying and curing period shall be not less than 45 days in any case, unless a variation is authorized by the Engineer in writing.

(4) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers and/or other approved rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels unless otherwise directed by the Engineer. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side unless otherwise directed by the Engineer. Rolling with pneumatic roller shall be done as directed by the Engineer.

Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller, one pneumatic tire roller and at least one three wheel roller as specified above shall be provided for each job. If the Contractor elects, he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller; but in no case shall less than three rollers be in use on each job. Additional rollers shall be provided if needed. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement

occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease or other foreign matter on the pavement, either when the rollers are in operation or when standing.

In lieu of the rolling equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent relative compaction as the specified equipment. If the substituted compaction equipment fails to produce the desired compaction as would be expected of the specified equipment, as determined by the Engineer, its use shall be discontinued.

(c) In Place Density. When in place density is required, it is the intent of this specification that the material be placed and compacted to the percent density shown on the plans and determined by the test method specified on the plans. The field specimens utilized for the in place density testing may be either cores or sections of asphaltic pavement. Other methods of determining in place density which correlate satisfactorily with those results obtained through use of the test method shown on the plans may be used. In place density tests are intended for compaction control tests. If the in place density of the mixture produced has a value lower than that specified and in the opinion of the Engineer is not due to a change in the quality of the material, production may proceed with subsequent changes in the mix and/or construction operations until the in place density equals or exceeds the specified density. Requirements specifying types of rollers to be furnished are not applicable when in place density is specified. Rolling procedures and rolling sequence shall be satisfactory to the Engineer.

(d) Hand Tamping. The edges of the pavement along curbs, headers and similar structures and all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacated with lightly oiled tamps.

(5) Surface Test. The surface of the pavement, after compression shall be smooth and true to the established line, grade and cross section, and when tested with a 10-foot straightedge placed parallel to the centerline of the roadway or tested by other equivalent and acceptable means, except as provided herein, the maximum deviation shall not exceed 1/8 inch in 10 feet, and any point in the surface not meeting this requirement shall be corrected as directed by the Engineer. When placed on existing surfaces, the 1/8 inch deviation in 10 feet requirements may be waived by the Engineer.

(6) Opening to Traffic. The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highway.

If the surface ravels, it will be the Contractor's responsibility to correct this condition at his expense.

350.7. Measurement.

Asphaltic concrete will be measured by the ton of 2,000 pounds of the type or types actually used in the completed and accepted work, in accordance with the plans and specifications for the project. Measurement, if batched by weight, may be made on the batch scales and records of the number of batches, batch designs and weight of each truck load will be kept. Measurement, if mixing is done by a continuous mixer, or shipped to job in railroad cars, will be made on truck scales.

350.8. Payment.

(1) The work performed and material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Hot Mix-Cold Laid Asphaltic Concrete Pavement" of the types specified, which price shall be full compensation for quarrying, furnishing all materials, freight involved, for all heating, mixing, hauling, cleaning the existing base course or pavement, tack coat, placing asphaltic concrete mixture, rolling and finishing, and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work, except prime coat, when required.

(2) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(3) All templates, straightedges, scales and other weighing and measuring devices necessary for the proper construction, measuring and checking of the work shall be furnished, operated and maintained by the Contractor at his expense.

ITEM 360
CONCRETE PAVEMENT
(Water Cement Ratio)

360.1. Description. This item shall consist of a pavement and/or base of portland cement concrete, with or without reinforcement as shown on plans, with or without monolithic curbs, constructed as herein specified on the prepared subgrade or other base course in conformity with the thickness and typical cross sections shown on plans and to the lines and grades established by the Engineer. Concrete shall be considered of satisfactory quality provided it is made (a) of materials accepted for the job, (b) in the proportions established by the Engineer and (c) mixed, placed, finished and cured in accordance with the requirements of this specification and meets the requirements herein specified.

360.2. Materials.

(1) Cement. The cement shall be Type I of a standard brand of portland cement. Type III cement shall be used when high early strength concrete is required by the plans or special provisions. If the use of high early strength cement is not specified, and the Contractor desires to use it, he shall obtain written permission of the Engineer and shall assume all additional costs incurred by the use of such cement. Type I and Type III cement shall

conform to the requirements of ASTM Designation: C 150. When Type III cement is used, the average strength of briquettes at the age of 7 days shall be higher than that attained at 3 days. Either the tensile or the compressive tests may be used for either type cement. In addition to the requirements of ASTM Designation C 150, the specific surface area of Type I cement shall not exceed 2,000 square centimeters per gram as measured by the Wagner Turbidimeter in accordance with Test Method Tex-310-D.

Bulk or sacked cement may be used, and a bag shall contain 94 pounds net. All bags shall be in good condition at the time of inspection. Bags varying more than 3 percent from the specified weight may be rejected and if the average net weight in any shipment as shown by weighing 50 bags taken at random is less than that specified, the entire shipment may be rejected. Bulk cement shall be weighed on approved scales as herein prescribed.

Any cement which has become partially set or which contains hard lumps or cakes, or cement salvaged from discarded or used bags, shall not be used.

Any cement storage shall be a suitable weather-tight building or bin which will protect the cement from dampness, and cement shall be so placed as to provide easy access for proper inspection and identification of each shipment.

(2) Admixtures. Unless otherwise provided in the plans or special provisions, approved types of admixtures to minimize segregation, to improve workability, or to reduce the amount of mixing water may be used in the rate of dosage specified by the Engineer. When specified on plans, air-entraining admixture will be required as directed by the Engineer. Admixtures shall not be used to replace cement. Admixtures shall comply with all the requirements and be measured and dispensed in accordance with the Item, "Concrete Admixtures".

(3) Coarse Aggregate. Coarse aggregate shall consist of durable particles of gravel, crushed blast furnace slag and/or crushed stone of reasonably uniform quality throughout, free from injurious amounts of salt, alkali, vegetable matter or other objectionable material, either free or as an adherent coating on the aggregate. It shall not contain more than 0.25 percent by weight of clay lumps, nor more than 1.0 percent by weight of shale nor more than 5.0 percent by weight of laminated and/or friable particles when tested in accordance with Test Method Tex-413-A.

Coarse aggregate shall have a wear of not more than 45 percent when tested according to Test Method Tex-410-A, and when tested by standard laboratory methods shall meet the following grading requirements:

Retained on 1-3/4" sieve	0%
Retained on 1-1/2" sieve	0 to 5%
Retained on 3/4" sieve	30 to 65%
Retained on 3/8" sieve	70 to 90%
Retained on No. 4 sieve	95 to 100%
Loss by Decantation Test Method Tex-406-A	1.0% Maximum

Where the coarse aggregate is delivered on the job in two or more sizes or types, each type and/or size shall be batched and weighed separately.

All aggregates shall be handled and stored in such a manner as to prevent size segregation and contamination by foreign substances. When segregation is apparent, the aggregate shall be remixed. At the time of its use, the aggregate shall be free from frozen material and aggregate containing foreign materials will be rejected. Coarse aggregate that contains more than 0.5 percent free moisture by weight shall be stockpiled for at least 24 hours prior to use.

Adequate storage facilities shall be provided for all approved materials. The intermixing of nonapproved materials with approved materials either in stockpiles or in bins will not be permitted. Aggregates from different sources shall be stored in different stockpiles unless otherwise approved by the Engineer.

Aggregates shall be stockpiled in such a manner to prevent segregation and maintained as nearly as possible in a uniform condition of moisture.

Each aggregate stockpile shall be reworked with suitable equipment at such times as required by the Engineer to remix the material to provide uniformity of the stockpile.

(4) Fine Aggregate. Fine aggregate shall consist of sand or a combination of sands, and shall be composed of clean, hard, durable, uncoated grains. Unless otherwise shown on plans, the acid insoluble residue of the fine aggregate shall be not less than 28 percent by weight when tested in accordance with Test Method Tex-612-J.

Fine Aggregate Exclusive of Mineral Filler. Fine aggregate shall be free from injurious amounts of salt, alkali or vegetable matter. It shall not contain more than 0.5 percent by weight of clay lumps. When subjected to the color test for organic impurities, Test Method Tex-408-A, the fine aggregate shall not show a color darker than the standard.

When the fine aggregate is tested in accordance with Test Method Tex-317-D, it shall have a tensile strength of mortar equal to or greater than the strength of standard Ottawa sand mortar.

Unless specified otherwise, fine aggregate shall meet the following grading requirements:

Retained on 3/8" sieve	0%
Retained on No. 4 sieve	0 to 5%
Retained on No. 8 sieve	0 to 20%
Retained on No. 16 sieve	15 to 30%
Retained on No. 30 sieve	35 to 75%
Retained on No. 50 sieve	70 to 90%
Retained on No. 100 sieve	90 to 100%
Retained on No. 200 sieve	97 to 100%

Fine aggregate will be subjected to the Sand Equivalent Test (Test Method Tex-203-F). The sand equivalent value shall not be less than 80, or less than the value shown on the plans, whichever is greater.

Mineral Filler. Mineral filler shall consist of clean stone dust, crushed sand, crushed shell or other approved inert material. When tested in accordance with Test Method Tex-401-A, it shall meet the following requirements:

Retained on No. 30 sieve	0%
Retained on No. 200 sieve	0 to 35%

Where fine aggregate is delivered to the job in two or more sizes or types, each type and/or size of material shall be batched and weighed separately. Where mineral filler is used, it shall be batched and weighed separately. At the time of its use the fine aggregate shall be free from frozen material, and aggregate containing foreign material will be rejected.

All fine aggregate shall be stockpiled for at least 24 hours prior to use.

(5) Mixing Water. Water for use in concrete and for curing shall be free from oil, acids, organic matter or other deleterious substances and shall not contain more than 1,000 parts per million of chlorides as Cl. nor more than 1,000 parts per million of sulfates as SO_4.

Water from municipal supplies approved by the State Health Department will not require testing, but water from other sources will be sampled and tested before use in structural concrete. A sample of approximately one gallon will be submitted to Materials and Tests Division, Camp Hubbard, Austin, for test and approval.

Tests procedure shall be in accordance with AASHO Designation: T 26.

(6) Asphalt. The bituminous material for sealing joints, when required, shall be of the type and grade shown on plans and shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

(7) Joint Filler. Boards for expansion joint filler and for contraction and longitudinal joints shall be of the size, shape and type indicated on the plans.

Board shall be obtained from Redwood, Cypress, Gum, Southern Yellow Pine or Douglas Fir timber. They shall be sound heartwood and shall be free from sapwood, knots, clustered birdseye, checks and splits. Occasional sound or hollow birdseye, when not in clusters, will be permitted provided the board is free from any other defects that will impair its usefulness as a joint filler. With the exception of Redwood and Cypress, all boards shall have a creosote or pentachlorophenol treatment of 6 pounds per cubic foot. When oven dried at 230 F to a constant weight, the weight of the board per cubic foot (minus treatment) shall not be less than 20 pounds nor more than 35 pounds.

(8) Joint Sealing Material. Unless otherwise shown on the plans, joint sealing material shall conform to the requirements for one of the classes listed herein. The material shall adhere to the sides of the concrete joint or crack and shall form an effective seal against infiltration of water and incompressibles. The material shall not crack or break when exposed to low temperatures.

(a) Class 1-a. (Two Component, Synthetic Polymer, Cold-Extruded Type). Curing is to be by polymerization and not by evaporation of solvent or fluxing of harder particles. This type is specifically designed for vertical or sloping joints and hence is not self levelling. It shall cure sufficiently at an average temperature of 77 F ± 3 F so as not to pick up under wheels of traffic in a maximum of 3 hours if so specified, otherwise a maximum of 24 hours is acceptable. For performance requirements see under 1-b below.

(b) Class 1-b. (Two Component, Synthetic Polymer, Cold-Pourable, Self-Levelling Type). Curing is to be by polymerization and not by evaporation of solvent or fluxing of harder particles. It shall cure sufficiently at an average temperature of 77 F ± 3 F so as not to pick up under wheels of traffic in a maximum of 3 hours.

Performance Requirements. Class 1-a and 1-b when tested in accordance with Test Method Tex-525-C shall meet the above curing times and the requirements as follows:

It shall be of such consistency that it can be mixed and poured, or mixed and extruded into joints at temperatures above 60 F.

Penetration, 77 F.
150 gm. Cone, 5 sec., max.-cm 0.90

Bond and Extension 75%, O F, 5 cycles:
Dry Concrete Blocks ..... Pass
Wet Concrete Blocks ..... Pass
Steel Blocks .....(Primed if specified by manufacturer) Pass

Flow at 200 F ..... None

Water content % by weight, max 5.0

Resilience:
Original sample min. %(cured) 50
Oven aged at 158 F. min. % 50

For Class 1-a material only
Cold Flow (10 min.) ..... None

(c) Class 2, (Hot Poured Rubber). This sealer shall be a rubber asphalt compound which when heated shall melt to the proper consistency for pouring and shall solidify on cooling at atmospheric temperatures.

The material when tested in accordance with Test Method Tex-525-C shall meet the following requirements:

Penetration:
32 F, 200 grams, 60 seconds ..... not less than 0.28 cm
77 F, 150 grams, 5 seconds ..... 0.45 to 0.75 cm

Flow:
5 hours, 140 F, 75° incline .....not more than 0.5 cm

Bond and Extension:
15 F, 5 cycles ..... There shall be no cracking of the joint sealing material or break in the bond between the joint materials and the mortar pieces.

(d) Class 3, (Ready-Mixed Cold-Applied Joint and Crack Sealer). This sealer shall consist of a homogeneous blend of asphalt, rubber, inert filler and a suitable solvent or solvents. The material shall be a resilient, adhesive compound capable of effectively sealing properly cleaned joints in concrete pavement against the infiltration of moisture throughout repeated cycles of contraction and expansion and which will not be picked up by vehicle tires, particularly at summer temperatures.

The material when tested in accordance with Test Method Tex-525-C shall meet the following requirements:

Penetration:

At 77 F: (As received) 150 grams, 5 seconds . . . . not less than 2.75 cm
(After evaporation of solvent) 150 grams, 5 seconds . . . not more than 2.20 cm

At 32 F: (After evaporation of solvent) 200 grams, 60 seconds . . . not less than 1.00 cm

Flow: Not more than 0.5 cm

Bond: There shall be no cracking of the material or failure in bond between the material and the mortar test blocks during or at the end of five cycles.

(e) Class 4, (Preformed Compression Seal). The material furnished shall comply with the specification for "Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements", ASTM Designation: D 2628 as hereafter modified.

The compression set clamp described in ASTM Designation: D 395 shall measure approximately 7" x 9" x 11/32" to permit the testing of large size seals. In lieu of spacers or shims, a double locknut adjustment may be used with the larger seals. Properly prepared thin sections may be "plied-up" to obtain the necessary thickness for specified tests.

The preformed elastomeric joint sealer shall have a maximum Oil Swell of 60 percent when tested in accordance with ASTM Designation: D 471.

Acceptance shall be based upon the manufacturer's certification in accordance with ASTM Designation: D 2628, Article 8.1.1A. Certification shall be supplied in all cases, with the purchasers option to accept or reject under Article 8.1.3, testing by the purchaser.

Use shall be made of a lubricant-adhesive in the installation of this seal. The lubricant-adhesive shall be compatible with the seal and with the concrete and shall be unaffected by the normal moisture in the concrete. It shall be a single-component compound containing only polychloroprene and soluble phenolic resins blended with antioxidants and acid acceptors in an aromatic hydrocarbon solvent mixture. It shall remain fluid in the manufactured conditions at temperatures between 5 F and 120 F and have a reasonable working life compatible with installation procedures.

The adhesive shall be stored at temperatures between 50 F and 80 F. The adhesive container shall be stamped with the date of manufacture and shall not be more than 9 months old when used. It shall be applied in accordance with the manufacturer's recommendations.

(9) Asphalt Board. Asphalt board when used in accordance with plans shall be of required size and uniform thickness and, when used in transverse joints, shall conform approximately to the shape of the pavement crown as shown on plans. Asphalt board shall consist of two liners of 0.016 inch asphalt impregnated paper filled with a mastic mixture of asphalt and vegetable fiber and/or mineral filler. Boards shall be smooth, flat and straight throughout, and shall be sufficiently rigid to permit easy installation. Boards that crack or shatter during installing and finishing operations will not be acceptable. Board shall be furnished in lengths equal to one-half the pavement width or in lengths equal to the width between longitudinal joints and may be furnished in strips or scored sheets of the required shape. When tested in accordance with Test Method Tex-524-C the asphalt board shall not deflect from the horizontal more than 3/4 inch in 3-1/2 inches.

(10) Load Transmission Devices for Expansion and Contraction Joints. Approved load transmission devices, if used in accordance with provisions of project and specifications, shall meet the requirements specified herein:

Steel Dowel Bars. Smooth steel bar dowels, if used in accordance with provisions of project plans, shall be of the size and type indicated on plans and shall be open-hearth, basic oxygen or electric-furnace steel conforming to the mechanical properties specified for grade 60 in ASTM Designation: A 615. The free end of dowel bars shall be smooth and free of shearing burrs.

When required by plans, one end of each dowel bar shall be encased in an approved cap having an inside diameter of 1/16 inch greater than the diameter of the dowel bar. The cap shall be of such strength, durability and design as to provide free movement of the dowel bar and shall be approved by the Engineer prior to use. One end of the cap shall be filled with a soft felt plug or shall be void in order to permit free movement of the dowel bar for a distance equivalent to 150 percent of the width of the expansion joint used. The dowel caps and dowels bars shall be held securely in place by bar ties as shown on plans, or an approved equivalent thereof.

Where red lead and oil bar coating is required by plans, the red lead may be of any standard commercial grade and the oil shall be clean and no lighter than Standard No. 30 SAE grade. Approved thinner and dryer may be added to the red lead, but the material upon application shall be of such consistency that will provide a uniform and heavy coating on the bar. Where asphalt bar coating is required by plans, the material may be any standard grade of oil asphalt and shall be applied hot. Cut-back asphalt will not be permitted for bar coating.

(11) Metal Installing Devices for Joint Assembly. Metal installing devices for expansion and contraction joint assemblies (such as welded wire bar chairs, bar stakes, and marker channels, channel caps, etc.) shall be as shown on plans or may be similar devices of equivalent or greater strength, approved

by the Engineer, that will secure the joint assembly in correct position during the placing and finishing of concrete. Load transmission devices used in joint assemblies shall be secured in position by a transverse metal brace of the type and design shown on plans, or may be secured by other approved devices of equivalent or greater strength that will provide positive mechanical connection between the brace and each unit (other than by wire tie) and prevent transverse movement of each load transmission device.

(12) Steel Reinforcement. Unless otherwise shown on the plans, steel reinforcing bars as required including the tie bars shall be open-hearth, basic oxygen or electric-furnace new billet steel of Grade 60 or Grade 40 for concrete reinforcement. Bars that require bending shall be Grade 40 conforming to requirements of ASTM Designation: A-615.

High yield reinforcing steel shall be either (1) open hearth, basic oxygen or electric-furnace new billet steel conforming to the requirements of ASTM Designation: A-615 Grade 60 or (2) rail steel bars for concrete reinforcement, conforming to the requirements of ASTM Designation: A-616 Grade 60. (Bars produced by piling method will not be accepted). High yield reinforcing steel bars shall be further identified by a special marking rolled into each bar. Unless otherwise designated on plans, all reinforcing steel shall be deformed bars conforming to the requirements of pertinent ASTM Specifications.

Where prefabricated deformed wire mats are specified or permitted, the wire shall be cold worked deformed steel wire conforming to the requirements of ASTM Designation: A 496, except that steel shall be made by open-hearth, electric-furnace, or basic oxygen processes. The prefabricated deformed wire mats shall conform to the requirements of ASTM Designation: A 497, except that all wires used shall be deformed and transverse wires shall project beyond the centerline of each edge longitudinal wire as specified on the plans and in these specifications. Mats that have been bent or wires dislocated or parted during shipping or project handling shall be realigned to within one-half inch of the original horizontal plane of the mat. Mats with any portion of the wires out of vertical alignment more than one-half inch after realignment and/or wires dislocated or mutilated so that, in the opinion of the Engineer, they do not represent the original mat, shall be rejected. The mats may be clamped or wired so that the mats will retain the horizontal and vertical alignment as specified by the plans or as approved by the Engineer. Deformed wire may be used for tie bars and load transfer bars that require bending. The nominal size and area and the theoretical weight of reinforcing steel wires covered by this provision are as listed in Table 1.

When fabricated steel bar or rod mats are specified, the mats shall meet the requirements of ASTM Designation: A 184.

TABLE I

DIMENSIONAL REQUIREMENTS FOR DEFORMED STEEL WIRE FOR CONCRETE REINFORCEMENT

		NOMINAL DIMENSIONS		
Deformed Wire Size No.	Unit Weight Pounds Per Ft.	Diam. Inches	Cross Sectional Area Sq. Inches	Perimeter Inches
1	2	3	4	5
D-1	.034	.113	.01	.355
D-2	.068	.159	.02	.499
D-3	.102	.195	.03	.612
D-4	.136	.225	.04	.706
D-5	.170	.252	.05	.791
D-6	.204	.276	.06	.867
D-7	.238	.298	.07	.936
D-8	.272	.319	.08	1.002
D-9	.306	.338	.09	1.061
D-10	.340	.356	.10	1.118
D-11	.374	.374	.11	1.174
D-12	.408	.390	.12	1.225
D-13	.442	.406	.13	1.275
D-14	.476	.422	.14	1.325
D-15	.510	.437	.15	1.372
D-16	.544	.451	.16	1.416
D-17	.578	.465	.17	1.460
D-18	.612	.478	.18	1.501
D-19	.646	.491	.19	1.542
D-20	.680	.504	.20	1.583
D-21	.714	.517	.21	1.624
D-22	.748	.529	.22	1.662
D-23	.782	.541	.23	1.700
D-24	.816	.553	.24	1.737
D-25	.850	.564	.25	1.772
D-26	.884	.575	.26	1.806
D-27	.918	.586	.27	1.841
D-28	.952	.597	.28	1.876
D-29	.986	.608	.29	1.910
D-30	1.020	.618	.30	1.942
D-31	1.054	.628	.31	1.973

Col. 1. The number following the prefix D identifies the nominal cross-sectional area of the deformed wire in hundredths of a square inch. Fractional sizes are also available between the sizes listed.

Col. 2. The unit weight in pounds per foot is obtained by multiplying the cross-sectional area in square inches by 3.4.

Col. 3. The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire.

Col. 4. The cross-sectional area is based on the nominal diameter. The area in square inches may be calculated by dividing the weight per lineal inch of specimen in pounds by 0.2833 (weight of 1 cu. in. of steel), or by dividing the weight per lineal foot of specimen in pounds by 3.4 (weight of steel 1 in. square and 1 ft. long).

Steel wire fabric reinforcement shall be of the gage and spacing shown on the plans and shall conform to the requirements of ASTM Designation: A 82. Longitudinal and transverse wires shall be electrically welded together at all points of intersection and the welds shall be of sufficient strength that they will not be broken during handling or placing. All welding and fabrication of the fabric sheets shall conform to the requirements of ASTM Designation: A 185. Welded steel wire fabric shall be furnished in sheets as per plan dimensions, and steel having been previously bundled into rolls will not be accepted. An approved hinge will be permitted in each sheet to provide for folding the sheet longitudinally. When wire fabric is used, it will replace only the longitudinal and transverse bars. The tie bars and load transmission units at joints will not be affected.

(13) Polyethylene Film. Polyethylene film shall be opaque pigmented white in color, and shall be manufactured from virgin resin without additives or scrap. It shall be sufficiently strong and tough to permit its use under the conditions existing on highway paving work without being torn or otherwise rendered unfit for the purpose during the curing period. The film shall have a minimum thickness of 4 mils (0.004 inch), shall have a minimum tensile strength of 1,700 psi at 77 F in the longitudinal direction and 1,200 psi at 77 F in the transverse direction and shall have a minimum elongation of 200 percent at 77 F in the longitudinal direction and 150 percent at 77 F in the transverse direction. The permissible percentage moisture loss shall not exceed 2 percent after 24 hours and 4 percent after 72 hours. Tests for tensile strength and elongation will be conducted in accordance with ASTM Designation: D 882, Method A. Tests for moisture retention will be conducted in accordance with ASTM Designation: C 156.

(14) Membrane Curing Compound. The membrane curing compound shall comply with the requirements of the Item, "Membrane Curing", Type 2 white pigmented.

(15) Asphalt Curing. Where emulsified asphalt is used for curing concrete base, the material shall conform to the Item, "Asphalts, Oils and Emulsions" for the type and grade shown on the plans.

360.3. Equipment.

(1) General. All equipment necessary for the construction of this item shall be on the project and shall be approved by the Engineer as to conditions before the Contractor will be permitted to begin construction operations on

which the equipment is to be used. When approved by the Engineer in writing, a commercial or independently operated batching plant for measuring materials outside the limits of the project may be used.

(2) Aggregate Weighing Equipment. Aggregate bins and scales shall conform to the Item, "Weighing and Measuring Equipment".

(3) Cement Weighing Equipment. Where bulk cement is used, it shall be batched by weight and the scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

(4) Mixer. The mixer furnished may be either a paving mixer (operated at the site of the construction or centrally located), a stationary mixer (central mixer) or a paving mixer (truck mounted) that will produce adequately mixed concrete meeting the specified requirements. The mixer, or mixers, shall conform to the following requirements:

Each mixer shall have attached in a prominent place a manufacturer's plate showing the rated capacity of the drum in terms of volume of mixed concrete and the recommended speed of rotation of the mixing drum or blades.

The stationary mixer (central mixer) or truck mounted paving mixer shall be operated at the manufacturer's recommended speed.

The size of the paving mixer shall not be less than that of a 27-E paver, as established by the Mixer Manufacturer's Bureau of the Associated General Contractors. The paving mixer shall be operated at a drum speed of not less than 16 revolutions per minute and not more than 22 revolutions per minute. Pick-up and throw-over blades in the drum of the mixer shall be replaced when worn down 3/4 inch or more.

Each truck mounted paving mixer shall be approved by the Engineer prior to use on the project. It shall be classified as a "paving mixer" by the manufacturer and shall be so designed that a uniform and low slump concrete (approximately 1-1/2 inch slump) can be mixed without aggregate size segregation. The mixer shall be capable of discharging the low slump concrete at a speed of 10 seconds per cubic yard or faster.

Each mixer shall be equipped with an approved automatic device for satisfactorily timing the mix and locking the discharging device in order to prevent the discharging of the mixer before the end of the required mixing period. This timing device shall operate a sounding device to signal plainly the completion of the mixing time. When permitted by the Engineer a light signal device may be used.

Multiple drum mixers will be permitted provided their operation is properly synchronized. The mixing time shall be determined exclusive of the time required to transfer concrete from one drum to the next drum.

Each mixer shall be equipped with a water measuring device so constructed that it will measure the water within 1 percent of the total amount required for each batch. Unless the water is to be weighed, the water measuring equipment shall include an auxiliary tank with a capacity greater than that of the measuring tank, and from which the measuring tank will be

filled by gravity flow. The measuring tank shall be open to the atmosphere and shall be so placed and constructed that the water for a batch can be discharged into a calibrated tank or weighing device for checking the accuracy of water measurement without seriously delaying the paving operations. The Contractor shall have a calibrated tank or weighing device available at all times at a location satisfactory to the Engineer.

If a paving mixer is furnished and operated at the site of construction, it shall be equipped with a power controlled boom and bucket, so designed as to permit uniform distribution of the concrete for the full width between pavement forms. Alternate equipment for distributing concrete may be substituted when approved by the Engineer in writing, provided uniform distribution is obtained without segregation.

If central mixed concrete is used on the project, the Contractor shall provide equipment designed to provide uniform distribution of the concrete for the full width between pavement forms without segregation.

Transit mixing will not be allowed on this project except for small or irregular areas approved by the Engineer.

(5) Hauling Equipment. Batch hauling equipment for the transportation of measured materials from the batching plant to the mixer shall be equipped with tight covers and shall be used when directed by the Engineer to prevent excessive evaporation of moisture or any loss of material.

If a central mixer is used, concrete may be transported to the point of delivery in truck agitators or nonagitating trucks.

Agitator trucks shall conform to one of the following:

(a) Horizontal axis, revolving drum.
(b) Inclined axis, revolving drum.
(c) Open top, revolving blade or paddle.
(d) Alternate agitating hauling equipment approved by the Engineer in writing.

The drum or agitating blades shall be actuated by an engine mounted as an integral part of the unit for the purpose of rotating the drum or agitating blades. It shall be capable of being governed accurately for the desired speed of rotation and be in satisfactory working condition. As an exception, where the truck agitator is equipped with a transmission that will govern the speed of the drum or agitating blades within the specified rpm, no separate engine for rotating the drum will be required.

Truck agitators shall be equipped with facilities to readily permit access for inspection, cleaning and repair of blades.

Each truck agitator shall have attached, in a prominent place, by the manufacturer, a metal plate or plates on which are plainly marked the various uses for which the unit is designed. The data shall include speed of rotation of drum or agitating blades for agitation and the capacity of the unit.

If a truck mounted paving mixer is used, it may be used to transport the concrete after mixing is complete.

If non-agitator trucks are used; they shall conform to the following requirements:

The bed of the non-agitating hauling equipment shall be a smooth, mortar-tight, metal container. The hauling equipment shall be capable of delivering the concrete to site of the work in a thoroughly mixed and uniform mass and capable of discharging the concrete at a satisfactory controlled rate without segregation.

If in the opinion of the Engineer any appreciable segregation or accumulation of excess water and/or mortar occurs on the surface of the concrete, this may be cause for rejection and this method of transporting the concrete to the point of delivery shall be suspended as directed by the Engineer.

(6) Subgrade or Subbase Planer and Templates. Unless a stabilized subbase is provided, an approved subbase planer shall be provided, mounted on visible rollers riding on the forms, and having adjustable cutting blades which shall trim the subgrade to the exact section shown on the plans. The planer frame shall be heavy enough to remain on the forms at all times and shall be of such strength and rigidity that, under a test made by changing the support from the wheels to the center, it shall not develop a deflection of more than 1/8 inch. Tractive power equipment used to pull the planer shall not be such as to produce ruts or indentations in the subgrade.

When the slipform method of paving is to be used, the subgrade planer will be operated on a prepared track grade or controlled by an electronic sensor system operated from a stringline that establishes the horizontal alignment and the elevation of the subbase.

A template for checking the contour of the subbase shall be provided and operated by the Contractor. The template shall rest upon the side forms and shall be of such strength and rigidity that, under a test made by changing the support to the center, it shall not show a deflection of more than 1/8 inch. It shall be provided with accurately adjustable rods projecting downward to the subgrade at 1-foot intervals, and these rods shall be adjusted to the required cross section of the bottom of the slab when the template is resting upon the side forms. Where stabilized subbase is provided, use of a scratch template will be required.

(7) Forms. Side forms shall be of metal of approved cross section. The preferred depth of the form shall be equal to the required edge thickness of the pavement. Forms with depth greater or less than the required edge thickness of the pavement will be permitted provided the difference between the form depth and the edge thickness is not greater than 1 inch, and further provided that forms of a depth less than the pavement edge are brought to the required edge thickness by securely attaching metal strips of approved section to the bottom of the form. Longitudinal hardwood strips not greater than one-inch in thickness may be used in lieu of metal strips.

The length of form sections shall not be less than 10 feet, and each section shall provide for staking in position with not less than three pins. Flexible or curved forms of wood or metal of proper radius shall be used for curves of 200-foot radius or less. Forms shall be of ample strength and shall

be provided with adequate devices for secure setting so that when in place they will withstand, without visible springing or settlement, the impact and vibration of the spreading and finishing machinery. In no case shall the base be less than 8 inches for a form 8 inches or more in height. The forms shall be free from warps, bends or kinks, and shall be sufficiently true to provide a reasonably straight edge on the concrete and the top of each form section, when tested with a straight-edge shall conform to the requirements specified for the surface of the completed pavement. Sufficient forms shall be provided for satisfactory prosecution of the work.

Outside curb forms shall be of wood or metal of a section satisfactory to the Engineer, straight, free of warp, and shall be of a depth at least equal to the depth of the curb. They shall be mounted on the paving forms and securely attached thereto and maintained in true position during the placing of the concrete. Inside curb forms, if required, shall be of approved material and of such design as to provide the curb required and shall be rigidly attached to the outside forms.

(8) Concrete Spreader. Use of a concrete spreader shall be required and it shall be a self-propelled machine having sufficient power and traction to spread and strike off concrete without slippage on the forms. It shall be equipped with a power driven device for spreading the concrete uniformly between the forms. The spreading device may be either a reciprocating blade, a screw conveyor or a belt conveyor. The spreader shall be capable of striking off the surface of the concrete between the forms in the longitudinal direction of the slab at any required elevation.

Mechanically-operated concrete spreaders of other designs, which uniformly distribute the concrete with a minimum of segregation, may be used when approved by the Engineer.

(9) Mechanical Vibratory Equipment. All concrete placed for pavement shall be consolidated by approved mechanical vibrators operated ahead of the transverse finishing machine and designed to vibrate the concrete internally and/or from the surface. Unless otherwise shown on the plans, vibrators of the surface-pan type will be used for two-lift placement of concrete and the internal type will be used for full-depth placement and both type vibrators shall be furnished and may be used concurrently at the discretion of the Engineer. Vibratory members shall extend across the pavement practically to, but shall not come in contact with the side forms. Mechanically-operated vibrators shall be mounted in such manner as to not interfere with the transverse or longitudinal joints.

The internal-type vibrators shall be spaced at not more than 24 inches and shall be equipped with synchronized vibratory units. Separate vibratory units shall be spaced at sufficiently close intervals to provide uniform vibration and consolidation to the entire width of the pavement. The frequency in air of the internal spud type vibratory units shall be not less than 8,000 cycles per minute and not less than 5,000 cycles per minute for tube types and the method of operation shall be as directed by the Engineer. The Contractor shall have a satisfactory tachometer available for checking the vibratory elements.

The pavement vibrators shall not be used to level or spread the concrete but shall be used only for purposes of consolidation. The vibrators will not be operated where the surface of the concrete, as spread, is below the elevation of the finished surface of the pavement, except for the first lift of concrete where the double strike off method of placement is employed, and the vibrators shall not be operated for more than 15 seconds while the machine upon which they are installed is standing still.

The pan type vibratory units shall apply the vibrating impulses directly to the surface of the concrete. The operating frequency shall be not less than 3,500 cycles, nor more than 4,200 cycles per minute in air. The Contractor shall have a satisfactory tachometer available for checking the speed of the vibratory elements.

Approved hand manipulated mechanical vibrators shall be furnished in the number required for provision of proper consolidation of the concrete along forms, at joints and in areas not covered by mechanically controlled vibrators. These vibrators shall be sufficiently rigid to insure control of the operating position of the vibrating head.

Complete and satisfactory consolidation of the concrete pavement is a most important requirement of this specification. Cores taken as required by Article 360.11 shall be carefully examined for voids, honeycombing or other evidence of incomplete consolidation. If such evidence is present, changes in the consolidation procedures and/or equipment will be made to insure satisfactory consolidation.

(10) Finishing Equipment.

(a) The Transverse Finishing Machine. The transverse finishing machine shall be provided with two screeds accurately adjusted to the crown of the pavement, shall be power driven and mounted in a substantial frame equipped to ride on the forms, and shall be so designed and operated as to strike off and consolidate the concrete.

(b) Longitudinal Finishing. A transverse drag float will be used in lieu of the longitudinal finishing machine unless otherwise shown on the plans.

Finishing machines shall be maintained in a tight and good operating condition, accurately adjusted to the required crown or profile, and free from deflection, wobble, or vibration tending to affect the precision of finish. Machines failing to meet these requirements will be condemned by the Engineer, and the Contractor shall provide approved equipment.

Where hand finishing is permitted under this specification, the Contractor shall provide a strike template and a tamping template both of 4 by 10 inch lumber or equivalent metal section and at least 2 feet longer than the width of the pavement. Both templates shall conform to the crown section of the pavement, and the tamp, if of wood, shall have a steel face not less than 3/8 inch in thickness. The Contractor shall also provide a longitudinal float of approved design and not less than 14 feet in length.

Unless otherwise specified on plans, the Contractor shall furnish a seamless burlap drag for finishing the pavement. The burlap drag shall consist of four or more plies of 10-ounce burlap fastened to a bridge to form a continuous strip of burlap the full width of the pavement and with approximately three feet of its width in contact with the pavement surface. To increase texture depth, the Engineer may require removal of transverse threads from the trailing six to twelve inches of the drag. Burlap drags shall be maintained clean and free of encrusted mortar.

The Contractor shall furnish, operate and maintain at least two standard 10-foot steel straightedges.

The Contractor shall furnish a sufficient number of bridges equipped to ride on the forms and span the pavement for finishing operations and for the installation and finishing of joints and center stripes. All necessary finishing and edging tools shall be furnished as may be required to complete the pavement in accordance with plans.

360.4. Proportioning of Concrete.

(1) Proportions. Concrete shall be composed of portland cement, fine aggregate, coarse aggregate, mineral filler and/or admixture if used and water, mixed in the proportions designated by the Engineer and in the manner set forth in this specification. On the basis of job and laboratory investigations of the proposed materials, the Engineer will fix the proportions by weight of water, coarse aggregate, fine aggregate, cement, admixture and mineral filler where required, in order to produce concrete of the specified strength and workability. Where curbs are placed separately the Engineer may direct that aggregate gradation conforming to the Item, "Concrete for Structures", be used.

(2) Concrete Strength. The concrete mix will be designed with the intention of producing a minimum average flexural strength (modulus of rupture) of 650 pounds per square inch at the age of 7 days using a standard testing machine in which the load is applied at the center of the beam span. The coarse aggregate factor (dry, loose volume of coarse aggregate per unit volume of concrete) shall not exceed 0.85. Unless otherwise shown on plans the concrete shall contain not less than five sacks of cement per cubic yard of concrete. The water-cement ratio (net gallons of water per sack of 94 pounds of cement) shall not exceed 6.25 gallons/sack. Concrete specimens shall be prepared, cured and tested as outlined in THD Bulletin C-11. The number of tests required shall be in accordance with the Guide Schedule of Minimum Sampling and Testing Requirements.

(3) Concrete Strength for High Strength Pavement. Where high strength concrete pavement is required, the concrete mix will be designed with the intention of producing a minimum average flexural strength of 700 pounds per square inch at the age of 7 days. The concrete shall contain not less than five sacks of cement per cubic yard of concrete. The water-cement ratio for this design shall not exceed 6.25 gallons/sack. Other provisions of this specification will not be modified by these requirements. Concrete specimens

shall be prepared, cured and tested as outlined in THD Bulletin C-11. The number of tests required shall be in accordance with the Guide Schedule of Minimum Sampling and Testing Requirements.

(4) Workability of Concrete. Concrete shall be uniformly plastic, cohesive and workable. Workable concrete is defined as concrete which can be placed without honeycomb and without voids in the surface of the pavement after the specified finishing machine has been over a given area twice. Workability shall be obtained without producing a condition such that free water appears on the surface of the slab when being finished as specified. Where water appears on the surface of the concrete after finishing and this condition cannot be corrected by reasonable adjustment in the batch design, the bleeding will be immediately corrected by one of the following measures or a combination of two or more of the following listed measures:

(a) Redesign of the batch.

(b) Addition of mineral filler to fine aggregate.

(c) Increase of cement content.

(d) Use of an approved air-entraining agent or other approved admixture.

In the event that the measures taken do not eliminate the bleeding immediately, concrete placement operations will be suspended, as directed by the Engineer, by placing a bulkhead or "header" according to details shown on the plans, and according to applicable requirements for intentional stoppage of placement in Subarticle 360.6(5) of this specification and will remain suspended, until such time as additional trial mixes demonstrate that a non-bleeding batch design has been achieved. Failing to achieve a satisfactory laboratory batch design the Contractor will be required to use different materials and to submit samples thereof for additional trial mixes and pilot beams as specified in THD Bulletin C-11.

The mix will be designed with the intention of producing concrete which will have a slump of 1-1/2 inches when tested in accordance with THD Bulletin C-11. The slump shall not be less than 1 inch nor more than 3 inches.

(5) Mix Design. It is the intent of this specification to develop and use an economical mix design with the proportion of fine aggregate in the concrete mix near the upper limit of the range that permits proper placing, finishing, and texturing and which will fulfill all requirements of this specification when using acceptable materials as furnished by the Contractor.

Prior to the beginning of concrete placement, and thereafter before any change in source or characteristics of any of the ingredients except mineral filler, adequate quantities of cement and aggregates proposed for use shall be supplied the Engineer for mix design tests.

Concrete mixes will be designed by the absolute volume method in accordance with the procedure outlined in THD Bulletin C-11. Mixes will be designed and made in sufficient number to represent a wide range of water-cement ratios. These mixes shall comply with the requirements herein prescribed for workability.

From the concrete of each mix design test beams will be made, cured and tested as outlined in THD Bulletin C-11 to determine the flexural strength of the concrete at the age of 7 days. From these preliminary tests the water-cement ratio required to produce concrete of the specified strength will be selected by the Engineer. The Contractor may at any time present in writing a suggested mix design and the Engineer will make the tests necessary to determine its acceptability under these specification requirements.

For mixing the concrete to be used in making the preliminary test specimens, the Contractor shall furnish and operate the mixer approved for use on this project. A minimum one cubic yard batch shall be mixed or a batch of sufficient size to afford proper mixing, whichever is the greater. In lieu of the above mixer and procedure, the Contractor may furnish a portable mixer of sufficient rated capacity to mix a minimum three-sack batch; in which case, the batch mixed for the preliminary test shall not be less than the rated capacity of the mixer furnished.

A coating batch will be mixed prior to mixing for test beams as prescribed in THD Bulletin C-11.

No additional compensation will be allowed for equipment, materials or labor involved in making preliminary test specimens.

After the mix proportions and water-cement ratio required to produce concrete of the specified strength have been determined, placing of the concrete may be started. The strength of the concrete in the completed pavement will be determined by flexural strength test specimens, made, cured and tested as provided in THD Bulletin C-11. Modifications of the mix design will be made by the Engineer on the basis of the conformity of the strength of these test specimens with the requirements and intent of this specification.

Changes in the water-cement ratio and the mix design, including an increase in cement factor if necessary, will be made when the average 7-day flexural strength of the concrete, as indicated by the last 10 flexural strength values (modulus of rupture) obtained from tests of beams made from concrete of the same water-cement ratio, departs from the desired minimum average strength by more than 4 percent.

The Engineer, at his option, may reject as non-representative any individual flexural strength value in each group of ten where strengths more than 10 percent above or below the average for the group are indicated and compute the average flexural strength on the basis of the remaining values. When the concrete fails to meet any of the requirements for workability, the Engineer will attempt to correct this condition by changing the mix design or by requiring the use of mineral filler. In case it is necessary to change aggregates, to use an additional aggregate or to use admixtures, preliminary strength tests will be required. Should tests representing 3 days production consistently indicate a considerable departure from the minimum specified strength, even though within the above limits, appropriate changes in the water-cement ratio and mix proportions will be made.

The Contractor or his duly authorized superintendent shall sign each daily paving report of the Texas Highway Department inspector to signify his acceptance and approval of the mix designs used.

Type I cement furnished for preliminary tests shall have a specific surface area within a range of 1,600 to 1,900 square centimeters per gram.

A change in the specific surface of the cement of more than 100 square centimeters per gram from that furnished for preliminary tests may require a new mix design. The cement shall be sampled and tested in accordance with the Texas Highway Department Manual of Testing Procedures, and the Contractor shall furnish to the Engineer with each shipment a statement as to the specific surface area of the cement expressed in square centimeters per gram.

Preliminary test beams required for pilot strength curve as described in THD Bulletin C-11 will not be required provided that the combination of material to be used has been previously tested and found to be satisfactory. An appropriate batch design will be selected and modified by the Engineer as necessary.

(6) Test Specimens. Unless otherwise specified on the plans, test beams for flexural strength value shall be taken in accordance with THD Bulletin C-11. The number of test beams shall be in accordance with the Guide Schedule of Minimum Sampling and Testing Requirements. Additional beams may be made as required by concrete placing conditions, or for adequately determining the strength of concrete where the early opening of the pavement to traffic is dependent upon concrete strength tests. No extra compensation will be allowed for materials and work involved in fulfilling these requirements.

360.5. Subgrade And Forms.

(1) Preparation of Subgrade. Where stabilized subbbase is not provided the subgrade shall be excavated as required, all unstable or otherwise objectionable material removed, and all holes, ruts and depressions filled with approved material. Rolling and sprinkling shall be performed when and to the extent directed, and the roadbed shall be completed to or above the plane of the typical sections shown on plans and the lines and grades established by the Engineer. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes, and any additional material required for the completion of the sections shall be secured from sources indicated on plans or designated by the Engineer. Drainage of the roadbed shall be maintained at all times. Sealed or treated subgrade cut in the preparation of the subgrade or setting of pavement forms shall be resealed or the subgrade restored to the original condition as directed by the Engineer.

The subgrade planer shall be operated from approved forms immediately ahead of paving operations, and the subgrade shall be finished to the exact section of the bottom of the pavement as shown on plans. Where traveling form pavers are used the subgrade planer shall operate on a prepared track grade or be controlled by electronic sensors operating from a stringline that establishes line and grade. It shall be tested with the approved template, operated and maintained by the Contractor. The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the pavement is placed and shall be kept

thoroughly wetted down sufficiently in advance of placing any pavement to insure its being in a firm and moist condition for at least 2 inches below the prepared surface. Sufficient subgrade shall always be prepared in advance to insure satisfactory prosecution of the work. No equipment or hauling shall be permitted on the prepared subgrade, except by special permission of the Engineer, which will be granted only in exceptional cases and only where suitable protection in the form of two-ply timber mats or other approved material is provided.

(2) **Placing and Removing Forms.** The subgrade under the forms shall be firm and cut true to grade so that each form section when placed will be firmly in contact for its whole length and base width, and exactly at the established grade. Any subgrade under the forms below established grade shall be corrected, using suitable material, placed, sprinkled and rolled as directed. Forms shall be staked with at least three pins for each 10-foot section. A pin shall be placed at each side of every joint. Form sections shall be tightly joined and keyed to prevent relative displacement. Forms shall be cleaned and oiled each time they are used.

Forms shall be set for a sufficient distance in advance of the point where concrete is being placed to permit a finished and approved subgrade length of not less than 300 feet ahead of the mixer. Conformity of the grade and alignment of forms shall be checked immediately prior to placing concrete, and all necessary corrections made by the Contractor. Where any form has been disturbed or any subgrade becomes unstable, the form shall be reset and rechecked. In exceptional cases, the Engineer may require suitable stakes driven to the grade of the bottom of the forms to afford additional support. Sufficient stability of forms to support the equipment operated thereon and to withstand its vibration without springing or settlement shall be required. If forms settle and/or deflect over 1/8 inch under finishing operations, paving operations shall be stopped and the forms shall be reset to line and grade.

Forms shall remain in place for not less than 8 hours after the concrete has been placed. They shall be carefully removed in such a manner that little or no damage will be done to the edge of the pavement. Any damage resulting from this operation shall be immediately repaired. After the forms have been removed, the ends of all joints shall be cleaned, and any honeycombed areas pointed up with approved mortar. Immediately after pointing is complete, the form trench, if used, shall be filled with earth from the shoulders in such manner as to shed water from rainfall or curing away from the edge of the pavement. On completion of the required curing, the subgrade or shoulders adjacent to the pavement shall be placed in condition to maintain drainage.

(a) Where payment for concrete pavement is to be made by the square yard, the forms may be adjusted to provide the minimum thickness provided on the plans in lieu of trimming the subbase to exact grade where high spots occur. When pavement forms are reset at a higher grade, the revised grade shall be secured with gradual transitions to the established grade at each end and by maintaining a proper drainage grade in the pavement. Forms shall rest on cement or asphalt stabilized material as directed by the Engineer.

Allowable grade revisions as provided herein shall in no way affect the governing finishing and surface requirements of the completed pavement.

All grade revisions shall be established by the Engineer. No additional payment over the contract unit price will be made for any pavement of a thickness exceeding that required on the plans as a result of adjustment of the forms.

(b) Where payment for concrete pavement is to be made by the cubic yard the pavement foundation or subgrade shall be tested after the forms are set to insure that the required pavement thickness will be obtained. Where high areas occur in the pavement foundation the pavement forms shall be reset at a higher grade. The revised grade shall be secured with gradual transitions to the established grade at each end and by maintaining a proper drainage grade in the pavement. Allowable grade revisions as provided herein shall in no way affect the governing finishing and surface requirements of the completed pavement. All grade revisions shall be established by the Engineer.

360.6. Concrete Mixing and Placing.

(1) Mixing Methods. The concrete shall be mixed in a mixer conforming to the requirements of Subarticle 360.3(4) of this specification item. Ready-Mix concrete may be used for mixing concrete for pavement only when specifically permitted in the proposal in the list of "Governing Specifications and Special Provisions" by inclusion of the Item (502) in parenthesis after the item or items on which this method of mixing will be permitted. Ready-Mix concrete may be used for curbs, irregular sections and/or small placements such as turnouts and leaveouts.

(2) Mixing. The aggregates, mineral filler if required, cement and water shall be measured separately, introduced into the mixer, and mixed for a period of not less than 50 seconds nor more than 90 seconds, measured from the time the last aggregate enters the drum to the time discharge of the concrete begins. The required water shall be introduced into the mixing drum during the first 15 seconds of mixing. The entire contents of the drum shall be discharged before any materials of the succeeding batch are introduced.

The Engineer may increase the minimum mixing time to that necessary to produce thoroughly mixed concrete based on inspection or appropriate uniformity tests. The mixing time may be varied at any time as necessary to produce acceptable concrete.

If a central mixer is used, the concrete shall be discharged into the specified hauling equipment and delivered to the road site. If truck agitators are used, the concrete shall be continuously agitated at not less than one nor more than six rpm as directed by the Engineer.

The maximum size of the concrete batch, absolute volume, shall not exceed 120 percent of the rated size of the mixer (40.8 cubic feet maximum batch for the 34 cubic foot paver). Spilling of material from the mixer drum shall be corrected by reducing the size of the batch. Retempering or remixing of concrete will not be permitted.

The initial batch of concrete mixed after each time the mixer is washed out shall be enriched by additional mortar. The additional mortar shall be one sack of cement and three parts of sand.

(3) Placing. Any concrete not placed as herein prescribed within 30 minutes after mixing shall be rejected and disposed of as directed except as provided otherwise herein. Except by specific written authorization of the Engineer, concrete shall not be placed when the temperature is below 40 F and falling but may be placed when the temperature is above 35 F and rising, the temperature being taken in the shade and away from artificial heat.

When such permission is granted, the Contractor shall furnish an approved enclosure, such as canvas-covered framework, to enclose and protect all pavement so placed, and shall maintain the temperature of the air surrounding the concrete at not less than 50 F for not less than 5 days. When concrete is being placed in cold weather, other than under the conditions stated above, the Contractor shall have available a sufficient supply of an approved covering material to immediately protect concrete if the air temperature falls to 32 F, or below, before concrete has been placed 4 hours. Such protection shall remain in place during the period the temperature continues below 32 F or for a period of not more than 5 days. Neither salt nor other chemical admixtures shall be added to the concrete to prevent freezing. The Contractor shall be responsible for the quality and strength of concrete under cold weather conditions and any concrete damaged by freezing shall be removed and replaced at his expense. Concrete shall not be placed before sunrise and shall not be placed later than will permit the finishing of the pavement during sufficient natural light.

Concrete shall be placed only on approved subgrade or subbase, and unless otherwise indicated on plans, the full width of the pavement shall be constructed monolithically. The concrete shall be deposited on the subgrade or subbase in such manner as to require as little rehandling as possible. Where hand spreading is necessary, concrete shall be distributed to the required depth by use of shovels. The use of rakes will not be permitted. Workmen will not be permitted to walk in the concrete with any earth or foreign material on their boots or shoes. The placing of concrete shall be rapid and continuous.

When the concrete is to be placed in separate lanes, the junction line shall not deviate from the true line more than 1/2 inch at any point and shall be finished as shown on plans.

The mixer shall not be located on completed pavement, except as herein provided, but may be located on the subgrade of that lane of the pavement being constructed, as provided under "Preparation of Subgrade". When limited space, in the opinion of the Engineer, requires operation of the mixer on completed pavement, the mixer may be so operated provided the concrete has attained the minimum average flexural strength required under Article 360.4. of these specifications and provided suitable protection to the pavement in the form of two ply timber mats or other approved material is provided.

Concrete shall be distributed to such depth that when consolidated and finished, the slab thickness required by plans will be obtained at all points and the surface shall not, at any point, be below the established grade. Special care shall be exercised in placing and spading concrete against forms and at all joints to prevent the forming of honeycombs and voids.

Unless otherwise shown on plans, when the placing of concrete is accomplished in two passes (double strike-off method) to allow placing the reinforcement in the form or bar mats after the first pass, the first pass shall be uniformly spread and/or struck off so that the final position of the longitudinal steel will be within 1/2 inch of the position dimensioned on the plans. The second pass shall be placed as soon as the reinforcing is in place prior to initial set and in no case shall it be placed later than 20 minutes after completion of the first pass.

When wire fabric reinforcement is used, the placement shall be accomplished in two passes (double strike-off method) unless authorized otherwise by the Engineer in writing.

Concrete for the monolithic curbs shall be the same as for the pavement and if carried back from the paving mixer shall be placed within 20 minutes after being mixed. It may be placed from the separate mixer if desired but in any case must be placed while the pavement concrete is still plastic. When sawed joints are used, curbs shall be doweled as shown on plans and poured after sawing. Curbs doweled on and placed separately may be placed with an extrusion machine and the mixture shall conform to Article 360.4.1.

If a central mixer is used, the Contractor shall provide a system satisfactory to the Engineer for determining that concrete delivered to the road meets the specified requirements for mixing and time of placing.

Unless otherwise shown on plans, two mixers will be required where the double strike-off method is employed.

If in the opinion of the Engineer, the temperature, wind and/or humidity conditions are such that the quality of the concrete will not be adversely affected, the specified placing time may be extended to a maximum of 45 minutes.

(4) Reinforcing Steel and Joint Assemblies. All reinforcing steel, including steel wire fabric reinforcement, tie bars, dowel bars, and load transmission devices used in accordance with plan provisions shall be accurately placed and secured in position in accordance with details shown on plans. Reinforcing bars shall be securely wired together at alternate intersections, following a pattern approved by the Engineer, and at all splices, and shall be securely wired to each dowel intersected. When wire fabric is used, it replaces only the longitudinal and transverse bars and shall be securely wired together at all splices and to each dowel intersected. Tie bars shall be installed in the required position by the method and device shown on plans or by approved method and device equivalent thereto. Bar coatings required by plans, and of material specified, shall be completed and the bars and coating shall be free of dirt or other foreign matter at the time of installation in the concrete.

Tightly adhered scale or rust which resists removal by vigorous wire brushing need not be removed except that excessive loss of section to the reinforcement due to rust shall be cause for rejection. Excessive loss of section shall be defined as loss of section to the extent that the reinforcement will no longer meet the physical requirements for the size and grade of steel specified.

Where plans require an assembly of parts at pavement joints, the assembly shall be completed, placed at required location and elevation, and

all parts rigidly secured in required position by the method and devices shown on plans or by approved method and devices equivalent thereto. Dowel bars shall be accurately installed in joint assemblies in accordance with plans, each parallel to the pavement surface and to the center line of the pavement, and shall be rigidly secured in required position by such means (as shown on plans, or approved equivalent thereto) that will prevent their displacement during placing and finishing of the concrete. Unless specifically authorized by the Engineer in writing, the load transmission devices, shall be accurately installed in joint assemblies in accordance with plans, each unit vertical with its length parallel to the center line of the pavement, and all units shall be rigidly secured in required position by such means (as shown on plans, or approved equivalent thereof) that will prevent their displacement during placing and finishing of the concrete. Header boards, joint filler and other material used for forming joints shall be accurately notched to receive each load transmission device. All load transmission devices shall be free of rust and clean when installed in the concrete.

(5) Construction Joints. Intentional stoppage of the placing of the concrete shall be at either an expansion joint or at a weakened plane joint. The following provisions shall govern for each type of joint at which the placing of concrete is stopped.

(a) When the placing of concrete is stopped at an expansion joint, the complete joint assembly shall be installed and rigidly secured in required position as shown on plans. A bulkhead of sufficient cross sectional area to prevent deflection, accurately notched to receive the load transmission devices or dowels, as the case may be, and shaped accurately to the cross section of the pavement shall be provided and installed as a back-up for the joint filler and rigidly secured in required position to permit accurate finishing of the concrete up to the joint. After the concrete has been finished to the joint, formation of the joint seal space and finishing of the joint shall be executed as specified herein and in accordance with plan requirements. The back-up bulkhead shall remain in place until immediately prior to the time when concrete placing is resumed, when it shall be carefully removed in such manner that no element of the joint assembly will be disturbed. The exposed portion of the joint assembly shall be free of adherent concrete, dirt or other material at the time placing of concrete is resumed.

(b) When placing of concrete is stopped at a weakened plane joint, all applicable provisions of paragraph (a) above shall apply in addition to the following requirements:

The face of the bulkhead adjoining the slab end shall be notched and grooved to fit the exposed half section of the joint assembly and shall be shaped to form the slab end at the center of the joint as shown on the plans. The half-width of joint seal-space may be formed by a strip of required section placed and removed in accordance with plan requirements for construction of transverse contraction joints. The Contractor shall have available a bulkhead shaped to the section of the pavement. This bulkhead must be drilled to permit the continuation of all longitudinal reinforcing steel through the construction joint and shall be of sufficient section and strength to prevent deflection.

Immediately upon the unintended stoppage of the placing of concrete, the Contractor shall place the available concrete to a line and install the above described bulkhead at right angles to the centerline of the pavement, perpendicular to the surface and at the required elevation. Concrete shall be placed and finished to this bulkhead. Any concrete remaining on the subgrade ahead shall be removed and disposed of as directed. When placing of concrete is resumed before the concrete has set to the extent that the concrete will stand on removal of the bulkhead, the new concrete shall be rodded with the first. An edge created by a construction joint of this type shall have a joint seal space and shall be sealed as required for contraction joints.

360.7. Joints.

(1) General. All transverse and longitudinal joints when required in the pavement shall be of the type or alternate type shown on plans and shall be constructed at required location, on required alignment, in required relationship to tie bars and joint assemblies, and in accordance with details shown on plans. Such stakes, braces, brackets or other devices shall be used as necessary to keep the entire joint assembly in true vertical and horizontal position. Where concrete base is overlaid by asphaltic concrete the joints shall be prepared as specified herein, but joint sealing will not be required unless specified on plans.

If necessary for proper installation of the sealer, excessive spalling of the joint groove shall be repaired to the satisfaction of the Engineer in the manner which he prescribes.

Careful workmanship shall be exercised in the construction of all joints to insure that the concrete sections are completely separated by an open joint or by the joint materials and to insure that the joints will be true to the outline indicated.

(2) Expansion Joints. Transverse expansion joints shall be formed perpendicular to the centerline and surface of the pavement and shall be constructed in accordance with the sequence of operations shown on plans. After the transverse finishing machine and before the longitudinal finishing machine have passed over the joint, the Contractor shall test the joint filler for correctness of position and make any required adjustment in position of the filler and shall install the joint seal space form in accordance with plans. After removal of the joint seal form as required by plans, the joint seal space above the joint filler shall be thoroughly sandblasted or machine routed to remove all projecting concrete, laitance, dirt or foreign matter. The concrete faces of the joint seal space shall be left true to line and section throughout the entire length of the joint. On completion of curing of the pavement, the joint sealing filler of the type specified shall be placed in accordance with plans. The faces of the joint seal space shall be clean and surface dry at the time joint sealing filler is placed. On completion of the joint seal, the pavement adjacent to the joint shall be left free of joint sealing material. The joint seal space shall be exactly above and not narrower than the joint filler with no concrete overhangings.

(3) **Weakened Plane Joints.** Weakened plane joints shall consist of transverse contraction joints and longitudinal joints and shall be formed or sawed as specified on the plans. When the joints are sawed, the saw shall be power driven, shall be manufactured especially for the purpose of sawing concrete, and shall be capable of performing the work. Saw blades shall be designed to make a clean smooth cut having a width and depth of cut as detailed on the plans. Tracks adequately anchored, chalk, string line or other approved methods shall be used to provide true alignment of the joints. The concrete saw shall be maintained in good operating condition and the Contractor shall keep a stand-by power saw on the project at all times when concrete operations are under way.

If membrane curing is used, the portion of the seal which has been disturbed by sawing operations shall be restored by the Contractor by spraying the areas with additional curing seal.

Forming, finishing and sealing of the joint seal space shall be in accordance with applicable provisions of Subarticle 360.7 (2) above and details shown on plans.

(a) Contraction Joints. Transverse contraction joints shall be formed or sawed joints perpendicular to the centerline and surface of the pavement and shall be constructed by the method, and in the sequence of operations, as shown on plans. Where sawed joints are used, contraction joints at approximately 60-foot intervals shall be sawed as soon as sawing can be accomplished without damage to the pavement and before 24 hours after the concrete has been placed, the exact time to be approved by the Engineer. The remaining contraction joints shall be sawed in a uniform pattern as directed by the Engineer, and they shall be completed before uncontrolled cracking of the pavement takes place. All joints shall be completed before placing concrete in succeeding lanes and before permitting traffic to use the pavement.

If the metal contraction joint form is used it shall be secured in position by a transverse metal brace or other approved device as required by Subarticle 360.2(10) that will securely hold the form in place. The concrete adjacent to the metal contraction joint form shall be vibrated to the extent necessary to insure complete consolidation without honeycombing.

(b) Longitudinal Joints. Longitudinal joints shall be of the type or alternate types shown on plans and shall be constructed of specified materials in accordance with provisions of the plans. Longitudinal joints shall be constructed accurately to required lines, shall be perpendicular to the pavement surface at the joint, and the pavement surface over and adjacent to the joint shall be finished as specified.

Longitudinal joints shall be sawed when required by the plans from two to seven days after construction of the pavement. Sawing shall not cause damage to the pavement and the groove shall be cut with a minimum of spalling. No traffic (including construction traffic) shall be permitted on the pavement until the longitudinal joint is cut.

When the flex plane type longitudinal joint is used, it shall be placed behind the longitudinal float.

(4) Joint Sealers. Unless otherwise specified on the plans, either Class 1-a, Class 1-b, Class 2, Class 3 or Class 4 materials, designated by Subarticle 360.2(8) "Joint Sealing Material", may be used at the option of the Contractor.

Class 1-a and 1-b Materials shall be mixed and applied according to the manufacturer's recommendations.

Class 2 Material. This material shall be melted in an approved oil-bath kettle equipped with temperature indicators and continuously operated mechanical agitators. The material shall not be heated above 450 F and any material heated above that temperature will be rejected.

For placement in vertical joints (curb faces, etc.) either of the following procedures may be used.

1. An amount of the mixed material may be set aside until partial curing has taken place and carefully trowelled into the joint with a suitable tool.

2. The portion of the joint in the roadway shall be poured and cured. The vertical curb faces shall then be taped or formed and the material poured into the vertical joint from the top.

Class 3 Material. After the joints in the hardened concrete have been thoroughly cleaned to the satisfaction of the Engineer, the material shall be installed into each joint by means of a powered, concrete joint sealing machine capable of continuously feeding the compound under pressure into the joint in such a way as to fill it solidly. The extruding nozzle tip of the sealing machine shall be of such design as to fill the joint opening uniformly from the bottom to the top in a neat and workmanlike manner. The joints shall be completely filled.

Class 4 Material. After the joints in the hardened concrete have been repaired (if necessary) and cleaned to the satisfaction of the Engineer, the material shall be installed into each joint by means of an appropriate hand or power operated installation device using the lubricant-adhesive specified. The seal shall be installed in a compressed condition and shall be free of an objectionable amount of curling and twisting during installation in the joint groove. It shall be of such material and so installed that it will effectively seal joints in concrete against water, dirt, and stones throughout repeated cycles of expansion and contraction. Stretching of the compression seal during installation in the joint will not be permitted.

(5) Asphalt Board. Premolded materials, wherever used, shall be anchored to the concrete on one side of the joint by means of copper wire or nails not lighter than No. 12 B & S gage. Such anchorage shall be sufficient to overcome the tendency of the material to fall out of the joint.

(6) Curbs. The curb shall be constructed in lengths equal to the adjoining pavement slab lengths, and expansion joints shall be provided in the

curb opposite each transverse expansion joint in the pavement. Expansion joint material shall be of the same thickness, type and quality as specified for the pavement and shall be of the section as shown for the curb. All expansion joints shall be carried through the curb.

When sawed joints are provided for the pavement, the curb placement shall be delayed until all transverse joints have been sawed. To provide bond for the curb, dowel bars shall be placed as indicated on the plans while the pavement concrete is still plastic.

Weakened plane joints shall be formed in monolithic curbs at a spacing to coincide with the joints in the concrete pavement. The joints shall be formed by inserting in the curb an asphaltic board strip cut to conform to the shape of the curb. When the concrete is sufficiently set, the joint on the top and face of curb shall be grooved with an approved type of grooving tool.

A finish coat of mortar shall be applied on the exposed surfaces of the monolithic curbs. The mortar shall be composed of one part of portland cement and two parts of fine aggregate. A mortar coat will not be required for extruded curbs.

The curb face, lower radius and top of curb shall be plastered with the sand-cement mortar. The mortar shall be applied with a template or "mule" made to conform to the curb dimensions shown on plans. All exposed surfaces of the curb shall be finished with a steel trowel and brushed to a smooth and uniform surface. The mortar finish as required shall be subsidiary to the Item, "Concrete Pavement".

360.8. Spreading And Finishing.

(1) Machine Finishing. All concrete pavement shall be finished mechanically with approved power-driven machines, except as herein provided. Hand finishing will be permitted on the transition from a crowned section to a superelevated section without crown on curves, and on straight line superelevation sections less than 300 feet in length. Hand finishing will also be permitted on that portion of a widened pavement outside the normal pavement width, on sections where the pavement width is not uniform, or required monolithic widths are greater than that of available finishing machines.

Machine finishing of pavement shall include the use of power-driven spreaders, power-driven vibrators, power-driven transverse strike-off, and screed, or such alternate equipment as may be substituted and approved under Subarticle 360.3(10).

All concrete pavement shall be consolidated by a mechanical vibrator. As soon as the concrete has been spread between the forms, the approved mechanical vibrator shall be operated to consolidate the concrete and remove all voids. Hand manipulated vibrators shall be used for areas not covered by the mechanical vibratory unit.

The transverse finishing machine shall first be operated to compact and finish the pavement to the required section and grade, without surface voids. The machine shall be operated over each area as many times and at such intervals as directed. At least two trips will be required and the last trip over a

given area shall be a continuous run of not less than 40 feet. After completion of finishing with the transverse finishing machine a transverse drag float may be used.

After finishing is complete and the concrete still workable, the surface shall be tested for trueness with an approved 10-foot steel straightedge. The straightedge shall be operated from the side of the pavement, placed parallel to the pavement centerline and passed across the slab to reveal any high spots or depressions. The straightedge shall be advanced along the pavement in successive stages of not more than one-half its length. Practically perfect contact of the straightedge with the surface will be required, and the pavement shall be leveled to this condition, in order to insure conformity with the surface test required below after the pavement has fully hardened. Any correction of the surface required shall be accomplished by adding concrete if required and by operating the longitudinal float over the area. The surface test with the straightedge shall then be repeated.

For one-lane pavement placement and uniform widening, the equipment for machine finishing of concrete pavement shall be as directed by the Engineer but shall not exceed the requirements of these specifications.

After completion of the straightedge operation, the first pass of the burlap drag shall be made as soon as construction operations permit and before the water sheen has disappeared from the surface. This shall be followed by as many passes as required to produce the desired texture depth. There shall be no unnecessary delays between passes. The drag shall be wet during use and maintained clean and free from encrusted mortar. It is the intent that the average texture depth resulting from the number of tests directed by the Engineer be not less than 0.025 inches with a minimum texture depth of 0.020 inches for any one test when tested in accordance with Texas Test Method 436 A. Should the texture depth fall below that intended, the finishing procedures shall be revised to produce the desired texture.

Emergency Procedures

The Contractor shall have available at all times hand brooms with stiff bristles for the purpose of providing textures when the pavement surface is in such a condition that the burlap drag or other methods being employed will not provide the desired texture.

The Contractor also shall have available a conventional garden spray type can containing a commercially available monomolecular film compound. This shall be applied in the case of equipment breakdown or other emergencies to prevent the pavement from drying too rapidly. The use of this product will give the Contractor additional time to provide adequate texturing.

After completion of dragging and about the time the concrete becomes hard, the edge of the slab and joints shall be carefully finished as directed by the Engineer, and the pavement shall be left smooth and true to line.

(2) Hand Finishing. Hand finishing shall be resorted to only in those conditions provided for above and upon specific authorization by the

Engineer. When hand finishing is permitted, the concrete shall be struck off with an approved strike-off screed to such elevation that when consolidated and finished the surface of the pavement shall conform to the required section and grade. The strike template shall be moved forward with a combined transverse and longitudinal motion in the direction the work is progressing, maintaining the template in contact with the forms, and maintaining a slight excess of material in front of the cutting edge. The concrete shall then be tamped with an approved tamping template to compact the concrete thoroughly and eliminate surface voids and the surface screeded to required section.

After completion of a strike-off, consolidation and transverse screeding, a hand-operated longitudinal float shall be operated to test and level the surface to the required grade.

Workmen shall operate the float from approved bridges riding on the forms and spanning the pavement. The longitudinal float shall be held in contact with the surface and parallel to the center line and operated with short longitudinal strokes while being passed from one side of the pavement to the other. If contact with the pavement is not made at all points, additional concrete shall be placed, if required, and screeded, and the float shall be used to produce a satisfactory surface. Care shall be exercised to keep the ends of the float from digging into the surface of the pavement. After a section has been smoothed so that the float maintains contact with the surface at all points in being passed from one side to the other, the bridges may be moved forward half the length of the float and the operations repeated.

Other operations and surface tests shall be as required for machine finishing.

(3) Optional Method and Equipment for Placing and Finishing Concrete Pavement. In lieu of construction methods employing forms, spreading, consolidating, finishing and floating equipment required in this specification, the Contractor, if he so elects, may use a "Traveling Form Paver" (also known by various other trade names such as "Formless Paver", "Slip Form Paver", etc.). If this method of construction is elected, all requirements of this specification in regard to subgrade and pavement tolerances, pavement depth, alignments, consolidating, finishing, workmanship, etc., shall be met in full.

In addition to the applicable provisions of this specification, the following requirements shall govern when a traveling form paver is employed.

(a) Equipment. If a "Traveling Form Paver" proves inadequate in the opinion of the Engineer in providing a pavement which meets the plans and specifications in all respects, the use shall be immediately discontinued when so ordered by the Engineer.

The traveling paver shall be equipped with a longitudinal transangular finishing float (also known by various trade names such as "V-Finisher", "Lewis Transangular Finisher", C.M.I. tube float, etc.) adjustable to crown and grade. The float shall extend across the pavement practically to the side forms and/or the edge of slab.

Mechanical placement of reinforcing steel will be permitted. In the event this method of steel placement does not meet the requirements of the plans and specifications, in the opinion of the Engineer, this method shall be discontinued immediately, and the work shall be completed using conventional methods of tieing steel, supporting steel with chairs, etc.

(b) Construction Methods. Prior to beginning paving operations, the Contractor shall insure that a continuous deposit of concrete can be made at the paver to minimize starting and stopping.

Locations inaccessible to a traveling paver or locations having horizontal or vertical curvature that a traveling paver cannot negotiate shall be paved using conventional means.

Where the plans require tie bars to be installed for adjacent paving, the bars shall be securely tied and supported to prevent displacement, or the tie bars may be installed with an approved mechanical bar inserter mounted on the traveling-form paver. The Contractor will be required to replace at his expense any pavement in which tie bars assume a final position other than that shown on the plans unless corrective alternates are authorized by the Engineer in writing and authorized measures are carried out to the satisfaction of the Engineer in the manner which he prescribes. Tie bars which require bending after concrete has been placed shall not be bent until the concrete has cured three days or until such time as the Engineer may direct.

(c) Curing. The concrete pavement, except that to be overlaid by asphaltic concrete, shall be cured with a Type II white pigmented curing compound in accordance with the requirements of the Item, "Membrane Curing". Concrete pavement to be overlaid by asphaltic concrete shall be cured by one of the methods specified in Article 360.9, "Curing".

(4) Surface Test. After the concrete has been placed 12 hours or more, the Engineer will test the surface of the pavement with a 10-foot straightedge placed parallel to the centerline. Unless specified otherwise, the surface shall not vary from the straightedge by more than 1/16 inch per foot from the nearest point of contact, and in no case shall the maximum ordinate from a 10-foot straightedge to the pavement be greater than 1/8 inch. Any high spots causing a departure from the straightedge in excess of that specified shall be ground down by the Contractor to meet the surface test requirements.

Where the pavement width is irregular or where the area to be paved is isolated or narrow in width, other paving equipment than that specified above will be permitted when approved by the Engineer unless otherwise shown on plans.

360.9. Curing.

(1) General. All concrete pavement shall be cured by protecting it against loss of moisture for a period of not less than 72 hours from the beginning of curing operations. Immediately after finishing operations have been completed, the entire surface of the newly laid concrete shall be covered and cured in accordance with the requirements specified for whichever of the following methods the Contractor may elect. Newly laid concrete base to be

overlaid by asphaltic concrete shall not be cured by "Membrane Curing", and surfaces not to be overlaid by asphaltic concrete shall not be cured by "Asphalt Curing". In all cases in which curing requires the use of water, the curing shall have prior right to all water supply or supplies. Failure to provide sufficient cover material of the type the Contractor elects to use, failure to maintain saturation in wet curing methods, lack of water to adequately take care of both curing and other requirements, or other failures to comply with curing requirements shall be cause for immediate suspension of concreting operations. The covering material used in curing shall be removed as necessary to saw joints or to comply with the requirements for "Surface Test". The concrete surface shall be maintained wet with a water spray if required, and the covering material replaced immediately on completion of sawing and testing and any required surface correction.

(2) Cotton Mat Curing. Immediately after the finishing of the surface has been completed and the concrete has taken its initial set, the surface shall be completely covered with cotton mats, thoroughly saturated before application, in such manner that they will contact the surface of the pavement equally at all points. Immediately upon removal of side forms, drainage shall be established as specified, and the pavement edges completely covered with either saturated cotton mats or saturated earth.

The cotton mats shall remain on the pavement for not less than the specified curing period and shall be kept saturated so that, when lightly compressed, water will drip freely from them. Earth banked against pavement edges, or cotton mat covering of edges, shall be kept saturated. The cotton mats used for curing shall meet the following requirements:

Each mat shall have a finished width of approximately 5-1/2 feet and after shrinkage shall be at least 6 inches longer than the width of the pavement to be cured.

The mats shall be composed of a single layer of cotton filler completely enclosed in a cover of cotton cloth. The cotton filler shall be of low grade cotton, cotton linters or such cotton waste as comber noils or card flat strips. The mats shall contain not less than 3/4 of a pound of cotton filler per square yard of mat uniformly distributed. The cotton cloth used for covering material shall be Osnaburg, weighing not less than 6.3 ounces per square yard.

All mats shall be stitched longitudinally with continuous parallel rows of stitching at intervals of not more than 4 inches or shall be tufted both transversely and longitudinally at intervals of not more than 3 inches. The sewing or tufting shall not be done so tightly that the mat will not contact the surface of the pavement at all points when saturated with water.

To insure the complete covering of the pavement where the mats fit together, there shall be a flap extending all along one side of each mat. This flap shall be composed of two thicknesses of the cover material and shall be at least 6 inches in width.

(3) Waterproofed Paper Curing. Immediately after the finishing of the surface has been completed and the concrete has taken its initial set, it shall be wetted with water applied in the form of a fine spray and covered with waterproofed paper so placed and weighted as to cause it to remain in

intimate contact with the surface. Waterproofed paper used for the curing of concrete pavement shall be of a type and quality approved by the Engineer. It shall be sufficiently strong and tough to permit its use under the conditions existing on highway paving work without being torn or otherwise rendered unfit for the purpose during the curing period. The paper covering shall be maintained in place continuously for not less than the specified curing period.

The waterproofed paper shall be prepared to form blankets of sufficient width to cover the entire surface and both edges of the pavement slab, and such blankets shall not be more than 60 feet in length. All joints in the blankets occasioned by joining paper sheets shall lap not less than 5 inches and shall be securely sealed with asphalt cement having a melting point of approximately 180 F. Blankets shall be placed to secure an overlap of at least 12 inches, and this lap securely weighted to form a closed joint.

The waterproofed paper blankets shall be adequately weighted to prevent displacement or billowing due to wind and the paper folded down over the side of the pavement shall be secured by a continuous bank of earth. Plowing of this windrow into place will not be permitted.

All tears or holes appearing in the paper during the curing period shall be immediately repaired by cementing patches over such defects. It shall be the Contractor's responsibility to prevent damage to the paper blankets which would affect their serviceability and effectiveness as a concrete curing method. Blankets may be rejected by the Engineer at any time when, in his opinion, they do not provide an airtight covering.

Paper blankets rejected on account of pinholes or minor tears may be continued in service by folding the blanket over lengthwise, first thoroughly spraying one-half the blanket with the asphalt cement used for seams. The two thicknesses shall be firmly pressed together and well cemented. All blankets shall be of a width sufficient to cover the pavement surface and both edges. Doubled blankets may be rejected for the same cause as provided for single blankets. All paper blankets condemned by the Engineer shall be immediately marked by the Contractor for identification and then destroyed or stored entirely separate from approved blankets.

No walking on the paper shall be permitted at any time, and, in locations where pedestrian traffic cannot be entirely controlled, the Contractor shall provide walkways and barricades or shall substitute other permissible curing methods on such sections of pavement.

(4) Polyethylene Film Curing. Immediately after the finishing of the surface has been completed and the concrete has taken its initial set, it shall be wetted with water applied in the form of a fine spray and covered with the polyethylene film so placed and weighted as to cause it to remain in intimate contact with the surface. The polyethylene film used for the curing of concrete pavement shall be of a type and quality approved by the Engineer. It shall be sufficiently strong and tough to permit its use under the conditions existing on highway paving work without being torn or otherwise rendered unfit for the purpose during the curing period. The polyethylene film covering shall be maintained in place continuously for not less than the specified curing period.

The film shall be prepared to form blankets of sufficient width to cover the entire surface and both edges of the pavement slab. All joints in the blankets occasioned by joining film sheets shall lap not less than 12 inches. All joints shall be sealed in a manner acceptable to the Engineer to provide a moisture-proof lap.

The polyethylene film blankets shall be adequately weighted to prevent displacement or billowing due to wind and the film folded down over the side of the pavement shall be secured by a continuous bank of earth. Plowing of this windrow into place will not be permitted.

All tears or holes appearing in the polyethylene film during the curing period shall be immediately repaired by placing acceptable moisture proof patches over such defects or by replacing the blankets. It shall be the Contractor's responsibility to prevent damage to the film blankets which would affect their serviceability and effectiveness as a concrete curing method. Blankets may be rejected by the Engineer at any time when, in his opinion, they do not provide an airtight covering.

Polyethylene film blankets rejected on account of pinholes or minor tears may be continued in service when repaired to an airtight condition. All polyethylene film blankets condemned by the Engineer shall be immediately marked by the Contractor for identification and then destroyed or stored entirely separate from approved blankets.

Should the film blanket be damaged or torn for any cause during the first 72 hours of the curing period such damage shall be repaired immediately.

(5) Membrane Curing. Immediately after the finishing of the pavement has been completed and after the free surface moisture has disappeared, the pavement shall be sprayed uniformly with a curing compound. Membrane curing shall conform to the requirements of the Item, "Membrane Curing", Type 2 white pigmented. Should the film of compound be damaged from any cause before the expiration of 72 hours after original application, the damaged portions shall be repaired immediately with additional compound.

(6) Asphalt Curing. The equipment and method of application shall be the same as described in Subarticle 360.9(5), "Membrane Curing", except that the rate of application may vary between the limits of 1 gallon per 180 square feet and 1 gallon per 90 square feet. The rate of application will be determined by the Engineer, after observation of sections where amounts varying between the above limits have been applied. If it is found necessary to add water to emulsion for the proper distribution through the spray, this may be done upon approval of the Engineer. When the emulsion is diluted with water the amount of the applied mixture shall be increased to give a coverage of the original emulsion between the limits as set out herein. Care must be taken to properly mix the emulsion and water and to keep the mixture well agitated during application.

360.10. Protection Of Pavement And Opening To Traffic.

(1) Protection of Pavement. The Contractor shall erect and maintain the barricades required by plans and such other standard and approved devices as will exclude public traffic and traffic of his employees and agents from the

newly placed pavement for the periods of time hereinafter prescribed. Portions of the roadway, or crossings of the roadbed required to be maintained open for use by traffic, shall not be obstructed by the above required barricades. Crossings of the pavement required by plans, or by construction sequence, during the period prior to opening to traffic as herein specified, shall be provided with an adequate and substantial bridge, approved by the Engineer.

(2) Opening Pavement to Traffic. The pavement shall be closed to all traffic, including vehicles of the Contractor, until the concrete is at least 7 days old and has attained a minimum average modulus of rupture as required under Article 360.4 of these specifications. This period of closure to all traffic may be extended if, in the opinion of the Engineer, weather or other conditions make it advisable to provide an extension of the time of protection.

At the end of the 7 day period and as long thereafter as ordered by the Engineer, and if so desired by the Contractor, the pavement may be opened for use by vehicles of the Contractor provided the gross weight (vehicle plus load) of such vehicles does not exceed 14,000 pounds. Such opening, however, shall in no manner relieve the Contractor from his responsibility for the work in accordance with Items 7.7, 7.11 and 7.12 of the Standard Specifications. On those sections of the pavement thus opened to traffic, all joints shall first be sealed, the pavement cleaned and earth placed against the pavement edges before permitting vehicles thereon.

After the concrete in any section is 14 days old, or as long thereafter as ordered by the Engineer, such section of pavement may be opened to all traffic as required by plans or when so directed by the Engineer. On those sections of the pavement thus opened to traffic, all joints shall first be sealed, the pavement cleaned, earth placed against the pavement edges and all other work performed as required for the safety of traffic. Such opening, however, shall in no manner relieve the Contractor from his responsibility for the work in accordance with Items 7.7, 7.11 and 7.12 of the Standard Specifications.

When High Early Strength Concrete, resulting from the use of Type III cement as required by plans or special provisions, is used, the pavement may be opened to all traffic after the concrete is 7 days old, or as long thereafter as ordered by the Engineer, subject to the same provisions governing the opening after 14 days as above prescribed.

Where the Contractor desires to move any equipment not licensed for operation on public highways, on or across any pavement opened to traffic, he shall protect the pavement from all damage by means of two-ply timber mats of 2 inch stock or runways of heavier material laid on a layer of earth, all as approved by the Engineer.

(3) Emergency Opening to Traffic. The Engineer may require the opening of pavement to traffic prior to the minimum time specified above under conditions of emergency which in his opinion require such action in the interest of the public. In no case shall the Engineer order opening of the pavement to traffic within less than 72 hours after the last concrete in the section is placed. The Contractor shall remove all obstructing materials, place earth against the pavement edges and perform other work involved in

providing for the safety of traffic as required by the Engineer in ordering emergency opening. Orders for emergency opening of the pavement to traffic will be issued by the Engineer in writing.

360.11. Penalty For Deficient Pavement Thickness. The adjustment in unit prices provided for in this article will apply only when measurement for payment is by the square yard.

It is the intent of this specification that the pavement be constructed in strict conformity with the thickness and typical sections shown on plans. Where any pavement is found not so constructed, the following rules relative to adjustment of payment for acceptable pavement and to replacement of faulty pavement shall govern.

(1) The pavement will be core drilled by the Texas Highway Department prior to final acceptance. Locations of core tests may be selected by the Engineer; however, the spacing interval for core tests, as specified herein, is to be maintained. The thickness of the pavement will be determined by measurement of the cores in accordance with Test Method Tex-424-A.

For the purpose of establishing an adjusted unit price for pavement, units to be considered separately are defined as 1000 linar feet of pavement in each traffic lane starting at the end of the pavement bearing the smaller station number. The last unit in each lane shall be 1000 feet plus the fractional part of 1000 feet remaining. Traffic lane width will be as shown on typical sections and pavement design standards.

For the purpose of establishing an adjusted unit price for ramps, widening, acceleration and deceleration lanes that are machine placed, isolated pavements of traffic lane width but less than 1000 feet in length, and other areas designated by the Engineer, units to be considered separately are defined as 1000 square yards of pavement or fraction thereof.

One core will be taken by the Department at the location selected by the Engineer or at random in each unit. When the measurement of the core from any unit is not deficient more than 0.2 inch from the plan thickness, full payment will be made. When the measurement of the core from any unit is deficient more than 0.2 inch but not more than 0.75 inch from the plan thickness, two additional cores will be taken from the unit and the average of the three cores determined. The two additional cores from any 1000-foot unit will be taken at intervals of not less than 300 feet. The two additional cores from any 1000-square yard unit will be taken at locations such that the pavement in the unit will be well represented. If the average measurement of these three cores is not deficient more than 0.2 inch from the plan thickness, full payment will be made. If the average thickness of the three cores is deficient more than 0.2 inch but not more than 0.75 inch from the plan thickness, an adjusted unit price as provided in Subarticle 360.11.(2) will be paid for the areas represented by these cores.

In calculating the average thickness of the pavement, measurements which are in excess of the specified thickness by more than 0.2 inch will be considered as the specified thickness plus 0.2 inch, and measurements which are less than the specified thickness by more than 0.75 inch will be considered as the specified thickness less 0.75 inch.

When the measurement of any core is less than the specified thickness by more than 0.75 inch, the actual thickness of the pavement in this area will be determined by taking additional cores at 10-foot intervals parallel to the center line in each direction from the deficient core until, in each direction, a core is taken which is not deficient by more than 0.75 inch. Exploratory cores for deficient thickness will not be used in averages for adjusted unit price. Exploratory cores are to be used only to determine the length of pavement in a unit that is to be left in place without pay and/or removed and replaced as provided in Subarticle 360.11.(2).

(2) Price Adjustments. Where the average thickness of pavement is deficient in thickness by more than 0.2 inch, but not more than 0.75 inch, payment will be made at an adjusted price as specified in the following table.

Concrete Pavement Deficiency

Deficiency in Thickness Determined by Cores Inches	Proportional Part of Contract Price Allowed
0.00 to 0.20	100 percent
0.21 to 0.30	80 percent
0.31 to 0.40	72 percent
0.41 to 0.50	68 percent
0.51 to 0.75	57 percent

Any area of pavement found deficient in thickness by more than 0.75 of an inch but not more than one inch or 1/8 of the plan thickness, whichever is greater, shall be evaluated by the Engineer. If, in the judgement of the Engineer, the area of such deficiency should not be removed and replaced, there will be no payment for the area retained. If, in the judgement of the Engineer, the area of such deficiency warrants removal, the area shall be removed and replaced, at the Contractor's entire expense, with concrete of the thickness shown on the plans.

Any area of pavement found deficient in thickness by more than one inch or more than 1/8 of the plan thickness, whichever is greater, shall be removed and replaced, at the Contractor's entire expense, with concrete of the thickness shown on the plans.

(3) No additional payment over the contract unit price will be made for any pavement of a thickness exceeding that required by plans.

360.12. Measurement.

(1) When provided by plans and proposal, concrete pavement will be measured by the square yard of surface area of completed and accepted work. The surface area will be so construed to also include that portion of the pavement slab extending beneath the curb. When concrete pavement is to be measured by the square yard and monolithic curb is required, measurements for "Monolithic Curb" will be by the linar foot complete in place.

(2) When provided by plans and proposal, concrete pavement, including monolithic curb when required, will be measured by the cubic yard of absolute volume of all materials entering the mixture as prescribed in THD Bulletin C-11.

360.13. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Pavement", "Concrete Pavement (High Strength)", "Concrete Pavement (High Yield Steel)", "Concrete Pavement (Deformed Wire Mat)" and "Monolithic Curb" (when pavement is measured by the square yard), as required, or the adjusted unit price for pavement of deficient thickness as provided under "Penalty for Deficient Pavement Thickness", which price shall be full compensation for shaping and fine grading the roadbed, including furnishing and applying all water required; for furnishing, loading and unloading, storing, hauling and handling all concrete ingredients, including all freight and royalty involved; for placing and adjusting forms, including supporting material or preparing track grade; for mixing, placing, finishing, sawing, cleaning and sealing joints, and curing all concrete; for furnishing and installing all reinforcing steel; for furnishing all materials for sealing joints and placing longitudinal, expansion and weakened plane joints, including all steel dowel caps and load transmission devices required, and wire and devices for placing, holding and supporting the steel bars, load transmission devices and joint filler material in proper position, for coating steel bars where required by plans, and for all manipulations, labor, equipment, appliances, tools, traffic provisions and incidentals necessary to complete the work.

Excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage shall be measured and paid for once only, regardless of the manipulations involved; or where shown on plans, such work will be measured and paid for in accordance with the provisions governing the Item, "Blading". Measurement of subgrade excavation for payment shall be limited to a total width of that of the pavement plus 1 foot on each side. Payment under excavation items will not be allowed within the areas designated for "Blading".

Sprinkling and rolling required for the compaction of the rough subgrade in advance of fine grading will be measured and paid for as indicated in the governing items of excavation. Maintenance of a moist condition of the subgrade in advance of fine grading and concrete placing will not be paid for directly but shall be considered subsidiary work, as provided above.

ITEM 364

CONCRETE PAVEMENT
(Class "A" Concrete)

364.1. Description. This item shall consist of a pavement and/or base of portland cement concrete, with or without reinforcement as shown on plans, with or without monolithic curbs, constructed as herein specified on the prepared subgrade or other base course in conformity with the thickness and typical cross sections shown on plans and to the lines and grades established by the Engineer.

364.2. Materials. All concrete and concrete ingredients shall conform to

the requirements for Class "A" Concrete as specified in the Item, "Concrete for Structures (Natural Aggregate)" except that when the temperature of the air or concrete is above 85 F, use of a cement dispersing agent is permissible but not required and Table 3 is modified as follows:

Class	Min. Sacks Cement Per Cubic Yard	Min. Comp. Strength 28 Day P.S.I.	Max. Water Cement Ratio	Slump Range Inches	Coarse Aggregate Number	Fine Aggregate Number
A	5.0	3000	7.0	1-3	2 or 3	1

All other materials shall conform to the requirements of Articles 360.2(6) to 360.2(15) inclusive of the Item, "Concrete Pavement (Water Cement Ratio)", which is made a part of these specifications.

364.3. Proportioning and Mixing. Proportioning and mixing of concrete shall be in accordance with the provisions of the Item, "Concrete for Structures (Natural Aggregate)", and pertinent special provisions, and all concrete shall meet the strength and quality requirements required by that item.

364.4. Construction Methods. Preparation of subgrade, and placing, finishing and curing of concrete shall conform to the requirements of the Item, "Concrete Pavement (Water Cement Ratio)", and pertinent special provisions except that equipment and construction methods, satisfactory to the Engineer, which will produce the desired results may be used in lieu of those specified.

Hand finishing will be permitted.

364.5. Penalty for Deficient Pavement Thickness. The provisions of Article 360.11 of the Item, "Concrete Pavement (Water Cement Ratio)", is made a part of these specifications and shall govern for this item.

364.6. Measurement.

(1) When provided by plans and proposal, concrete pavement will be measured by the square yard of surface area of completed and accepted work. The surface area will be construed to also include that portion of the pavement slab extending beneath the curb. When "Monolithic Curb" is required, measurement will be by the linear foot complete in place.

(2) When provided by plans and proposals, concrete pavement, including monolithic curb when required, will be measured by the cubic yard complete in place.

364.7. Payment. The work performed and materials furnished, as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Pavement (Class "A" Concrete)", and for "Monolithic Curb" (when measured by the square yard), or the adjusted unit price for pavement of deficient thickness as provided under "Penalty for Deficient Pavement Thickness", which price shall be full compensation for loading, hauling, utilizing and/or disposing of all excavated

materials; for shaping and fine-grading the roadbed, including furnishing and applying all water required; for coating steel bar dowels, if dowels are required; for furnishing all material and constructing all joints, for all reinforcing steel, and for all manipulations, labor, equipment, appliances, tools and incidentals necessary to complete the work.

All excavation required by this item in prepartion of subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved.

ITEM 366

CONCRETE PAVEMENT
(Continuously Reinforced)

366.1. Description. This item shall conform to the description and all the requirements and conditions governing the Item, "Concrete Pavement (Water Cement Ratio)" which is made a part of this specification, except for the additions and/or modifications specified herein.

366.2. Materials. All concrete and concrete materials shall conform to the requirements for the Item, "Concrete Pavement (Water Cement Ratio)".

All other materials shall conform to the requirements of Article 360.2.(6) to 360.2.(15) inclusive, of the Item, "Concrete Pavement (Water Cement Ratio)" except for the following:

Where "high yield" reinforcing steel is specified or permitted, the steel shall be either (1) open-hearth, basic oxygen or electric-furnace new billet steel conforming to the requirements of ASTM Designation: A 615, Grade 60 or (2) rail steel bars for concrete reinforcement conforming to the requirements of ASTM Designation: A 616, Grade 60 (bars produced by the piling method will not be accepted). "High yield" reinforcing steel bars shall be further identified by a special marking rolled into each bar. Bars that require bending shall be grade 40 conforming to the requirements of ASTM Designation: A 615.

Where prefabricated deformed wire mats are specified or permitted, the wire shall be cold worked deformed steel wire conforming to the requirements of ASTM Designation: A 496, except that steel shall be made by open-hearth, electric-furnace, or basic oxygen processes. The prefabricated deformed wire mats shall conform to the requirements of ASTM Designation: A 497, except that all wires used shall be deformed and transverse wires shall project beyond the center line of each edge longitudinal wire as specified on the plans and in these specifications. Mats that have been bent or wires dislocated or parted during shipping or project handling shall be realigned to within one-half inch of the original horizontal plane of the mat. Mats with any portion of the wires out of vertical alignment more than one-half inch after realignment and/or wires dislocated or mutilated so that, in the opinion of the Engineer, they do not represent the original mat, shall be rejected. Deformed wire may be used for tie bars and load transfer bars that require

bending. The nominal size and area and the theoretical weight of reinforcing steel wires covered by this provision are as listed in Table 1.

366.3. Equipment. Equipment required for this item shall be as specified under Article 360.3. "Equipment" of the Item, "Concrete Pavement (Water Cement Ratio)" with the extra provision that where specified by these specifications, a minimum of two mixers shall be required; and the requirements relating to the operation of these mixers shall be strictly adhered to.

366.4. Proportioning Of Concrete. The requirements of Subarticle 360.4.(1), (4), (5), and (6) of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for this item. Subarticle 360.4.(2), "Concrete Strength" is replaced by the following:

Concrete Strength. The concrete mix will be designed with the intention of producing a flexural strength (Modulus of Rupture) not less than 575 pounds per square inch at the age of 7 days when tested in accordance with THD Bulletin C-11.

The coarse aggregate factor (dry loose volume of coarse aggregate per unit volume of concrete) shall not exceed 0.85. The fine aggregate factor in the concrete mix shall be as high as practicable near the upper limit of the range that permits proper placing, finishing and texturing. Unless specified otherwise on the plans the concrete shall contain not less than 5 sacks of cement per cubic yard. The concrete mixtures shall be designed to entrain 5 percent air with a tolerance of ± 1 percent based upon measurement made on concrete immediately after discharge from the mixer.

The water-cement ratio (net gallons of water per sack of 94 pounds of cement) shall not exceed 6.25 gallons per sack. Concrete specimens shall be prepared, cured and tested as outlined in THD Bulletin C-11.

366.5. Subgrade And Forms. The requirements of Article 360.5. of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for this item.

366.6. Concrete Mixing And Placing. The requirements of Article 360.6. of the Item, "Concrete Pavement (Water Cement Ratio)" supplemented by the following addition to Subarticle (4) thereof, shall govern for this item:

The spacing of bar splicing shall be distributed and conform to the requirements set forth in the plans. Splices shall have a length not less than 20 times the nominal size or diameter of the reinforcing bar with the exception that when "high yield" steel is used for the longitudinal reinforcement, splices shall have a length not less than 24 times the nominal size or diameter of the reinforcing bar. The bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer.

If welded bar lap splices are permitted in lieu of regular lap splices, all welding shall conform to the pertinent requirements of the Texas Highway Department or as directed by the Engineer.

Where deformed wire mats are specified the spacing of wire splicing shall conform to the requirements set forth in the plans. Splices shall have a length not less than 31 times the nominal size or diameter of the reinforcing wire.

The mats may be clamped or wired so that the mats will retain the horizontal and vertical alignment as specified by the plans or as approved by the Engineer.

366.7. Joints. Joints shall conform to the requirements of Article 360.7. of the Item, "Concrete Pavement (Water Cement Ratio)" and to details shown on plans.

366.8. Spreading And Finishing. The requirements of Article 360.8. of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for this item subject to the additional requirements of Article 366.6. of this specification.

366.9. Curing. The requirements of Article 360.9. of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for this item.

366.10. Protection Of Pavement And Opening To Traffic. The requirements of Article 360.10. of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for this item.

366.11. Penalty For Deficient Pavement Thickness. The provisions of Article 360.11. of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for this item.

366.12. Measurement.

(1) When provided by plans and proposal, concrete pavement will be measured by the square yard of surface area of completed and accepted work. The surface area will be construed to include that portion of pavement area extending beneath the curbs. When concrete pavement is to be measured by the square yard and monolithic curb is required, measurement for "Monolithic Curb" will be by the linear foot complete in place.

(2) When provided by plans and proposal, concrete pavement, including monolithic curb when required, will be measured by the cubic yard of absolute volume of all materials entering the mixture as prescribed in THD Bulletin C-11.

366.13. Payment. The work performed and material as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Pavement (Continuously Reinforced – High Yield Steel)", "Concrete Pavement (Continuously Reinforced – Deformed Wire Mat)", and "Monolithic Curb" (when pavement is measured by the square yard), as required, or the adjusted unit price for pavement of deficient thickness as provided under "Penalty for Deficient Pavement Thickness". The unit price bid shall be full compensation for shaping and fine-grading of the roadbed; including furnishing and applying all water required, for furnishing, loading, and unloading, storing, hauling and handling all concrete ingredients, including all freight and royalty involved; for mixing, placing, finishing, sawing, cleaning, and sealing joints and curing all concrete; for furnishing and installing all reinforcing steel; for furnishing all materials for sealing joints and placing longitudinal and expansion joints, including all steel dowel caps and load transmission devices required, and wire and devices for placing, holding,

and supporting the steel bars, load transmission devices and joint filler material in proper position; for coating steel bars where required by plans and for all manipulations, labor, equipment, appliances, tools, traffic provisions and incidentals necessary to complete the work.

Excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provisions that yardage shall be measured and paid for once only regardless of the manipulation involved; or, where shown on plans, such work will be measured and paid for in accordance with the provisions governing the Item, "Blading". Measurement of subgrade excavation for payment shall be limited to a total width of that of the pavement plus 1 foot on each side. Payment under excavation items will not be allowed within the areas designated for "Blading".

Sprinkling and rolling, required for the compaction of the rough subgrade in advance of fine-grading, will be measured and paid for as indicated in the governing items of excavation. Maintenance of a moist condition of the subgrade in advance of fine-grading and concrete placing will not be paid for directly, but shall be considered subsidiary work, as provided above.

TABLE I

DIMENSIONAL REQUIREMENTS FOR DEFORMED STEEL WIRE FOR CONCRETE REINFORCEMENT

		NOMINAL DIMENSIONS		
Deformed Wire Size No.	Unit Weight Pounds Per Ft.	Diam. Inches	Cross Sectional Area Sq. Inches	Perimeter Inches
1	2	3	4	5
D-1	.034	.113	.01	.355
D-2	.068	.159	.02	.499
D-3	.102	.195	.03	.612
D-4	.136	.225	.04	.706
D-5	.170	.252	.05	.791
D-6	.204	.276	.06	.867
D-7	.238	.298	.07	.936
D-8	.272	.319	.08	1.002
D-9	.306	.338	.09	1.061
D-10	.340	.356	.10	1.118
D-11	.374	.374	.11	1.174
D-12	.408	.390	.12	1.225
D-13	.442	.406	.13	1.275
D-14	.476	.422	.14	1.325
D-15	.510	.437	.15	1.372
D-16	.544	.451	.16	1.416
D-17	.578	.465	.17	1.460

Deformed Wire Size No.	Unit Weight Pounds Per Ft.	NOMINAL DIMENSIONS Diam. Inches	Cross Sectional Area Sq. Inches	Perimeter Inches
1	2	3	4	5
D-18	.612	.478	.18	1.501
D-19	.646	.491	.19	1.542
D-20	.680	.504	.20	1.583
D-21	.714	.517	.21	1.624
D-22	.748	.529	.22	1.662
D-23	.782	.541	.23	1.700
D-24	.816	.553	.24	1.737
D-25	.850	.564	.25	1.772
D-26	.884	.575	.26	1.806
D-27	.918	.586	.27	1.841
D-28	.952	.597	.28	1.876
D-29	.986	.608	.29	1.910
D-30	1.020	.618	.30	1.942
D-31	1.054	.628	.31	1.973

Col. 1. The number following the prefix D identifies the nominal cross-sectional area of the deformed wire in hundredths of a square inch. Fractional sizes are also available between the sizes listed.

Col. 2. The unit weight in pounds per foot is obtained by multiplying the cross-sectional area in square inches by 3.4.

Col. 3. The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire.

Col. 4. The cross-sectional area is based on the nominal diameter. The area in square inches may be calculated by dividing the weight per lineal inch of specimen in pounds by 0.2833 (weight of 1 cu. in. of steel), or by dividing the weight per lineal foot of specimen in pounds by 3.4 (weight of steel 1 in. square and 1 ft. long).

ITEM 370

ASPHALT UNDERSEAL FOR CONCRETE PAVEMENT

370.1. Description. This item shall consist of pumping an asphaltic material under concrete pavement in accordance with these specifications.

The asphalt shall not be applied when the air temperature is below 60 F and is falling, but it may be applied when the air temperature is above 50 F and is rising, the temperature being taken in the shade and away from artificial heat, with the further provision that the asphalt shall be placed only when general weather conditions, in the opinion of the Engineer, are suitable.

370.2. Materials.

(1) Asphalt. The asphalt used shall be an oil asphalt of the type and grade shown on the plans and shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

(2) Backfill Material. Material of suitable quality for backfilling holes will be furnished the Contractor free of cost in a stockpile within the limits of the work. The material will consist of crushed stone, gravel or premixed asphaltic concrete.

370.3. Construction Methods. One and one-half inch diameter holes shall be drilled through the concrete pavement as directed by the Engineer. Asphalt shall then be pumped through the holes and under the pavement by means of an approved type of self-propelled pressure distributor so operated that the pressure shall be from 15 to 45 pounds per square inch. The distributor shall be equipped with an accurate pressure gauge. A 1-inch metallic hose shall connect the asphaltic tank through the asphalt pump to a special 1-inch nozzle, and another 1-inch metallic hose shall connect the nozzle to the asphalt distributor tank. The nozzle shall be equipped with a three-way valve so designed that the asphaltic material may be circulated back into the asphalt distributor tank when pumping operations are not in progress.

Prior to pumping, the surface of the concrete pavement around the previously drilled 1-1/2 inch holes shall be thoroughly sprinkled with water, or shall be covered with sand, earth or other suitable material in order to prevent any asphalt that may be spilled on the pavement from adhering to the surface. The nozzle shall then be inserted in the hole, driven to a snug fit, and pumping operations begun. Asphalt shall be pumped through the hole and under the pavement until the voids under the pavement are filled as directed and the pavement shall be raised and levelled by pumping operations only when specifically directed by the Engineer.

The Contractor shall furnish and operate a satisfactory string line during all pumping operations. The holes shall be drilled and asphalt pumped at locations designated by the Engineer.

Pumping operations shall cease, when directed by the Engineer, and the nozzle left in the hole until the asphalt has chilled sufficiently to allow the nozzle to be removed and a wooden plug driven into the hole without an excessive back flow of asphalt through the hole. After the asphalt has hardened, the wooden plug shall be removed and the backfill material shall be thoroughly tamped in the hole, flush with the surface of the concrete pavement. All asphalt spilled on the pavement shall be removed by the Contractor.

All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphalt shall be kept clean and in good operating condition at all times, and they shall be operated in such a manner that there will be no contamination of the asphalt with foreign material. Asphalt shall not be heated above the maximum allowable temperature specified in the Item, "Asphalts, Oils and Emulsions", and all asphalt heated above the

maximum will be rejected. When pumped under the pavement the temperature of the asphalt shall be not less than 350 F and not more than the maximum allowed in the Item, "Asphalts, Oils and Emulsions". The Contractor shall provide all necessary facilities for determining the temperature of the asphalt in all heating equipment and distributors.

370.4. Measurement. Asphalt shall be measured in gallons at the applied temperature.

"Holes" shall be measured as each hole drilled.

370.5. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", of the type and grade specified, and "Holes", which prices shall each be full compensation for furnishing all materials; for all freight involved; for drilling and backfilling holes; for furnishing, preparing, heating, hauling and pumping all asphalt; for cleaning surface of concrete pavement; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 372

ASPHALT SUBGRADE MEMBRANE

372.1. Description. This item shall consist of treating, as specified herein, that portion of the prepared subgrade as indicated on plans or directed by the Engineer, for the immediate placement of concrete pavement.

372.2. Materials. The materials for treating the subgrade shall consist of an oil asphalt and granular material. The oil asphalt shall be of the type and grade shown on the plans and shall meet the requirements for that type and grade of asphalt as specified in the Item, "Asphalts, Oils and Emulsions". The granular material shall consist of sand or other suitable granular material, free from lumps of earth, vegetation or other objectionable matter.

372.3. Construction Methods. Subsequent to the preparation of the road to conform to the typical sections shown on plans and the lines and grades established by the Engineer, the subgrade shall be coated with an application of oil asphalt applied with an approved type of pressure distributor so operated as to distribute the material in the quantity specified evenly and smoothly, under a pressure necessary for proper distribution.

The number of applications, the amount of asphalt to be applied and the distance ahead of paving operations that asphalt may be placed shall be directed by the Engineer. The Engineer will select the temperature of application based on the temperature-viscosity relationship that will permit application of asphalt within the limits recommended in the Item, "Asphalts, Oils and Emulsions". The recommended range for the viscosity of the asphalt is 50 seconds to 60 seconds, Saybolt Furol. The Contractor shall apply the asphalt at a temperature within 15 F of the temperature selected.

The Asphalt shall be covered with sand at the rate indicated on the plans or as directed by the Engineer. The sand shall be spread, sprinkled if directed,

and lightly rolled with a hand operated roller of sufficient weight to set and compact the sand. Extreme care should be exercised to prevent and avoid damaging the asphalt subgrade membrane in any manner, and where such damage occurs, it shall be repaired immediately at the Contractor's expense.

372.4. Measurement. Asphalt will be measured at point of application on the road in gallons at the applied temperature. The quantity to be paid for shall be the number of gallons used, as directed, in the accepted asphalt subgrade membrane.

Sand will be measured by the cubic yard in vehicles at the point of delivery on the road.

372.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Asphalt", of the type and grade specified, and for "Sand", which prices shall each be full compensation for furnishing, preparing, hauling and placing all materials; for all freight and royalty involved; for all sprinkling and rolling; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

PART II, CONSTRUCTION DETAILS

DIVISION IV, STRUCTURES

ITEM 400

STRUCTURAL EXCAVATION

400.1. Description. This item shall govern the excavation for the placing of structures, except pipe sewers; for the disposal of such excavated material; and for the backfilling around completed structures to the level of the original ground. The work shall include all necessary pumping or bailing, sheathing, drainage, and the construction and removal of any required cofferdams. Unless otherwise provided, the work included hereunder shall provide for the removal of old structures or portions thereof (abutments, wingwalls, piers), trees, and all other obstructions necessary to the proposed construction.

Where excavation is not classified, it will be grouped under the Item, "Unclassified Structural Excavation", which shall include the removal of all materials encountered regardless of their nature or the manner in which they are removed.

Where excavation is classified, it shall be classed as "Common Structural Excavation" or "Rock Structural Excavation" in accordance with the following criteria:

"Common Structural Excavation" shall include the removal of all materials other than rock.

"Rock Structural Excavation" shall include the removal of firm and compact materials that cannot be excavated with power equipment, without first being loosened or broken by blasting, sledging or drilling.

To avoid the grouping of excavation of widely different character into a single bid item, the proposal may show "Structural Excavation" subdivided into items relating to individual structures, to parts of structures, or to groups of structures, as for example, "Unclassified Structural Excavation-Retaining Walls", "Unclassified Structural Excavation-Bridges", or "Unclassified Structural Excavation-Culverts".

400.2. Construction Methods. (1) Excavation shall be done in accordance with the lines and depths indicated on the plans or as established by the Engineer. Unless otherwise specified on the plans or permitted by the Engineer no excavation shall be made outside a vertical plane three feet from the footing lines and parallel thereto. When caissons are provided, no excavation will be permitted outside the outer faces of the caissons.

(2) To permit the Engineer to judge the adequacy of a proposed foundation, the Contractor, if requested, shall make soundings or take cores to determine the character of the subgrade materials. The maximum depth of soundings or cores will, in general, not exceed five feet below the proposed footing grade. It is the intent of this provision that soundings shall be made at the time the excavation in each foundation is approximately complete.

(3) Excavations shall conform to elevations shown on the plans, or raised or lowered by written order of the Engineer, when such alterations are judged proper. When deemed necessary to increase or decrease the plan depth of footings, the alterations in the details of the structure shall be as directed by the Engineer. The Department shall have the right to substitute revised details resulting from consideration of changes in the design conditions.

(4) When a structure is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation and the final excavation to grade shall not be performed until just before the footing is placed.

(5) Rock or other hard foundation material shall be free from all loose material, clean, and cut to a firm surface either level, stepped, or serrated, as directed by the Engineer. All seams shall be cleaned out and filled with concrete at the time the footing is placed. The quantity of concrete required for filling seams shall be measured and included for payment in the quantities for the unit of the structure for which the excavation is made.

(6) Excavated material required to be used for backfill may be deposited by the Contractor in storage piles at points convenient for its rehandling during the backfilling operations. The location of storage piles shall be subject to the approval of the Engineer, who may require that the survey center line of the structure and the transverse or hub line of any unit of the structure be kept free of any obstruction. In all cases, the Contractor shall comply with the provisions of Article 5.7 in locating storage piles for excavated material.

(7) Excavated material required to be wasted shall be disposed of as directed by the Engineer, in a manner which will not obstruct the stream or otherwise impair the efficiency or appearance of the structure or other part of the work.

(8) For all single and multiple box culverts, pipe culverts, pipe arch culverts, and box sewers of all types, where the soil encountered at established footing grade is a quicksand, muck, or similar unstable material, the following procedure shall be used unless other methods are called for on the plans:

The depth to which unstable material is removed will be determined by the Engineer. It will not exceed two feet below the footing of culverts that are two feet or more in height, and will not exceed the height of culverts for those less than two feet high. Excavation shall be carried at least one foot horizontally beyond the limits of the structure on all sides. All unstable soil removed shall be replaced with suitable stable material, in uniform layers of suitable depth for compaction as directed by the Engineer. Each layer shall be wetted, if necessary, and compacted by rolling or tamping as required to provide a stable foundation for the structure. Soil which has sufficient stability to properly sustain the adjacent sections of the roadway embankment will be considered a suitable foundation material.

When, in the opinion of the Engineer, it is not feasible to construct a stable footing as outlined above, the Contractor shall construct it by the use of special materials, such as flexible base, cement stabilized base, cement stabilized backfill or other material, as directed by the Engineer. This work will be paid for as provided in Article 400.7.

Special materials used, or additional excavation made, for the Contractor's convenience to expedite the work will not be paid for directly, but shall be subsidiary to the various classes of structural excavation.

(9) When the material encountered at footing grade of a culvert is found to be partially rock, or incompressible material, and partially a compressible soil which is satisfactory for the foundation, the incompressible material shall be removed for a depth of six inches below the footing grade and backfilled with a compressible material similar to that used for the rest of the structure.

(10) When the material encountered at footing grade of a bridge bent or pier is found to be partially of rock or incompressible material, and partially of a compressible material, the foundation shall not be placed until the Engineer has inspected the footing and authorized such changes found necessary to provide an adequate foundation.

400.3. Cofferdams and Caissons. The term cofferdam, whenever used in this specification, designates any temporary or removable structure constructed to hold the surrounding earth, water, or both, out of the excavation, whether the structure is formed of earth, timber, steel, concrete, or a combination of these. It includes earthen dikes, timber cribs, any type of sheet piling, removable steel shells and the like and all necessary bracing; and it shall be understood also to include the use of pumping wells or well points for the same purpose. The cost of cofferdams, when required, shall be included as a part of the bid price for excavation.

The term caisson, wherever used in this specification, designates a permanent part of the substructure constructed to sink gradually into place as material is excavated within the area protected by its sidewalls. A caisson may be of either the open-well or pneumatic type, and quantities for same will always be included as bid items separate from excavation.

In addition to interior dredging, the lowering of caissons may be faciliated by the following methods:

Addition of weight by increasing the thickness of caissons, where an increase is permitted by the type of design and is requested by the Contractor prior to beginning the work. Increased quantities due to this change shall be at the Contractor's expense.

Addition of removable loads to the caisson.

The use of water or air jets placed around the caisson.

The use of light charges of explosives placed to preclude likelihood of damage to the construction. Written permission shall be secured from the Engineer prior to the use of explosives, and the work shall be under the direction of an expert in their use.

Steel shell caissons may be driven with a pile driving hammer if the Contractor, at his expense, will provide a suitable driving ring. The ring shall be of sufficient strength, and the driving regulated to preclude damage to the caisson.

When no provision for caissons is shown on the plans, it is the intent of this specification to require that a suitable cofferdam be provided for all excavations when necessary in order to control water, so that the foundation

may be placed in a dry condition, or to preclude sliding and caving of the walls of the excavation. Where no ground or surface water is encountered, the cofferdam need be sufficient only to protect the workmen and to avoid cave-ins or slides extending beyond the excavation limits set forth in Article 400.2.

The Contractor shall submit drawings showing his proposed method of cofferdam construction and other details left open to his choice or not fully shown on the plans. The type, strength and clearance of cofferdams, insofar as such details affect the character of the finished work and the safety of laborers and inspectors working therein, will be subject to the approval of the Engineer. Other details or design will be left to the choice of the Contractor, who will be responsible for the successful completion of the work. Approval of the drawings by the Engineer will not relieve the Contractor of responsibility in any manner. The interior dimensions of cofferdams shall provide sufficient clearance for the construction and removal of any required forms and the inspection of their exteriors and to permit pumping outside of the forms.

In general, sheet piling cofferdams shall extend well below the bottom of the footings and shall be well braced and as water-tight as practicable.

When a concrete seal is required by the plans, the design will have been based on the normal water elevations as shown on the plans. If the foundation concrete can be placed in the dry under construction conditions, the seal will not be required. If additional seal is necessary for the conditions existing during the time of construction, the seal thickness shall be increased as deemed necessary at the expense of the Contractor. If the conditions existing at the time of construction require a seal for placing the foundation concrete in the dry, and none is provided in the plans, the Contractor shall place an adequate seal at his expense.

When the Engineer judges it impractical to de-water a caisson or cofferdam before placing a concrete seal around piling driven therein, the excavation may be extended below the footing grade deep enough to allow for swell of the material during pile driving operations. After driving the piling, all foundation material that has risen to a level more than one foot above the footing grade shall be removed. It is the intention of this provision to establish a construction tolerance to be applied when a foundation is being constructed under water. Where it is possible to de-water the caisson or cofferdam before a seal is placed, it is considered practicable to remove the foundation material to exact footing grades after piling are driven. Back-filling in a foundation to compensate for excavation which has been extended below grade will not be permitted. Such areas below grade shall be filled with concrete at the time the seals or footings are placed. The concrete quantities involved shall be at the Contractor's expense.

Caissons or cofferdams which tilt or move laterally during the process of sinking shall be righted or enlarged, as necessary, at the expense of the Contractor.

Unless otherwise provided, cofferdams shall be removed by the Contractor after the completion of the substructure without disturbing or marring the structure.

400.4. Pumping or Bailing. The manner of pumping or bailing from the interior of any foundation enclosure shall preclude the possibility of the movement of water through or alongside any concrete being placed. No pumping or bailing will be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless from a suitable sump separated from the concrete work by a water-tight wall. Pumping or bailing to de-water a sealed cofferdam or caisson shall not be started until the seal has set at least 36 hours.

400.5. Backfilling.

(1) General. As soon as practicable, all portions of excavation not occupied by the permanent structure shall be backfilled. Back-fill material shall be free from large or frozen lumps, wood or other extraneous material.

That portion of backfill which will not support any portion of completed roadbed or embankment shall be placed in layers not more than 10 inches in depth (loose measurement) and shall be compacted to a density comparable with the adjacent, undisturbed material.

If the excavation has been made through a hard material resistant to erosion, the backfill around piers and in front of abutments and wings may be ordered by the Engineer to be of stone or lean concrete. Unless otherwise provided, such backfill shall be paid for as extra work.

That portion of the backfill which will support any portion of the roadbed or embankment shall be placed in uniform layers not to exceed six inches in depth (loose measurement) and each layer compacted to the density specified herein. Each layer of backfill material, if dry, shall be wetted uniformly to the moisture content required to obtain the specified density and shall be compacted to that density by means of mechanical tamps or rammers, except that the use of rolling equipment of the type generally used in compacting embankments will be permitted on portions which are accessible to such equipment. All portions of embankment too close to any portion of a structure to permit compaction by the use of the blading and rolling equipment used on adjoining sections of embankment, shall be placed and compacted in the same manner as specified above for backfill material. These provisions require the mechanical compaction, by means of either rolling equipment or mechanical tamps or rammers, of all backfill and embankment adjoining the barrels and wingwalls of culverts and adjoining all sides of bridge abutments and retaining walls, regardless of whether or not such embankment or backfill is above or below the original surface of the ground and regardless of whether the excavation at structure site was performed as "Structural Excavation", "Road Excavation", or "Channel Excavation". Unless otherwise provided by the plans or special provisions, hand tamping will not be accepted as an alternate for mechanical compaction. As a general rule, material used in filling or backfilling the portions described in this paragraph shall be an earth free of any appreciable amount of gravel or stone particles more than four inches in greatest dimension and of a gradation that permits thorough compaction. When, in the opinion of the Engineer, such material is not readily available, the use of rock or gravel mixed with earth will be permitted, provided that no particles larger than 12 inches in the

greatest and 6 inches in least dimension may be used. The percentage of fines shall be sufficient to fill all voids and insure a uniform and thoroughly compacted mass of proper density. When required by the plans or by written order of the Engineer, cement stabilized material shall be used for backfilling.

All portions of fill and backfill described in the preceding paragraph shall be compacted to the same density requirements specified for the adjoining sections of embankment in accordance with the governing specifications therefor.

Where no embankment is involved on the project and no specifications therefor are included in the contract, all backfill shall be compacted to a density comparable with the adjacent undisturbed material.

No backfill shall be placed against any abutment or retaining wall until such structure has been in place at least seven days. No backfill shall be placed adjacent to or over single and multiple boxes until the top slab has attained 500 psi flexural strength. Backfill placed around abutments and piers shall be deposited on both sides to approximately the same elevation at the same time.

Care shall be taken to prevent any wedging action of backfill against the structure, and the slopes bounding the excavation shall be stepped or serrated to prevent such action.

No backfilling shall be done except in the presence of the Engineer or his authorized representative.

(2) Pipe Culverts. The following requirements shall apply to the backfilling of pipe culverts in addition to the pertinent portions of the general requirements given in the preceding section.

Selected materials from excavation, borrow or other approved material shall be wetted, if required, and placed along both sides of the pipe equally, in uniform layers not exceeding six inches in depth (loose measurement) and thoroughly compacted so that there shall be a berm of thoroughly compacted material on each side of the pipe. The method and degree of compaction shall be the same as specified in Subarticle 400.5.(1) for portions of backfill within the limits of embankment or roadbed.

Filling and/or backfilling shall be continued in this manner to the elevation of the top of the pipe. Special care shall be taken to secure thorough compaction of the material placed under the haunches of the pipe. All fill or backfill below the top of pipe shall be compacted mechanically in the manner and to the density prescribed above, regardless of whether or not such material is placed within the limits of the embankment or roadbed. In the case of pipe placed in trenches, that portion of the backfill above the top of the pipe which supports embankment or the roadbed shall receive mechanical compaction as specified in Subarticle 400.5.(1) and the portion which will not support any portion of embankment or roadbed shall be placed in layers not more than 10 inches in depth (loose measurement) and shall be compacted by whatever means the Contractor chooses, to a density comparable with the adjacent, undisturbed material. Embankments above the

top of pipe shall be placed in accordance with the provisions for placing roadway embankment as prescribed in the pertinent specifications. During construction adequate cover must be provided to protect the structure from damage.

Whenever excavation is made for installing pipe culverts or box sewers across private property or beyond the limits of the embankment, the top soil removed in excavating the trench shall be kept separate and replaced, as nearly as feasible in its original position, and the entire area involved in the construction operations shall be restored to a presentable condition.

(3) Cement Stabilized Backfill. When indicated on the plans, trenches shall be backfilled to the elevations shown with stabilized backfill containing a minimum of 2 sacks of standard Portland cement per cubic yard of material as placed. The materials for such cement stabilized backfill shall consist of aggregate, standard Portland cement, and water. Cement and water shall conform to the requirements of the Item, "Concrete Pavement". Aggregate shall be as noted on the plans and approved by the Engineer.

Cement stabilized backfill below the spring line of pipe culverts shall be sufficiently plastic to completely fill all voids in the trench. The pipe shall be held in alignment by jacks or other suitable means to prevent the mortared joints from cracking due to displacement caused by placing the backfill material.

Cement stabilized backfill above the spring line of pipe culverts may be dry enough to be transported without special mixing equipment.

On structures other than pipe culverts, special mixing equipment will not be required to transport the cement stabilized backfill unless indicated otherwise on the plans.

Hand-operated mechanical tampers may be used with approval of the Engineer for compacting this backfill.

400.6. Measurement. Unless otherwise shown on the plans, structural excavation for pipe headwalls, inlets, manholes, culvert widening (extensions), bridge abutments, and side road and private entrance pipe culverts will not be measured but shall be considered subsidiary to the various bid items. Determination of quantities for structural excavation shall be made by the method of average end areas using the following limits to establish templates for measurement.

(1) For all structures requiring measurement, except the barrels of pipe culverts, no material outside of vertical planes one foot beyond the edges of the footings and parallel thereto will be included.

(2) For the barrels of pipe culverts of 42 inches or less nominal or equivalent diameter, no material outside of vertical planes one foot beyond the horizontal projection of the outside surfaces of the pipe and parallel thereto will be included. For the barrels of pipe culverts more than 42 inches in nominal or equivalent diameter, no material outside of vertical planes located two feet beyond the horizontal projection of the outside surfaces of the pipe and parallel thereto will be included.

(3) If a caisson, as herein defined, is shown on the plans, only material to the outside face of it will be included.

(4) If a cofferdam, as herein defined, is used, the limitations of Subarticle 400.6.(1) shall apply just as if no cofferdams were used.

(5) Where excavation in addition to that allowed for the footings is required for other portions of the structure, such as for the cap, cross strut, or tie beam of a pier or bent or for the superstructure, measurements for such additional excavation will be limited laterally by vertical planes one foot beyond the face of the member and parallel thereto and vertically to a depth of one foot below the bottom of such member.

(6) Except as allowed by the above conditions, no account will be taken of any excavation necessary for placing forms or falsework.

(7) Except at side road culverts, all road excavation called for on the contract plans at all structure sites shall be assumed to be completed before starting the structural excavation, and the measurement of structural excavation will include only material below or outside the limits of the completed road excavation. Excavation for side road and private entrance pipe culverts will not be measured for payment but shall be subsidiary to the Item.

(8) On all structures of bridge classification as defined in Article 1.31 where the contract plans call for channel excavation at the structure site, it shall be assumed to have been completed before starting the structural excavation, and the measurement of structural excavation will include only material below or outside the limits of the completed channel section. This will not apply to structures of culvert classification as defined in Article 1.32. On such structures, all excavation below natural ground and within the specified limits will be measured as structural excavation regardless of whether or not plans call for channels at the structure site. The method of measurement for payment will be in accordance with this procedure regardless of the actual construction methods followed.

(9) Where excavation diagrams are shown on the plans, they shall take precedence over these provisions.

(10) Measurement will not include materials removed below footing grades to compensate for anticipated swellage due to pile driving, and it will not include material required to be removed due to swellage beyond the specified limits during pile driving operations.

(11) Measurement will not include additional yardage caused by slips, slides, cave-ins, siltings, or fillings due to the action of the elements or the carelessness of the Contractor. Water will not be classed as excavated material.

(12) Where rock, other incompressible or unstable material is undercut to provide suitable foundation for pipe or box culverts, such material below grade, ordered by the Engineer to be removed, will be measured for payment.

(13) Except for any required undercut, quantities for "Structural Excavation", as shown on the plans and in the proposal, shall be considered as final quantities and no further measurement will be required, unless the alignment, grades or structure locations are revised by the Engineer during construction. Final determination of quantities for individual structures will be made, if in the opinion of the Engineer or upon evidence furnished by the Contractor, substantial variations exist between quantities shown on the plans and actual quantities due to changes in cross sections or apparent errors. Excavation quantities for foundations shown on the plans and in the proposal where caissons and cofferdams are required shall be considered as final quantities and no further measurement will be made.

(14) For any footing, foundation, or other structure unit within the scope of this specification, additional measurement will be made of the volume of excavation involved in the lowering or raising of the elevation of a footing, foundation, or structure unit, when such grade change is authorized by the Engineer. Measurement will be made by the addition to, or the deduction from, the original quantities for the volume of excavation involved in the authorized grade change.

(15) Cement stabilized backfill shall be measured by the backfill diagram as shown on the plans. The quantity of "Cement Stabilized Backfill" as shown on the plans and in the proposal shall be considered as final quantities and no further measurement will be required, unless alignment or grade elevations as shown on the plans are revised by the Engineer. If such revisions result in an increase or decrease in this quantity, the final quantity will be revised by the amount represented by the changes in alignment or grade elevations.

400.7. Payment. Payment for all work prescribed under this item and measured as provided above will be made at the unit price bid per cubic yard for the particular class of excavation specified on the plans in the amount shown on the plans and in the proposal. Payment for revised quantities will be made as specified in Subarticles 400.6.(13) and (14) and the fifth paragraph of this Article, and for the removal of unstable and incompressible material as noted below.

Payment for removal and replacement of unstable or incompressible material below the footing grades of culverts and box sewers as provided for in Article 400.2. will be made as follows:

When the plans specify or when the Engineer directs the use of special materials such as flexible base, cement stabilized base, cement stabilized backfill or other special material, payment for excavation below the footing grades shall be made at the unit price bid for "Unclassified Structural Excavation", "Common Structural Excavation" or "Rock Structural Excavation", as the case may be. Payment for furnishing, hauling, placing and compacting the flexible base, cement stabilized base, cement stabilized backfill or other special material will be made at the unit price bid for these items in the contract or in accordance with Article 9.4., in cases where the required material is not a bid item.

Where special materials are not required or specified, the removal and replacement of the unstable material will be performed as described in Subarticle 400.2.(8). Payment therefor will be made at a price equal to 200 percent of the unit price bid per cubic yard for "Unclassified Structural Excavation", "Common Structural Excavation" or "Rock Structural Excavation", as the case may be, which price shall be full compensation for removing the unstable or incompressible material, furnishing, hauling, placing and compacting suitable material required to replace it, and for all labor, equipment, tools and incidentals necessary to complete the work.

Payment for "Cement Stabilized Backfill" measured as prescribed above shall be made at the unit price bid per cubic yard of "Cement Stabilized Backfill". Such payment shall be full compensation for furnishing all materials, tools, labor, equipment, sheathing, and incidentals required to perform the applicable work prescribed herein.

To avoid the grouping of cement stabilized backfill of widely different character into a single bid item, the proposal may show "Cement Stabilized Backfill" subdivided into items relating to individual structures, to parts of structures or to groups of structures, as for example, "Cement Stabilized Backfilled-Culverts", "Cement Stabilized Backfill-Bridges" and "Cement Stabilized Backfill-Pipe Lines".

Should the Engineer judge it necessary to lower the structure footings to an elevation below the grade shown on the plans, payment for the "Unclassified Structural Excavation", "Common Structural Excavation", or "Rock Structural Excavation" as the case may be, required below plan grade down to and including an elevation five feet below plan grade for any individual footing will be made at a unit price equal to 115 percent of the contract unit bid price. Payment for the excavation from an elevation over five feet below plan grade down to and including an elevation 10 feet below plan grade will be made at a unit price equal to 125 percent of the contract unit bid price for "Unclassified Structural Excavation", "Common Structural Excavation", or "Rock Structural Excavation" as the case may be. No increase in unit price will be allowed for any other bid items of the contract, and no additional extra compensation will be allowed for any required cofferdam adjustments made necessary by such lowering of footings. These provisions shall not apply to the lowering of culverts, except when the flow line grade is lowered one foot or more below plan grade.

In cases where the extra depths required for any footing or footings exceeds 10 feet, a supplemental agreement shall be made covering the quantities removed from depths in excess of 10 feet below plan grade.

Since this item provides for an adjustment in unit price for additional excavation quantities, the 20 percent limitation referred to in Article 4.3 will not apply to overruns due to extra depth of 10 feet or less.

No direct payment will be made for filling or backfilling around structures. Payment for the backfilling and compacting of areas which were removed as structural excavation shall be included in the unit prices bid for the various classes of structural excavation.

Unless otherwise shown on the plans, no payment for excavation will be

made until the required backfill has been made to the satisfaction of the Engineer.

Filling or backfilling of areas above the natural ground level or above the limits of road excavation or channel excavation sections shall be considered as "Embankment", and payment therefor shall be included in the unit prices bid for the various classes of "Roadway Excavation", "Channel Excavation" or "Borrow" as the case may be.

Where no channel excavation is provided for at culvert sites and where it is necessary to excavate within the limits of the right-of-way but beyond the limits of structural excavation as herein described in order that the culvert may function properly, such excavation will be considered as road ditch excavation and will be measured and paid for under the governing specifications for "Roadway Excavation".

Payment for all work prescribed under this item shall be full compensation for all excavation and backfill including compaction; all soundings; sinking all caissons; constructing all cofferdams; all de-watering; and for furnishing all materials, labor, equipment, tools, sheathing, bracing, cofferdams, pumps, drills, explosives and incidentals necessary to complete the work, except for specific allowances stated above.

ITEM 401

EXCAVATION AND BACKFILL FOR SEWERS

401.1. Description. This item shall govern for all excavation required for the construction of storm or sanitary pipe sewers, sewer structures, appurtenances and connections, and for the backfilling around completed sewers to the level of the original ground, all in conformity with the locations, lines, and grades shown on the plans or as given by the Engineer, and in accordance with these specifications. This item shall govern, also, for the necessary pumping or bailing and drainage, and all sheathing and bracing of trench walls. Unless otherwise provided, this item shall govern for the removal and disposition of tree stumps and other obstructions, of old structures or portions thereof (such as house foundations, old sewers, and sewer appurtenances), the blocking of the ends of abandoned sewers cut and left in place, and the restoration of existing utilities damaged in the process of excavation. It shall include the cutting and restoration of pavement and base courses and special operations involved in crossing railroads, the furnishing and placing of cement stabilized backfill, and hauling and disposition of surplus materials, and the bridging of trenches and other provisions for maintenance of traffic or access as provided herein.

401.2. Construction.

(1) Trenches. Unless otherwise specified on the plans or permitted by the Engineer, all sewers shall be constructed in open cut trenches with vertical sides. Trenches shall be sheathed and braced to the extent necessary to maintain the sides of the trench in vertical position throughout the construction period. Adequacy of the sheathing and bracing shall be the responsibility of the Contractor but will be subject to the approval of the Engineer.

Trenches for precast concrete pipe sewers shall have a width 1 foot beyond the horizontal projections of the outside surfaces of the pipe and parallel thereto on each side for sewers 42 inches or less nominal diameter. For pipe more than 42 inches in nominal diameter, the trenches shall have a width 2 feet beyond the horizontal projections of the outside surfaces of the pipe and parallel thereto on each side, unless otherwise shown by excavation diagram.

Trenches for monolithic pipe sewers shall have a width below the horizontal diameter of the pipe equal to the outside horizontal diameter unless otherwise shown by excavation diagram.

For all pipe sewers to be constructed in fill above natural ground, the embankment shall first be constructed to an elevation not less than 1 foot above the top of the pipe, after which excavation for the pipe shall be made as noted above.

For pipe sewers of all types, where the soil encountered at established footing grade is a quicksand, muck, or similar unstable material, the following procedure shall be used unless other methods are called for on the plans: All unstable soil shall be removed to a depth of 2 feet below bottom of sewer for sewers 2 feet or more in height and to a depth equal to the height of sewer for sewers less than 2 feet in height. Such excavation shall be carried at least 1 foot beyond the horizontal limits of the structure on all sides. All unstable soil so removed shall be replaced with suitable stable material, placed in uniform layers of suitable depth as directed by the Engineer, and each layer shall be wetted, if necessary, and compacted by mechanical tamping as required to provide a stable foundation for the structure. Soil which is considered to be of sufficient stability to sustain properly the adjacent sections of the roadway embankment will be considered a suitable foundation material for the culvert or sewer.

When the material encountered at footing grade of a sewer is found to be partially rock or other incompressible material and partially a soil or material that is compressible, but otherwise satisfactory for the foundation, the incompressible material shall be removed for a depth of 6 inches below the footing grade and backfilled with a material similar to the compressible material used for the rest of the structure.

For unstable trench conditions requiring outside forms, seals, sheathing, and bracing, or where ground water is encountered, any additional excavation and backfill required shall be done at the Contractor's expense.

(2) Shaping of Trench Bottom. For precast concrete pipe sewers, the trench bottom shall be undercut a minimum depth sufficient to accomodate the class of bedding indicated on the plans and conforming to bedding requirements of the Item, "Reinforced Concrete Pipe Culverts". Where cement stabilized backfill is indicated on the plans, the trench shall be undercut a minimum of 4 inches and backfilled to support the pipe to grade.

(3) Dewatering Trench. Sewers shall not be constructed or laid in a trench in the presence of water. All water shall be removed from the trench sufficiently prior to the sewer placing operation to insure a dry, firm bed on which to place the sewer, and the trench shall be maintained in such

unwatered condition until all concrete and mortar is set. Removal of water may be accomplished by bailing, pumping, or by a well-point installation as conditions warrant.

In the event that a trench cannot be dewatered to the point where the pipe subgrade is free of mud, or it is difficult to keep the reinforcing steel clean in cast-in-place monolithic sewers, a seal shall be used in the bottom of the trench. Such seal shall consist of a lean concrete mixture (not less than 3 sacks of cement per cubic yard), with a minimum depth of 3 inches.

(4) Excavation in Streets. Excavation in streets, together with the maintenance of traffic where specified, and the restoration of the pavement riding surface shall be in accordance with plan details or as required by other specifications included in the contract.

(5) Removing Old Structures. When old masonry structures or foundations are encountered in the excavation, such obstructions shall be removed for the full width of the trench and to a depth of 1 foot below the bottom of the trench. When old inlets or manholes are encountered and no plan provision is made for adjustment or connection to the new sewers, such manholes and inlets shall be removed completely to a depth 1 foot below the bottom of the trench. In each instance, the bottom of the trench shall be restored to grade by backfilling and compacting by the methods provided hereinafter for backfill. Where the trench cuts through storm or sanitary sewers which are known to be abandoned, these sewers shall be cut flush with the sides of the trench and blocked with a concrete plug in a manner satisfactory to the Engineer.

(6) Protection of Utilities. The Contractor shall conduct his work such that a reasonable minimum of disturbance to existing utilities will result. Particular care shall be exercised to avoid the cutting or breakage of water and gas lines. Such lines, if broken, shall be restored promptly by the Contractor. When active sanitary sewer lines are cut in the trenching operations, temporary flumes shall be provided across the trench, while open, and the lines shall be restored when the backfilling has progressed to the original bedding lines of the sewer so cut.

The Contractor shall inform utility owners sufficiently in advance of the Contractor's operations to enable such utility owners to reroute, provide temporary detours, or to make other adjustments to utility lines in order that the Contractor may proceed with his work with a minimum of delay and expense. The Contractor shall cooperate with all utility owners concerned in effecting any utility adjustments necessary and shall not hold the State liable for any expense due to delay or additional work because of conflicts.

(7) Surplus Excavated Materials. All materials from excavation operations not required for backfilling the trench shall be placed in embankments if considered suitable. All material not suitable for use in embankments will be declared surplus by the Engineer and shall become the property of the Contractor to dispose of as he wishes, without injury to the State or any individual. Such surplus material shall be removed from the work promptly following the completion of the portion of the sewer involved.

(8) Backfill. Trenches shall be backfilled with material selected from the sewer trench excavation, or obtained from other sources, which is free from stones of such size as to interfere with compaction and is free from large lumps which will not break down readily under compaction. The Engineer shall have the right to reject any material containing more than 20 percent by weight of material retained on a 3 inch sieve, or material excavated in such a manner as to produce large lumps not easily broken down or which cannot be spread in loose layers. In general, material excavated by means of a trenching machine will meet the requirements above provided large stones are not present.

The following requirements shall apply to the backfilling of sewers in addition to the pertinent portions of the general requirements given in the preceding paragraph.

After the bedding has been prepared and the pipes installed as required by the pertinent specifications, selected materials from excavation or borrow shall be placed along both sides of the pipe equally, in uniform layers not exceeding 6 inches in depth (loose measurement), wetted if required, and thoroughly compacted so that on each side of the pipe there shall be a berm of thoroughly compacted material at least as wide as the external diameter of the pipe, except insofar as undisturbed material obtrudes into this area.

Filling and/or backfilling shall be continued in this manner to the elevation of the top of the pipe. Special care shall be taken to secure thorough compaction of the materials placed under the haunches of the pipe. All fill or backfill below the top of pipe shall be compacted mechanically in the manner prescribed above, regardless of whether or not such material is placed within the limits of the embankment or roadbed.

In the case of pipe placed in trenches, that portion of the backfill above the top of the pipe which supports the embankment or roadbed shall receive mechanical compaction. The portion which will not support any part of the embankment or roadbed shall be placed in layers not more than 10 inches in depth (loose measurement) and shall be compacted by whatever means the Contractor chooses to a density comparable with the adjacent undisturbed material.

In the case of embankments, the remainder of the fill above the top of the pipe shall be placed in accordance with the provisions for placing roadway embankment as prescribed in the pertinent specifications included in the contract. During construction, adequate cover must be provided to protect the pipe sewer from damage.

Where storm sewers extend beyond the toe of slope of the embankment and the depth of cover provided by backfill to the original ground level is less than the minimum required by the specifications for the type of pipe involved, additional material shall be placed and compacted, as herein specified for backfill outside the limits of the roadbed, until this minimum cover has been provided.

Whenever excavation is made for installing pipe culverts or sewers across private property or beyond the limits of the embankment, the top soil removed in excavating the trench shall be kept separate and replaced, as nearly as feasible, in its original position, and the entire area involved in the

construction operations shall be restored to a presentable condition.

When indicated on the plans, trenches shall be backfilled to the elevations shown with stabilized backfill containing a minimum of 2 sacks of standard Portland cement per cubic yard of material as placed. The materials for such cement stabilized backfill shall consist of aggregate, standard Portland cement, and water. Cement and water shall conform to the requirements of the Item, "Concrete Pavement". Aggregate shall be as noted on the plans and approved by the Engineer.

Backfill below the top of sewers, manholes, inlets, or other structures shall be placed and compacted equally along both sides of the structure so as to prevent strain on or displacement of the structure.

Cement stabilized backfill below the spring line of the pipe shall be sufficiently plastic to completely fill all voids in the trench. The pipe shall be held in alignment by jacks or other suitable means to prevent the mortared joints from cracking due to displacement caused by placing the backfill material.

Cement stabilized backfill above the spring line of the pipe may be dry enough to be transported without special mixing equipment.

Hand-operated mechanical tampers may be used with approval of the Engineer for compacting backfill.

401.3. Measurement.

Determination of plan quantities for "Sewer Excavation" shall be made by the method of average end areas, using the following limits to establish templates for measurement.

(1) For all jointed pipe sewers of 42 inches or less nominal or equivalent diameter, no material outside of vertical planes 1 foot beyond the horizontal projections of the outside surfaces of the pipe and parallel thereto will be included.

(2) For jointed pipe sewers more than 42 inches nominal or equivalent diameter no material outside of vertical planes located 2 feet beyond the horizontal projection of the outside surfaces of the pipe and parallel thereto will be included.

(3) For monolithic sewers, no material outside the vertical plane of the outside surface of the pipe and parallel thereto will be included, unless otherwise shown on the plans.

(4) For sewer appurtenances no material outside of vertical planes 1 foot beyond the edges of the footings and parallel thereto will be included.

(5) Where rock, other incompressible material, or unstable material is undercut in order to provide suitable foundation for sewers, such material below grade as is ordered by the Engineer to be removed, will be measured for payment.

(6) For all sewers where the contract plans call for road excavation, such road excavation shall be assumed to have been completed before starting sewer excavation and the measurement of sewer excavation will include only material below or outside the limits of the completed road excavation.

(7) Excavation quantities required for constructing sewers in fill above natural ground, as specified in Subarticle 401.2.(1) paragraph 4, will be measured for payment. Quantities will include that area as specified in (1), (2) or (3) above plus 1 foot above the top of the pipe, regardless of the height of fill previously made.

(8) Cement stabilized backfill shall be measured as dimensioned on backfill diagrams as shown on the plans.

(9) In all cases where excavation diagrams are shown on the plans, such diagrams shall take precedence over these provisions.

(10) Quantities for "Sewer Excavation" and "Cement Stabilized Backfill" as shown on the plans and in the proposal shall be considered as final quantities and no further measurement will be required, unless the alignment, grades or sewer locations are revised by the Engineer during construction. In addition, final determination of sewer excavation and cement stabilized backfill quantities for individual sewer mains and laterals will be made, if, in the opinion of the Engineer or upon evidence furnished by the Contractor, substantial variations exist between quantities shown on the plans and actual quantities due to changes in cross sections or apparent errors.

401.4. Payment. Payment for sewer excavation, measured as prescribed above shall be made at the unit price bid per cubic yard of "Sewer Excavation".

Payment for backfilling and compaction in accordance with these specifications shall be included in the unit price bid for "Sewer Excavation".

Unless otherwise shown on the plans, no payment for excavation will be made until backfilling is completed to the satisfaction of the Engineer.

Payment for removal and replacement of unstable material and incompressible material below the footing grades of pipe sewers, measured as provided above, will be made at the unit price equal to 200 percent of the unit price bid per cubic yard for "Sewer Excavation".

Payment for "Cement Stabilized Backfill" measured as prescribed above shall be made at the unit price bid per cubic yard of "Cement Stabilized Backfill".

Such payment shall be full compensation for furnishing all materials, tools, labor, equipment, sheathing, and incidentals required to perform the applicable work prescribed herein.

ITEM 404

DRIVING PILING

404.1. Description. This item shall govern for the equipment to be furnished and for the methods to be followed in driving piling. The requirements herein are minimum. Strict compliance with these requirements will not relieve the Contractor of the responsibility of adopting whatever additional provisions may be necessary to insure the successful completion of the work.

404.2. General. Unless otherwise shown on the plans, the embankment at bridge ends shall be constructed to required compaction and grade, prior to the driving of abutment piling.

Foundation piling shall not be driven until the excavation is approximately complete.

Any piling raised when driving adjacent piling shall be redriven. Broken, split, or displaced piling shall be withdrawn and properly replaced, or corrected as specified by the Engineer based on a design analysis.

404.3. Tolerance For Driving. Trestle piling shall be driven to the vertical or batter line indicated. Allowable variations from the plan alignment shall not exceed the following:

Transverse to the centerline of bent, the top of the piling shall not be more than 2 inches from the position shown on the plans.

Parallel to the center line of the bent, the top of the piling shall not be more than 4 inches from the position shown on the plans.

Foundation piling shall be driven to the vertical or batter line indicated and the top of the pile will not be more than 4 inches in any direction from the position shown on the plans. If the center of gravity of the pile group varies by more than 3 inches from the center of gravity determined from plan location, a structural analysis will be required.

Foundation piling shall be cut off reasonably square at the elevation shown on the plans. A tolerance of not more than 2 inches above or below established cut off grade will be permitted.

The minimum edge distance for piling in a footing shall be 5 inches. Additional concrete required for the maintenance of this and the required reinforcing steel cover shall be at the Contractor's expense.

Piling shall be driven in alignment holes and/or with templates when necessary to comply with the above tolerances. The required depth of alignment holes shall not exceed 5 feet.

404.4. Protection of Pile Heads. A structural steel driving head suitable for the type and size of piling being driven shall be used.

For concrete piling, a cushion block shall be provided between the driving head and the top of the pile. It shall be a *minimum* of four inches thick for short piling (50 feet or less) and at least six inches thick for longer piling. The cushion block shall be multiple layers of one of the following:

(1) Three-quarter inch or one inch structural grade southern pine or fir plywood,

(2) Green oak or gum, with the grain of the wood horizontal,

(3) Asbestos discs, or

(4) Other material which has been pretested and approved by the Department.

Careful attention shall be given to the condition of the cushion material. Generally, one block shall not be used to drive more than three piling, but

Type	Type Hammer		Weight of Ram Min.	Weight of Ram Max.	Maximum Ram Stroke ft.	Minimum (3) Hammer Energy Foot-Pounds
Timber	Gravity		2000	3500	15	330R
	Power	Steam, Air, Hydraulic	2000		4	
		Diesel	2000		8	
Steel H	Gravity		2000	5000	10	250 R or 2½ Wp whichever is larger
	Power	Steam, Air, Hydraulic	3000		4	
		Diesel	2000		8	
Metal Shell	Gravity		2000	5000	10	350R(1)
	Power	Steam, Air, Hydraulic	3000		4	
		Diesel	2000		8	
Metal Shell Driven with mandrel insert	Gravity		2000		10	220R but not less than one Ft-Lb per Lb of pile weight. Includes weight of mandrel.
	Power	Steam, Air, Hydraulic	3000		4	
		Diesel	2000		8	
Concrete	Gravity		3000 but not less than ½ WP		8	
	Power	Steam, Air, Hydraulic	3000 but not less than ¼ WP		4	250R but not less than one Ft-Lb per Lb of pile weight.
		Diesel(2)	2700 but not less than ¼ WP		8	

TABLE 1

Size of Driving Equipment

R = Design load in tons
Wp = Weight of pile in pounds based on plan length.

(1) Minimum hammer energy for metal shell piling with plan lengths over 65 ft. shall be 430R.
(2) Diesel hammers with less ram weight and/or greater ram stroke may be permitted if a wave equation analysis indicates that the combination of ram weight, stroke, and cushioning will not overstress the piling.
(3) See Subarticle 404.10.2. paragraph 4.

shall be changed more frequently, if necessary, to prevent damage. The driving head shall be large enough to permit the pile head to rotate freely. A tight fitting head will not be permitted.

404.5. Driving Equipment. The driving of piling shall be done with power hammers, unless gravity hammers are permitted by the plans.

Boiler or air compressor capacity furnished shall be at least equal to that specified by the manufacturer of the hammer used. The boiler or compressor shall be equipped with an accurate pressure gage at all times.

Enclosed ram diesel hammers shall be equipped with a gage and charts to evaluate the equivalent energy being produced. Calibration of the gage and charts will be required.

The valve mechanism and other parts of all power hammers shall be maintained in first class condition so the hammers will operate at the speed and stroke length specified by the manufacturer.

Cap Block cushioning material, when used between the ram and anvil or follow block, shall consist of layers of southern pine or fir plywood, oak, gum, asbestos discs, micarta plastic or other material which has been submitted and pretested by the Department and approved by the Engineer.

Power hammers shall be operated at not less than 80 percent of the manufacturer's rated capacity.

The size of hammer shall comply with Table 1.

When gravity (drop) hammers are used, the height of drop shall be regulated to avoid injury to the piling and shall in no case exceed the maximum drop shown in Table 1. The Contractor shall furnish the Engineer a certified public scale weight of the hammer to be used.

Concrete piling shall not be subjected to excessive stresses caused by the combination of a particular hammer with the given soil conditions.

To control stresses in concrete piling during driving, the Engineer may require:

(1) Increase in cushion thickness,

(2) Reduction of ram stroke,

(3) Reduced ram stroke for driving through very soft soil and longer ram stroke as soil resistance increases,

(4) Combination of increased cushion thickness and reduced ram stroke,

(5) Heavier ram with a shorter stroke to obtain the desired driving energy,

(6) Combination of increased cushion thickness and heavier ram with shorter stroke, or

(7) Use of pilot holes or jetting when driving through hard or alternating hard and soft strata.

All test piling in a particular structure or any approved segment thereof, shall be driven with the same hammer. The same type and size hammer shall be used to drive the remainder of the piling in the structure or approved segment thereof that was used to drive the test piling.

Pile drivers shall be equipped with leads which are constructed to afford freedom of movement of the hammer and provide adequate support to the pile during driving. The longitudinal axis of the leads, hammer and pile shall coincide.

Except where piling are driven through water, the leads shall be long enough so that a follower will not be necessary. Where a follower is required when driving piling under water, one pile in each 10 shall be long enough to permit driving without a follower. It shall be driven as a test pile for proper correlation of the follower-driven piling. Payment will be made as regular piling.

404.6. Rating of Diesel Hammers. For initial rating of diesel hammers to determine compliance with the requirements of Table 1, the height of fall of the ram of the single-acting (open end) hammer will be 7 feet. For a double-acting (enclosed ram) hammer the energy rating shall be 85 percent of the rated output by the manufacturer.

404.7. Penetration. Except as noted herein, the piling lengths shown on the plans are the lengths estimated to give required bearing and are for estimating purposes only.

The elevation shown on the plans as 'minimum penetration' is the minimum depth to which it is necessary to drive the pile to satisfy the design requirements for lateral stability. Piling shall be driven to this approximate elevation and to such greater depths required to obtain the specified bearing resistance.

When the plans show a 'required penetration' into a particular stratum of rock, shale, or other hard material, this penetration will be required although the strata may be found at a higher or lower elevation than indicated on the plans.

Where no 'required penetration' or 'minimum penetration' is shown on the plans and test piling or test loads are not used, the lengths shown on the plans shall be considered as the 'minimum penetration'. Piling shall be driven to this approximate elevation and to such greater depths required to obtain the specified bearing resistance.

When test piling or test loads are used, subsequent pile lengths will be established by the Engineer on the basis of these test data. These lengths shall then supersede all other requirements and will be considered lengths for minimum penetration. In these cases, piling shall be driven to this approximate elevation and to greater depths as required to obtain the specified bearing resistance.

When the specified penetration cannot be obtained by driving without damage to the piling, the Contractor shall provide either pilot holes or jetting equipment or a combination of both.

404.8. Pilot Holes. Except as specified herein, pilot holes shall not be deeper than five feet below bottom of footings for foundation piling or ten feet below finished ground line for trestle piling unless the specified penetration cannot be obtained by using the depth of holes indicated. When

deeper pilot holes are required, their size and depth shall be determined from the results of trial operations on the first few piling driven and/or available test pile data. Any excess depth and/or size of pilot holes shall require approval by the Engineer. Generally, the diameter of hole permitted will be approximately four inches less than the diagonal of octagonal piling, and one inch less than the diameter of round piling. Hole size and depth may be varied by the Engineer to obtain penetration and/or sufficient bearing value. Pilot holes shall extend through all embankments to natural ground.

Where a pilot hole is required in granular material that cannot be sealed off by ordinary drilling methods, a casing may be required around the boring device deep enough to prevent loose material from falling into the pilot hole.

The piling shall be driven below the depth of the pilot hole a minimum of one foot or 100 blows, but to not less than the approximate penetration and required bearing. If damage to the pile is apparent, driving shall cease.

404.9. Jetting. Jetting will be required when the specified penetration cannot be obtained by driving and other methods are not feasible. Prior to jetting, the Contractor shall submit details of the proposed methods to the Engineer for approval. The Engineer may authorize varying depths of jetting to achieve the desired results.

Jetting may be done as required in conjunction with driving but only to the depth approved by the Engineer.

For jetting operations, sufficient power shall be provided to simultaneously operate a minimum of two, 2-1/2 inch diameter pipes equipped with three-fourths inch nozzles at a pressure of 150 psi.

The jetting operations may use one or two jets as determined by the Contractor, and approved by the Engineer from the results of trial operations.

The final penetration of the pile shall be obtained by driving below the depth of jetting a minimum of one foot or 100 hammer blows, but to not less than the approximate penetration and required bearing value. If damage to the pile is apparent, driving shall cease.

404.10. Bearing Evaluation.

1. Hammer Formula Method. Unless otherwise shown on the plans, the dynamic bearing resistance of piling will be determined by the following formulas:

For gravity hammers:

$$P=\frac{2WH}{S+1.0}$$

For single-acting power hammers:

$$P=\frac{2WH}{S+0.1}$$

For double-acting power hammers:

$$P=\frac{2E}{S+0.1}$$

P = Dynamic Resistance in pounds.

S = average penetration in inches per blow for the last 20 blows.

W= weight of ram in pounds.

H = height of fall of ram in feet.

E = manufacturer's rated energy in foot-pounds (for double-acting power hammers).

E = the equivalent energy in foot-pounds, determined by a calibrated gage attached to the hammer and taken when the average penetration in inches per blow is determined (for enclosed ram diesel hammer).

2. Wave Equation Method. When it is specified on the plans that the bearing capacity of the piling will be determined by the Wave Equation Method, the Contractor shall submit to the Engineer the following data:

a. Manufacturer's specification data of the hammer proposed for use, including any and all modifications thereto;

b. Complete description and dimensions including total thickness of all cushioning material used between the pile and helmet;

c. Complete description and dimensions including total thickness of the cushioning material in the cap block including the direction of grain if wood is used.

The above data will be used to determine the required number of blows per unit of penetration the hammer must deliver to obtain the required bearing resistance. This will be determined and furnished by the Bridge Division in the form of Bearing Graphs.

After evaluation by Wave Equation analysis, any change in the driving equipment may require reevaluation, but in all cases such changes shall be approved by the Engineer.

A hammer which produces less energy than required by TABLE 1, may be approved if a wave equation analysis indicates the hammer can drive the specified pile against a bearing resistance of three times the required design load before reaching practical refusal. Practical refusal is defined as 1/16 of an inch penetration per blow. The bearing resistance of the piling driven with this particular equipment will be determined in accordance with the Wave Equation Method.

404.11. Bearing and Length Determination. Piling shall be driven and evaluated by one of the following methods:

1. Penetration Data. Piling shall be driven to the 'minimum penetration', or "required penetration", required by the plans and as defined herein. The appropriate hammer formula or wave equation bearing graph will be used to determine the bearing resistance.

2. **Test Piling.** When required by the plans, test piling shall be driven and approved lengths determined from the data obtained. The pertinent hammer formula or wave equation bearing graph will be used to determine the bearing resistance.

3. **Test Load.** When required by the plans, piling shall be driven and test loaded. The appropriate hammer formula will be used to determine the dynamic resistance of the test load pile and any anchor piling. The test load data will be used to determine pile lengths, and to develop a "K" factor to modify the hammer formula.

Subsequent to the test load, driving shall be to approved tip elevations, or to such greater depth necessary to obtain the required bearing determined by the appropriate hammer formula modified by the test load factor:

$K=\frac{L}{P}$ where:

K = a static correction factor to a dynamic formula.

L = a maximum safe static load proven by test load.

P = dynamic resistance of the test loaded pile determined by hammer formula.

4. **Soil Tests.** When required by the plans, the piling designated thereon shall be driven to the tip elevations shown. The appropriate hammer formula will be used to determine the dynamic resistance.

All subsequent piling shall be driven to approved tip elevations, or to such greater depth necessary to obtain the required bearing determined by the appropriate hammer formula modified by the factor K, or to the maximum penetration shown on the plans.

$K=\frac{R}{P}$ where:

K = a static correction factor to a dynamic formula.

R = maximum safe static load predetermined by soil studies and designated on the plans.

P = dynamic resistance of the selected piling determined by hammer formula. The average of the several piling will be used.

404.12. Measurement and Payment. No direct measurement or payment will be made for the work to be done or the equipment to be furnished under this item, but shall be considered subsidiary to the particular item of piling as required by the plans and the contract.

ITEM 405

FOUNDATION TEST LOAD

405.1. Description. This item shall govern for the material and equipment to be furnished and the work to be performed for the test loading of piling or drilled shaft foundations.

405.2. General. The piling or shaft to be test loaded shall be as specified on the plans or as designated by the Engineer. A complete record of the driving resistance on the anchor and test piling, or drilling data on the anchor and test shafts, shall be made under the supervision of the Engineer.

The test load shall not be applied to the foundation until 5 days after driving the test piling, or 7 days after placing concrete in the test shaft. (Concrete in the shaft must have reached design strength.)

Unless otherwise specified, the Department will furnish the jacking equipment, suitable jacking beams and extensometers.

The Contractor shall furnish and drive the piling or place the shaft to be test loaded and such appropriate anchors that may be necessary, and shall furnish all necessary material, labor, work, tools, equipment in addition to that furnished by the State, shelter to protect the test load equipment from sun and rain, and incidentals necessary for the proper installation of the complete test load. After the test has been completed, the test set-up shall be dismantled by the Contractor in a manner satisfactory to the Engineer.

Piling or shafts to be test loaded and any anchor piling or shafts required, which are not a part of the permanent structure, shall be included as a part of the "Foundation Test Load".

The method of test loading and the location of piling and/or shafts shall be as shown on the plans, or as designated by the Engineer.

405.3. Construction Methods. The test piling shall be of the same type and cross section as the piling to be used in the structure. When precast concrete piling are to be test loaded, prestressed concrete piling of the same size and section may be used.

A permanent piling or shaft may be used as an anchor or for test loading when shown on the plans or when directed by the Engineer. Piling or shafts, not a part of the structure, shall be removed or cut off at least one foot below the bottom of the footing or finished elevation of the ground upon completion of the test load. Permanent piling used as anchor piling which are raised during the test load shall be redriven to original grade and bearing.

The driving of piling to be test loaded shall be in accordance with the Item, "Driving Piling".

The drilling and placing of shafts to be test loaded shall be in accordance with the Item, "Drilled Shaft Foundations".

405.4. Method of Loading. Test loading shall consist of the application of incremental static loads to a pile or shaft and measuring the resultant

settlement. The loads shall be applied by a hydraulic jack acting against suitable anchorage, transmitting the load directly to the pile or shaft, or other methods designated by the plans or approved by the Engineer.

The load shall be applied in increments of 5 or 10 tons as directed by the Engineer. Gross settlement readings, loads and other data shall be recorded by the Engineer immediately before and after the application of each load increment.

Each load increment shall be held for an interval of 2-1/2 minutes. Each succeeding increment shall be as directed by the Engineer or as shown on the plans and shall be applied immediately after the 2-1/2 minute interval readings have been made.

When the load-settlement curve obtained from these test data shows that the pile or shaft .has failed; i.e., the load can be held only by constant pumping and the pile or shaft is being driven into the ground, pumping shall cease. Gross settlement reading, loads and other data shall be recorded immediately after pumping has ceased and again after an interval of 2-1/2 minutes for a total period of 5 minutes. All load shall then be removed and the member allowed to recover. Gross settlement readings shall be made immediately after all loads have been removed and at each interval of 2-1/2 minutes for a total period of 5 minutes.

All test loads shall be carried to failure or to the capacity of the equipment, unless otherwise noted on the plans.

405.5. Evaluation of Tests. Interpretation of the results will be in accordance with the 'Quick Test Load' requirements of the Bridge Foundation Exploration and Design Manual.

405.6. Measurement. Measurement will be made for each complete test load, satisfactorily performed and accepted.

Anchor and test piling, or anchor and test shafts, which are a part of the permanent structure, will be measured by the linear foot before cutting them to final plan grade.

Anchor and test piling or anchor and test shafts, which are not a part of the permanent structure, will not be measured for payment but will be included in the price bid for "Test Load".

If subsequent test loads are required on a previously loaded test piling or test shaft after the Engineer has directed the Contractor to dismantle the test equipment, any additional build up and driving of the test pile and/or reinstallation of the test equipment shall be considered as a separate test load.

405.7. Payment. The load tests provided under this item will be paid for at the unit price bid for each "Test Load", which price shall be considered full compensation for furnishing all material, labor, work, tools, equipment and incidentals necessary for the proper installation and completion of the test load. Anchor and test piling or anchor and test shafts, which are not a part of the permanent structure, will be included in the unit price bid for each "Test Load". Anchor and test piling or anchor and test shafts, which are a part of the permanent structure, will be paid for under the appropriate item.

If a subsequent test load is required, as described above under Article 405.6, such test will be paid for at the rate of one-half the price bid for each "Test Load".

ITEM 406

TIMBER PILING

406.1. Description. This item shall govern the furnishing of untreated or treated timber piling of the type and in accordance with the lines, spacing, and dimensions shown on the plans.

Driving and test loading of piling shall be in accordance with the Item, "Driving Piling", and the Item, "Foundation Test Load".

The lengths of piling to be furnished shall be as shown on the plans or as determined by the Engineer from the results of driving test piling, if test piling are required in the contract.

406.2. Material.

General Requirements. Untreated piling may be of any species of durable timber which will satisfactorily stand driving. Treated piling shall consist of Southern Pine or Douglas Fir, impregnated with a preservative of such quantity and process as shown on the plans and/or as specified in the Item, "Timber Preservative and Treatment". Piling shall be cut from sound, live trees, except that fire-killed, blight-killed, or wind-felled timber may be used if not attacked by decay or insects. Piling shall be free from any defects which may impair utility, strength, or durability, such as decay, red heart, ring shakes, unsound or loose knots, numerous knots or holes, knots in clusters, groups of single knots, or twist of grain exceeding one-half of the circumference in any 20 foot length. Piling which have been scored for turpentine may be accepted, provided the scar does not exceed 36 inches, and provided the scoring is of recent date, showing the scar to be entirely sound and free from insect damage. Any defect or combination of defects which would be more injurious than the maximum allowable knot will not be permitted.

Knots. All knots shall be trimmed close to the body of the pile. Sound knots will be permitted, provided they are not in clusters. A knot cluster is the grouping of two or more knots together as a unit with the fibers of the wood deflected around the entire unit. A group of single knots is not a knot cluster. A single knot is one occuring by itself with the fibers of the wood in which it occurs deflected around it. The diameter of a sound knot shall not be greater than one-third of the minimum diameter of the pile at the section where it occurs, and shall not exceed 4 inches. The diameter of the knot shall be measured at right angles to the length of the pile. The sum of widths of all knots in any 1 foot length of piling shall not exceed twice the width of the maximum allowable knot for that section of pile.

Checks, Splits, and Shakes. Piling which show excessive checking or splitting before or after treatment and prior to driving shall be rejected. Checked piling, on which the checks are not judged excessive, shall have the checks completely filled with hot tar pitch before being driven and after driving if necessary. Excessive splitting or checking shall be gauged as follows:

(1) A large check or split at the butt of pile which will permit a number 10 B & S (diameter 0.102 inches) wire to be extended 3 feet into the body of the pile.

(2) Checking and splitting of such size that at any point along the pile two checks or splits occur into which a number 10 wire may be inserted for a depth of more than seven eights of an inch.

Shakes smaller than one-third of the diameter of the pile may be permitted, provided the location and proximity to other defects do not affect the utility of the pile.

Density. Piling shall average not less than six annual rings per inch, and in addition one third or more summer-wood measured over the third, fourth, and fifth inches from the center of the pile along a radial line. Where there are less than six annual rings per inch, piling may be accepted if there is an average of one half or more summer-wood. Density shall be determined on butt ends of piling. Untreated piles shall have as little sapwood as possible and, when used in exposed work, the diameter of the heartwood shall be not less than eight tenths of the actual diameter of the pile at the butt. Treated piles, preferably, shall have as much sapwood as possible. In Southern Pine, the sapwood thickness shall be not less than 1-1/2 inches, and in Douglas Fir, not less than 1 inch at the butt end. The outer three annual rings of all piling shall be free from compression wood.

Peeling and Trimming. Piling shall be peeled of bark, including the inner skin, soon after cutting so the piling are smooth and clean. Care shall be taken to remove as little sapwood as possible, and it should not be injured by unnecessary axe cuts. All of the rough bark and at least 80 percent of the inner bark shall be removed. In no case shall any piece of inner bark be over three fourths of an inch in width or 8 inches in length and there shall be at least 1 inch of clean cut surface between any two strips of inner bark. Machine trimming shall be kept to a practicable minimum of the piling surface, and in no case to be more than one fourth of an inch, except at knot whorls. The circumference at any point between the knot whorls shall not be reduced by more than 1 inch.

Soundness. Whenever there is any sign of decay visible in untreated timber, the material shall be rejected. In any case where the condition of timber is doubtful, and in all cases of air-seasoned material, the inspector shall require a section 2 inches thick, or more, to be cut from the butt and tip. Evidence of decay, such as softness of the wood fibers, red heart, sponginess, or brownish discoloration, even though there are no definite areas of breakdown in the wood fibers, shall be sufficient cause for rejection.

Seasoning. When air-seasoning is utilized, great care should be exercised in the examination of the piling during the seasoning to protect such from conditions conducive to deterioration. Piling should be cut preferably during the winter season, and the maximum air-seasoning period shall be limited to 120 days except by special permission from the Engineer. Storage yards should be kept free of vegetation, standing pools of water, and debris

harboring fungi. Proper stacking and protection practices shall be followed to reduce possible contamination of the piling while it is seasoning. Necessary records shall be kept by marking suitably the seasoning stacks to facilitate inspection as to time of seasoning.

Pre-treated stock will not be acceptable to the inspector except in emergencies, and even then special permission must be obtained from the Engineer.

Length. Piling shall be furnished cut to the lengths shown on the plans or specified by the Engineer. Variation of 6 inches from the ordered length will be allowed, but the average length in any shipment shall be equal to, or greater than, the specified lengths. The supplier shall stencil size and length on the butt end of each piling with numerals at least 1 inch high. Tips and butts shall be cut at right angles to the axis of piling.

Diameter. The minimum diameter of round piling at a section 4 feet from the butt, measured under the bark, shall be as follows:

Length of Piling	Minimum Diameter 4' from Butt
40' and under	12"
Over 40'	13"

The minimum diameter of the tip shall be as follows:

Length of Piling	Minimum Diameter of Tip
20' and under	9"
21' to 44'	8"
Over 45'	7"

The maximum diameter of the butt shall be 18 inches, unless otherwise specified. When a tree is not exactly round, the diameter shall be determined either by measuring the circumference and dividing by 3.14, or by taking the average of the maximum and minimum diameters at the location specified.

Straightness. Piling shall be butt cut from the main body of the tree and shall be cut above the ground swell with a gradual taper from the point of butt measurement to the tip. Any localized deviation from straightness in a 5 foot section or less shall be classified as short crook, and the deviation of a line drawn from the center of the pile above the bend to the center of the pile below the bend, shall not exceed 2 inches in such a section. Piling may have a sweep in one plane in one direction, provided that a straight line from the center of the tip to the center of the butt does not deviate from the center line of the pile at any point more than 1 percent of the length, and in no case shall it fall outside the body of the pile. Piling may have sweeps in two planes (double sweep) or sweeps in two directions in one plane (reverse bend or sweep) provided that the line applied as above does not deviate from the center line of the pile by more than one fourth the diameter of the pile at the point of greatest deviation, and provided further, that the reversal or change in direction is within the middle half of the length.

Inspection. All piling shall be subject to inspection by the Engineer or an authorized inspection agency before and after treatment. The inspector shall be allowed free access to all points from which materials are being produced or processed, and the producer shall render him whatever assistance that in the inspector's judgment is necessary for the proper inspection of materials. In the rejection of materials not found suitable, the judgment of the inspector shall be final. The butt and tip of each piece accepted as conforming to the specification will be branded with a marking hammer showing the identity of the inspector who performed the work.

Inspection at all points shall be made with the intention of securing materials complying with these specifications, but in the event any material is found which does not comply in any respect, the Engineer may require corrections or replacement of defective material. The shippers should exercise caution in making final inspection of piling prior to shipment to be sure that conditions subsequent to treatment have not caused excessive splitting, checking, warping, or any distortion which may cause the piling to fail to conform to the specifications. Likewise, the Contractor shall store and protect piling at the construction site in such a way as to eliminate possible variations from the specifications.

406.3. Storing and Handling. The method of storing and handling piling shall be such as to avoid injury to the piling. Treated piling shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. The piling shall be handled with rope slings. Cant dogs, hooks, or pike poles shall not be used where such tools will penetrate the untreated wood.

406.4. Cut-Offs and Build-Ups. The tops of all piling shall be sawed to a true plane as shown on the plans and at the elevation fixed by the Engineer. Piling which support timber caps or grillage work shall be sawed to the exact plane of the superimposed structure and shall fit it exactly.

Piling which must be driven below established grade in order to attain the required bearing capacity shall be built up to the required grade by splicing on an additional length of piling of the same diameter and quality as the pile to be built up. Splices shall be made in accordance with the details shown on the plans after the pile head and the lower end of the build-up section have been squared up and treated in accordance with Article 406.5. Length of build-up sections used shall be such as to preclude the use of more than one splice in any one pile, and no splices or build-ups will be permitted except under the conditions outlined herein.

406.5. Treatment of Cuts, etc. After the necessary cutting has been done, the heads of treated timber piling shall be given three coats of hot creosote oil and one coat of hot tar pitch. When indicated on the plans, the pile heads then shall be covered with a sheet of roofing felt weighing 55 pounds per 100 square feet or 20 gage galvanized metal. The cover shall measure at least 6 inches more in each dimension than the diameter of the piling and it shall be bent down over the piling and edges fastened with large-headed galvanized nails or secured by binding with galvanized wire as indicated on the plans.

The heads of untreated timber piling, unless otherwise provided, shall be coated thoroughly with a thick protective coat of red lead and oil, hot tar, hot asphaltum, or hot tar creosote and, when indicated on the plans, covered with felt or galvanized metal as provided above.

All places where the surface of treated piling is broken by cutting, boring, or otherwise, shall be coated thoroughly with hot creosoted oil and then with a coating of hot tar pitch. Hot creosote oil shall be injected under pressure into the bolt holes before the insertion of the bolts in such manner that the entire surface of the holes shall receive a coating of the oil.

Creosote oil used for treatment of cuts, bolt holes, etc., shall conform to the requirements of the Item, "Timber Preservative and Treatment".

406.6. Test Piling. The lengths of piling shown on the plans are approximate and shall be used for estimating purposes only. Whenever called for on the plans, test piling shall be driven to determine the length of piling to be used for the proposed structure. Test piling shall meet the requirements herein specified for untreated timber piling or treated timber piling as the case may be. The test piling shall be of the lengths shown on the plans. The locations for driving and disposal of test piling above the ground line will be as directed by the Engineer. The number of test piling shown on the plans may be increased or decreased as deemed necessary to secure the desired information.

Test piling shall be driven with the same type and size of equipment proposed to be used to drive the piling in the structure.

When test piling are specified, no piling for the proposed structure shall be ordered until test piling results with recommended lengths have been examined and approved by the Engineer.

406.7. Measurement. Timber piling, treated or untreated, furnished in lengths specified on the plans or approved by the Engineer from test pile data and driven in accordance with these specifications, in the location specified on the plans or as directed by the Engineer, will be measured by the linear foot complete in place after all cut-offs and build-ups have been made.

Cut-offs will be measured by the linear foot. The pay length of cut-off for each pile will be determined by deducting the length of accepted pile in place, after cut-off has been made, from the "approved length" of the pile, except that no measurement will be made of cut-offs necessitated by brooming, splitting, or other injuries arising from careless or improper driving. Where test piling are not provided, the "approved length" of the pile shall be that shown on the plans. Where test piling are provided, the "approved length" shall be the length shown in the approved schedule of piling as established subsequent to the driving of test piling. No cut-off will be measured on any pile which is spliced and built-up.

Splices for build-ups made in accordance with details shown on the plans will be measured as a unit.

Each test pile will be measured as a unit.

406.8. Payment. Timber piling measured as provided above will be paid for at the unit price bid per linear foot for "Treated Timber Piling" or "Untreated Timber Piling", as the case may be.

Cut-offs for Treated or Untreated Timber Piling measured as provided above will be paid for by the linear foot at one-half the unit price bid respectively for "Treated Timber Piling" or "Untreated Timber Piling".

Splices for Build-ups for Treated or Untreated Timber Piling measured as provided above will be paid for each at four times the unit price bid respectively for "Treated Timber Piling" or "Untreated Timber Piling". This shall not include any allowance for the length of piling used in the build-ups as this is measured and paid for as timber piling as provided elsewhere in this specification.

Test piling will be paid for at the unit price bid for each "Untreated Timber Test Piling" or "Treated Timber Test Piling" as the case may be.

The foregoing shall be full compensation for furnishing all materials, tools, labor, equipment, jetting, pilot holes, alignment holes, and incidentals necessary to complete the work, except that any loading test ordered by the Engineer that is not provided for in the contract shall be paid for in accordance with Article 9.4, and no additional compensation will be allowed the Contractor because of any delay in any work resulting directly or indirectly from this extra work.

ITEM 407

STEEL PILING

407.1. Description. This item shall govern for the furnishing of steel piling of H-section and sheet piling, in place, of the type and weight, and in the locations shown on the plans.

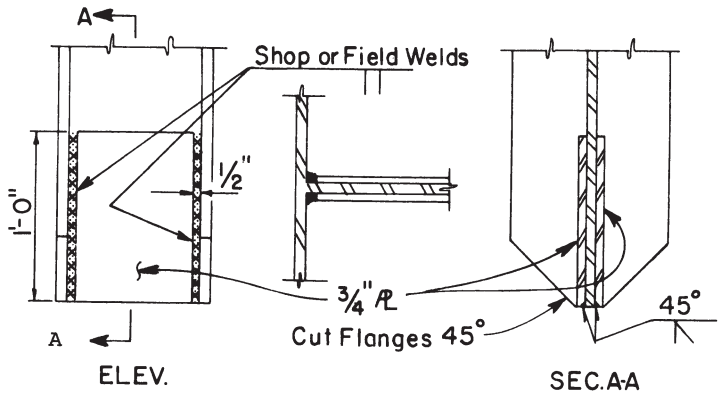
Driving of piling and test loading (when required) shall be in accordance with the Item, "Driving Piling", and the Item, "Foundation Test Load".

Unless otherwise shown on the plans, the embankment at bridge ends shall be in place, thoroughly compacted, and to grade prior to driving piling therein.

Reinforcement of steel H-pile tips in accordance with the following detail shall be furnished and measured under these conditions:

(1) When the contract plans show the piling driven into rock, shale or other material of similar hardness, the Contractor shall furnish piling with reinforced tips without any additional measurement or payment being made therefor.

(2) When the contract plans show the piling founded in materials other than those mentioned above, any tip reinforcement ordered by the Engineer in writing will be measured for payment as provided in Article 407.8.



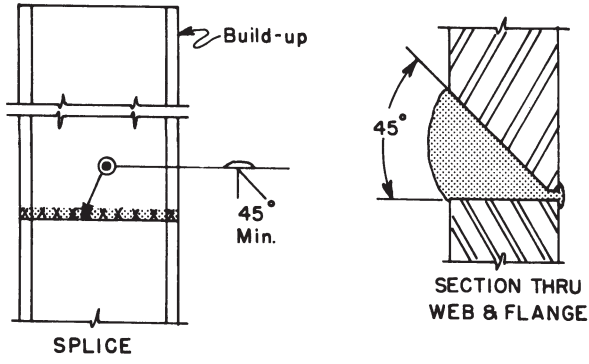
407.2. Material. Steel H-piling and steel sheet piling shall be manufactured in accordance with the Item, "Steel Structures", and the Item, "Metal for Structures". Steel sheet piling with a section modulus and minimum thickness of material equal to or greater than that of the section specified may be substituted therefor.

407.3. Storing and Handling. A sufficient number of skids shall be used to prevent deflection in the stored piling and prevent contact with the ground. The methods of handling shall prevent damage to the piling and when stored, they shall be kept clean and fully drained at all times.

407.4. Cut-Offs, Splices and Build-Ups. All splices for steel H-piling shall be made in accordance with the details shown herein. If the required penetration or bearing resistance has not been secured, the spliced piling may be driven the additional depth required as soon as the splice is completed.

The Contractor may, at his entire expense, fabricate piling by welding together not more than three sections of the project piling, provided the distance between welds is not less than five feet.

Build-ups shall be governed by the provisions of Articles 407.8 and 407.9.



STEEL BEARING PILING DETAIL

After the pile has been driven to the approximate penetration and bearing resistance required, it shall be cut off square to the plan grade, or to the grade established by the Engineer. Where pile heads are specifed, the end surfaces shall be made as smooth as practicable before the head is welded in place. The pile head shall conform to the plan details.

If the head of the pile is appreciably distorted or otherwise damaged below cut-off level, the damaged portion shall be cut off and an undamaged section shall be spliced in its place at the Contractor's expense.

Sheet pile splices shall be prepared similar to the details shown for H-piling with care taken not to interfere with the interlocks.

Welding shall be in accordance with the Item, "Structural Welding".

407.5. Concrete Collars. When shown on the plans, piling which extend above the permanent ground line shall be provided with concrete collars at the ground line. The concrete shall conform with the Item, "Concrete for Structures", and the Item, "Concrete Structures".

The surface of the piling to be covered by the concrete collar shall be thoroughly cleaned of loose mill scale, rust, dirt, grease and all other foreign substances before placing concrete.

The portion of the concrete collar above the ground line shall be formed in a manner to provide a smooth, uniform appearance for all collars. Where the material on the sides of the hole is sufficiently stable to stand without caving during the concrete placing operation, the forms may be omitted from the portion of the collar below the permanent ground line, otherwise they shall extend to the bottom of the collar. Concrete collars shall be cured for a minimum of four curing days.

407.6. Painting. Steel piling shall not be painted before driving. After driving, capping and placing collars, all exposed portions of the piling shall be cleaned and painted in accordance with the Item, "Paint and Painting". Painting shall extend to a point one foot below finished ground line, unless the pile is standing in water, in which case, painting shall extend to low water line. Earth removed for this painting shall be replaced after paint has hardened.

407.7. Driving Sheet Piling. Sheet piling will be driven in the location and to the elevation shown on the plans or as designated by the Engineer.

The driving equipment shall have the capability required to drive the piling to the required depths without damage. The equipment shall include a head compatible with the shape of the sheet pile.

407.8. Measurement. Steel H-piling will be measured by the linear foot of acceptable piling in place after all cut-offs and build-ups have been made. A splice made necessary by driving beyond the authorized pile length to obtain the required bearing will be measured as "One Splice". Each additional splice required for build-up will be measured as "One Splice", provided the distance between splice points in not less than 10 feet.

Where a reinforced tip is ordered by the Engineer in accordance with Subarticle 407.1.(2), it will be measured as "One Pile Tip".

For piling specified to be driven to a "minimum penetration", no measurement will be made on that portion driven below the elevation at which the penetration and bearing requirements were first obtained.

Portions of required test piling directed by the Engineer to be driven below the elevation at which penetration and bearing were first obtained will be measured for payment.

Steel sheet piling shall be measured by the square foot of acceptable piling in place. Sheet piling driven below the elevation required by the plans or as directed by the Engineer will not be measured for payment.

407.9. Payment. Steel H-piling will be paid for at the unit price bid per linear foot for "Steel H-Piling", or "Steel H-Test Piling", as the case may be, of the specified size and weight.

Steel sheet piling will be paid for at the unit price bid per square foot for "Sheet Piling" of the type shown on the plans.

No direct payment will be made for cut-offs, pile heads, concrete collars, painting, or for excavation and backfill required by the placing of collars or the painting of portions of piling below ground line. Payment for all work and materials required by these items shall be included in the unit price bid per linear foot for "Steel H-Piling", "Steel H-Test-Piling", or in the unit price bid per square foot for "Sheet Piling", as the case may be.

Test piling, when shown on the plans, will be paid for at the unit price bid per linear foot for "Steel H-Test Piling" of the specified size and weight. When test piling are driven at the option of the Contractor, they shall be paid for at the unit price bid per linear foot for "Steel H-Piling", if so located as to form a portion of the completed structure as shown on plans and if structurally acceptable and driven to required penetration and bearing.

Payment for the work and materials (exclusive of additional length of piling) required in making each authorized splice will be made at a price equal to three times the unit price bid per linear foot for "Steel H-Piling" of the size and weight on which the splice is made.

Payment for the work and materials required for each reinforced tip ordered by the Engineer will be made at a price equal to two times the unit price bid per linear foot for "Steel H-Piling" of the size and weight on which the tip is added.

No payment will be made for cut-off or splices of sheet piling.

The foregoing shall be full compensation for furnishing all materials, tools, labor, equipment, jetting, pilot holes, alignment holes and incidentals necessary to complete the work, except that any load test ordered by the Engineer that is not provided for in the contract shall be paid for in accordance with Article 9.4, and no additional compensation will be allowed the Contractor because of any delay in any work resulting directly or indirectly from this extra work.

ITEM 408
METAL SHELL PILING

408.1. Description. This item shall govern for the furnishing of metal shell piling in place, fabricated, reinforced, and filled with concrete in accordance with these specifications and plans, of the type and size shown on the plans, and in the locations as required by the plans.

Driving and test loading of piling (when required), shall be in accordance with the Item, "Driving Piling", and the Item, "Foundation Test Load".

Unless otherwise shown on the plans, the embankment at bridge ends shall be in place, thoroughly compacted, and to grade prior to driving end bent piling.

408.2. Material. Metal shell piling may be of any of the sections and of the minimum thickness or gauge indicated on the plans. The entire metal shell shall form an integral water-tight unit. The shoe or point shall be tightly fastened to the shell and adequately welded or otherwise connected to prevent the entrance of water. The shell shall be of sufficient strength to resist the earth pressure after being driven and shall retain its original form free from harmful distortions after it and adjacent shells in the bent or pier have been driven.

Metal in the shell shall conform to the Item, "Metal for Structures". All concrete materials and their preparation and placing shall be in accordance with the requirements of the Item, "Concrete Structures", and the Item, "Concrete for Structures", except that the use of a tremie will not be required. All concrete shall be Class "A" unless otherwise shown on the plans. Reinforcement shall conform to the requirements of the Item, "Reinforcing Steel". The sizes and dimensions of reinforcing steel shall be as shown on the plans. Welding shall be done in accordance with the Item, "Structural Welding". The required sizes and dimensions of the metal shell piling shall be as shown on the plans.

408.3. Storing and Handling. The methods of handling shall be such that will not result in damage to the piling. Piling to be stored shall be placed on skids to prevent contact with the ground. A sufficient number of skids shall be used to prevent deflection in the stored piling. The stored piling shall be kept clean and fully drained at all times.

408.4. Cut-Offs, Splices, and Build-Ups. After the metal shell has been driven to the approximate penetration and bearing resistance to satisfy the design requirement, it shall be cut off or built up as necessary to bring the top of the shell to plan grade. Cut-offs shall be made with a cutting torch or other acceptable methods which will give the desired result of a smooth, level end of shell at the proper elevation. Build-ups shall be made by welding on a section of shell in such manner as to develop fully the section of the shell and give a smooth, water-tight joint.

Where the top of the pile is appreciably deformed or otherwise damaged below cut-off level, the damaged portion shall be cut off and replaced with a new section spliced in place. No additional compensation will be allowed for this work and material.

408.5. Test Piling. Test piling, generally, will not be required except where load tests are to be made. Where required, test piling shall be furnished and driven at locations as shown on the plans or as directed by the Engineer, and shall conform to the requirements herein provided for metal shell piling. In general, test piling shall be made a part of the completed work and shall be cut off or built up to grade elevations as necessary. The Contractor will be given the option of driving test piling for his own information in estimating the length of piling, even though they are not required or indicated on the plans.

Load tests will be required when called for on the plans or special provisions. When required bearing resistance, as computed by the proper formula, cannot be attained at or near the depth of penetration indicated on plans, the Engineer may require load tests on one or more piling as necessary to establish the actual bearing capacities of the piling and to develop a modified bearing resistance formula.

408.6. Construction Methods. The length of a metal shell pile may be built up in sections either before or during the driving operation. The minimum length of a section measured between splices shall be 5 feet and only one splice will be permitted in that portion of pile exposed above ground line or normal water line.

Care shall be taken to properly align the sections to be spliced to insure a straight axis, and the sections shall be welded together in a manner that will fully develop the section of the shell and also form a water-tight joint.

After all driving and splicing is completed, the shell shall be free of buckles, water, and other foreign matter and shall be of required shape and dimensions before filling with concrete. The Contractor shall provide equipment and facilities necessary for the proper inspection of the shells. Any broken, improperly driven, or otherwise defective shell shall be removed and replaced at the Contractor's expense.

The concrete shall be placed in a continuous operation from tip to butt. Care shall be taken to prevent segregation in depositing concrete, and special devices shall be used if necessary. No concrete shall be placed in the piling in any bent or footing until all driving of piling in that bent or footing has been completed. The tops of shells shall be kept covered after driving until the concrete has been placed.

Metal shell piling shall be reinforced when and as indicated on the plans. Care shall be taken to hold the reinforcement to true position in the shell when placing concrete. Concrete blocks or other suitable devices shall be used to prevent the displacement of the core reinforcing.

408.7. Painting. All surfaces of metal shells which will be exposed to view in the completed structure shall be cleaned and painted in accordance with the Item, "Paint and Painting" and in compliance with the following additional requirements.

Metal shell piling shall not be painted prior to driving. After driving and placing concrete in the metal shell, all exposed portions of the metal shell pile

shall be cleaned and painted in accordance with the Item, "Paint and Painting". Painting shall extend to a point one foot below the finished ground line unless pile is standing in water, in which case, paint shall extend to low water line. Earth removed for this painting shall be replaced after paint has hardened.

408.8. Measurement. Measurement will be made by the linear foot of acceptable piling in place after all cut-offs and build-ups have been made except that where piling, other than required test piling, are driven to depths greater than required to meet the specified penetration and bearing requirements, no measurement will be made on that portion of piling below the elevation at which penetration and bearing requirements were first obtained. Portions of required test piling driven below the level at which penetration and bearing were first obtained, at the direction of the Engineer, shall be measured for payment.

408.9. Payment. Metal shell piling will be paid for at the unit price bid per linear foot for the specified size of "Metal Shell Piling", or "Metal Shell Test Piling", as the case may be.

No direct payment will be made for cut-offs or splices, for cleaning and painting metal shells, or for the excavation and backfill required in the painting of piling below ground line. Build-ups will be paid for at the unit price bid per linear foot for "Metal Shell Piling", or "Metal Shell Test Piling".

Test piling, when shown on the plans, will be paid for at the unit price bid per linear foot for "Metal Shell Test Piling". When test piling are driven at the option of the Contractor, such shall be paid for at the unit price bid per linear foot for "Metal Shell Piling" if so located as to form a portion of the completed structure as shown on plans and if structurally acceptable and driven to required penetration and bearing.

The foregoing shall be full compensation for furnishing all materials, tools, labor, equipment, jetting, pilot holes, alignment holes, and incidentals necessary to complete the work, except that any loading test ordered by the Engineer that is not provided for in the contract shall be paid for in accordance with Article 9.4, and no additional compensation will be allowed the Contractor because of any delay in any work resulting directly or indirectly from this extra work.

ITEM 409

CONCRETE PILING

409.1. Description. This item shall govern for the furnishing of concrete piling in place, of the size, and in the locations shown on the plans.

409.2. General. Driving and test loading, when required, shall be in accordance with the Item, "Driving Piling", and the Item, "Foundation Test Load".

Unless otherwise shown on the plans, the embankment at bridge ends shall be to grade and compacted prior to driving piling therein.

Precast piling shall be cast on or near the job site.

Prestressed piling, whether pre- or post-tensioned shall be fabricated on properly designed and constructed casting beds on the job or in a central plant.

After casting, each pile shall be marked with the date of casting and an identifying number.

409.3. Designation and Selection of Piling. Unless otherwise noted on the plans, the Contractor has the choice of furnishing precast piling or prestressed piling. For the purpose of this item, precast piling shall be defined as regularly reinforced (non-prestressed) piling.

In either case, the piling shall be of the shape, size, section and reinforced and/or prestressed in accordance with the plan requirements and the pertinent specifications.

409.4. Materials. Reinforcing steel shall be in accordance with the Item, "Reinforcing Steel".

For precast piling, concrete shall be Class "C" unless otherwise shown on the plans. Concrete, materials, design, mixing and placing shall be in accordance with the Item, "Concrete Structures", and the Item, "Concrete for Structures".

For prestressed piling, concrete shall be of the class shown on the plans. Concrete, materials, design, mixing and placing shall be as specified in the Item, "Prestressed Concrete Structures". Stressing materials and prestressing shall be in accordance with the Item, "Prestressing".

409.5. Construction Methods.

(1) Prestressed Piling. Prestressed piling fabrication shall be governed by the pertinent requirements of the Item, "Prestressed Concrete Structures", and the Item, "Prestressing". This includes the design, mixing, placing, curing and quality of concrete construction and removal of forms, submission of prestressing details and plant facilities' plans, tensioning and release of stress to the concrete and inspection facilities.

(2) Precast Piling. The following shall govern for precast piling in addition to the applicable requirements of the Item, "Concrete Structures":

(a) Forms. The form foundation shall be unyielding. Timber sills or joists, when used, shall be wide enough and spaced sufficiently close to support the weight of the concrete without settlement and prevent sagging of the bottom forms.

Piling to be turned over for removal of a single unit steel form shall be cast on a 6 inch (minimum) thick sand bed placed on an unyielding foundation. The sand bed shall be kept clean and free of all coarse aggregate, extraneous concrete or other hard material.

Timber for bottom and side forms shall not be less than three-fourths of an inch in thickness after surfacing, and lined with an approved material such as masonite, plywood, or equal. Lining will not be required for piling

completely hidden from view in the finished structure. Forms may also be constructed of plywood of one half of an inch minimum thickness. Clear spacing of supporting studs or joists shall not exceed 20 times the actual lumber or plywood thickness. Face ply grain of plywood forms shall be laid parallel to the length of the pile. All forms shall be built and maintained reasonably mortar tight.

When metal forms are used, they shall conform to the requirements of the Item, "Concrete Structures", except that corners may be filleted or rounded.

All square piling corners shall have a one-inch chamfer unless otherwise provided.

Reused forms shall be oiled and their accuracy of shape, rigidity, strength and smoothness shall be maintained.

Before reuse, warped and bulged lumber must be properly sized and reconditioned.

Forms shall be accessible for placing and vibrating the concrete.

Piling may be turned over for removal of a single unit steel form after the concrete strength reaches 400 psi minimum as evidenced by test beams made and cured under the same conditions as the piling. Curing shall be resumed upon removal of the forms.

Side forms may be removed at the discretion of the Contractor any time after the concrete has reached sufficient strength to prevent physical damage to the surface, provided curing is not interrupted for more than 30 minutes and the pile is not moved on its supports until the minimum curing period has elapsed.

(b) Reinforcement. Reinforcement shall be accurately placed and rigidly supported as required by the Item, "Reinforcing Steel".

(c) Placing Concrete. Concrete shall be placed continuously in each pile. Special care shall be taken to avoid cold joints. Approved types of mechanical vibrators shall be used to thoroughly consolidate the concrete without displacing the reinforcing steel.

Due to the close spacing of reinforcement in the pile tip, special care shall be taken to avoid accumulations of large sizes of aggregates in this area. Large particles shall be moved as required to insure complete filling of the space between bars and to avoid honeycomb in the interior of the pile.

(d) Curing. As soon as a pile is completed and the top surface finished as specified herein, it shall be covered with wet cotton mats which shall remain in place until the side forms are removed. Upon their removal, the entire pile or bed of piling, including the ends, shall be covered with wet cotton mats or wet earth, or submerged by ponding. This condition shall be maintained throughout the curing period. While removing side forms and placing curing material, the piling surfaces shall be kept covered and wet to the greatest extent practicable, but in no case shall they be permitted to become dry. It is the intent of this provision not only to keep the piling wet, but also to provide for covering them in order to maintain constant curing

conditions which will gradually and uniformly dispel the heat from the hydration process. The minimum curing period shall be six days, and until the concrete has a minimum flexural strength of 600 psi or a minimum compressive strength of 3600 psi, tested in accordance with THD Bulletin C-11 and cured in the casting bed under the same conditions as the piling. The piling may be driven after curing is completed.

(e) **Finishing.** The top surface of all piling shall be struck off and finished with a wood float bringing grout to the surface, to cover the aggregate and present a reasonably smooth appearance. Form marks, small corner fins and discolorations need not be removed, unless the piling is to be exposed to view.

409.6. Handling and Storing. The method of handling and storing piling shall minimize the danger of fracture by impact or undue bending stresses. Any broken or cracked piling shall be cause for immediate review and correction of the conditions causing the failure. The use of chain slings will not be permitted. After the curing and strength requirements are met, the piling may be removed to a storage area where they shall be stored above ground on adequate blocking that will prevent undue stresses.

409.7. Workmanship and Tolerances. The maximum sweep (curvature along the axis of the pile) shall not exceed one-eighth of an inch per 10 feet of length.

The head of the pile shall not be out of square by more than one-eighth of an inch.

Small damaged or honeycombed areas which are purely surface in nature (not over one inch deep) may be repaired. Damage or honeycomb in excess of this will be tentatively rejected, but will be subject to structural review.

When piling are cast with internal voids, the position of the void shall be within plus or minus one-half inch.

409.8. Defects and Breakage. Piling cracked in the process of curing, handling and driving shall be subject to the following provisions:

(1) Piling which have cracks showing severe spalling or sufficient opening to indicate the reinforcement has been permanently distorted shall be rejected, if the cracks occur in a portion which will be below ground after driving.

(2) Piling with cracks as described in the above paragraph, which will be located above ground when driving is completed, may be used provided the Contractor will cut the piling back to the crack, and rebuild it to grade. No additional payment will be made for this buildup.

(3) Piling with cracks that show spalling but are closed sufficiently to indicate no permanent distortion of the reinforcement may be used if the Contractor will seal the area over the crack with an approved epoxy waterproofing material. Cracks one thirty-second of an inch or greater in width, shall have a vee formed one-eighth of an inch in width and depth prior to application of the waterproofing.

The waterproofing shall be applied in the crack and over an area not less than one-inch each side. If, during driving, cracks develop in the portion which will be below ground, driving operations shall be stopped and the required waterproofing applied before driving continues.

(4) Fine hair cracks or surface checks, which, as determined by the Engineer, do not extend to the plane of the nearest reinforcing steel, will not require extra treatment and will not be cause for rejection unless they are numerous and extensive.

(5) Any tendon breakage which may occur, shall be analyzed in accordance with the Item, "Prestressing".

(6) All replacements or repairs specified herein, and other replacements due to faulty materials or construction methods, shall be made at the Contractor's expense.

409.9. Cut-offs or Build-ups. Build-ups shall be made in accordance with the details shown on the plans.

Welding of reinforcing steel shall conform to the Item, "Structural Welding".

The pile ends shall be cut back, leaving the steel exposed. The final cut of the concrete shall be normal to the longitudinal axis and any damage shall be remedied by further cut back. The build-up form shall be placed, care being taken to prevent leakage along the pile. The build-up shall be of Class "C" concrete. Just prior to placing the concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of cement grout.

If no further driving is required, form removal and curing shall conform to requirements for concrete columns in the Item, "Concrete Structures".

Where additional driving is required, the build-up portion shall be water cured 6 curing days.

409.10. Test Piling. When required, test piling shall be furnished and driven at locations, as shown on the plans or as directed by the Engineer, and shall conform to the requirements herein. In general, they shall be made a part of the completed work and shall be cut off or built up to grade as necessary. The Contractor shall be given the option of driving test piling for his own information in estimating the length of piling, even though they are not required or indicated on the plans.

Test loading shall be as required by the plans. When the required bearing, as computed by the pertinent formula, cannot be attained at or near the penetration indicated on plans, the Engineer may require load tests.

409.11. Measurement. Piling will be measured by the linear foot of acceptable piling in place after all cut-offs and build-ups have been made. Each authorized build-up made, other than those made necessary by improper casting or handling or driving, shall be measured as "One Build-up".

Anchor piling and piling to be test loaded shall be measured as provided in the Item, "Foundation Test Load". Measurement of all other test piling will be made by the linear foot of acceptable piling in place after all cut-offs and build-ups have been made. Each authorized build-up, other than those made necessary by improper casting, handling or driving, shall be measured as "One Build-up".

Cut-offs for both regular and test piling will be measured by the linear foot of cut-off above grade. The portions of test loaded piling which are cut off after making the tests will not be measured as cut-offs, since payment is provided for them in the Item, "Foundation Test Load".

When piling, other than required test piling, are driven deeper than required to meet the specified penetration and bearing requirements, no measurement will be made on that portion below the elevation at which penetration and bearing requirements were first obtained. Portions of test piling, directed by the Engineer to be driven below the level at which penetration and bearing were first obtained, will be measured for payment.

409.12. Payment. Piling will be paid for at the unit price bid per linear foot for the specified size of "Concrete Piling", or "Concrete Test Piling", as the case may be, measured as outlined above. When test piling are driven at the option of the Contractor, payment will be made at the unit price bid per linear foot for "Concrete Piling", if so located as to form a portion of the completed structure as shown on the plans, structurally acceptable and driven to the required penetration and bearing.

Each authorized build-up, measured as outlined above, shall be paid for at four times the unit price bid per linear foot for "Concrete Piling".

Anchor piling and piling to be test loaded shall be paid for as provided in the Item, "Foundation Test Load".

Cut-offs for both regular piling and test piling will be paid for at one-half the unit price bid per linear foot for "Concrete Piling". Where cut backs are made below grade for the purpose of making build-ups, payment for same will be included in the allowance for build-ups.

A partial allowance will be made for materials and for piling (cast, but not driven) in accordance with the provisions of Article 9.6.

The foregoing shall be full compensation for furnishing all materials, tools, labor, equipment, jetting, pilot holes, alignment holes and incidentals necessary to complete the work, except that any loading test ordered by the Engineer that is not provided for in the contract shall be paid for in accordance with Article 9.4, and no additional compensation will be allowed the Contractor because of any delay in any work resulting directly or indirectly from this extra work.

ITEM 416

DRILLED SHAFT FOUNDATIONS

416.1. Description. This item shall govern for the construction of foundations consisting of "reinforced concrete drilled shafts" and/or "non-reinforced concrete drilled shafts", with or without concrete bell

footings. Concrete shafts shall be placed in a drilled excavation when the shafts are without bell footings, and in a drilled and underreamed excavation when shafts are with bell footings. Foundations shall be constructed in accordance with this Item and in conformance with the details and dimensions shown on the plans. Any required test loading of shafts shall be in accordance with the Item, "Foundation Test Load".

416.2. Materials. All concrete and materials shall be in accordance with the requirements of the Item, "Concrete for Structures", and the requirements herein. Concrete shall be Class "A", unless otherwise shown on the plans. The maximum size coarse aggregate shall be 1½ inches for cased shafts. A retarder or water reducing agent will be required in all concrete when casing is used. Reinforcing steel shall conform to the requirements of the Item, "Reinforcing Steel". The sizes and dimensions shall be as shown on the plans. Welding shall be in accordance with the Item, "Structural Welding".

416.3. Construction Methods.

(1) Excavation. The Contractor shall perform the excavation required for the shafts and bell footings, through whatever materials encountered, to the dimensions and elevations shown on the plans or required by the site conditions.

Shaft alignment shall be within a tolerance of one inch per ten feet of depth.

Bells shall be excavated to form a bearing area of the size and shape shown on the plans. Bell outlines varying slightly from those shown on the plans are permissible provided the bottom bearing area equals that specified.

Bells may be excavated either by hand or by mechanical methods. Blasting may be used only with permission of the Engineer and shall be controlled to avoid disturbance of the formations below or outside the limits of the proposed shaft.

The plans indicate the expected depths and elevations where satisfactory bearing material will be encountered. This information will be used as a basis for the contract. If satisfactory material is not encountered at plan elevation, the footing may be raised or lowered as determined by the Engineer. Alteration of plan depth shall be made to satisfactorily comply with the design requirements. Casing will be required when necessary to prevent caving of the material or when necessary to exclude seepage water. Casing shall be metal of ample strength to withstand handling stresses, the pressure of concrete and of the surrounding earth or backfill materials, and shall be watertight. The outside diameter of casing shall not be less than the specified size of shaft; otherwise, the size of casing and the size of drilled excavation in which it is to be placed will be left to the discretion of the Contractor, except as noted below. No extra compensation will be allowed for concrete required to fill an oversize casing or oversize excavation.

Where caving conditions and/or excessive ground water is encountered, no further drilling will be allowed until a construction method is employed

which will prevent excessive caving that will make the excavation appreciably larger than the size of casing to be used. Drilling in a mud slurry, or other method which will control the size of excavation, will be required.

If the elevation of the top of shaft is below ground level at the time of concrete placement, an oversize casing from ground elevation to a point below the top of the shaft will be required to control caving of any material into the freshly placed concrete.

Where casing is not required, any excavation for the bells or shafts beyond the lines required by the plans shall be filled with Class "A" concrete at the Contractor's expense. Where casings are used, the Contractor will be permitted to backfill around the upper portions of the casing with pea gravel or other granular material, but space shall be provided to allow for escape of muck, slurry or water displaced by the concrete.

When casing is used, it shall be smooth and well oiled and shall extend approximately to the top of the shaft.

Under normal operations, the removal of the casing shall not be started, until all concrete placement is completed in the shaft. Movement of the casing for short pulls of a few inches, rotating, exerting downward pressure and tapping it to facilitate extracation will be permitted. When unusual conditions warrant, the casing may be pulled in partial stages. A sufficient head of concrete shall be maintained above the bottom of the casing to overcome hydrostatic pressure. Casing extraction shall be at a slow, uniform rate with the pull in line with the center of the shaft.

The elevation of the top of the steel cage shall be carefully checked before and after casing extraction. Generally any upward movement of the steel not exceeding 2 inches, or any downward movement thereof not exceeding 6 inches per 20 feet of shaft length will be acceptable. Any upward movement of the concrete or displacement of the steel beyond the above limits will be cause for rejection.

The minimum length of steel required for lap with column steel shall be maintained. Dowel bars may be used if the proper lap length is provided both into the shaft and into the column.

Placing of drilled shaft concrete under water shall not be done without the permission of the Engineer. If permission is granted, the concrete shall be placed in accordance with the Item, "Concrete Structures", and shall be placed with a closed tremie. Provisions shall be made for a sump, or other approved method to channel displaced water away from the shaft.

Material excavated from shafts and bells, including drilling mud, and not used in the backfill around the completed bents or piers shall be disposed of as directed by the Engineer and shall not be placed in the stream or otherwise impair the efficiency or appearance of the structure or other parts of the work.

At the time concrete is placed, the excavation shall be free from accumulated seepage water. All loose material shall be removed from the bottom of the excavation prior to placing concrete.

The Contractor shall provide suitable access and lighting for proper inspection of the completed excavation, to check the dimensions and alignment of shafts and underreamed excavation.

Any required lighting shall be electric. Any mechanical equipment used within the excavation shall be operated by air or electricity. The use of gasoline driven engines within the excavation for pumping or drilling will not be permitted.

In order that the Engineer may judge the adequacy of a proposed foundation, the Contractor, if requested, shall make soundings or take cores at his expense to determine the character of the supporting materials. The depth of such soundings or cores will not be required to exceed 5 feet below the proposed footing grade. It is the intent of this provision that soundings shall be made or cores taken at the time the excavation in each foundation is approximately complete.

When the plans require shafts in abutment bents, the embankment at the bridge ends shall be completed to grade and thoroughly compacted prior to drilling.

(2) Reinforcing Steel. The cage of reinforcing steel, consisting of longitudinal bars and spiral reinforcement, lateral ties or horizontal bands, shall be completely assembled and placed as a unit immeditately prior to concrete placement.

If the shaft is lengthened, and the plans require full depth reinforcement, a minimum of one-half of the longitudinal bars required in the upper portion of the shaft shall be extended to the bottom, with proper lateral reinforcement. These bars may be lap spliced, spliced by welding, or unspliced bars of the proper length. Any splices required shall be in the lower portion of the shaft.

Where spiral reinforcement is used, it shall be tied or tack welded to the longitudinal bars at a spacing not to exceed 12 inches. Unless otherwise shown, welding will not be permitted within the top 15 feet of the steel cage.

Horizontal steel bands shall be placed and welded as shown on the plans.

The cage shall be supported from the top by some positive method, to minimize its slumping downward during concrete placement and/or extraction of the casing. The support shall be concentric with the cage to prevent racking and distortion of the steel. A minimum of one half of the vertical bars shall be supported.

In uncased shafts, concrete spacer blocks, or steel chairs shall be used at sufficient intervals to insure concentric spacing for the entire length of the cage. In cased shafts, concrete spacer blocks shall not be used. Metal "chair" type spacers or bent pieces of steel bars shall be placed at sufficient intervals around the steel cage to insure concentric spacing inside the casing.

(3) Concrete. The work shall be performed in accordance with the provisions of the Item, "Concrete Structures", and with the requirements herein.

Concrete shall be placed as soon as possible after all excavation is

complete and reinforcing steel placed, and shall be of such workability that vibrating or rodding will not be required.

Concrete placing shall be continuous in the shaft to the construction joint indicated on the plans.

Concrete shall be placed through a suitable tube or tremie to prevent segregation of materials. The tube or tremie shall be made in sections to provide proper discharge and permit raising it as the placement progresses. A non-jointed pipe may be used if sufficient openings of the proper size are provided to allow for the flow of concrete into the shaft.

The elapsed time from the beginning of concrete placement in the cased portion of the shaft, until extraction of the casing is begun, shall not exceed one hour.

Where a cap or tie beam is required to be placed monolithically with the shaft, a time interval will be allowed for placing the required form and reinforcing after casing removal.

A riser block of equal diameter as the column and of a maximum height of 6 inches may be cast at the top of the completed shaft.

The top surface shall be cured and any construction joint area shall be treated as prescribed in the Item, "Concrete Structures".

416.4. Test Holes. When shown on the plans, or when ordered by the Engineer in writing, test holes will be required to establish elevations for "belling", to determine elevation of ground water, or other soil characteristics.

The diameter and depth of test hole or holes shall be as shown on the plans or as directed by the Engineer.

416.5. Test Bells. When shown on the plans, or when ordered by the Engineer in writing, the reaming of bells on specified test holes will be required to establish the feasibility of belling in a specific soil strata.

The diameter and shape of the test bell shall be as shown on the plans or as approved by the Engineer in writing.

416.6. Measurement. Acceptable drilled shafts (of the specified diameter), complete in place, will be measured by the linear foot. Shafts for interior bents and piers will be measured from a point approximately six inches below the ground elevation at the center of shaft unless specific elevations or dimensions are indicated on the plans or unless the Engineer directs otherwise to meet unusual conditions. (The bent height shown on the plans is for estimating purposes only and does not control the top of shaft measurement.) For highway-highway grade separations and railroad underpasses, the ground elevation used will be the completed subgrade section under the structure. At stream crossings and at railroad overpasses, the existing ground elevation at the time drilling begins will be used. For abutment bents and retaining walls, the length of shaft shall be measured from the bottom of footing or cap elevation. For sign structures and illumination towers, the elevation of top of shaft will be shown either as a dimension above ground, or as a dimension to the bottom of footing.

Drilled shafts used with commercial designs of overhead sign bridges will not be measured for payment but will be considered as subsidiary to the overhead sign support.

The quantity for acceptable bell footings placed will be measured by the cubic yard, computed by using dimensions and shape specified on the plans or as revised in diameter by the Engineer. The bell shall consist of the volume outside the plan or authorized dimensions of the shaft, which will extend to the bottom of the bell for the purpose of measurement.

Test holes of the specified diameter will be measured from the elevation of the ground at the time drilling begins, by the linear foot of acceptable test hole drilled.

Test bells will be measured by the cubic yard of material excavated, computed from the dimensions shown on the plans or those authorized by the Engineer in writing.

416.7. Payment. Drilled shafts will be paid for at the unit price bid per linear foot of "Drilled Shaft", or "Drilled Shaft (Non-reinforced)", of the specified diameter, subject to the following limitations for overruns authorized by the Engineer:

(1) Payment for individual completed shaft lengths up to and including five feet in excess of the maximum plan length shaft, as defined herein, will be made at the unit price bid per linear foot of the specified diameter of "Drilled Shaft".

(2) Payment for that portion of individual completed shaft length in excess of five feet and up to, and including, 15 feet more than the maximum plan length shaft, as defined herein, will be made at a unit price equal to 115 percent of the unit price bid per linear foot of the specified diameter of "Drilled Shaft".

(3) Payment for that portion of individual completed shaft length in excess of 15 feet and up to, and including, 25 feet more than the maximum plan length shaft, as defined herein, will be made at a unit price equal to 125 percent of the unit price bid per linear foot of the specified diameter of "Drilled Shaft".

(4) Payment for that portion of individual completed shaft length, over 25 feet in excess of the maximum plan length shaft, as defined herein, will be in accordance with Article 9.4.

(5) For extra depth drilling at interior bents and piers, the maximum plan length shaft shall be the maximum length shaft, regardless of diameter, for any interior pier or bent of any bridge included in the contract.

(6) For extra depth drilling for abutment bents and retaining walls, the maximum plan length shaft shall be the maximum length shaft, regardless of diameter, for any abutment bent of any bridge or of any retaining wall included in the contract.

(7) For extra depth drilling for sign structures, the maximum plan length shaft shall be the maximum length shaft, regardless of diameter, for any sign structures included in the contract.

(8) For extra depth drilling for illumination towers, the maximum plan length shaft shall be the maximum length shaft, regardless of diameter, for any illumination tower included in the contract.

The 20 percent limitation referred to in Article 4.3, will not apply to overruns due to extra depth of drilled shafts.

Bell footings, constructed to the specified dimensions or to the altered dimensions authorized by the Engineer, will be paid for at the contract unit price bid per cubic yard for "Bell Footings". Authorized increase in bell footing diameter beyond three times the specified shaft diameter, unless specified on plans, shall be considered as beyond the scope and intent of these specifications. Payment for such increased bell footing quantity shall be in accordance with Article 9.4.

Test holes, of the specified diameter, will be paid for at the contract unit price bid per linear foot for "Test Hole".

Test bells of the diameter and shape specified, or authorized by the Engineer, will be paid for at the contract unit price bid per cubic yard of "Test Bells".

Test holes or test bells required by the Engineer, but not otherwise specified by the contract plans, will be paid for in accordance with Article 9.4.

The foregoing unit prices shall be full compensation for making all excavations, for drilling all test holes and test bells, for doing any necessary pumping, for furnishing, placing and removing any required casings, for furnishing and placing all concrete and reinforcing steel, for all backfilling, and for furnishing all tools, labor, equipment and incidentals necessary to complete the work. When the bottom of any drilled shaft is ordered to be placed at an elevation below plan grade and a splice of reinforcement is required, no payment will be made for the extra reinforcement required, but it shall be considered subsidiary to the price bid per foot of shaft. No extra payment will be made for casings left in place.

No partial estimates will be allowed for "Bell Footing" or for "Drilled Shaft" until the concrete has been placed, except that partial payments will be made for concrete and reinforcing steel materials delivered on the job in accordance with the provisions of Article 9.6.

ITEM 420

CONCRETE STRUCTURES

420.1. Description. This item shall govern for the construction of all types of structures involving the use of structural concrete, except where the requirements are waived or revised by other governing specifications.

All concrete structures shall be constructed in accordance with the design requirements and details shown on the plans; in conformity with the pertinent provisions of the items contracted for; the incidental items referred to; and in conformity with the requirements herein.

420.2. Materials.

(1) Concrete. All concrete shall conform to the provisions of the Item, "Concrete for Structures", or the Item, "Lightweight Concrete for Structures".

The class of concrete for each type of structure or unit shall be as specified on the plans, or by pertinent governing specifications.

(2) Expansion Joint Material.

(a) Preformed Fiber Material. Preformed fiber expansion joint material shall be of the dimensions shown on the plans. At the Contractor's option, the material shall be one of the following types, unless otherwise noted on the plans:

1. "Preformed Bituminous Fiber Material" shall meet the requirements of the Standard Specifications for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction, ASTM Designation: D1751.

2. "Preformed Non-Bituminous Fiber Material" shall meet the requirements of the Standard Specifications for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction, ASTM Designation: D1751, except that the requirements pertaining to bitumen content, density and water absorption shall be voided.

(b) Joint Sealing Material. Unless otherwise noted on the plans, the sealer shall be a two-component, synthetic polymer conforming to the requirements of the Item, "Concrete Pavement".

(c) Asphalt Board. Asphalt Board shall consist of two liners of 0.016 inch asphalt impregnated paper, filled with a mastic mixture of asphalt and vegetable fiber and/or mineral filler. Boards shall be smooth, flat and sufficiently rigid to permit installation. When tested in accordance with Test Method Tex-524-C, the asphalt board shall not deflect from the horizontal more than one inch in three and one-half inches.

(d) Rebonded Neoprene Filler. Rebonded neoprene filler shall consist of ground closed-cell neoprene particles, rebonded and molded into sheets of uniform thickness of the dimensions shown on plans.

Filler material shall have the following physical properties and shall meet the requirements of ASTM Designation: D1752, Type 1 where applicable:

PROPERTY	METHOD	REQUIREMENT
Color		Black
Density	ASTM D1752 Type 1	40 PCF Min.
Recovery	ASTM D1752 Type 1	90% Min.
Compression	ASTM D1752 Type 1	50 to 500 psi
Extrusion	ASTM D1752 Type 1	0.25 In. Max.
Tensile strength	ASTM D1752 Type 1	20 psi Min.
Elongation		75% Min.

The manufacturer shall furnish the Engineer with certified test results as to the compliance with the above requirements and a 12 inch x 12 inch x 1 inch sample from the shipment for approval.

(3) Waterstop.

(a) Unless otherwise noted on the plans, copper waterstop shall be 16 ounce material conforming to the Item, "Metal for Structures".

(b) Rubber waterstop or Poly-Vinyl-Chloride (PVC) waterstop shall be in conformance with the Item, "Elastomeric Materials".

(c) Other types as specified on the plans.

(4) Curing Materials.

(a) Membrane curing shall conform to the Item, "Membrane Curing".

Type 1 *(Resin Base Only)* curing compound will be permitted for slab concrete in bridge decks and top slabs of direct traffic culverts.

(b) Emulsified linseed oil curing compound shall meet the requirements of Special Specification, "Emulsified Linseed Oil Curing Compound".

(c) Cotton mats shall consist of a filling material of cotton 'bat' or 'bats' (min. 12 oz. per sq. yd.); covered with unsized cloth (min. 6 oz. per sq. yd.); tufted or stitched to maintain stability; shall be free from tears; and shall be in good general condition.

(d) Polyethlene sheeting shall be opaque, of 4 mil minimum thickness and free from visible defects.

(e) Burlap-Polyethylene mats shall be made from burlap impregnated on one side with a film of opaque polyethylene and free from visible defects.

(f) Laminated mats shall have not less than one layer of an impervious material such as polyethylene, vinyl plastic or other acceptable material (either as a solid sheet or impregnated into another fabric) and shall be free of visible defects.

(5) Retarding, water reducing and air entraining agents shall comply with the requirements of the Item, "Concrete Admixtures".

420.3. General Requirements. Before starting work, the Contractor shall inform the Engineer fully of the construction methods he proposes to use, the adequacy of which shall be subject to the approval of the Engineer. Plans for forms and falsework for piers and superstructure spans over 20 feet long and for all widening details shall be submitted to the Engineer for review and approval. Similar plans shall be submitted for other units of the structure, if requested by the Engineer. The plans shall be prepared on standard 22 inch by 36 inch sheets and shall show all essential details of the proposed forms, falsework and bracing to permit a structural analysis. Four sets of such plans will be required.

Concurrence on the part of the Engineer in any proposed construction methods, approval of equipment, or of form and falsework plans does not relieve the Contractor of the responsibility for the safety or correctness of his methods and adequacy of his equipment or from carrying out the work in full accordance with the contract.

Unless otherwise provided on the plans, the requirements in the succeeding five paragraphs shall govern the time sequence in which construction operations may be carried on and for the opening of completed structures to traffic:

Superstructure members, forms, falsework, or erection equipment shall not be placed on the substructure before the concrete therein has attained a 500 psi flexural strength.

Storage of materials on completed portions of a structure will not be permitted until all curing requirements for those particular portions have been met.

No forms shall be erected on concrete footings supported by piling or drilled shafts until the concrete therein has attained a minimum flexural strength of 400 psi. Such work may begin on spread footings after the concrete therein has aged at least two curing days. Concrete may be placed as soon as the forms and reinforcing steel are approved.

The support of tie beam and/or cap forms by falsework placed on previously placed tie beams is permissible provided such beams have attained 500 psi flexural strength, curing requirements are completed, and they are properly supported to eliminate stresses not provided for in the design.

Bridges and direct traffic culverts shall not be opened to construction traffic or to the traveling public until authorized by the Engineer in accordance with the following:

Authorization may be given after the last slab concrete has been in place at least 14 days for light construction traffic not to exceed a three-quarter ton vehicle.

Authorization for normal construction traffic, and when necessary to the traveling public, may be given after the last slab concrete has been in place 30 days. Construction vehicles which exceed the legal load limit, except as specified herein, which would require a permit to haul over the highway system will not be authorized across structures, except that vehicles with a minimum of three axles may be permitted if the total

gross load does not exceed 51,000 pounds. Speed of such vehicles shall be limited to no more than 10 miles per hour.

Where a detour is not readily available or economically feasible to use, an occasional crossing of a structure with overweight equipment may be permitted for relocating equipment only but not for hauling material providing a structural analysis of the structure using the exact equipment in question indicates no damage will result. The structural analysis must be approved by the Engineer. Temporary matting and/or other requirements may be imposed by the Engineer if an occasional crossing is permitted.

Forms or screed supports may be attached to I-beams or girders by welding subject to the following requirements:

(1) Welds will *not* be permitted on flanges in those areas specified on the plans or as directed by the Engineer.

(2) Welds shall be made in accordance with the Item, "Structural Welding".

420.4. Drains. Weep holes and roadway drains shall be installed and constructed as shown on the plans.

420.5. Expansion Joints. Joints and devices to provide for expansion and contraction shall be constructed where and as indicated herein or on the plans.

The bearing area under the expansion ends of concrete slabs and slab and girder spans shall be given a steel trowel finish, and finished to the exact grades required. The material used to separate expansion surfaces shall be as shown on the plans and placed so that concrete or mortar cannot be subsequently worked around or under it.

Concrete adjacent to armor joints and finger joints shall be placed carefully to avoid defective anchorage and porous or honeycombed concrete in such areas.

All open joints and joints to be filled with expansion joint material, shall be constructed using forms adaptable to loosening or early removal. To avoid expansion or contraction damage to the adjacent concrete, these forms shall be loosened as soon as possible after final concrete set to permit free movement of the span without requiring full form removal.

When designated as a "Type A" joint, preformed fiber joint material, or other material shown on the plans, shall be used in the vertical joints of the roadway slab, curb, median or sidewalk. The top one inch thereof shall be filled with joint sealing material, as specified herein. When different material is shown on the plans it shall be used.

Prior to placing the sealing material, the vertical faces of the joint shall be cleaned of all laitance by sandblasting or by mechanical routing. Cracked or spalled edges shall be repaired. The joint shall be blown clean of all foreign material and sealed.

Where preformed fiber joint material is used, it shall be anchored to the concrete on one side of the joint by light wire or nails, to prevent the material from falling out.

Finished joints shall conform to the indicated outline with the concrete sections completely separated by the specified opening or joint material.

Soon after form removal and again where necessary after surface finishing, all projecting concrete shall be removed along exposed edges to secure full effectiveness of the expansion joints.

420.6. Construction Joints. The joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set shall be deemed a construction joint. The term monolithic placement shall be interpreted to mean that the manner and sequence of concrete placing shall not create construction joints.

Construction joints shall be of the type and at the locations shown on the plans. Additional joints will not be permitted without written authorization from the Engineer, and when authorized, shall have details equivalent to those shown on the plans for joints in similar locations.

Unless otherwise provided, construction joints shall be square and normal to the forms. Bulkheads shall be provided in the forms for all joints, except when horizontal.

Construction joints requiring the use of joint sealing material shall be as detailed on the plans. The material will be specified on the plans without reference to joint type.

A concrete placement terminating at a horizontal construction joint shall have the top surface roughened thoroughly as soon as practicable after initial set is attained. The surfaces at bulkheads shall be roughened as soon as the forms are removed.

The hardened concrete surface shall be thoroughly cleaned of all loose material, laitance, dirt or foreign matter and saturated with water so it is moist when placing fresh concrete against it. Forms shall be drawn tight against the existing concrete and the joint surface flushed with grout just prior to placing the fresh concrete.

420.7. Foundations. Excavation for foundations shall be made in accordance with the requirements of the Item, "Structural Excavation".

Caissons shall be constructed of the materials and to the dimensions and details shown on the plans. Forms for concrete caissons shall meet the requirements of Article 420.9. The sinking operation may proceed immediately after form removal.

Where necessary, falsework shall be provided to support the caisson during the construction and lowering period. It shall be strong enough to support the caisson in combination with the forces of wind, water current and drift.

Concrete for foundation seals, unless otherwise specified, shall be Class "E", and placed in accordance with the requirements herein and Article 420.14. The top of the completed seal shall not vary from plan grade or the grade established by the Engineer, by more than one foot.

Where a concrete seal is required by the plans, the design will be based on the normal water elevation as shown on the plans. If the foundation concrete can be placed in the dry at the time of construction, the seal will not be required. If additional seal is necessary for the conditions existing during the time of construction, its thickness shall be increased as deemed necessary by the Contractor and at his expense. If the conditions existing at the time of construction require a seal for placing the foundation concrete in the dry and none is provided on the plans, the Contractor shall place an adequate seal at his expense.

The seal shall be allowed to set for at least 36 hours before the caisson or cofferdam is de-watered, after which the top of the seal shall be cleaned of all laitance or other soft material, and all high spots exceeding the above limitation shall be cut off and removed.

420.8. Falsework. All falsework shall be designed and constructed to safely carry the maximum anticipated loads and to provide the necessary rigidity. Details of falsework construction shall be subject to review and approval by the Engineer in accordance with the provisions of Article 420.3.

For evaluating the adequacy of job fabricated falsework, a weight of 150 pounds per cubic foot shall be assumed for concrete, and a live load allowance of 50 pounds per square foot of horizontal surface of the form work shall be included. The maximum stresses shall not exceed 125 percent of the allowable stresses used by the Department for the design of structures.

Commercially produced structural units used in falsework shall not exceed the manufacturer's maximum allowable working load for moment and shear or end reaction. The maximum allowable working load shall include an allowance of 35 pounds per square foot of horizontal form surface and sufficient details and data shall be submitted for use in checking falsework details for approval.

All timber used in falsework centering shall be sound, in good condition, and free from defects which will impair its strength. When wedges are used to adjust falsework to desired elevations, they shall be used in pairs to insure even bearing.

Sills or grillages shall be large enough to support the superimposed load without settlement, and unless founded on solid rock, shale or other hard materials, precautions shall be taken to prevent yielding of the supporting material.

Falsework which cannot be founded on a satisfactory spread footing shall be placed on piling driven to a bearing capacity sufficient to support the superimposed load without settlement. The safe bearing capacity of piling shall be determined by test loads or by the applicable formula given in the Item, "Driving Piling."

In general, each falsework bent shall be capped transversely by a member of proper size. A short cap section forming a T-head may be substituted to permit the removal of portions of the forms without disturbing the falsework. Caps shall be securely fastened to each pile or column in the bent and set at the proper elevation to produce, in conjunction with the use of approved wedges or jacks, permanent camber indicated on the plans or specified, plus a

construction camber covering allowance for deformation of the forms and falsework. The use of wedges to compensate for incorrectly cut bearing surfaces will not be permitted. Welding, when used, shall conform to requirements of the Item, "Structural Welding". Each falsework bent shall be securely braced to provide the stiffness required with the bracing securely fastened to each pile or column it crosses.

In setting falsework for arches, allowances shall be made for settlement of falsework, deflection of the arch and permanent camber. Provision shall be made by suitable wedges, sand jacks, or other acceptable devices for the controlled lowering of falsework when the arch is swung. Falsework may be required to be placed on jacks to provide for settlement correction during concrete placement.

When the falsework is no longer required, it shall be removed. Falsework piling shall be pulled or cut off not less than six inches below finished ground level. Falsework and piling in a stream, lake, or bay shall be completely removed to a point specified by the Engineer to prevent any obstruction to the waterway.

420.9. Forms. Forms for precast prestressed concrete members and for prestressed piling shall be constructed in accordance with the provisions of the Item, "Prestressed Concrete Structures".

(1) General. Except where otherwise specified, forms may be of either timber or metal.

Forms for round columns exposed to view shall be of steel, except that other materials will be allowed with written permission of the Engineer.

Forming plans shall be submitted for approval subject to the requirements of Article 420.3. Forms shall be designed for the pressure exerted by a liquid weighing 150 pounds per cubic foot. The rate of placing the concrete shall be taken into consideration in determining the depth of the equivalent liquid. For job fabricated forms an additional live load of 50 pounds per square foot shall be allowed on horizontal surfaces. The maximum unit stresses shall not exceed 125 percent of the allowable stresses used by the Department for the design of structures.

Commercially produced structural units used in form work shall not exceed the manufacturer's maximum allowable working load for moment, shear or end reaction. The maximum working load shall include a live load of 35 pounds per square foot of horizontal form surface and sufficient details and data shall be submitted for use in checking form work details for approval.

Forms shall be practically mortar-tight, rigidly braced and strong enough to prevent bulging between supports and maintained to the proper line and grade during concrete placement. Forms shall be maintained in a manner that will prevent warping and shrinkage.

Offsets at form joints shall not exceed one-sixteenth of an inch. Form supports for slabs may not be welded to the top flange of I-beams or girders except in accordance with the provisions of Article 420.3.

Deflections due to cast-in-place slab concrete and railing shown in the dead load deflection diagram shall be taken into account in the setting of slab forms.

All forms and footing areas shall be cleaned of any extraneous matter before placing concrete.

Permission to place concrete will not be given until all of such work is complete to the satisfaction of the Engineer.

If, at any stage of the work, the forms show signs of bulging or sagging, the portion of the concrete causing such condition shall be removed immediately, if necessary, and the forms shall be reset and securely braced against further movement.

(2) Timber Forms. Lumber for forms shall be properly seasoned, of good quality, and free from imperfections which would affect its strength or impair the finished surface of the concrete. The lumber used for facing or sheathing shall be finished on at least one side and two edges and shall be sized to uniform thickness.

Form lining will be required for all formed surfaces, except for the inside of culvert barrels, inlets, manholes and box girders; the bottom of bridge decks between beams or girders; surfaces that are subsequently covered by backfill material or are completely enclosed; and, any surface formed by a single finished board. Lining will not be required when plywood forms are used.

Form lining shall be of an approved type such as masonite or plywood. Thin membrane sheeting such as polyethylene sheets shall not be used for form lining.

Forms may be constructed of plywood not less than one-half inch in thickness, with no form lining required. The grain of the face plies on plywood forms shall be placed parallel to the span between the supporting studs or joists.

Plywood used for forming surfaces which remain exposed shall be equal to that specified as B-B Plyform Class I or Class II Exterior of the U.S. Department of Commerce, National Bureau of Standards, U.S. Product Standard, latest edition.

Forms or form lumber to be reused shall be maintained clean and in good condition. Any lumber which is split, warped, bulged, marred or has defects that will produce inferior work shall not be used and, if condemned, shall be promptly removed from the work.

Studs and joists shall be spaced so that the facing form material remains in true alignment under the imposed loads.

Wales shall be spaced close enough to hold forms securely to the designated lines and scabbed at least 4 feet on each side of joints to provide continuity. A row of wales shall be placed near the bottom of each placement.

Facing material shall be placed with parallel and square joints and securely fastened to supporting studs.

Forms for surfaces receiving only an ordinary finish and exposed to view shall be placed with the form panels symmetrical, i.e., long dimensions set in the same direction. Horizontal joints shall be continuous.

Molding specified for chamfer strips or other uses shall be made of materials of a grade that will not split when nailed and which can be maintained to a true line without warping. Wood molding shall be mill cut and dressed on all faces. Unless otherwise provided, forms shall be filleted at all sharp corners and edges with triangular chamfer strips measuring three-fourths inch on the sides.

Forms for railings and ornamental work shall be constructed to standards equivalent to first-class millwork. All moldings, panel work and bevel strips shall be straight and true with neatly mitered joints designed so the finished work is true, sharp and clean cut.

All forms shall be constructed to permit their removal without marring or damaging the concrete. The forms may be given a slight draft to permit ease of removal.

Metal form ties of an approved type or a satisfactory substitute shall be used to hold forms in place and shall be of a type that permits ease of removal of the metal as hereinafter specified.

All metal appliances used inside of forms for alignment purposes shall be removed to a depth of at least one-half inch from the concrete surface. They shall be made so the metal may be removed without undue chipping or spalling, and when removed, shall leave a smooth opening in the concrete surface. Burning off of rods, bolts or ties will not be permitted.

Any wire ties used shall be cut back at least one-half inch from the face of the concrete.

Devices holding metal ties in place shall be capable of developing the strength of the tie and adjustable to allow for proper alignment.

Metal and wooden spreaders which are separate from the forms shall be removed entirely as the concrete is being placed.

Adequate clean-out openings shall be provided for narrow walls and other locations where access to the bottom of the forms is not readily attainable.

Prior to placing concrete, the facing of all forms shall be treated with oil or other bond breaking coating of such composition that it will not discolor or otherwise injuriously affect the concrete surface. Care shall be exercised to prevent coating of the reinforcing steel.

(3) Metal Forms. The foregoing requirements for timber forms as regards design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse and wetting shall also apply to metal forms, except that these will not require lining, unless specifically noted on the plans.

The thickness of form metal shall be as required to maintain the true shape without warping or bulging. All bolt and rivet heads on the facing sides

shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used. Metal shall be kept free from rust, grease or other foreign materials.

(4) Form Supports for Overhang Slabs. Form supports which transmit a horizontal force to a steel girder or beam, or to a prestressed concrete beam will be permitted, but shall not be used unless a structural analysis has been made of the effect on the girder or beam and approval is granted by the Engineer.

When overhang brackets are used on prestressed concrete beams, the following shall apply:

(a) In normal spans, or in spans skewed not more than 15 degrees, overhang brackets may be used to support standard slab overhangs of widths not exceeding 3 feet, 1-1/2 inches without additional support or bracing, when Type A, B, C and Type IV beams are used. When the 15 degree skew angle is exceeded, additional support shall be provided by welding No. 5 reinforcing bars to the stirrups of the exterior beam and adjacent interior beam. Such bars shall be approximately 1-1/2 inches above the bottom of the slab and spaced not more than 5 feet, c-c. All welding shall be done in accordance with the Item, "Structural Welding".

(b) In normal or skewed spans with standard overhangs not exceeding 3 feet, 1-1/2 inches, additional support shall be provided using No. 5 bars as specified above and in addition, braces or struts, equivalent in size to a 4 inch x 4 inch timber, shall be wedged between the bottom flanges of the exterior and adjacent interior beam and spaced not more than 15 feet between struts or struts and permanent diaframs, when THD Size 48 inch through 72 inch beams are used.

(c) Spans in which the overhang width exceeds 3 feet, 1-1/2 inches will require additional support for the outside beams to resist torsion. Details of the Contractor's proposed method of providing additional support shall be included with the slab forming plans submitted to the Engineer for review and approval.

(d) To counteract torsion effects, diafram concrete shall be placed and cured and the diafram bars tightened prior to slab placing.

Holes in steel members for support of overhang brackets may be punched or drilled full size or may be torch cut to one-fourth inch under size and reamed full size. In no case shall the holes be burned full size. The hole shall be left open unless specified on the plans to be filled with a button head bolt. They shall never be filled by welding.

420.10. Placing Reinforcement. Reinforcement in concrete structures shall be placed carefully and accurately and rigidly supported as provided in the Item, "Reinforcing Steel". Reinforcing steel supports shall not be welded to I-beams or girders.

420.11. Placing Concrete-General. The minimum temperature of all concrete at the time of placement shall be not less than 50 F.

The maximum temperature of cast-in-place concrete in bridge superstructures shall not exceed 85 F when placed. Concrete diaframs, parapets, concrete portions of railing, curbs and sidewalks, unless monolithically placed with the slab, shall not be subject to the above maximum. Other portions of structures, when so noted on the plans, shall require the temperature control specified.

For continuous placement of the deck on continuous steel units, the initial set of the concrete shall be retarded sufficiently to insure that it remains plastic in not less than three spans immediately preceding the one being placed. For simple spans, retardation shall be required only if necessary to complete finishing operations or as required by Article 420.13.

The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When conditions are such that additional moisture is needed for finishing, the required water shall be applied to the surface by *fog spray only*, and shall be held to a minimum amount. Fog spray for this purpose may be applied with hand operated fogging equipment.

The maximum time interval between the addition of cement to the batch and the placing of concrete in the forms shall not exceed the following:

Air or Concrete Temperature	Maximum Time
Non-Agitated Concrete	
Up to 80 F	30 minutes
Over 80 F	15 minutes
Agitated Concrete	
90 F or above	45 minutes
75 F to 89 F	60 minutes
35 F to 74 F	90 minutes

The use of an approved retarding agent in the concrete will permit the extension of each of the above temperature-time maximums by 30 minutes, for bridge decks, top slabs of direct traffic culverts and cased drilled shafts, and one hour for all other concrete except that the maximum time shall not exceed 30 minutes for non-agitated concrete.

From the time of initial strike-off until final finish is complete, the unformed surfaces of slab concrete in bridge decks and top slab of direct traffic culverts, shall be kept *damp, not wet,* to offset the effects of rapid evaporation of mixing water from the concrete due to wind, temperature, low humidity or combinations thereof. Fogging equipment capable of applying water in the form of a fine fog mist, *not a spray,* will be required. Fogging will be applied at the times and in the manner directed by the Engineer.

Fogging equipment may be either water, pumped under high pressure, or a combination of air and water, either system in combination with a proper

atomizing nozzle. The equipment shall be sufficiently portable for use in the direction of any prevailing winds. The equipment shall be adapted for intermittent use to prevent excessive wetting of the surfaces.

Upon completion of the final finish, interim curing will be required for slab concrete in bridge decks and top slabs of direct traffic culverts as follows:

(1) Unless otherwise shown on the plans, Type 1 membrane curing compound (*Resin Base Only*) shall be applied to the slab surface.

Required water curing shall begin as soon as it can be done without damaging the concrete finish.

(2) When required by the plans, emulsified linseed oil curing compound shall be applied to the slab as interim curing in accordance with the Special Specification, "Emulsified Linseed Oil Curing Compound".

The Contractor shall give the Engineer sufficient advance notice before placing concrete in any unit of the structure to permit the inspection of forms, reinforcing steel placement, and other preparations. Concrete shall not be placed in any unit prior to the completion of form work and placement of reinforcement therein.

Concrete mixing, placing and finishing shall be done in daylight hours, unless adequate provisions are made to light the entire site of all operations.

Concrete placement will not be permitted when impending weather conditions will impair the quality of the finished work. If rainfall should occur after placing operations are started, the Contractor shall provide ample covering to protect the work. In case of drop in temperature, the provisions set forth in Article 420.12 shall be applied.

The sequence of placing concrete shall be as provided on the plans or as required herein. The placing shall be regulated so the pressures caused by the plastic concrete shall not exceed the loads used in the form design.

The method of handling, placing and consolidation of concrete shall minimize segregation and displacement of the reinforcement, and produce a uniformly dense and compact mass. Concrete shall not have a free fall of more than 5 feet, except in the case of thin walls such as in culverts. Any hardened concrete spatter ahead of the plastic concrete shall be removed.

The method and equipment used to transport concrete to the forms shall be capable of maintaining the rate of placement approved by the Engineer. Concrete may be transported by buckets, chutes, buggies, belt conveyors, pumps or other acceptable methods.

When belt conveyors or pumps are used, sampling for testing will be done at the discharge end. Concrete transported by conveyors shall be protected from sun and wind, if necessary, to prevent loss of slump and workability. Pipes through which concrete is pumped shall be shaded and/or wrapped with wet burlap, if necessary, to prevent loss of slump and workability. Concrete shall not be transported through aluminum pipes, tubes or other aluminum equipment. The coarse aggregate content of the concrete shall be within the limits specified in the Item, "Concrete for Structures".

Chutes, troughs, conveyors or pipes shall be arranged and used so that the concrete ingredients will not be separated. When steep slopes are necessary, the chutes shall be equipped with baffle boards or made in short lengths that reverse the direction of movement, or the chute ends shall terminate in vertical down-spouts. Open troughs and chutes shall extend, if necessary, down inside the forms or through holes left in them. All transporting equipment shall be kept clean and free from hardened concrete coatings. Water used for cleaning shall be discharged clear of the concrete.

Each part of the forms shall be filled by depositing concrete as near its final position as possible. The coarse aggregate shall be worked back from the face and the concrete forced under and around the reinforcement bars without displacing them. Depositing large quantities at one point and running or working it along the forms will not be allowed.

Concrete shall be deposited in the forms in layers of suitable depth but not more than 36 inches in thickness, unless otherwise directed by the Engineer.

The sequence of successive layers or adjacent portions of concrete shall be such that they can be vibrated into a homogeneous mass with the previously placed concrete without a cold joint. Not more than one hour shall elapse between adjacent or successive placements of concrete. Unauthorized construction joints shall be avoided by placing all concrete between the authorized joints in one continuous operation.

An approved retarding agent shall be used to control stress cracks and/or unauthorized cold joints in mass placements where differential settlement and/or setting time may induce stress cracking, such as on false work, in deep girder stems, etc.

Openings in forms shall be provided, if needed, for the removal of laitance or foreign matter of any kind.

All forms shall be wetted thoroughly before the concrete is placed therein.

All concrete shall be well consolidated and the mortar flushed to the form surfaces by continuous working with immersion type vibrators. Vibrators which operate by attachment to forms or reinforcement will not be permitted, except on steel forms. At least one stand-by vibrator shall be provided for emergency use in addition to the ones required for placement. For lightweight concrete, vibrators of the high frequency type, which produce a minimum of 7000 impulses per minute, will be required.

The concrete shall be vibrated immediately after deposit. Prior to the beginning of work, a systematic spacing of the points of vibration shall be established to insure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Immersion type vibrators shall be inserted vertically, at points 18 to 30 inches apart, and slowly withdrawn. The vibrator may be inserted in a sloping or horizontal position in shallow slabs. The entire depth of each lift shall be vibrated, allowing the vibrator to penetrate several inches into the preceding lift. Concrete along construction joints shall be thoroughly

consolidated by operating the vibrator along and close to but not against the joint surface. The vibration shall continue until thorough consolidation, and complete embedment of reinforcement and fixtures is produced, but not long enough to cause segregation. Vibration may be supplemented by hand spading or rodding, if necessary, to insure the flushing of mortar to the surface of all forms.

Holes for anchor bolts in piers, abutments, bents or pedestals may be drilled or formed by the insertion of oiled wooden plugs or metal sleeves in the plastic concrete. Formed holes shall be large enough to permit horizontal adjustments of the bolts. The bolts shall be carefully set in mortar. In lieu of the above, anchor bolts may be set to exact locations when the concrete is placed.

Slab concrete shall be mixed in a plant located off the structure. Carting or wheeling concrete batches over completed slabs will not be permitted until they have aged at least four full curing days. If carts are used, timber planking will be required for the remainder of the curing period. Carts shall be equipped with pneumatic tires. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.

After concrete has taken its initial set, at least one curing day shall elapse before placing strain on projecting reinforcement to prevent damage to the concrete.

The storing of reinforcing or structural steel on completed roadway slabs generally shall be avoided and, when permitted, shall be limited to quantities and distribution that will not induce excessive stresses.

420.12. Placing Concrete in Cold Weather.

(1) Cast-in-Place Concrete. Concrete may be placed when the atmospheric temperature is not less than 35 F. Concrete shall not be placed in contact with any material coated with frost or having a temperature less than 32 F.

Aggregates shall be free from ice, frost and frozen lumps. When required, in order to produce the minimum specified concrete temperature, the aggregate and/or the water shall be heated uniformly, in accordance with the following:

The water temperature shall not exceed 180 F, and/or the aggregate temperature shall not exceed 150 F. The heating apparatus shall heat the mass of aggregate uniformity. The temperature of the mixture of aggregates and water shall be between 50 F and 85 F before introduction of the cement.

All concrete shall be effectively protected as follows:

(a) The temperature of slab concrete of all unformed surfaces shall be maintained at 50 F or above for a period of 72 hours from time of placement and above 40 F for an additional 72 hours.

(b) The temperature at the surface of all concrete in bents, piers, culvert walls, retaining walls, parapets, wingwalls, bottom of slabs, and other similar formed concrete shall be maintained at 40 F or above for a period of 72 hours from time of placement.

(c) The temperature of all concrete, including the bottom slabs of culverts placed on or in the ground, shall be maintained above 32 F for a period of 72 hours from time of placement.

Protection shall consist of providing additional covering, insulated forms or other means, and if necessary, supplementing such covering with artificial heating. Curing as specified under Article 420.21 shall be provided during this period until all requirements for curing have been satisfied.

When impending weather conditions indicate the possibility of the need for such temperature protection, all necessary heating and covering material shall be on hand ready for use before permission is granted to begin placement.

Sufficient extra test specimen will be made and cured with the placement to ascertain the condition of the concrete as placed prior to form removal and acceptance.

(2) **Precast Concrete.** A fabricating plant for precast products which has adequate protection from cold weather in the form of permanent or portable framework and covering, which protects the concrete when placed in the forms, and is equipped with approved steam curing facilities, may place concrete under any low temperature conditions provided:

(a) The framework and covering are placed and heat is provided for the concrete and the forms within one hour after the concrete is placed. This shall not be construed to be one hour after the last concrete is placed, but that no concrete shall remain unprotected longer than one hour.

(b) Steam heat shall keep the air surrounding the concrete between 50 F and 85 F for a minimum of three hours prior to beginning the temperature rise which is required for steam curing.

(c) For fabricating plants without the above facilities and for job site precast products, the requirements of Sub-article 420.12(1) will apply.

The Contractor is responsible for the protection of concrete placed under any and all weather conditions. Permission given by the Engineer for placing during freezing weather will in no way relieve the Contractor of the responsibility for producing concrete equal in quality to that placed under normal conditions. Should concrete placed under such conditions prove unsatisfactory, it shall be removed and replaced.

420.13. Placing Concrete in Hot Weather. When the temperature of the air is above 85 F, an approved retarding agent will be required in all concrete used in superstructures, top slabs of direct traffic culverts, and will be required in all cased drilled shafts regardless of temperature.

420.14. Placing Concrete in Water. Concrete shall be deposited in water only when specified on the plans or with written permission of the Engineer. The forms, cofferdams or caissons shall be sufficiently tight to prevent any water current passing through the space in which the concrete is being deposited. Pumping will not be permitted during the concrete placing, nor until it has set for at least 36 hours.

The concrete shall be placed with a tremie, closed bottom-dump bucket, or other approved method, and shall not be permitted to fall freely through the water nor shall it be disturbed after it has been placed. Its surface shall be kept approximately level during placement.

The tremie shall consist of a water-tight tube 14 inches or less in diameter. It shall be constructed so that the bottom can be sealed and opened after it is in place and fully charged with concrete. It shall be supported so that it can be easily moved horizontally to cover all the work area and vertically to control the concrete flow.

Bottom-dump buckets used for underwater placing shall have a capacity of not less than one-half cubic yard. It shall be lowered gradually and carefully until it rests upon the concrete already placed and raised very slowly during the upward travel, the intent being to maintain still water at the point of discharge and to avoid agitating the mixture.

The placing operations shall be continuous until the work is complete.

Unless otherwise specified by the plans, all concrete placed under water shall be Class "E".

420.15. Placing Concrete in Superstructure. Unless otherwise specified on the plans, simple span roadway slabs shall be placed without transverse construction joints by using a longitudinal screed, or a self propelled transverse finishing machine. The screed shall be adequately supported on a header or rail system sufficiently stable to withstand the longitudinal or lateral thrust of the equipment. Unless otherwise shown on the plans, temporary intermediate headers will be permitted for placements exceeding 50 feet in length for the longitudinal screed, provided the rate of placement is rapid enough to prevent a cold joint and these headers are designed for early removal to permit satisfactory consolidation and finish of the concrete at their locations.

Unless otherwise specified on the plans, slabs on continuous units shall be placed in one continuous operation without transverse construction joints using a longitudinal screed, or a self propelled transverse finishing machine. Rails for transverse finishing machines supported from the beams or girders shall be installed so they may be removed without damage to the slab. Bond between removable supports and the concrete shall be prevented in a manner acceptable to the Engineer. Rail support parts which remain embedded in the slab shall not project above the upper mat of reinforcing steel. Rail or screed supports attached to I-beams or girders shall be subject to the requirements of Article 420.3.

One or more passes shall be made with the screed over the bridge deck segment prior to the placement of concrete thereon to insure proper operation and maintenance of grades and clearances.

Slab concrete shall be deposited between the exterior beam and the adjacent beam prior to placing concrete in the overhang portion of the slab.

For transverse slab finishing, concrete shall be placed in transverse strips, proceeding from the lowest end of the placement.

For longitudinal screeding, concrete shall be placed in longitudinal strips starting at a point in the center of the segment adjacent to one side, except as provided herein, and the strip completed by placing uniformly in both directions toward the ends except that for spans on a grade of 1.5 percent or more, placing shall start at the lowest end. The width of strips shall be such that the concrete therein will remain plastic until the adjacent strip is placed. Where monolithic curb construction is specified, the concrete shall be placed therein in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs.

Forms for the bottom surface of concrete slabs, girders and overhangs shall be maintained true to the required vertical alignment during concrete placing. An approved system of checking shall be used to detect any vertical movement of the forms or falsework. Unless otherwise provided on the plans, girders, slab and curbs of deck girder spans shall be placed monolithically.

Filling girder stems first will be permitted provided the slab concrete is placed within the time limits specified in Article 420.11. Construction joints when permitted for slab placements on steel and prestressed concrete beams shall be as shown on the plans. Where plans permit segmental placing, without specifying a particular order of placement, any logical placing sequence which will not result in the overstressing of any of the supporting members will be permitted subject to the approval of the Engineer.

Any falsework under steel girder or truss spans shall be released and the spans swung free on their permanent supports before placing any slab concrete thereon.

When the curb forms are filled, the top of curb and sidewalk section shall be brought to the correct camber and alignment and finished as described in Articles 420.19 and 420.24.

The slab shall be finished as specified in Article 420.20. When the slab is to receive an additional wearing surface or level-up (widening), it shall be given a reasonably smooth float or screed finish.

420.16. Placing Concrete in Concrete Arches. Concrete shall be placed in arch rings so the loading is kept symmetrical on the falsework. The arch rings and ribs shall be placed in one continuous operation unless otherwise specified or permitted by the Engineer. The spandrel walls or columns and the beams shall not be placed until the arch is swung. Floor slab, railing, parapet walls, etc., shall not be placed until all spandrels are complete. Slab placement shall be symmetrical about the transverse centerline so the loading of the arch is kept approximately symmetrical.

The placing sequence shall be as shown on the plans.

420.17. Placing Concrete in Box Culverts. In general, construction joints will be permitted only where shown on the plans.

Where the top slab and walls are placed monolithically in culverts more than 4 feet in clear height, an interval of not less than one nor more than 2 hours shall elapse before placing the top slab to allow for shrinkage in the wall concrete.

The base slab shall be finished accurately at the proper time to provide a smooth uniform surface. Top slabs which carry direct traffic shall be finished as specified for roadway slabs in Article 420.20. Top slabs of fill type culverts shall be given a reasonably smooth float finish.

420.18. Placing Concrete in Foundations and Substructure. Concrete shall not be placed in footings until the depth and character of the foundation has been inspected by the Engineer and permission has been given to proceed.

Placing of concrete footings upon seal courses will be permitted after the caissons or cofferdams are free from water and the seal course cleaned. Any necessary pumping or bailing during the concreting operation shall be done from a suitable sump located outside the forms.

All temporary wales or braces inside cofferdams or caissons shall be constructed or adjusted as the work proceeds to prevent unauthorized construction joints in footings or shafts.

When footings can be placed in a dry excavation without the use of cofferdams or caissons, forms may be omitted, if desired by the Contractor and approved by the Engineer, and the entire excavation filled with concrete to the elevation of the top of footing in which case measurement for payment will be based on the footing dimensions shown on the plans.

Concrete in columns shall be placed monolithically unless otherwise provided. Columns and caps and/or tie beams supported thereon may be placed in the same operation. To allow for shrinkage of the column concrete, it shall be placed to the lower level of the cap or tie beam and placement delayed for not less than one hour nor more than two before proceeding.

420.19. Treatment and Finishing of Horizontal Surfaces Except Roadway Slabs. All unformed upper surfaces shall be struck off to grade and finished. The use of mortar topping for surfaces under this classification will not be permitted.

After the concrete has been struck off, the surface shall be floated with a suitable float. Bridge sidewalks shall be given a wood float or broom finish or may be striped with a brush, as specified by the Engineer. Top of caps and piers shall be given a smooth finish with a steel trowel, except that where elastomeric pads are used under beams the bearing area shall be given a wood float finish. Other surfaces shall be wood float finished and striped with a fine brush leaving a fine grained texture.

420.20. Finish of Roadway Slabs. As soon as the concrete has been placed and vibrated in a section of sufficient width to permit working, the surface shall be approximately leveled, struck off and screeded, carrying a slight excess of concrete ahead of the screed to insure filling of all low spots. The screed shall be designed rigid enough to hold true to shape and shall have sufficient adjustments to provide for the required camber. A vibrating screed may be used if heavy enough to prevent undue distortion. The screeds shall be provided with a metal edge.

Longitudinal screeds shall be moved across the concrete with a saw-like motion while their ends rest on headers or templates set true to the roadway grade or on the adjacent finished slab.

The surface of the concrete shall be screeded a sufficient number of times, and at such intervals to produce a uniform surface, true to grade and free of voids.

If necessary, the screeded surface shall be worked to a smooth finish with a long handled wood or metal float of the proper size, or hand floated from bridges over the slab.

When required by the Engineer, the Contractor shall perform sufficient checks with a long handled 10 foot straightedge on the plastic concrete to insure that the final surface will be within the tolerances specified below. The check shall be made with the straightedge parallel to the centerline. Each pass thereof shall lap half of the preceding pass. All high spots shall be removed and all depressions over one-sixteenth inch in depth shall be filled with fresh concrete and floated. The checking and floating shall be continued until the surface is true to grade and free of depressions, high spots, voids or rough spots.

Rail support holes shall be filled with concrete and finished to match the top of the slab.

A broom finish shall be applied with longitudinal screeding. A broom or burlap drag finish shall be applied with transverse screeding.

Unless otherwise specified, the burlap drag shall consist of four or more layers of 10-ounce burlap fabric, free of seams, dirt or hardened concrete; it shall be kept wet when in use and it shall be drawn over the surface in as many passes as required to produce the desired texture depth. Broom finishes shall be applied with stiff bristled brooms. The Contractor shall have on hand at all times brooms for the purpose of providing the desired texture depth when surface conditions are such that the burlap drag will not provide it.

Upon completion of the floating and/or straight edging and before the disappearance of the moisture sheen, the surface shall be given a broom or burlap drag finish. The grooves of these finishes shall be parallel to the structure centerline. It is the intent that the average texture depth resulting from the number of tests directed by the Engineer be not less than 0.035-inches with a minimum texture depth of 0.030-inches for any one test when tested in accordance with Test Method Tex-436-A. Should the texture depth fall below that intended, the finishing procedures shall be revised to produce the desired texture.

Work bridges or other suitable facilities shall be provided from which to perform all finishing operations and check measurements for slab thickness and reinforcement cover.

After the concrete has attained its final set, the roadway surface shall be tested with a standard 10 foot straightedge. The straightedge shall be placed parallel to the centerline of roadway to bridge any depressions and touch high spots. Ordinates of irregularities measured from the face of the straightedge to the surface of the slab shall not exceed one-eighth of an inch, making

proper allowances for camber, vertical curvature and surface texture. Occasional variations, not exceeding three-sixteenth of an inch will be acceptable, if in the opinion of the Engineer it will not affect the riding qualities.

When directed by the Engineer, irregularities exceeding the above requirements shall be corrected.

In all roadway slab finishing operations, camber for specified vertical curvature and transverse slopes shall be provided.

For concrete slab or concrete girder spans cast in place on falsework, an additional amount of camber shall be provided to offset the initial and final deflections of the span. The additional amount of camber shall be determined from the dead load deflection diagram shown on the plans. When dead load deflection is not shown on the plans, the additional amount of camber shall be one-eighth inch per ten foot of span length but not to exceed one-half inch. For pan girder spans the additional camber for initial and final deflections shall be approximately one-half inch for 30 foot spans and three-fourths inch for 40 foot spans.

Roadway slabs supported on prestressed concrete, steel beams or girders shall receive no additional amount of camber, except that for slabs without vertical curvature, the longitudinal camber shall be approximately one-fourth inch.

Dead load deflection shall be taken into account in setting the grades of headers and rail systems.

420.21. Curing Concrete. The Contractor shall inform the Engineer fully of the methods and procedures proposed for curing; shall provide the proper equipment and material in adequate amounts, and shall have the proposed method, equipment and material approved prior to placing concrete.

Inadequate curing and/or facilities therefor shall be cause for the Engineer to stop all construction on the job until remedial action is taken.

All concrete shall be cured for a period of 4 curing days except as noted herein.

EXCEPTIONS TO 4-DAY CURING

Description	Required Curing
Upper Surfaces of Bridge Slabs and Top Slabs of Direct Traffic Culverts.	8 curing days (Type I or III cement). 10 curing days (Type II cement).
Concrete Piling (non-prestressed).	6 curing days.

When the air temperature is expected to drop below 35 F, the water curing mats shall be covered with polyethylene sheeting, burlap-polyethylene blankets or other material to provide the protection required by Article 420.12.

A curing day is defined as a calendar day when the temperature, taken in the shade away from artificial heat, is above 50 F for at least 19 hours, (or

colder days if satisfactory provisions are made to maintain the temperature at all surfaces of the concrete above 40 F for the entire 24 hours). The required curing period shall begin when all concrete therein has attained its initial set.

The following methods are permitted for curing concrete subject to the restrictions of Table 1 and the following requirements for each method of curing.

(1) Form Curing. When forms are left in contact with the concrete, other curing methods will not be required except for cold weather protection.

(2) Water Curing. All exposed surfaces of the concrete shall be kept wet continuously for the required curing time. The water used for curing shall meet the requirements for concrete mixing water as specified in the Item, "Concrete for Structures". Sea water will not be permitted. Water which stains or leaves an unsightly residue shall not be used.

(a) Wet Mat. Cotton mats shall be used for this curing method. They shall be placed as soon as possible after the surface has sufficiently hardened to prevent damage to the concrete. (See Article 420.11 & Special Specification.) Damp burlap blankets made from nine ounce stock may be placed on the damp concrete suface for temporary protection prior to the application of the cotton mats which may be placed dry and wetted down after placement.

The mats shall be weighted down adequately to provide continuous contact with all concrete surfaces where possible. The surfaces of the concrete shall be kept wet for the required curing time. Surfaces which cannot be cured by contact shall be enclosed with mats, anchored positively to the forms, or to the ground, so that outside air cannot enter the enclosure. Sufficient moisture shall be provided inside the enclosure to keep all surfaces of the concrete wet.

(b) Water Spray. This method shall consist of overlapping sprays or sprinklers, that keeps all unformed surfaces continuously wet.

(c) Ponding. This method requires the covering of the surfaces with a minimum of two inches of clean granular material, kept wet at all times, or a minimum of one-inch depth of water. Satisfactory provisions shall be made to provide a dam to retain the water or saturated sand.

(3) Membrane Curing. Unless otherwise provided herein or shown on the plans, either Type 1 or Type 2 membrane curing compound may be used where permitted except that Type 1 *(Resin Base Only)* will be permitted for slab concrete in bridge decks and top slabs of direct traffic culverts.

For substructure concrete, only one Type of curing compound will be permitted on any one structure. Material requirements and construction methods shall be as required by the Item, "Membrane Curing", except as changed herein. Membrane shall be applied in a single, uniform coating at the rate of coverage recommended by the manufacturer and as approved by the Engineer, but not less than one gallon per 180 square feet of area. Tests for acceptance shall be at this specified rate.

STRUCTURE UNIT DESCRIPTION	REQUIRED		PERMITTED	
	Water for Complete Curing	Membrane for Interim Curing	Water for Complete Curing	Membrane for Complete Curing
1. Upper surfaces of Bridge Roadway, Median and Sidewalk Slabs, Top Slabs of Direct Traffic Culverts.	X	See Article 420.11 and Special Specification		
2. Top Surface of any Concrete Unit upon which Concrete is to be placed and bonded at a later interval (Stub Walls, Risers, etc.). Other Superstructure Concrete (Curbs, Wingwalls, Parapet Walls, etc.).	X			
3. Top Surface of Precast and/or Prestressed Piling.	X	X		
4. All Substructure Concrete, Culverts, Box Sewers, Inlets, Manholes, Retaining Walls, Riprap.			*X	*X

*Polyethylene Sheeting, Burlap Polyethylene Mats or Laminated Mats to prevent outside air from entering will be considered equivalent to water or membrane curing for Items under 4.

TABLE 1

Membrane curing shall not be applied to dry surfaces, but shall be applied just after free moisture has disappeared. Formed surfaces and surfaces which have been given a first rub shall be dampened and *shall be moist* at the time of application of the membrane.

When membrane is used for complete curing, the film shall remain unbroken for the minimum curing period specified. Membrane which is damaged shall be corrected immediately by reapplication of membrane. Unless otherwise noted herein or on the plans, the choice of membrane type shall be at the option of the Contractor, except that the Engineer may require the same curing method for like portions of a single structure.

420.22. Removal of Forms and Falsework. Except as herein provided, forms for vertical surfaces may be removed when the concrete has aged not less than one day when Type I or Type II cement is used, and not less than one-half day when Type III cement is used, provided it can be done without damage to the concrete.

Forms for inside curb faces may be removed in approximately three hours provided it can be done without damage to the curb.

Weight supporting forms and falsework for all bridge components and culvert slabs, shall remain in place a minimum of 4 curing days after which they may be removed if the concrete has attained a flexural strength of 500 psi, as evidenced by strength tests using specimen made from the same concrete and cured under the same conditions as the portion of the structure involved. Forms for other structural components may be removed as specified by the Engineer.

If all beams made for the purpose of form removal have been broken without attaining the required strength, forms shall remain in place for a total of 14 curing days.

The above provisions relative to form removal shall apply only to forms or parts thereof which are constructed to permit removal without disturbing forms or falsework required to be left in place for a longer period on other portions of the structure.

420.23. Defective Work. Any defective work discovered after the forms have been removed shall be repaired as soon as possible in accordance with Article 420.24.

If the surface of the concrete is bulged, uneven or shows excess honeycombing or form marks, which in the opinion of the Engineer, cannot be repaired satisfactorily, the entire section shall be removed and replaced at the expense of the Contractor.

420.24. Finishing Exposed Surfaces.

(1) Ordinary Surface Finish. An Ordinary Surface Finish shall be applied to all concrete surfaces either as a final finish or preparatory to a higher grade or class of finish. Higher grades and classes of finish shall be in accordance with the Special Specification, "Surface Finishes for Concrete". Where neither a grade or class of finish is specified, an Ordinary Surface Finish, only, will be required.

Ordinary Surface Finish shall be provided as follows:

After form removal, all porous or honeycombed areas and spalled areas shall be corrected by chipping away all loose or broken material to sound concrete.

Feather edges shall be eliminated by cutting a face perpendicular to the surface. Shallow cavities shall be repaired using adhesive grout or epoxy grout. If judged repairable by the Engineer, large defective areas shall be corrected using concrete or other material approved by the Engineer.

Holes and spalls caused by removal of metal ties, etc., as required by Article 420.9 shall be cleaned and filled with adhesive grout or epoxy grout. Exposed parts of metal chairs on surfaces to be finished by rubbing, shall be chipped out to a depth of one-half inch and the surface repaired.

All fins, runs, drips or mortar shall be removed from surfaces which remain exposed. Form marks and chamfer edges shall be smoothed by grinding and/or dry rubbing.

Grease, oil, dirt, curing compound, etc., shall be removed from surfaces

requiring a higher *grade* of finish. Discolorations resulting from spillage or splashing of asphalt, paint or other similar material shall be removed.

Repairs shall be dense, well bonded and properly cured, and when made on surfaces which remain exposed and do not require a higher finish, shall be finished to blend with the surrounding concrete.

Unless otherwise specified on the plans Ordinary Surface Finish shall be the final finish for the following exposed surfaces: inlets, manholes, sewer appurtenances, inside of culvert barrels, bottom of bridge decks between beams or girders, vertical and bottom surfaces of interior concrete beams or girders, except that form marks and chamfer edges will not require smoothing on the inside of culvert barrels and the bottom of bridge decks between beams or girders.

(2) **Special Surface Finishes.** Striated, exposed aggregate and other special surface finishes shall be in accordance with the Special Specification, "Surface Finishes for Concrete" and/or with the requirements shown on the plans.

420.25. Measurement and Payment. No direct measurement or payment will be made for the work to be done or the equipment to be furnished under this item, but it shall be considered subsidiary to the particular items required by the plans and the contract.

ITEM 421
CONCRETE FOR STRUCTURES

421.1. Description. This item shall govern for the materials used; for the storing and handling of materials; and for the proportioning and mixing of concrete for bridges, culverts, prestressed concrete, and incidental concrete construction.

The concrete shall be composed of Portland cement, aggregates (fine and coarse), admixtures if desired or required, and water, proportioned and mixed as hereinafter provided.

421.2. Materials.

(1) Cement. The cement shall be either Type I, II or III Portland Cement conforming to ASTM Designation: C 150, modified as follows:

Unless otherwise specified by the Engineer, the specific surface area of Type I and II cements shall not exceed 2000 square centimeters per gram (Wagner Turbidometer – Test Method Tex-310-D). For concrete piling, the above limit on specific surface area is waived for Type II cement only. The Contractor shall furnish the Engineer, with each shipment, a statement as to the specific surface area of the cement expressed in square centimeters per gram.

For cement strength requirements, either the tensile or compressive test may be used.

Either Type I or II cement shall be used unless Type II is specified on the plans. Except when Type II is specified on the plans, Type III cement may be used when the anticipated air temperature for the succeeding 12 hours will not exceed 60 F. Type III cement may be used in all precast prestressed concrete except in piling when Type II cement is required for substructure concrete.

Different types of cement may be used in the same structure, but all cement used in any one monolithic placement shall be of the same type and brand. Only one brand of each type will be permitted in any one structure unless otherwise authorized by the Engineer.

Cement may be delivered in bulk where adequate bin storage is provided. All other cement shall be delivered in bags marked plainly with the name of the manufacturer and the type of cement. Similar information shall be provided in the bills of lading accompanying each shipment of packaged or bulk cement. Bags shall contain 94 pounds net. All bags shall be in good condition at time of delivery.

All cement shall be properly protected against dampness. No caked cement will be accepted.

Cement remaining in storage for a prolonged period of time may be retested and rejected if it fails to conform to any of the requirements of these specifications.

(2) Mixing Water. Water for use in concrete and for curing shall be free from oils, acids, organic matter or other deleterious substances and shall not contain more than 1000 parts per million of chlorides as Cl nor more than 1000 parts per million of sulfates as SO_4.

Water from municipal supplies approved by the State Health Department will not require testing, but water from other sources will be sampled and tested before use in structural concrete. A sample of approximately one gallon will be submitted to Materials and Tests Division, Camp Hubbard, Austin, for test and approval.

Tests shall be made in accordance with the "Standard Method of Test for Quality of Water to be used in Concrete" (AASHO Method T 26), except where such methods are in conflict with provisions of this specification.

(3) Coarse Aggregate. Coarse aggregate shall consist of durable particles of gravel, crushed blast furnace slag, crushed stone, or combinations thereof; free from frozen material or injurious amounts of salt, alkali, vegetable matter, or other objectionable material either free or as an adherent coating; and its quality shall be reasonably uniform throughout. It shall not contain more than 0.25 percent by weight of clay lumps, nor more than 1.0 percent by weight of shale, nor more than 5 percent by weight of laminated and/or friable particles when tested in accordance with Test Method Tex-413-A. It shall have a wear of not more than 40 percent when tested in accordance with Test Method Tex-410-A.

Unless otherwise specified on the plans, coarse aggregate will be subjected to five cycles of the soundness test in accordance with Test Method Tex-411-A. The loss shall not be greater than 12 percent when sodium sulfate is used, or 18 percent when magnesium sulfate is used.

Permissible sizes of aggregate shall be governed by Table 4, except that when exposed aggregate surfaces are required, coarse aggregate gradation will be as specified on the plans.

When tested by approved methods, the coarse aggregate, including combinations of aggregates when used, shall conform to the grading requirements shown in Table 1.

		Percent Retained on each Sieve							
Aggregate Grade No.	**Nominal Size**	**3 in.**	**2-1/2 in.**	**2 in.**	**1-1/2 in.**	**3/4 in.**	**1/2 in.**	**3/8 in.**	**No. 4**
1	2-1/2 in.	0	0 to 5	0 to 20	15 to 50	60 to 80			95 to 100
2	1-1/2 in.			0	0 to 5	30 to 60		70 to 90	95 to 100
3	1 in.				0 to 5	10 to 40	40 to 75		95 to 100
4	3/8 in.						0	5 to 30	75 to 100

Table 1
Coarse Aggregate Gradation Chart

The aggregate shall be washed. The Loss by Decantation (Test Method Tex-406-A) plus the allowable weight of clay lumps, shall not exceed one percent, or the value shown on the plans, whichever is smaller.

(4) Fine Aggregate. Fine aggregate shall consist of clean, hard, durable and uncoated particles of natural or manufactured sand or a combination thereof, with or without a mineral filler. It shall be free from frozen material or injurious amounts of salt, alkali, vegetable matter or other objectionable material and it shall not contain more than 0.5 percent by weight of clay lumps. When subjected to the color test for organic impurities (Test Method Tex-408-A), it shall not show a color darker than standard.

The fine aggregate shall produce a mortar having a tensile strength equal to or greater than that of Ottawa sand mortar when tested in accordance with Test Method Tex-317-D.

Where manufactured sand is used in lieu of natural sand for *slab* concrete subject to direct traffic, the acid insoluble residue of the fine aggregate shall be not less than 28 percent by weight when tested in accordance with Test Method Tex-612-J.

When tested by approved methods, the fine aggregate or combinations of aggregates including mineral filler shall conform to the grading requirements shown in Table 2.

Aggregate Grade No.	Percent Retained on Each Sieve							
	3/8 in.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
1	0	0 to 5	0 to 20	15 to 50	35 to 75	70 to 90	90 to 100	97 to 100

NOTE 1: Where manufactured sand is used in lieu of natural sand, the percent retained on the No. 200 sieve shall be 94 to 100.

NOTE 2: Where the sand equivalent value is greater than 85, the retainage on the No. 50 sieve may be 70 to 94 percent.

Table 2

Fine Aggregate Gradation Chart

Fine aggregate will be subjected to the Sand Equivalent Test (Test Method Tex-203-F). The sand equivalent shall not be less than 80 nor less than the value shown on the plans, whichever is greater.

For Class A, C, E and F Concrete, the fineness modulus as defined below for fine aggregates shall be between 2.30 and 3.10.

For Class H Concrete, the fineness modulus of the fine aggregates shall be between 2.40 and 2.90.

The fineness modulus will be determined by adding the percentages by weight retained on the following sieves, and dividing by 100; Nos. 4, 8, 16, 30, 50 and 100.

(5) Mineral Filler. Mineral filler shall consist of stone dust, clean crushed sand, or other approved inert material.

(6) Mortar (Grout). Mortar for repair of concrete, shall consist of 1 part cement, 2 parts finely graded sand, and enough water to make the mixture plastic. When required to prevent color difference, white cement shall be added to produce the color required. When required by the Engineer, latex adhesive shall be added to the mortar.

(7) Admixtures. Calcium Chloride will not be permitted. Unless otherwise noted, Air-entraining, retarding and water-reducing admixtures may be used in all concrete and shall conform to the requirements of the Item, "Concrete Admixtures".

421.3 Storage of Cement. All cement shall be stored in well ventilated weatherproof buildings or approved bins, which will protect it from dampness or absorption of moisture. Storage facilities shall be ample, and each shipment of packaged cement shall be kept separated to provide easy access for identification and inspection.

The Engineer may permit small quantities of sacked cement to be stored in the open for a maximum of 48 hours on a raised platform and under waterproof covering.

421.4. Storage of Aggregate. The method of handling and storing concrete aggregate shall prevent contamination with foreign materials. If the aggregates are stored on the ground, the sites for the stock piles shall be clear of all vegetation and level. The bottom layer of aggregate shall not be disturbed or used without recleaning.

When conditions require the use of two or more sizes of aggregates, they shall be separated to prevent intermixing. Where space is limited, stock piles shall be separated by physical barriers.

Methods of handling aggregates during stockpiling and subsequent use shall be such that segregation will be minimized.

Unless otherwise authorized by the Engineer, all aggregate shall be stockpiled at least 24 hours to reduce the free moisture content.

421.5. Measurement of Materials. The measurement of the materials, except water, used in batches of concrete shall be by weight. The fine aggregate, coarse aggregate and mineral filler shall be weighed separately. Where bulk cement is used it shall be weighed separately but batch weighing of sacked cement will not be required. Where sacked cement is used, the quantities of material per batch shall be based upon using full bags of cement. Batches involving the use of fractional bags will not be permitted.

Allowances shall be made for the water content in the aggregates.

Bags of cement varying more than 3 percent from the specified weight of 94 pounds may be rejected; and when the average weight per bag in any shipments, as determined by weighing 50 bags taken at random, is less than the net weight specified, the entire shipment may be rejected. If the shipment is accepted, the Engineer will adjust the concrete mix to a net weight per bag fixed by an average of all individual weights which are less than the average weight determined from the total number weighed.

421.6. Weighing and Measuring Equipment. Weighing and measuring equipment shall conform to the Item, "Weighing and Measuring Equipment".

421.7. Classification and Mix Design. It shall be the responsibility of the Contractor to furnish the mix design, using a Coarse Aggregate Factor acceptable to the Engineer, for the class(es) of concrete specified. The mix shall be designed by a qualified concrete technician to conform with the requirements contained herein and in accordance with THD Bulletin C-11. The Contractor shall perform, at his own expense, the work required to substantiate the design, except the testing of strength specimens, which will be done by the Engineer. Complete concrete design data shall be submitted to the Engineer for approval.

It shall also be the responsibility of the Contractor to determine and measure the batch quantity of each ingredient, including all water, so that the mix conforms to these specifications and any other requirements shown on the plans.

In lieu of the above mix design responsibility, the Contractor may accept a design furnished by the Engineer, however, this will not relieve him of

providing concrete meeting the requirements of these specifications.

Trial batches will be made and tested using all the proposed ingredients prior to the placing of concrete, and when the aggregate and/or brand of cement or admixture is changed. Trial batches shall be made in the mixer to be used on the job. When Transit Mix concrete is to be used, the trial designs will be made in a transit mixer representative of the mixers to be used. Batch size shall not be less than 50 percent of the rated mixing capacity of the truck.

Mix designs from previous or concurrent jobs may be used without trial batches if it is shown that no substantial change in any of the proposed ingredients has been made.

The coarse aggregate factor shall not be more than 0.82 except that when the voids in the coarse aggregate exceed 48 percent of the total dry loose volume, the coarse aggregate factor shall not exceed 0.85. The coarse aggregate factor shall not be less than 0.70 for Grades 1, 2 and 3 aggregate.

If the strength required for the class of concrete being produced is not secured with the cement specified in Table 4, the Contractor may use an approved water reducing or retarding admixture, or he shall furnish aggregates with different characteristics, which will produce the required results. Additional cement may be required or permitted as a temporary measure until the redesign is checked.

Water reducing or retarding agents *may* be used with all classes of concrete at the option of the Contractor, and will be required for hot weather concreting and for continuous *slab* placement.

When a retarding admixture is required for hot weather concreting, as specified in Article 420.13, the amount to be used will be as required in the Item, "Concrete Admixtures". When used in continuous *slab* placement, the amount to be used will be established by *several* trial batches with *varying retarder content* and simulating the placing conditions to be encountered. When water reducing or retarding agents are used at the option of the Contractor, reduced dosage of the admixture will be permitted.

Entrained air will be required in accordance with Table 4. The concrete shall be designed to entrain 5 percent air when Grade 2 coarse aggregate is used and 6 percent when Grade 3 coarse aggregate is used. Concrete as placed in the structure shall contain the proper amount as required above with a tolerance of plus or minus 1-1/2 percentage points. Occasional variations beyond this tolerance will not be cause for rejection. When the quantity of entrained air is found to be above 7 percent with Grade 2 coarse aggregate or 8 percent for Grade 3 coarse aggregate, additional test beams or cylinders will be made. If these beams or cylinders pass the minimum flexural or compressive requirements, the concrete will not be rejected because of the variation in air content.

421.8. Consistency. In cases where the consistency requirements cannot be satisfied without exceeding the maximum allowable amount of water, the Contractor may use, or the Engineer may require an approved water reducing or retarding agent or the Contractor shall furnish additional aggregates, or

aggregates with different characteristics, which will produce the required results. Additional cement may be required or permitted as a temporary measure until aggregates are changed and designs checked with the different aggregates or admixture.

The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When field conditions are such that additional moisture is needed for the final concrete surface finishing operation, the required water shall be applied to the surface by fog spray only, and shall be held to a minimum. The concrete shall be workable, cohesive, possess satisfactory finishing qualities, and of the stiffest consistency that can be placed and vibrated into a homogeneous mass. Excessive bleeding shall be avoided. Slump requirements will be as specified in Table 3.

Concrete Designation	Desired Slump	Max. Slump
Structural Concrete		
(1) Cased Drilled Shafts	5	6
(2) Uncased Drilled Shafts, Thin-Walled Sections (9" or less), and Prestressed Concrete Members	4	5
(3) Slabs, Caps, Columns, Piers, Wall Sections Over 9", etc.	3	4
Underwater or Seal Concrete	5	6
Riprap, Curb, Gutter and Other Miscellaneous Concrete	as specified by Engineer	

Note: No concrete will be permitted with slump in excess of the maximums shown.

Table 3
Slump Requirements

421.9. Quality of Concrete, General. The concrete shall be uniform and workable. The cement content, maximum allowable water cement ratio, the desired and maximum slump and the strength requirements of the various classes of concrete shall conform to the requirements of Table 3 and 4 and as required herein.

During the progress of the work the Engineer will cast test cylinders or beams as a check on the compressive or flexural strength of the concrete actually placed.

A test shall be defined as the average of the breaking strength of two cylinders or two beams as the case may be. Specimen will be tested in accordance with Test Methods Tex-418-A or Tex-420-A.

Test beams or cylinders will be required as specified in The Schedule of Minimum Requirements. For small placements on structures such as manholes, inlets, culverts, wingwalls, etc., the Engineer may vary the number of tests to a minimum of one for each 25 cubic yards placed over a several day period.

All test specimens, beams or cylinders, representing tests for removal of forms and/or falsework shall be cured using the same methods, and under the same conditions as the concrete represented.

"Design Strength" beams and cylinders shall be cured in accordance with THD Bulletin C-11.

The Contractor shall provide and maintain curing facilities as described in Bulletin C-11 for the purpose of curing test specimens. Provision shall be made to maintain the water in the curing tank at temperatures between 70 F and 90 F.

When control of concrete quality is by twenty-eight day compressive tests, job control will be by seven day compressive tests which are shown to provide the required twenty-eight day strength, based on results from trial batches. If the required seven day strength is not secured with the cement specified in Table 4, changes in the batch design will be made as specified in Article 421.7.

Class of Conc.	Sx. Cement per C.Y.	Min. Comp. Strength (f'_c) 28 Day psi	Min. Beam Strength 7 Day psi	Max. Water Cement Ratio	Coarse Aggr. No.
A*	5.0	3000	#500	6.5	2-3-4X
B	4.0	2000	330	8.0	2-3-4X
C*	6.0	3600	#600	6.0	**1-2-3
D	3.0	1500	250	11.0	2-3-4X
E	6.0	3000	500	7.0	2-3
F*	6.0 to 8.0	As Specified on Plans	$\frac{f'_c}{6}$	5.5	2-3
H***	6.0 to 8.0	As Specified on Plans	N.A.	5.5	3

*Entrained Air (slabs, pier and bent concrete).

**Grade 1 coarse Aggregate may be used in foundation only (except cased drilled shafts).

***Entrained Air for slab concrete.

When Type II Cement is used with Class C Concrete, the 7 day beam break requirement will be 550 psi; with Class A, 460 psi. min.

X Permission to use grade 4 aggregate must have prior approval of the Engineer.

Table 4—Classes of Concrete.

421.10. Mixing Conditions. The concrete shall be mixed in quantities required for immediate use. Any concrete which is not in place within the limits outlined in Article 420.11, shall not be used. Retempering of concrete will not be permitted.

In threatening weather, which may result in conditions that will adversely affect quality of the concrete to be placed, the Engineer may order postponement of the work. Where work has been started and changes in weather conditions require protective measures, the Contractor shall furnish adequate shelter to protect the concrete against damage from rainfall, or from freezing temperatures as outlined in Article 420.12. If necessary to continue operations during rainfall, the Contractor shall also provide protective coverings for the material stock piles. Aggregate stock piles need be covered only to the extent necessary to control the moisture conditions in the aggregates to adequately control the consistency of the concrete.

421.11. Mixing and Mixing Equipment. All equipment, tools, and machinery used for hauling materials and performing any part of the work shall be maintained in such condition to insure completion of the work under way without excessive delays for repairs or replacements.

The mixing shall be done in a batch mixer of approved type and size that will produce uniform distribution of the material throughout the mass. Mixers may be either the revolving drum type or the revolving blade type, and shall be capable of producing concrete meeting the requirements of these specifications.

The mixing equipment shall be capable of producing sufficient concrete to provide the quantities required to comply with Article 420.11.

After all the ingredients are assembled in the drum, the mixing shall continue not less than 1 minute for mixers of one cubic yard or less capacity plus 15 seconds for each additional cubic yard or portion thereof.

The mixer shall operate at the speed and capacity designated by the Mixer Manufacturers Bureau of the Associated General Contractors of America. The mixer shall have a plate affixed showing the manufacturer's recommended operating data.

The absolute volume of the concrete batch shall not exceed the rated capacity of the mixer.

The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch.

The first batch of concrete materials placed in the mixer for each placement shall contain an extra quantity of sand, cement, and water sufficient to coat the inside surface of the drum.

Upon the cessation of mixing for any considerable length of time, the mixer shall be thoroughly cleaned.

The concrete mixer shall be equipped with an automatic timing device which is put into operation when the skip is raised to its full height and dumping. This device shall lock the discharging mechanism and prevent emptying of the mixer until all the materials have been mixed together for the minimum time required, and it shall ring a bell after the specified time of mixing has elapsed.

The water tank shall be arranged so that the amount of water can be measured accurately, and when the tank starts to discharge, the inlet supply shall cut off automatically.

Whenever a concrete mixer is not adequate or suitable for the work, it shall be removed from the site upon a written order from the Engineer and a suitable mixer provided by the Contractor.

Pick-up and thro-over blades in the drum of the mixer which are worn down more than 10 percent in depth shall be repaired or replaced by new blades.

Improperly mixed concrete shall not be placed in the structure.

Job mix concrete shall be concrete mixed in an approved batch mixer, in accordance with the requirements stated above, adjacent to the structure for which the concrete is being mixed, and moved to the placement site in non-agitating equipment.

The use of ready-mixed concrete will be permitted provided the batching plant and mixer trucks meet the requirements of the Item, "Ready-Mix Plants".

When Ready-Mix Concrete is used, additional mortar (one sack cement, three parts sand and sufficient water) shall be added to the batch to coat the drum of the mixer or agitator truck. This shall be required for every load of Class C, F and H concrete only.

Delivery of concrete to the site of the work and its discharge from the truck mixer, agitator, or non-agitating equipment shall be in accordance with the requirements of Article 420.11.

Hand mixing of concrete will be permitted only for small placements or in case of an emergency and then only on the authorization of the Engineer. Hand-mixed batches shall not exceed a two bag batch in volume.

421.12. Placing, Curing and Finishing. The placing of concrete, including construction of forms and falsework, curing and finishing, shall be in accordance with the Item, "Concrete Structures", and the Special Specification, "Surface Finishes for Concrete".

421.13. Measurement. The quantities of concrete of the various classifications which will constitute the completed and accepted structure or structures in place will be measured by the cubic yard, each, square foot, square yard, or linear foot as the case may be. Measurement will be as follows:

(1) General.

(a) All concrete quantities will be based on the dimensions shown on the plans or those established in writing by the Engineer. Diafram concrete, when required, will be included in the slab measurement.

(b) In determining quantities, no deductions will be made for chamfers less than two inches, embedded portions of structural steel or prestressed concrete beams, piling, anchor bolts, reinforcing steel, drains, weep holes, junction boxes, electrical conduit, conduit and/or voids for prestressed tendons or for embedded portions of light fixtures.

(c) For Pan Girder Spans, a quantity will be included for the screed setting required to provide proper camber in the roadway surface after form removal.

(d) For Slabs on Steel and Prestressed Beams, a quantity for the haunch between the slab and beams will be included when required. No measurement will be made during construction for variation in the amount of haunch concrete due to deviation from design camber in the beams.

(e) For Slabs on Panels or Tee-Beams, the combination of span length, theoretical camber in beams, computed deflections, and plan vertical curve will be taken into account in determining the quantity for the slab.

Additional concrete which may be required by an adjustment of the profile grade line during construction, to insure proper slab thickness, will be measured for payment. The additional quantity will be based on the difference between the plan profile grade line and the adjusted profile grade line, using the overall width of the bridge, when cantilever panels are used in the overhang, and the out to out width between the exterior beams, when the overhang is cast in place. No other quantity will be included.

(f) Quantities revised by a change in design, measured as specified herein, will be increased or decreased, as the case may be, and included for payment.

(2) Plan Quantity. For those items measured for plan quantity payment, adequate calculations have been made in accordance with Article 9.1. If no adjustment is required by Article 421.14, additional measurements or calculations will not be required.

(3) Measured in Place. For those items not measured for plan quantity payment, measurement will be made in place.

421.14. Payment. For structure elements designated in Table 5, and when measured by the cubic yard, the quantity to be paid for will be that quantity shown on the contract plans and in the proposal, regardless of errors in calculation, except as may be modified by the following:

Plan quantities will be adjusted:

(1) When a complete structure element has been erroneously included or omitted from the plans, the quantity shown on the plans for that element will be added to or deducted from the plan quantity and included for payment. A complete structure element will be the smallest portion of a total structure for which a quantity is included on the plans. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(2) When the plan quantity for a complete structure element is in error by 5 percent or more, a recalculation will be made and the corrected quantity included for payment. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(3) When quantities are revised by a change in design the 'plan quantity' will be increased or decreased by the amount involved in the design

change. Quantities revised in this manner will be subject to the provisions of Article 4.3.

The party to the contract requesting the adjustment shall present to the other, three copies of the description and location, together with calculations of the quantity for the structure element involved. When this quantity is certified correct by the Engineer, it will become the revised plan quantity.

Culverts and Wingwalls	Abutments
Headwalls for Pipe	Slab and Girder Spans
Retaining Walls	Slabs on Steel Spans
Inlets and Manholes	Slabs on Prestressed Spans
Slab Spans	Pan Girder Spans

Table 5
Plan Quantity Payment
(Cubic Yard Measurement Only)

Note: Other structure elements may be paid for as 'plan quantity', including pier and bent concrete, when so noted on the plans.

For those portions of structures not listed in Table 5, the concrete quantities, measured as provided in Subarticle 421.13.(1) will be paid for at the unit price bid per "Cubic Yard", per "Each", per Square Foot", per "Square Yard", or per "Linear Foot", in place, for the various classifications of concrete shown.

Payment for increased or decreased costs due to a change in design, on those items measured as "Each", by the "Square Foot", "Square Yard" or "Linear Foot" will be determined by "Supplemental Agreement". Quantities revised in this manner will be subject to the provisions of Article 4.3.

Payment of any additional concrete required for slab on panel or tee-beam construction due to adjustment of the profile grade line, measured as outlined in Subarticle 421.13.(1).(e) will be made at 20 percent of the bid price for the class of slab concrete involved. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

The unit prices bid for the various classifications of concrete shown shall be full compensation for furnishing, hauling, and mixing all concrete material; placing, curing and finishing all concrete; all grouting and pointing; furnishing and placing drains; furnishing and placing metal flashing strips; furnishing and placing expansion joint material required by this item, and for all forms and falsework, labor, tools, equipment, and incidentals necessary to complete the work.

ITEM 423

LIGHTWEIGHT CONCRETE FOR STRUCTURES

423.1. Description. This item shall govern for the materials and equipment used; for the storing, measuring, and handling of materials; for the mixing, placing, finishing, and curing of lightweight concrete for bridges and other structures.

The concrete shall be composed of Portland cement, natural sand fine aggregate, lightweight coarse aggregate, a retarding or water reducing admixture, an air entraining admixture and water, proportioned and mixed as provided herein.

423.2. Materials.

(1) Cement. Either Type I or II cement shall be used unless Type II is specified on the plans. Type III cement may be used when the anticipated air temperature for the succeeding 12 hours will not exceed 60 F except when Type II is specified. Type III cement may be used in all precast prestressed concrete. Cement and water shall conform to the pertinent requirements of the Item, "Concrete for Structures".

(2) Sand. The natural fine aggregate shall conform to the requirements for Grade 1 aggregate as required in the Item, "Concrete for Structures." The fine aggregate shall have a fineness modulus within the range of 2.40 to 2.90.

(3) Lightweight Coarse Aggregate. Lightweight coarse aggregate shall have strong durable particles, conforming to the requirements contained herein. When tested by approved laboratory methods, lightweight coarse aggregate shall conform to the following:

(a) Gradation—The coarse aggregate shall conform to the grading requirements shown in Table 1.

PERCENT RETAINED ON SIEVE				
3/4"	1/2"	3/8"	#4	#8
0-10	–	45-80	90-100	95-100

Table 1—Coarse Aggregate Gradation

(b) Wear—The wear shall be not more than 35 percent when tested in accordance with Test Method Tex-410-A.

(c) Freeze-Thaw Test—The freeze-thaw loss shall not exceed 7 percent when tested in accordance with Test Method Tex-432-A.

(d) Potential Reactivity—Aggregate shall be innocuous when prepared and tested in accordance with ASTM Designation: C 289.

(e) Drying Shrinkage—The drying shrinkage of concrete specimens, prepared and tested in accordance with Test Method Tex-422-A shall not exceed 0.07 percent.

Tests (b), (c), (d) and (e) are source qualification tests.

Tests (a), (f), (g) and (h) are field control tests. A minimum of one test per 60 cubic yards of lightweight aggregate will be required.

(f) Unit Weight—The maximum dry loose unit weight shall not exceed 55 pounds per cu. ft. If the unit weight of any shipment of lightweight aggregate differs by more than 4 percent from that of the sample submitted for acceptance, the shipment may be rejected. Tests shall be in accordance with Test Method Tex-404-A, except that the aggregate shall be tested in an oven-dry condition.

(g) Absorption Test—The 100 minute saturation of the aggregate shall not exceed 15 percent, and shall not vary from that of the sample submitted for acceptance by more than 33 percent, when prepared and tested in accordance with Test Method Tex-433-A.

(h) Pressure Slaking Test—The pressure slaking value of the aggregate shall not exceed 6 percent when prepared and tested in accordance with Test Method Tex-431-A.

(4) Concrete Admixtures. A retarding admixture or a water reducing agent, and an air entraining admixture will be required in all lightweight concrete, and shall conform to the Item, "Concrete Admixtures".

423.3. General. Mixing water, storage of cement, measurement of materials, weighing and measuring equipment, condition of equipment, mixing conditions and mixing equipment shall conform to the pertinent provisions of the Item, "Concrete for Structures"; the Item, "Ready-Mix Plants"; and the Item, "Weighing and Measuring Equipment".

423.4. Storage of Aggregate. Storage of aggregate shall be in accordance with the requirements of Article 421.4 and as noted below.

An approved sprinkler system, or other method approved by the Engineer, shall be provided to maintain a uniform moisture content in the coarse aggregate stockpile.

423.5. Classification and Mix Design. It shall be the responsibility of the Contractor to furnish the mix design, using a Coarse Aggregate Factor acceptable to the Engineer, for the class(es) of concrete specified. The mix shall be designed by a qualified concrete technician to conform with the requirements contained herein and in accordance with THD Bulletin C-11. The Contractor shall perform, at his own expense, the work required to substantiate the design, except the testing of strength specimens, which will be done by the Engineer. Complete concrete design data shall be submitted to the Engineer for approval.

It shall also be the responsibility of the Contractor to determine and measure the batch quantity of each ingredient, including all water, so that the mix conforms to these specifications and any other requirements shown on the plans.

In lieu of the above mix design responsibility, the Contractor may accept a design furnished by the Engineer, however, this will not relieve him of providing concrete meeting the requirements of these specifications.

The concrete shall be designed to entrain 6 percent air. Concrete as placed in the structure shall contain this prescribed amount with a tolerance of plus or minus 1-1/2 percentage points. Occasional variations beyond this tolerance are to be expected and will not be cause for rejection. When the quantity of entrained air is found to exceed 8 percent, test cylinders will be made for testing to establish the quality of concrete prior to acceptance.

Trial batches will be made and tested using all the proposed ingredients prior to the placing of concrete, and when the aggregate and/or brand of cement or admixture is changed. Trial batches shall be made in the mixer to be used on the job.

When Transit Mix concrete is to be used, the trial designs will be made in a transit mixer representative of those to be used. Batch size shall not be less than 50% of the rated mixing capacity of the truck.

Mix designs from previous or concurrent jobs may be used without trial batches if it is shown that no substantial change in any of the proposed ingredients has been made.

Variations from the mix design shall not be made except as authorized by the Engineer.

Class	Min-Max Bags Cement per cu yd	Min. Comp. Strength 28 Day psi	Air-Dried Weight Max. *lbs.
X	6.0-7.0	3600	112
Y	6.5-7.5	4200	115
Z	6.5-8.0	As Specified on plans	118

Table 2
Classes of Lightweight Concrete

*Air-dried weight shall be determined in accordance with Test Method Tex-417-A, Part II.

If the strength required for the class of concrete produced is not secured with the minimum cement content specified, additional cement shall be used or other aggregates provided at the Contractor's expense.

423.6. Consistency. Concrete consistency shall insure a workability producing a compact mass with dense, uniform surfaces.

In general, the consistency of lightweight concrete should be similar to that of natural aggregate concrete. Concrete which is harsh and unworkable will be redesigned. The Contractor shall provide other or additional materials required to produce a batch of a satisfactory consistency.

The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When field conditions are such that additional moisture is needed for the final surface finishing operation, the required water shall be applied to the surface by fog spray only, and shall be held to a minimum amount. The concrete shall be workable, cohesive, possess satisfactory finishing qualities, and be of the stiffest consistency that can be placed and vibrated into a homogeneous mass. Excessive bleeding shall be avoided. Slump requirements will be as specified in Table 3.

Concrete Designation	Desired Slump	Max. Slump
Structural Concrete		
1 Thin-Walled Sections (9" or less). Prestressed Concrete Members	4	5
2 Slabs, Caps, Columns, Piers, Wall Sections Over 9", etc.	3	4
Riprap, Curb, Gutter and Other Miscellaneous Concrete	as specified by Engineer	

NOTE: No concrete will be permitted with slump in excess of the maximums shown.

Table 3—Slump Requirements

423.7. Quality of Concrete. During the progress of the work, the Engineer will cast and test cylinders to maintain a check on the compressive strength of the concrete being placed.

A test shall be defined as the average of the breaking strength of two cylinders.

Two tests (four test cylinders) will be required for each 60 cubic yards, or portion thereof, placed in each days' placement. For small placements, tests may be for each 25 cubic yards placed over a period of several days. For mass placements, test cylinders will be made for each 300 cubic yards, or portion thereof placed each day. Additional tests will be made if required. One set of cylinders will be tested at 7 days to provide job control. The 7 day strength requirements will be based on results obtained from trial batches. The second set of cylinders will be tested at 28 days and will represent design strength.

Testing and curing of cylinders shall be in accordance with the Item, "Concrete for Structures". Air content will be checked in accordance with Test Method Tex-416-A, Part B.

Tests for wet weight will be made in accordance with Test Method Tex-417-A.

The relationship between the air-dried weight and the wet weight of the concrete will be established by the Engineer, based on trial batches and checks made during progress of the work.

For each change in batch design and for each 50 cubic yards of concrete placed in the structure, two tests for wet weight will be made. For mass placements, two tests for wet weight will be made for each 150 cubic yards placed. Additional tests will be made when required for control of the batch. When the average of these tests indicate that the wet weight of the concrete being placed is either above or below the theoretical batch weight, the batch will be adjusted by the Engineer.

423.8. Mixing. The following shall govern the mixing of lightweight concrete.

The lightweight coarse aggregate, and at least two-thirds of the total mixing water shall be introduced in the mixer and mixed for 60 seconds.

The cement, sand and remaining water and admixtures shall be added and mixing completed. The minimum mixing time will be determined by the Engineer for the concrete batch and the equipment used but in no case shall the total mixing time be less than 3 minutes. Minimum mixing for concrete mixed in trucks shall be 100 revolutions of the drum.

The drum on truck mixers shall be rotating while charging. Immediately prior to discharge of the concrete, the drum shall be rotated at maximum mixing speed for at least 30 seconds.

423.9. Placing, Curing, and Finishing. The placing of concrete, including construction and removal of forms and falsework, temperature control, curing, and finishing shall be in accordance with the Item, "Concrete Structures" and the Special Specification, "Surface Finishes for Concrete".

423.10. Measurement. The quantities of concrete of the various classifications which will constitute the completed and accepted structure or structures in place will be measured by the cubic yard, each, square foot, square yard, or linear foot as the case may be. Measurement will be as follows:

(1) General.

(a) All concrete quantities will be based on the dimensions shown on the plans or those established in writing by the Engineer. Diafram concrete, when required, will be included in the slab measurement.

(b) In determining quantities, no deductions will be made for chamfers less than two inches, embedded portions of structural steel or prestressed

concrete beams, piling, anchor bolts, reinforcing steel, drains, weep holes, junction boxes, electrical conduit, conduit and/or voids for prestressed tendons or for embedded portions of light fixtures.

(c) For Pan Girder Spans, a quantity will be included for the screed setting required to provide proper camber in the roadway surface after form removal.

(d) For Slabs on Steel and Prestressed Beams, a quantity for the haunch between the slab and beams will be included when required. No measurement will be made during construction for variation in the amount of haunch concrete due to deviation from design camber in the beams.

(e) For Slabs on Panels or Tee-Beams, the combination of span length, theoretical camber in beams, computed deflections, and plan vertical curve will be taken into account in determining the quantity for the slab.

Additional concrete which may be required by an adjustment of the profile grade line during construction, to insure proper slab thickness, will be measured for payment. The additional quantity will be based on the difference between the plan profile grade line and the adjusted profile grade line, using the overall width of the bridge, when cantilever panels are used in the overhang, and the out to out width between the exterior beams, when the overhang is cast in place. No other quantity will be included.

(f) Quantities revised by a change in design, measured as specified herein, will be increased or decreased, as the case may be, and included for payment.

(2) Plan Quantity. For those items measured for plan quantity payment, adequate calculations have been made in accordance with Article 9.1. If no adjustment is required by Article 423.11, additional measurements or calculations will not be required.

(3) Measured in Place. For those items not measured for plan quantity payment, measurement will be made in place.

423.11. Payment. For structure elements designated in Table 4, and when measured by the cubic yard, the quantity to be paid for will be that quantity shown on the contract plans and in the proposal, regardless of errors in calculation, except as may be modified by the following:

Plan quantities will be adjusted:

(1) When a complete structure element has been erroneously included or omitted from the plans, the quantity shown on the plans for that element will be added to or deducted from the plan quantity and included for payment. A complete structure element will be the smallest portion of a total structure for which a quantity is included on the plans. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(2) When the plan quantity for a complete structure element is in error by 5 percent or more, a recalculation will be made and the corrected quantity included for payment. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(3) When quantities are revised by a change in design the 'plan quantity' will be increased or decreased by the amount involved in the design change. Quantities revised in this manner will be subject to the provisions of Article 4.3.

The party to the contract requesting the adjustment shall present to the other, three copies of the description and location, together with calculations of the quantity for the structure element involved. When this quantity is certified correct by the Engineer, it will become the revised plan quantity.

Culverts and Wingwalls	Abutments
Headwalls for Pipe	Slab and Girder Spans
Retaining Walls	Slabs on Steel Spans
Inlets and Manholes	Slabs on Prestressed Spans
Slab Spans	Pan Girder Spans

Table 4
Plan Quantity Payment
(Cubic Yard Measurement Only)

Note: Other structure elements may be paid for as 'plan quantity', including pier and bent concrete, when so noted on the plans.

For those portions of structures not listed in Table 4, the concrete quantities, measured as provided in Subarticle 423.10.(1), will be paid for at the unit price bid per "Cubic Yard", per "Each", per "Square Foot", per "Square Yard", or per "Linear Foot", in place, for the various classifications of concrete shown.

Payment for increased or decreased costs due to a change in design, on those items measured as "Each", by the "Square Foot", "Square Yard", or "Linear Foot", will be determined by "Supplemental Agreement". Quantities revised in this manner will be subject to the provisions of Article 4.3.

Payment of any additional concrete required for slab on panel or tee-beam construction due to adjustment of the profile grade line, measured as outlined in Subarticle 423.10.(1).(e). will be made at 20 percent of the bid price for the class of slab concrete involved. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

The unit prices bid for the various classifications of concrete shown shall be full compensation for furnishing, hauling, and mixing all concrete material; placing, curing and finishing all concrete; all grouting and pointing; furnishing and placing drains; furnishing and placing metal flashing strips; furnishing and placing expansion joint material required by this item; and for all forms and falsework, labor, tools, equipment, and incidentals necessary to complete the work.

ITEM 425
PRESTRESSED CONCRETE STRUCTURES

425.1. Description. This item shall govern for the construction and erection of precast prestressed concrete members, in accordance with the plans, with approved shop and/or working drawings and with these specifications.

425.2. General. Prior to the beginning of casting, the Contractor shall give the Engineer ample notice as to the location of the casting site and the date on which the work will begin.

An Inspection Laboratory shall be furnished in accordance with the Item, "Plant Inspection Laboratory (Equipped)".

The Contractor shall submit to the Engineer, a proposed sequence of erection by structure and span or unit number, with the approximate date that the members are to be erected. Shop plans shall be submitted following this proposed sequence.

When alternate designs are permitted by the contract plans, the designs proposed shall be submitted in the format and on forms furnished by the Department. Approval of these designs must be given prior to preparation of Shop Drawings. Once alternate designs are submitted and approved, subsequent changes will not be permitted. Submission shall be made to the Bridge Engineer, Texas Highway Department, 11th and Brazos St., Austin, Texas 78701.

The Shop Plans required by this Item shall follow the standard format adopted by the Texas Highway Department, copies available upon request to the Bridge Engineer.

Shop Plans for precast prestressed members shall be submitted for approval in accordance with these specifications and shall consist of the following:

Erection Plan – 7 Copies
Index Sheet – 6 Copies
Bearing Sheet – 6 Copies
Fabrication Sheet – 6 Copies

When a Railroad Underpass Structure(s) is a part of the contract, one additional set of Shop Plans will be required for the Railroad Structure(s) only.

When fabrication is to be at more than one casting plant, two additional sets of Shop Plans will be required for *each* additional casting location. Index sheets shall reflect the plant locations where each member is to be fabricated.

After completion of fabrication a corrected set of final 'as-built' drawings shall be submitted for inclusion in the final contract plans.

Submission of the above Shop Plans shall be to the Bridge Engineer.

A Casting Schedule shall be prepared on standard forms and submitted to the Materials and Tests Engineer, or his duly authorized representative, prior to stressing.

Prior to the casting of members, detailed drawings reflecting the complete facilities to be used in fabrication shall be required. For central plant fabrication, three copies shall be submitted to the Materials and Tests Engineer, Camp Hubbard, Austin, Texas 78703. For job site fabrication, three copies shall be submitted to the Bridge Engineer.

The design of casting beds and facilities for pretensioned construction, including Plans and Specifications shall be done by a Professional Engineer registered in the State of Texas, and shall bear his seal. The Contractor (Fabricator) shall furnish a certificate bearing his signature, or that of a responsible Officer of the Company, that the bed, facilities and hardware have been constructed in accordance with the above plans and specifications.

The Contractor (Fabricator) shall specify the maximum loading for which the bed is to be used. Prior to approval for that loading, the facilities shall be proofloaded to a minimum ten percent overload for eight hours. Additional proof loads shall be performed every 12 months at a ten percent overload for four hours, if deemed necessary by the Engineer. Minor changes in facilities will not require proofloading but will require submission of the details of changes accompanied with design calculations.

Shop plans and/or working drawings for precast post-tensioned members will be in accordance with Article 426.5.

Erection plans and final shop plans will be required in accordance with this Item.

425.3. Materials. Materials required for use under this Item shall conform to the following:

Concrete	Item 421 and/or 423
Prestressing	Item 426
Reinforcing Steel (Non-prestressed)	Item 440
Structural Steel	Items 441, 442
Elastomeric Materials	Item 435

425.4. Construction Methods. Prestressing shall be in accordance with the Item, "Prestressing".

Reinforcing steel shall be fabricated and placed in accordance with the plans and as required herein.

The construction of forms and the placing, curing and finishing of concrete shall be in accordance with the provisions contained herein and requirements of the plans.

(1) Forms. All side and bottom forms for precast prestressed concrete construction shall be constructed of steel, unless otherwise noted on the plans. End headers and inside forms may be of other material as approved on the shop drawings.

Forms shall be of sufficient thickness, with adequate external bracing and stiffeners, and shall be sufficiently anchored to withstand the forces due to placement and vibration of concrete. Internal bracing and holding devices in forms will not be permitted if such would remain in the finished prestressed member. Joints shall be maintained reasonably mortar tight.

The grade and alignment of forms shall be checked each time they are set and shall be maintained during the casting of concrete.

Metal forms shall be reasonably free from rust, grease or other foreign materials. All forms shall be cleaned thoroughly prior to each casting operation.

Wood forms, when permitted, shall conform to the requirements of Article 420.9.

The soffit for casting members shall be constructed and maintained to provide not more than one-fourth inch variation in any 50 foot length of the bed from the theoretical plane of the bottom of the member.

Forms for internal voids in members shall be anchored securely to prevent movement or misalignment during the placing of concrete. For forming internal voids with a mandrel, special attention shall be given to maintaining the correct position and alignment of the mandrel throughout the casting operation.

The facing of all forms shall be treated with form oil or other bond breaking coating prior to placing of concrete. The oil or other materials used for this prupose shall be of a consistency and composition to facilitiate form removal. Materials which appreciably stain or react with the concrete will not be permitted.

All forms shall be constructed to facilitate removal without damage to the concrete. At the Contractor's option, forms for piling may be constructed with a one-eighth inch draft to permit ease of removal.

(2) Placing Concrete. All concrete shall be placed during daylight hours unless the fabrication plant or site is provided with an approved lighting system.

The method of concrete placement shall avoid segregation of the aggregate or displacement of the reinforcing steel, prestressing steel or conduit. Concrete shall be deposited as near as possible in its final position in the forms. Depositing large quantities of concrete at one location in the forms and running or working it along the forms will not be permitted.

Special attention shall be directed toward working the coarse aggregate back from the face of the concrete and to forcing the concrete under and around the reinforcing steel, prestressing steel or conduit.

Placement of concrete in large members shall be subject to approval of the Engineer. Concrete may be placed in beams and girders in one lift or in multiple continuous horizontal layers. In the latter case the thickness of the first layer shall be slightly above the juncture of the bottom flange and web. Not more than one hour shall elapse between the placing of the successive layers. Vibration of subsequent layers of concrete shall extend into the previously placed layers as specified in Subarticle 425.4.(3).

When casting concrete piling or concrete slab units, the concrete shall be placed in one continuous horizontal layer.

Concrete shall not be placed at outdoor casting beds during inclement weather or when weather conditions may result in rainfall or low temperature during the casting operation which might impair the quality of the finished member. In case rainfall should occur after placing operations are underway, the Contractor shall provide adequate covering to protect exposed concrete. The completion of a member being cast will be permitted, provided adequate provisions are made to prevent damage to the concrete.

(a) Placing Concrete in Cold Weather. When members are produced in a fabricating plant which has adequate provisions to protect the concrete when placed and which has approved elevated temperature curing facilities, concrete may be placed under any low temperature conditions provided:

The temperature of the concrete is not less than 50 F nor more than 85 F when placed in the forms.

The framework and covering are in place and heat is provided for the concrete and forms within one hour after the concrete is placed. This shall not be construed to be one hour after the last concrete is placed but that no concrete shall remain unprotected and unheated for longer than one hour.

The air surrounding the concrete shall be kept between 50 F and 85 F for a minimum of three hours prior to beginning the temperature rise which is required for elevated temperature curing. The temperature of the concrete shall not be less than 50 F at any time after all materials are added and mixing commences.

For central fabricating plants or job site casting operations which do not provide facilities necessary to accomplish the above provisions, concrete may be placed when the atmospheric temperature is 35 F or greater. The temperature of the concrete at the time of placement shall not be less than 50 F nor more than 85 F. The concrete shall not be placed in contact with any material having a temperature less than 32 F or any material coated with frost.

Aggregates shall be free from ice, frost and frozen lumps. When required, in order to produce the minimum temperature specified above, the aggregate and/or the water shall be heated uniformly in accordance with the following:

Water shall be heated to a temperature not to exceed 180 F and/or the aggregate shall be heated to a temperature not to exceed 150 F. The equipment furnished shall be capable of heating the aggregate uniformly to eliminate overheated areas in the stockpile which might cause flash set of the cement. The temperature of the mixture of the aggregates and water shall be between 50 F and 85 F before introduction of the cement.

Protection shall be provided to maintain the temperature of the concrete at all surfaces above 50 F for the required total curing time as specified in Subarticle 425.4.(5). Protection shall consist of providing additional covering and, if necessary, supplementing such covering with artificial heating. When weather conditions indicate the possibility of the need for such temperature protection, all necessary heating equipment and covering material shall be on hand ready for use before permission is granted by the Engineer to begin placement of concrete.

(b) Placing Concrete in Hot Weather. When concrete is to be placed during hot weather, it shall be placed without the addition of more water to the concrete than required by the design (slump and consistency), and it shall be finished properly without adding water to the surface. Control of the initial set of the concrete and lengthening the time for finishing operations, under adverse wind, humidity and hot weather conditions, may be accomplished with the use of an approved retarder in accordance with Article 421.7.

The *maximum* time interval between the addition of mixing water and/or cement to the batch, and the placing of concrete in the forms shall not exceed the following:

Air or Concrete Temperature (Whichever is Higher)	Maximum Time (Addition of Water or Cement to Placing in Forms)
Non-Agitated Concrete	
Over 80 F	15 Minutes
50 F to 79 F	30 Minutes
Agitated Concrete	
90 F or Above	45 Minutes
75 F to 89 F	60 Minutes
50 F to 74 F	90 Minutes

The use of an approved retarder in the concrete will permit the extension of each of the above temperature time maximum by 30 minutes, except that for non-agitated concrete, the maximum time shall not exceed 30 minutes.

Under conditions of extreme temperature, wind or humidity, when the specified temperature-time maximums are excessive, the Engineer may require the use of an approved retarder, or may suspend concrete placing operations, if quality concrete is not being placed.

The values which govern for minimum concrete strengths during different phases of construction shall be as shown on approved shop drawings.

For Class H, Y and Z Concrete, the control of the concrete shall be by compressive tests of cylinders. An adequate number of cylinders will be made for each pertinent strength test required. Tests for determining "Release Strength" and/or "Handling Strength" of members, will be the average of the breaking strength of two cylinders.

All test specimens, beams or cylinders representing tests for removal of forms and/or falsework and for "Release Strength" shall be cured under the same conditions, be subjected to the same curing materials and to the same weather conditions as the concrete represented.

"Design Strength" cylinders for acceptance of members shall be cured with the member which the cylinders represent until release of stress or until partial tensioning strength is obtained. These cylinders shall then be cured for the remainder of the test period in accordance with Test Method Tex-704-I.

(3) Vibration of Concrete. All concrete shall be compacted and the mortar flushed to the surface of the forms by continuous working with approved high frequency mechanical vibrators, operating at a minimum of 7,000 impulses per minute. Use of external vibrators *in conjunction with* internal vibrators will be permitted when the forms are of steel.

At least one stand-by vibrator shall be provided for emergency use to avoid delays.

The vibrators shall be inserted systematically into the concrete immediately after deposit, thoroughly consolidating and working the concrete around the reinforcement, and into the corners and angles of the forms until it has been reduced to a plastic mass. When the concrete is placed in more than one layer, the vibrator shall be operated so that it will penetrate the previously placed layer of concrete. The vibration shall be of sufficient duration to accomplish thorough compaction and complete embedment of the reinforcing steel and prestressed tendons, but not so excessive as to result in segregation. Vibration shall be supplemented by hand spading, if necessary, to insure the flushing of mortar to the surface of all forms.

(4) Finishing of Concrete. Top surfaces of prestressed members against which cast-in-place concrete will be placed later shall be screeded or rough floated to bring grout to the surface and cover all aggregate. At the approximate time of initial set, the surface shall be roughened by brushing, brooming or other approved methods. Sound concrete shall not be removed or aggregate loosened. Fresh concrete shall be removed from exposed reinforcing steel.

The top surfaces of beams upon which panels are to be placed shall be finished smooth from the reinforcing bar out to the outside edges. The center portion of these beams shall be roughened.

Top surfaces of members which will be the riding surface in the finished structure, shall be finished in accordance with Article 420.20. Roadway surfaces which are to be given an additional wearing course, shall be screeded and given a wood float finish.

Erection holes (lifting eyes, form anchors, etc.) in exterior beams shall be filled with mortar and made flush with the surrounding surface. Holes in interior beams need not be filled unless steel is exposed. Erection or fabrication holes in the bottom of all beams shall be filled with non-stain, non-shrink mortar and made flush with the surrounding surface.

Form marks in excess of that permitted in Article 425.7., and all fins and rough edges along chamfer lines shall be removed in an acceptable manner.

Unless otherwise shown on the plans, strands shall be removed flush with the end of the member, or recessed approximately three-eights of an inch. In either case, the ends of the strands and a minimum of one inch around each strand shall be cleaned and coated with approximately 10 mils of an acceptable commercial grade epoxy or epoxy grout.

After slab placement, the outside and bottom surfaces of exterior beams or members shall be given the grade of surface finish specified for the structure. Other members shall be given the grade or class of finish required by the plans.

(5) Curing of Concrete. Careful attention shall be given to the proper curing of concrete. The Contractor shall inform the Engineer regarding the methods and procedures proposed for curing; shall provide the proper equipment and necessary materials; and shall have approval of the Engineer of such methods, equipment and materials prior to placing concrete.

Inadequate curing facilities or lack of attention to the proper curing of concrete shall be cause for the Engineer to stop all construction until approved curing is provided. Inadequate curing may be cause for rejection of the member.

Side forms may be removed at the discretion of the Contractor at any time after the concrete has reached sufficient strength to prevent physical damage to the member. Weight supporting forms shall remain in place until the concrete has reached the "Handling Strength" shown on the plans. Removal of the forms shall be done in such a manner that curing is not interrupted on any member by more than 30 minutes.

Curing shall be commenced prior to the formation of surface shrinkage cracks but in no case delayed longer than one hour after the concrete has been placed in the forms.

An approved water or membrane cure (when permitted) shall be used as an interim measure prior to elevated temperature or other methods of curing.

Concrete shall be cured continuously, except as provided for form removal, until the concrete strength as indicated by compressive test of cylinders cured with the members, has reached the "Release Strength" or "Handling Strength" designated on the plans or shop drawings. Riding surfaces of members shall be cured an additional four curing days. Concrete piling shall be steam or water cured for an additional three curing days. Other members shall be covered to prevent rapid drying for a period of 72 hours after release of stress or after reaching handling strength. All members shall be protected from freezing during the above period.

A period not to exceed four hours will be permitted for removal to a storage area prior to resuming the balance of curing and protection required.

A curing day is defined as a calendar day when the temperature, taken in the shade away from artificial heat, is above 50 F for at least 19 hours, or for colder days, if satisfactory provisions are made to maintain the temperature at all surfaces of the concrete above 50 F for the entire 24 hours.

All concrete shall be steam or water cured, except that membrane curing may be used as interim curing on the top surface of concrete piling. Only Type 1 membrane curing compound will be permitted for interim curing.

(a) **Water Curing.** All exposed surfaces of the concrete shall be kept wet continuously for the required curing time. The water used for curing shall meet the requirements for concrete mixing water as specified in the Item, "Concrete for Structures". Sea water will not be permitted. Water which stains or leaves an unsightly residue shall not be used.

Water curing will be permitted as follows:

1. **Wet Mat Method.** For water curing by the wet mat method, cotton mats, polyethylene sheeting, or polyethylene burlap blankets may be used.

The mats, sheets, or blankets shall not be placed in contact with the prestressed concrete member until such time that damage will not occur to the surfaces.

The mats, sheets, or blankets shall be adequately anchored and weighted to provide continuous contact with all concrete surfaces. Any concrete surfaces which cannot be cured by contact shall be enclosed by mats, adequately anchored, so that outside air cannot enter the enclosure. Sufficient moisture shall be provided inside the enclosure to keep all of the surfaces of the concrete wet for the required curing time.

2. **Water Spray Method.** For water curing by the water spray method, overlapping sprays or sprinklers shall be used so that all concrete surfaces are kept wet continuously.

(b) Elevated Temperature Curing. Curing by elevated temperatures will be permitted as follows:

1. **Steam Curing.** (Steam curing is defined as use of steam above 85 F for curing). When steam curing of concrete is provided, the temperature inside the curing jacket at the surface of the concrete shall not exceed 165 F for more than one hour during the entire steam curing period. Concrete exposed to temperatures exceeding 180 F will not be accepted.

Sufficient moisture shall be provided inside the curing jacket so that all surfaces of the concrete are wet.

An unobstructed air space of not less than six inches shall be provided between all surfaces of the concrete and the curing jacket. Steam outlets shall be positioned so that live steam is not applied directly on the concrete, reinforcing steel or tendons.

The location of steam lines, location of control points for discharge of steam into the curing jacket, and the number and type of openings for steam distribution within the curing jacket shall be arranged so that temperature variation between any points in the enclosure shall not exceed 20 F.

Steam curing shall not commence until the concrete has been in place a minimum of three hours.

During the application of steam, the temperature inside the curing jacket shall be raised uniformly at a rate not to exceed 40 F per hour.

Temperature decrease at the end of the curing operation shall not exceed the same rate.

When elevated temperature curing is used, members shall remain protected until the differential between the temperature inside the curing jacket and the outside air is not more than 25 F.

2. **Alternate Methods.** Other methods of elevated temperature curing may be permitted by the Engineer provided temperature maximums, rate of temperature variation, humidity control, etc., are in accordance with the requirements for steam curing. Permission shall be obtained from the Engineer, in writing, for use of any alternate method.

425.5. Handling, Hauling and Erection. The Contractor (Fabricator) shall be responsible for proper handling, lifting, storing, hauling and erection

of all members so that they may be placed in the structure without damage.

Unless approved on erection and/or shop drawings, prestressed members shall be maintained in an upright position at all times and shall be picked up and supported near the ends of the member in such a way to prevent torsion. Members may be lifted with the lifting devices as approved on the shop plans or by other methods approved by the Engineer in writing.

No member shall be moved from the casting yard until all requirements for tensioning (when pertinent), curing and strength requirements have been attained.

All concrete beams or girders, placed over a traveled roadway or railroad, shall be securely tied and/or braced to prevent overturning until diaframs capable of providing lateral stability are permanently in place. When railroad or roadway traffic must be maintained beneath girders or beams already placed, traffic shall be protected against falling objects during the erection of diaframs and other structural members, during the placing of cast-in-place concrete and during the erection and dismantling of forms therefor. The protection shall consist of safety nets (1 inch mesh maximum) or a flooring with openings not larger than 1 inch.

425.6. Defects and Breakage. Failure of individual wires in a seven-wire strand, or of wires in a parallel wire tendon is acceptable provided the total area of wire failure is not more than two percent of the total cross-sectional area of tendons in any member. Failure of entire strand will be subject to structural review.

Fine hair cracks or checks on the surface of the member which, as determined by the Engineer, do not extend to the plane of the nearest reinforcement will not be cause for rejection unless they are numerous and extensive. Diagonal cracks, which indicate damage from torsion, will be subject to a structural review prior to acceptance. Vertical or horizontal cracks, which are one-sixteenth inch or less in width and which tend to close upon transfer of stress to the concrete, are acceptable. Cracks in excess of this are subject to review prior to acceptance.

Cracks which extend into the plane of the reinforcing steel and/or prestressed tendons, but are acceptable otherwise, shall be repaired by sealing with a latex-base adhesive grout or with epoxy.

Small damaged or honeycombed areas which are purely surface in nature, (not over one inch deep) may be repaired. Damage or honeycomb in excess of this will be tentatively rejected, but will be subject to structural review.

425.7. Workmanship and Tolerance.

Reinforcing steel shall not project above the top of the member more than one half of an inch or less than three fourths of an inch from plan dimension. In the plane of the steel parallel to the nearest surface of concrete, bars shall not vary from plan placement by more than one fourth of an inch, or one twelfth of the spacing between bars, whichever is greater. In the plane of the steel perpendicular to the nearest surface of concrete, bars shall not vary from plan placement by more than one fourth of an inch.

Allowable tolerances from the dimensions and configuration shown on the approved shop drawings shall be as follows:

		Beams	Boxes	Tees
Length		±3/4"	±1/2"	±3/4"
Width		+3/4"-1/4"	±1/4"	±1/4"
Depth		+1/2"-1/4"	±1/4"	±1/4"
Thickness	Top Slab or Flange	+1/2"-1/4"	±1/2"	±1/4"
	Bottom Slab or Flange	+1/2"-1/4"	+1/2"-1/8"	+1/2"-1/4"
	Web	+3/4"-1/4"	±3/8"	±1/4"
Horizontal Alignment–Upon release of stress		±1/8" per 10' of Length	±1/4"	±1/4"
Deviation of Ends from	Horizontal	1/4"	1/4"	1/8" per 1' of width
Designated Skew or Bevel	Vertical	±1/8" per 1' of depth	1/4"	±1/8" per 1' of depth
Bearing Surfaces	⊥ to Vertical Axis	±1/8"		±1/16"
	Deviation from Plane	±1/16"	±1/8"	±1/16"
Anchor Hole Location	From End of Member	+3/4"-1/4"	±1/4"	+3/4"-1/4"
	Longitudinal Spacing	±3/4"	±1/2"	±3/4"
	Transverse Location	±1/4"	±1/4"	±1/4"
Diafram or Lateral Tie Holes		±1/2"	±1/2"	±1/2"
Longitudinal Position of Void			1"	
Position of Strands		±1/4"	±1/4"	±1/4"
Position of Hold-Down Points		±6"	±6"	±6"
Position of Handling Devices		±6"	±6"	±6"

Where sections of forms are to be joined, an offset of one sixteenth of an inch for flat surfaces and one eighth of an inch for corners and bends will be permitted. Offsets between adjacent end header sections shall not exceed one fourth of an inch.

Variations greater than specified above shall be corrected to within these tolerances or be subject to structural review. Horizontal alignment (sweep) in beams and girders only, which may increase at a later time over that shown in the table, will be acceptable if the member can be hauled, erected and aligned to within the above tolerance without being damaged.

Tolerances for piling shall be as specified in the Item, "Concrete Piling".

Tolerances for post-tensioned segmental members shall be subject to the requirements of the Item, "Concrete for Structures".

425.8. Measurement.

Precast, prestressed concrete beams or girders of the type specified, cast and stressed as required by the plans, will be measured by the linear foot, as established on approved shop drawings. Other precast, prestressed concrete members of the size and type specified, cast and stressed as required by the plans, will be measured by the linear foot, each, the square foot, or by the square yard as the case may be, as established on approved shop drawings, or as required by the plans.

Precast, prestressed concrete spans of the size and type specified, cast and stressed as required by the plans, will be measured as each prestressed span complete in place.

Cast-in-place structures (or structures where the Contractor has the option of casting-in-place) will be measured in accordance with the provisions of the Item, "Prestressing".

425.9. Payment.

Precast, prestressed concrete beams or girders will be paid for at the unit price bid per linear foot for "Prestressed Concrete Beams" of the type specified.

Precast, prestressed concrete spans will be paid for at the unit price bid for each "Prestressed Concrete Span".

Other prestressed concrete members will be paid for at the unit price bid per linear foot, at the unit price bid for each, at the unit price bid per square foot, or at the unit price bid per square yard as the case may be for "Prestressed Concrete" (specify name and/or type).

A partial allowance will be made for materials and for precast, prestressed concrete members (cast, but not erected) in accordance with the provisions of Article 9.6.

The above prices shall be full compensation for constructing the members, furnishing and tensioning prestressing steel; conduit, when required; furnishing and placing reinforcing steel, bearing plates, bearing pads; all bars, anchorage plates and appurtenances which become an integral part of the structure; for grouting of holes; for any necessary repair and for any special treatment of end anchorages and shoes as indicated on plans; and, for furnishing all materials, tools, equipment, labor and incidentals necessary to fabricate, transport and erect the members in the structure as indicated on the plans.

ITEM 426
PRESTRESSING

426.1. Description. This item shall govern for the furnishing, fabricating, storing and handling of prestressing materials, for the prestressing of precast members, and for the construction and prestressing of cast-in-place structural units, in accordance with the plans, with approved shop and working drawings and with these specifications.

Unless otherwise shown on the plans, the Contractor has the option of furnishing any type of post-tensioning system meeting the requirements of the specifications. The system selected shall provide the magnitude and distribution of prestressing force and ultimate strength required by the plans without exceeding allowable temporary stresses. Unless otherwise shown on the plans all design procedures, coefficients and allowable stresses as well as tendon spacing and clearances shall be in accordance with the latest Standard AASHO Specifications for Highway Bridges.

426.2. Materials. Materials required for use under this Item shall conform to the following:

Concrete	Item 421 and/or 423
Reinforcing Steel (non-prestressed)	Item 440
Structural Steel	Items 441, 442
Elastomeric Materials	Item 435
Expansion Joints	Item 420 and/or 436
Prestressing Hardware	Proprietary

Concrete shall be of the class shown on the plans.

Prestressing steel shall conform to one of the following types:

Steel wire conforming to ASTM Designation: A421; seven wire strand conforming to ASTM Designation: A416; or, alloy bars having a minimum ultimate strength of 145,000 psi. (based on the gross section of the bar), a minimum yield strength of 130,000 psi. at 0.7 percent extension and a minimum elongation in 20 bar diameters, after rupture, of 4.0 percent. Each bar shall be proof tested during the manufacturing process to 90 percent of its required ultimate strength, and shall be thermally stress relieved to provide suitable and uniform properties. (Prestressing bars will not be allowed in pretensioned members.)

Tendon is defined as "any single unit used to apply prestressing forces to the member". For post-tensioned units, this shall be each bar, each group of wires or each group of strands having common end anchorage, and for pre-tensioned units shall be each individual strand. Post-tensioned tendons shall be grouted or coated, as required by the plans.

Tendon couplers shall be used only at locations specifically shown on the plans or approved by the Engineer.

(1) For grouted tendons, end anchorages and tendon couplers shall develop a minimum of 95 percent of the required ultimate strength of the tendon with a minimum elongation of 2 percent when tested in the unbonded condition.

(2) For coated tendons, end anchorages and tendon couplers shall develop at least 100 percent of the required ultimate strength of the tendon, with a minimum elongation of 2 percent, and in addition shall withstand 500,000 cycles from 60 to 70 percent of the required ultimate strength of the tendon without failure or slippage.

Wires, strands or bars with greater ultimate strength but otherwise produced and tested in accordance with ASTM Designation: A416 and/or A421, and the requirements of this specification, will be permitted provided the physical properties as outlined in the applicable specification are shown on the shop drawings and provided they have no properties which make them less satisfactory than the specified material.

Material for coating non-bonded (ungrouted) tendons shall be a nonvolatile, low friction mineral oil base grease, with a rust preventing additive having a relatively uniform viscosity under temperature ranges of 20 F to 120 F. A protective sheathing shall be provided around the tendon consisting of a waterproof material capable of maintaining the tendon tightly bundled and containing the lubricant.

The conduit to enclose grouted, post-tensioned tendons shall be mortar tight, and may be either rigid, galvanized, ferrous metal, with a smooth inner wall, capable of being curved to the proper configuration, or may be flexible, interlocking, galvanized ferrous metal. Couplers for either type shall also provide a mortar tight connection. Rigid conduit may be fabricated with either welded or interlocking seams. Galvanizing of welded seams for the rigid conduit or for conduit couplings will not be required. Either type of conduit shall be capable of withstanding all forces due to construction operations, without damage.

For all conduit, the inside area shall be at least two times the area of the enclosed prestressing steel. It shall be adaptable to enlarging or flaring near the ends as required to accommodate the necessary anchoring system. The conduit shall be equipped with fittings for injection of grout and ports for venting.

Grout to be used for the grouting of tendons shall be proportioned as follows:

94 Lbs.	Portland Cement—Type II
1 Lb.	Expanding Admixture
5½ Gals. Max.	Water

50 lbs. Max. of Fly ash with a maximum carbon content of 8 percent may be added to the above mixture if desired. Other pozzolans will not be approved. Other mixtures of equal or better strength, workability and freedom from corrosive elements may be approved by the Engineer. The grout mixture shall be tested in accordance with Test Method Tex-437-A.

All tendons shall be identified by heat number, or reel number in the case of seven wire strand, and tagged for identification. Anchorage assemblies shall be identified in a like manner. The Contractor shall furnish specimens for test purposes in accordance with Test Method Tex-710-I.

Testing of complete tendons for compliance with the requirements of paragraphs (1) and (2) above will be at the Contractor's expense and the results certified in writing to the Engineer. In addition, the Contractor shall furnish, for testing, one specimen of each size of prestressing tendon, including couplings, of the selected type, with end fittings attached, for ultimate strength tests only. These specimen shall be 5 feet in clear length, measured between ends of fittings. If the results of the test indicate the necessity of check tests, additional specimen shall be furnished without cost. For prestressing systems previously tested and approved on Department projects, complete tendon samples need not be furnished, provided there is no change in the material, design, or details previously approved. Shop drawings or prestressing details shall identify the project on which approval was obtained, otherwise sampling will be necessary.

For prefabricated tendons, the Contractor shall notify the Materials and Tests Engineer at least 10 days *prior* to the installation of end fittings or the heading of wires in order that sampling and testing may be arranged.

426.3. Packaging, Storing and Handling. All prestressing steel shall be protected against physical damage and corrosion from the time of manufacture to grouting or encasing in concrete.

Rust on prestressing steel which can be removed by light rubbing is acceptable. Streaks or spots, which may remain after rust removal, are acceptable if no pitting is present. Tight mill scale is acceptable but loose mill scale shall be removed.

Prefabricated post-tensioning elements shall be protected from moisture by taping or wrapping the ends and all openings in the conduit or by other acceptable means.

426.4. Equipment. The Contractor shall furnish suitable hydraulic jacks for stressing the steel. These jacks shall be equipped with gages graduated to read directly to one percent of the total load applied, and calibrated to measure accurately the stress induced in the steel.

For post-tensioning, the jacks shall have a stroke of adequate length so that the stressing, including temporary overstress, can be done in one movement. They shall be equipped with proper ports or windows for adequate visual examination and measurement of tendon movement. They shall also be capable of slow release of stress to allow relaxation from overstress to the proper seating force.

For pretensioning, the jacks shall have sufficient capacity to provide the required stressing force and to permit simultaneous release of all straight strands. Single strand stressing is permitted, but release of strands individually with single strand jacks will not be permitted. Flame release of deflected strands will be permitted provided the method and sequence is shown on the shop drawings.

The Contractor shall furnish a grout pump of sufficient capacity to properly place grout in the quantities and pressures required.

When required to post-tension cast-in-place or pre-cast units, the Contractor shall furnish a compression testing machine, meeting the requirements of the Item, "Plant Inspection Laboratory (Equipped)". In lieu of the above, and with permission of the Engineer, the Contractor may provide the facilities of an approved Commercial Laboratory for the testing of cylinders.

426.5. Working Drawings. For cast-in-place prestressed units, in addition to forming and falsework plans required by the Item, "Concrete Structures", the Contractor shall submit prestressing details. These details shall contain all necessary information for construction including:

(1) Design Calculations. Sufficient calculations to support the system and method of prestressing proposed for use shall be submitted. When the required jacking force for a particular type of tendon and conduit is shown on the plans, and that type of tendon and conduit are furnished, design calculations need not be submitted except as necessary to adjust the jacking force for a different seating loss than shown on the plans.

(2) Prestressing Details. These drawings shall show details of type, size and number of units per tendon, forces applied per tendon, end anchorage systems, tendon profile, grouting and venting ports, marking used to identify unlike tendons and their location, total force per tendon with proper conversion to the units expressed on the jack gauge, total elongation and 90 percent elongation (measureable elongation), temporary overstress and other information necessary to properly complete the work.

A complete numbered layout showing the pattern to be followed in stressing tendons to properly stress the member, and a step-by-step stressing sequence shall be submitted. Complete provisions shall be made for each operation, including tendon slack removal, overstress, gauge

reading for seating, elongation measurement, shim insertion or wedge seating.

Details of the method of support for, and location of the conduit, with dimensions provided to properly locate the conduit so that the center of gravity of the enclosed steel will be at its proper location. The details shall show the offsets from the bottom of the conduit taking into account the position of the prestressing steel within the conduit.

The prestressing details shall be submitted on standard 22 inch x 36 inch sheets.

Design calculations may be on standard letter size sheets.

Six sets of details and three sets of design calculations shall be submitted to the Engineer, or directly to the Bridge Division when so directed.

When a railroad underpass structure is involved, an additional set will be required.

426.6. Construction Methods.

(1) General. The general requirements of the Item, "Concrete Structures" shall govern for cast-in-place construction.

Prior to stressing, the Contractor shall furnish the Engineer certified copies of load calibration curves on all jacks and gauge systems to be used in the work. Stressing systems shall be recalibrated when required by the Engineer.

The test for "Partial Tensioning Strength", "Handling Strength", and/or "Tensioning Strength" shall be the average breaking strength of two cylinders.

(2) Post-Tensioning. Suitable means shall be provided for measuring the elongation of the steel to the nearest one-sixteenth of an inch. In the event of apparent discrepancies of more than 5 percent between stresses indicated by elongation and gauge pressure, the entire operation shall be checked carefully and the source of error determined and corrected before proceeding further.

If end anchorages permit, tendons may be inserted in the member after placing of the concrete. Positive means of holding the conduit in its correct position shall be provided in all cases and shall be indicated on the working drawings submitted for approval. The conduit shall be supported at intervals of not more than five feet, or as shown on the plans. They shall be securely fastened to prevent movement during placement of concrete.

Tolerance for vertical positioning of tendons will be ± one fourth of an inch.

After the concrete has reached a compressive strength equal to the "Partial Tensioning Strength" specified on the plans, as indicated by compressive cylinder tests, the members may be partially prestressed for the purpose of removal of members from the casting bed to a curing area, provided satisfactory provision is made to bring all stressing units (including units stressed for handling) up to full required stress at the time of final stressing. The units to be stressed and the amount and pattern of the stressing

for the partial prestressing shall be submitted with the prestressing details and approved by the Engineer.

The temporary overload force, when required, and the post-tensioning force may be applied when the concrete has reached a compressive strength equal to the "Tensioning Strength". These forces may be applied to one or both ends of the tendon, unless otherwise shown on the plans. The sequence of post-tensioning shall prevent overstressing the member in vertical or lateral bending at anytime, and shall be indicated on the prestressing details.

The Prestressing Details submitted by the Contractor shall reflect the following general tensioning procedure, modified for each particular installation:

(a) The tendons will be tensioned in the sequence designated in the Prestressing Details.

(b) Initial tensioning to take the slack out of the tendons will be at 10 percent of the maximum tensioning load unless otherwise shown on the approved Prestressing Details.

(c) After the initial tensioning, the tendons shall be reference marked to determine elongation.

(d) After tensioning to overcome friction, the tension shall be reduced to that required to set the anchorage.

Loss of elongation due to anchor set shall be checked for agreement with the anticipated value used in the stress calculations. Excessive anchor set shall be deducted from the measured elongation and corrected if necessary to maintain agreement between elongation and gauge pressure within 5 percent.

(e) After stressing and anchoring all tendons and upon the Engineer's approval, projecting tendons shall be trimmed as shown in the approved Prestressing Details.

For grouted tendons the conduits shall be grouted within 48 hours after the completion of the tensioning operation. Grout must be pumped toward an open vent. Grout shall be pumped continuously under moderate pressure at one end of the conduit until all entrapped air is forced out the open vents downstream from the grout pump. The open vents shall be closed as soon as grout issues in a steady stream. After all grout ports have been closed, the pressure shall be increased to a minimum of 75 psi and held at this pressure for approximately 15 seconds. The grouting entrance port shall then be closed.

Grout ports will be required at the far end of the tendon, and at the high points of the tendon profile when there is more than 6 inch variation in the vertical position of the conduit. Tendons with less than 6 inch vertical variation shall have grout ports at the far end and at intervals between the far end and injection end not to exceed 100 feet. Grout ports shall consist of one half of an inch minimum diameter galvanized metal pipe, with caps or other arrangements having a minimum port diameter of one half of an inch, and as approved by the Engineer. The tops of the grout ports shall be set

approximately one half of an inch below the finished surface of the concrete. Recesses caused by the grout ports in the concrete surface shall be filled with mortar and finished as directed upon completion of grouting.

Unless otherwise shown on the plans, lightweight concrete prestressed units shall be stressed with a temporary force equal to 125 percent of the final prestress force and maintained for a period of 45 days. The temporary force shall be applied when the concrete has aged a minimum of 10 days, and when the test cylinders indicate the "Tensioning Strength" has been attained. At the end of the period specified, all the individual post-tensioning units shall be restressed to correct final prestress force.

(3) Pretensioning. All tendons to be prestressed in a group shall be brought to a uniform initial tension of 1000 pounds (plus or minus 50 pounds) per tendon prior to being given their full pretensioning. Initial tension greater than that specified herein may be used when designated and approved on the shop drawings. The tension shall be measured by some suitable means such as a dynamometer so that its amount can be used as a check against elongation computed and measured.

After this initial stressing, the straight strands shall be stressed to a total tension as required by the plans by means of hydraulic jacks equipped with gages graduated to read directly to one percent of the total load to be applied, and calibrated to measure accurately the stress induced in the steel. The induced stress shall be measured by elongation of the strands and checked by gage pressure. The results shall agree within 5 percent.

Means shall be provided for measuring the elongation of the straight strands to an accuracy of one percent of the theoretical elongation or one eighth of an inch, whichever is smaller. In the event of apparent discrepancies of more than 5 percent between stresses indicated by gage pressure and elongation, the entire operation shall be checked carefully and the source of error determined and corrected before proceeding further.

Where a combination of straight and draped strands are used, the measured elongation of the draped strand shall not vary by more than 5 percent from the calculated elongation. Measurements on individual deflected strands to establish differential stresses at different points in the member shall be averaged at a cross section of the member, and the averages shall be within 5 percent of the calculated elongation. No individual strand shall vary from the calculated elongation by more than 10 percent at any measured cross section.

Independent references shall be established adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the tendons.

With the tendons fully stressed as prescribed above and all other reinforcing in place, the concrete shall be cast to lengths necessary to provide the lengths required by the plans, after shrinkage and elastic shortening has occurred.

After strength requirements are attained, the tension in the tendons shall be gradually and simultaneously released and the tendons cut off as required, using a sequence to minimize shock and reduce premature tendon breakage.

When draped tendons are used, positive external hold downs may be required to offset the vertical forces in the beam at the time of stress release.

(4) Combined Pretensioning and Post-Tensioning. Where the plans call for a combination of pretensioning and post-tensioning, all of the requirements of both the pretensioning and post-tensioning shall apply, in this order, and the requirements shall overlap as necessary to fulfill the intent of this specification.

426.7. Measurement.

(1) All precast concrete members (except piling) either pretensioned, post-tensioned, or combined pre- and post-tensioned, will be measured and paid for as specified in the Item, "Prestressed Concrete Structures". Prestressed piling will be measured and paid for as specified in the Item, "Concrete Piling".

(2) Cast-in-place prestressed concrete structures and units will be measured as follows:

(a) Concrete, non-prestressed reinforcing steel, and structural steel (except bearing and anchorage devices integrally a part of the post-tensioning system) will not be measured by this Item, but will be measured by the cubic yard or by the pound in accordance with the applicable specifications for these items. Grout and ducts for post-tensioning will not be measured but will be considered subsidiary to this item.

(b) The prestressing steel required and the work involved in prestressing of cast-in-place structures will be measured by the product of the required final prestress force and the horizontal length over which the prestressing is applied, expressed in thousands of kip-feet (MKF). For slab units this will be calculated as the product of the required final prestress force per foot of width and the area out-to-out of the slab unit. Unless otherwise shown on the plans, the required final prestress force used will be the maximum value required within a unit, and the length of prestressing or the area in the case of a slab will be taken as the overall dimensions of the unit, no deductions being made for the clearance distance between the ends of tendons and the edges of the unit.

426.8. Payment. Payment for the work and all materials for prestressing cast-in-place units, measured as specified above will be made at the unit price bid per thousand kip feet of Prestressing (Grouted) or Prestressing (Coated).

The amount to be paid for will be that quantity shown on the contract plans except as modified by the following:

Either party to the contract may request an adjustment of quantities shown on the contract plans (by each separate bid item), if the quantities, calculated as outlined in Article 426.7., vary from those shown on the contract plans by more than the following:

(1) Over 5000 MKF ..... one half of 1 percent

(2) 1000 MKF through 5000 MKF ..... 1 percent

(3) Less than 1000 MKF ..... 1½ percent

The party to the contract which requests an adjustment shall present to the other, two copies of calculations showing the revised quantities for the portion or portions of the structure in question. These revised quantities when proven correct, together with all other quantities under the same bid item, shall constitute the final quantity for which payment will be made.

The above payment shall be full compensation for furnishing all prestressing steel, all materials, fabrication, transportation, erection, prestressing and for furnishing all metal encasing ducts, grout fittings, end anchorages, bearing plates, and all tools, labor, equipment and incidentals necessary to complete the work.

ITEM 428

CONCRETE SURFACE TREATMENT

428.1. Description. This item shall govern for the furnishing and application of a linseed oil treatment to concrete surfaces. Unless otherwise noted on the plans, the upper surfaces of the roadway slab (including direct traffic culverts), bridge sidewalks and medians, and the inside faces of curbs shall be treated. Any surfaces given a higher grade or class of finish as specified in the Special Specification, "Surface Finishes for Concrete", will not be given linseed oil treatment.

428.2. Materials. This material shall consist of Boiled Linseed Oil and Mineral Spirits for any ambient temperature range above 40 F. Boiled Linseed Oil and Kerosene may be used at the option of the Contractor for an ambient temperature range above 70 F. The materials shall meet the following specifications and shall be shipped combined in a mixture containing a minimum of 50 percent and a maximum of 70 percent boiled linseed oil by volume.

(1) Boiled Linseed Oil. Boiled Linseed Oil shall conform to the requirements of Standard Specifications for Boiled Linseed Oil, ASTM Designation: D 260, Type 1.

(2) Mineral Spirits. Mineral Spirits shall conform to the requirements of Standard Specifications for Mineral Spirits, ASTM Designation: D 235.

(3) Kerosene. Kerosene shall conform to the requirements of Federal Specifications for Kerosene VV-K-211d.

(4) Shipment. The material shall be shipped in clean, leakproof containers with contents clearly stated on them.

428.3. Construction Methods. Before application, concrete surfaces shall be power broomed, air blasted or cleaned by other means acceptable to the

Engineer, to remove any laitance, oil or grime which may retard or prevent absorption of the mixture by the concrete.

The concrete surfaces shall be dry and the ambient temperature shall be 40 F or above at the time of application. Surface treatment shall not be applied earlier than 14 days after the placement of concrete when interim curing is by linseed oil emulsion nor earlier than 28 days when Type 1 (Resin Base) membrane curing is used.

Unless otherwise shown on the plans, the material shall be applied in two stages at the rate of approximately 40 square yards per gallon for the first stage and approximately 67 square yards per gallon for the second stage for a total coverage of approximately 25 square yards per gallon. The second application shall not be made until 24 hours after the first application is made.

Application to slabs shall be made with a herbicide, insecticide or similar type spray machine equipped with a spray bar and driven at such speed as to provide the required coverage. In isolated cases application may be made using a hand operated pressure pump equipped with spray nozzles.

Traffic shall not be permitted on treated surfaces for a minimum of 24 hours after the final application has been completed.

Any excess liquid remaining on the surface after four hours shall be broomed off or covered with an application of fine sand.

The mixture shall not be heated.

428.4. Measurement. Concrete Surface Treatment shall be measured by the square yard of concrete surface treated at the specified total rate of application, using the dimensions shown on the plans.

428.5. Payment. The amount to be paid will be that quantity shown on the contract plans and in the proposal, except as may be modified by the following:

Either party to the contract may request an adjustment of the quantities shown on the contract plan (by each separate bid item), if the quantities, measured as outlined in Article 428.4., vary from those shown on the contract plans by more than 5 percent.

The party to the contract which requests an adjustment shall present to the other, three copies of field measurements and calculations showing the revised lengths for the structure or structures in question. These revised lengths of seal, when proven correct, together with all other seal under the same bid item, shall constitute the final quantity for which payment will be made.

Payment for revised quantities due to a change in design will be at the unit price bid per square yard measured as provided in Article 428.4.

This price shall be full compensation for all materials, tools, labor, equipment and incidentals required to perform the work prescribed herein.

Adjustment of quantities will be subject to the provisions of Article 4.3.

ITEM 430

EXTENDING CONCRETE STRUCTURES

430.1. Description. This item shall govern for concrete for extending structures and for preparation of the existing structures for extending or widening, including the materials used; the removal of portions of the existing structure, preparation of exposed surfaces of steel and concrete for bonding new construction to old; and the construction of the proposed extensions, all as indicated on the plans.

430.2. Materials. All materials shall conform to the requirements of the pertinent items as follows:

Materials	Item No.
Concrete	420, 421, 423
Expansion Joint Material	420 and/or 436
Reinforcing Steel	440

430.3. Construction Methods. The work shall be performed in accordance with the provisions of the Item, "Concrete Structures", and in conformance with the requirements herein.

Portions of the old structure shall be removed to the lines and dimensions shown on the plans, and these materials shall be disposed of as shown on the plans or as directed by the Engineer. Unless otherwise noted on the plans, metal railing shall be removed in such a manner that it will not be damaged, stacked neatly on the right-of-way at convenient loading points which will not interfere with traffic or construction and will remain the property of the Department. Any portion of the existing structure, outside of the limits designated for removal, damaged during the operations of the Contractor shall be restored to its original condition at his entire expense. Explosives shall not be used in the removal of portions of the existing structure unless approved by the Engineer, in writing.

When the headwalls, wingwalls and apron are specified on the plans to be reused in the extended structure, the portion to be reused shall be severed from the old structure to the lines and details shown on the plans. The headwall unit shall be removed to the new location specified, by methods approved by the Engineer, and the extension concrete and reinforcement placed according to the plan details. Any portion of the headwall unit damaged by the moving operation shall be restored to its original condition at the expense of the Contractor.

Unless otherwise noted on the plans, a demolition ball, other swinging weight or impact tool, will be permitted on those portions of the structure not immediately adjacent to the 'break' line of the concrete.

The concrete shall be severed at the 'break' line by pneumatic tools and may be followed by the use of the demolition ball, or other methods acceptable to the Engineer. The final removal of concrete at the 'break' line

shall be with pneumatic tools. Damaged concrete shall be treated as specified above. Bridge slabs (other than multiple box culverts) shall first be sawed along the 'break' line one-half of an inch deep prior to beginning the removal of concrete.

In those instances where precast sections are used for the extension of an existing structure, the concrete placed as a filler block between sections shall contain an approved nonshrinkage additive.

Except when otherwise provided on the plans, new reinforcing bars shall be spliced to exposed bars in the old structure by lap splices in accordance with Table 1 of the Item, "Reinforcing Steel". When welded splices are permitted by the plans, they shall conform with the Item, "Structural Welding". For lap splices (not welded), new reinforcing steel need not be tied to existing steel where spacing and/or elevation does not match that of existing steel provided the proper lap length is attained.

Dowels, if required by the plans, shall be installed by grouting reinforcing bars to a minimum length of 12 inches into the old structure. Holes for dowel bars shall be cleaned of all loose material, wetted and filled with a 1:3 mix grout or other approved material, as may be specified on the plans, immediately prior to placing of dowel bars.

Concrete surfaces which will be in contact with new construction shall be roughened and cleaned prior to placing of forms. These surfaces shall be dampened and coated with mortar just prior to placing fresh concrete.

Roadway slabs shall be finished in accordance with Article 420.20 except that when an overlay is required, the slabs shall be given a reasonably smooth surface finish by longitudinal or transverse screeding without any straight edge requirements.

The widened portion of bridges and direct traffic culverts shall not be opened to construction traffic or to the traveling public until authorized by the Engineer in accordance with the following:

Authorization may be given after the last slab concrete has been in place at least 14 days for light construction traffic not to exceed a three-quarter ton vehicle.

Authorization for construction traffic, and when necessary to the traveling public, may be given after the last slab concrete has been in place 30 days.

Construction traffic on the widened or existing portion of bridges and direct traffic culverts will be governed as follows:

Construction vehicles which exceed the legal load limit, except as specified herein, which would require a permit to haul over the highway system will not be authorized across structures, except that vehicles with a minimum of three axles will be permitted if the total gross load does not exceed 51,000 pounds. Speed of such vehicles shall be limited to no more than 10 miles per hour.

Where a detour is not readily available or economically feasible to use, an occasional crossing of a structure with overweight equipment may be

permitted for relocating equipment only but not for hauling material, providing a structural analysis of the structure using the exact equipment in question, indicates no damage will result. The structural analysis must be approved by the Engineer. Temporary matting and/or other requirements may be imposed by the Engineer if an occasional crossing is permitted.

430.4. Measurement. The quantities of concrete of the various classifications which will constitute the completed and accepted structure or structures in place will be measured by the cubic yard, each, square foot, square yard, or linear foot as the case may be. Measurement will be as follows:

(1) General.

(a) All concrete quantities will be based on the dimensions shown on the plans or those established in writing by the Engineer. Diafram concrete, when required, will be included in the slab measurement.

(b) In determining quantities, no deductions will be made for chamfers less than two inches, embedded portions of structural steel or prestressed concrete beams, piling, anchor bolts, reinforcing steel, drains, weep holes, junction boxes, electrical conduit, conduit and/or voids for prestressed tendons or for embedded portions of light fixtures.

(c) For Pan Girder Spans, a quantity will be included for the screed setting required to provide proper camber in the roadway surface after form removal.

(d) For Slabs on Steel and Prestressed Beams, a quantity for the haunch between the slab and beams will be included when required. No measurement will be made during construction for variation in the amount of haunch concrete due to deviation from design camber in the beams.

(e) For Slabs on Panels or Tee-Beams, the combination of span length, theoretical camber in beams, computed deflections, and plan vertical curve will be taken into account in determining the quantity for the slab.

Additional concrete which may be required by an adjustment of the profile grade line during construction, to insure proper slab thickness, will be measured for payment. The additional quantity will be based on the difference between the plan profile grade line and the adjusted profile grade line, using the overall width of the bridge, when cantilever panels are used in the overhang, and the out to out width between the exterior beams, when the overhang is cast in place. No other quantity will be included.

(f) Quantities revised by a change in design, measured as specified herein, will be increased or decreased, as the case may be, and included for payment.

(2) Plan Quantity. For those items measured for plan quantity payment, adequate calculations have been made in accordance with Article 9.1. If no

adjustment is required by Article 430.5., additional measurements or calculations will not be required.

(3) Measured in Place. For those items not measured for plan quantity payment, measurement will be made in place.

430.5. Payment. For structure elements designated in Table 1, and when measured by the cubic yard, the quantity to be paid for will be that quantity shown on the contract plans and in the proposal, regardless of errors in calculation, except as may be modified by the following:

Plan quantities will be adjusted:

(1) When a complete structure element has been erroneously included or omitted from the plans, the quantity shown on the plans for that element will be added to or deducted from the plan quantity and included for payment. A complete structure element will be the smallest portion of a total structure for which a quantity is included on the plans. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(2) When the plan quantity for a complete structure element is in error by 5 percent or more, a recalculation will be made and the corrected quantity included for payment. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(3) When quantities are revised by a change in design the 'plan quantity' will be increased or decreased by the amount involved in the design change. Quantities revised in this manner will be subject to the provisions of Article 4.3.

The party to the contract requesting the adjustment shall present to the other, three copies of the description and location, together with calculations of the quantity for the structure element involved. When this quantity is certified correct by the Engineer, it will become the revised plan quantity.

Culverts and Wingwalls	Abutments
Headwalls for Pipe	Slab and Girder Spans
Retaining Walls	Slabs on Steel Spans
Inlets and Manholes	Slabs on Prestressed Spans
Slab Spans	Pan Girder Spans

Table 1
Plan Quantity Payment
(Cubic Yard Measurement Only)

NOTE: Other structure elements may be paid for as 'plan quality', including pier and bent concrete, when so noted on the plans.

For those portions of structures not listed in Table 1, the concrete quantities, measured as provided in Subarticle 430.4.(1). will be paid for at the unit price bid per "Cubic Yard", per "Each", per "Square Foot", per

"Square Yard", or per "Linear Foot", in place, for the various classifications of concrete shown.

Payment for increased or decreased costs due to a change in design, on those items measured as "Each", by the "Square Foot", "Square Yard" or "Linear Foot" will be determined by "Supplemental Agreement". Quantities revised in this manner will be subject to the provisions of Article 4.3.

Payment of any additional concrete required for slab on panel or tee-beam construction due to adjustment of the profile grade line, measured as outlined in Subarticle 430.4.(1).(e). will be made at 20 percent of the bid price for the class of slab concrete involved. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

The unit prices bid for the various classifications of concrete shown shall be full compensation for furnishing, hauling, and mixing all concrete material; placing, curing and finishing all concrete; all grouting and pointing; furnishing and placing drains; furnishing and placing metal flashing strips; furnishing and placing expansion joint material required by this item; removing the designated portion of the existing structure; moving of headwall units for reuse; cleaning, bending and cutting of exposed reinforced steel; welding of new reinforcing steel to old; all drilling and grouting for dowels; cleaning and painting old concrete with neat cement mortar; and for all forms and falsework, labor, tools, equipment, and incidentals necessary to complete the work.

ITEM 431

PNEUMATICALLY PLACED CONCRETE

431.1. Description. This item shall govern the furnishing and placing of "Pneumatically Placed Concrete" for riprap, riprap for headerbanks, encasement of designated structural steel members, concrete channel or canal lining, the covering of designated portions of concrete structures and for other miscellaneous construction as indicated on the plans.

431.2. Materials. The cement, water, and sand shall conform to the requirements of the Item, "Concrete for Structures". For encasement of structural members and covering portions of structures, the sand, when tested by approved laboratory methods, shall conform to the following gradation requirements:

Passing No. 4 sieve	98-100% (by weight)
Passing No. 20 sieve	60-85%
Passing No. 50 sieve	15-35%
Passing No. 100 sieve	0-5%

Bar reinforcement and wire fabric reinforcement shall conform to the requirements of the Item, "Reinforcing Steel".

Expansion joint material shall conform to the requirements of the Item, "Concrete Structures".

Steel drive pins or studs used for the attachment of reinforcing when covering designated portions of concrete structures with pneumatically placed concrete shall be capable of being driven to the specified depth without deforming or otherwise becoming unsuitable for the purpose intended. The pins shall have a minimum diameter of one eighth of an inch and a minimum length of 2 inches. Size and location of drive pins or studs and method of attachment of reinforcing shall be as specified herein or as detailed on the plans.

The equipment used for driving the pins or studs shall be of the type which uses an explosive for the driving force, and shall be capable of inserting the stud or pin to the required depth without damage to the surrounding concrete. The Engineer may require that a test be made of the equipment prior to approving it for use.

431.3. Proportioning and Mixing. Unless otherwise specified, the pneumatically placed concrete shall be proportioned as follows:

Type I—one part cement (minimum) to four parts sand (by volume)

Type II—one part cement (minimum) to five parts sand (by volume)

Type III—one part cement (minimum) to seven parts sand (by volume)

At the time of mixing, the sand shall contain from 3 to 6 percent moisture. When visual inspection indicates that lumps or oversize particles are going into the machine, all materials shall be thoroughly mixed and passed through a one fourth of an inch sieve before being placed in the machine. The minimum mixing time for each batch shall be not less than 1½ minutes after the sand and cement are in the drum when the drum rotates at a peripheral speed of about two hundred feet per minute. Each batch shall be entirely discharged before recharging is begun.

The mixer shall be cleaned at regular intervals to remove all adherent material from the mixing vanes and from the drum.

No water shall be added to the mix after mixing and before application. Mixed material that has not been used within 45 minutes shall be rejected and no remixing or tempering will be permitted.

At the beginning of work the Engineer may require that cylinders be made to represent the quality of the pneumatically placed concrete. Additional cylinders will be made during prosecution of the work as directed by the Engineer. If, in the opinion of the Engineer, the cylinder strengths are indicating undesirable variation in the concrete, the Contractor may be required to change the mix design and/or method of placing so as to correct this condition.

The Contractor shall furnish specially constructed cylinders 6 inches in diameter and 12 inches high, made of three fourths of an inch square mesh hardware cloth. Test cylinders for pneumatically placed concrete shall be shot with the same air pressure and nozzle tip as the pneumatically placed concrete. At the end of the first 24 hour curing period, the hardware cloth form shall be removed and the cylinders stored and cured as directed by the Engineer.

The use of approved admixtures conforming to the requirements of the Item, "Concrete Admixtures", will be permitted at the option of the Contractor.

431.4. Construction Methods.

(1) Reinforcement. All reinforcement to be embedded in pneumatically placed concrete shall be clean and free from loose mill scale, rust, oil, or other coatings which might prevent adequate bond.

Reinforcement shall be secured rigidly in the position indicated on the drawings. The clear distance between reinforcing bars shall be at least 2½ inches.

Minimum clear distance between forms and reinforcement and for cover shall be as shown on the plans. Space shall be provided for splicing bars in the approved manner.

For the covering of designated portions of concrete structures, welded wire fabric shall be held securely about three fourths of an inch out from the surface to be covered. Adjacent sheets shall lap at least 6 inches and sheets shall be fastened together securely by tying at intervals not to exceed 18 inches. In placing the wire fabric, steel drive pins spaced at 2 feet on centers each way shall be driven to a penetration of not less than 1 inch into the face of the designated portion to be covered, and the wire fabric shall be fastened securely to each pin. Any pin that does not reach the desired depth may remain in place but must be supplemented by another pin meeting specification requirements.

For the encasement of designated portions of steel structures, the welded wire fabric shall be bent to a template to conform as nearly as possible to the outlines of the steel members to be encased. Holes not less than one half of an inch in diameter shall be provided in the webs of the members as near as practicable to the flanges for the purpose of attaching the reinforcing fabric. These holes shall be spaced approximately 3 feet on centers. The welded wire fabric shall be held securely about three fourths of an inch out from the surfaces of the members to be encased. Adjacent sheets shall lap at least 6 inches and sheets shall be fastened together securely by tying at intervals not to exceed 18 inches. In placing the wire fabric, three eighths of an inch round rods shall be fastened to the structural steel through the holes provided in the webs of the members to be encased and the fabric shall be tied securely outside to rods. Ties shall be spaced approximately 12 inches on centers. The formed fabric shall conform, in so far as possible, to the shape of the structural member with a space of three fourths of an inch between the fabric and the faces of the members to be encased.

(2) Existing Structural Steel and Concrete Surfaces. All steel and concrete surfaces shall be cleaned thoroughly of all paint, rust, loose mill scale, grease, and such other foreign materials which are likely to prevent adequate bond between the surface to be encased or covered and the pneumatically placed concrete. Structural steel to be encased with pneumatically placed concrete shall not be painted. Concrete surfaces to be covered with pneumatically placed concrete shall be kept damp a day in

advance of application and shall be thoroughly cleaned and washed with water and compressed air just prior to the application.

(3) Operating Requirements. The compresser or blower used to supply air shall be capable of delivering a sufficient volume at a pressure range of 30 to 60 psi as required by the size of the nozzle employed. When a hose length of 100 feet is used, the pneumatic pressure at the nozzle shall be 45 psi or more as necessary to efficiently prosecute the work. For lengths over 100 feet the pressure shall be increased 5 psi for each additional 50 feet of hose required. Steady pressure must be maintained throughout the placing process. The water pump shall be of sufficient size and capacity to deliver the water to the nozzle at a pressure of not less than 15 psi in excess of the required air pressure.

(4) Rebound. Rebound recovered clean and free of foreign matter may be reused as sand in quantity not to exceed 20 percent of the total sand requirements.

(5) Construction Joints. Particular care shall be given to the formation of construction joints. Unless otherwise noted on the plans, all joints shall be square butt joints.

(6) Curing. Pneumatically placed concrete shall be cured in accordance with the Item, "Concrete Structures".

(7) Placing of Pneumatically Placed Concrete. Proper consistency shall be controlled at the nozzle valve by the operator and a low water-cement ratio must be maintained. The mix shall be sufficiently wet to adhere properly and sufficiently dry so that it will not sag or fall from vertical or inclined surfaces or separate in horizontal work.

When encasing structural steel members or covering portions of structures the concrete may be applied in one coat; however, if the concrete, after being placed, shows any tendency to sag, it shall be applied in two or more coats. Pneumatically placed concrete for overhead work shall be placed in two or more coats as may be necessary to insure proper bond and to eliminate sag. In covering vertical surfaces, placing of the concrete shall begin at the bottom and be completed at the top.

The nozzle shall be held at such distance (2 or 4 feet) and position that the stream of flowing concrete shall impinge as nearly as possible at right angles to the surface being covered. Any deposit of loose sand shall be removed prior to placing any original or succeeding layers of pneumatically placed concrete. Should any deposit of loose sand be covered with pneumatically placed concrete, the concrete shall be removed and replaced with a new coat of pneumatically placed concrete after the receiving surface has been properly cleaned.

Before channel or canal lining or riprap is placed, the earth canal or channel slopes shall have been compacted uniformly and thoroughly and brought to a uniform moist condition. The subgrade for lining shall be excavated and fine graded to the required section. The use of forms for lining will not be required. The surfaces of pneumatically placed concrete for both

channel lining and riprap shall be finished accurately by hand floating methods before the concrete has attained its initial set.

The original surface and each surface which is permitted to harden before applying succeeding layers shall be washed with water and air blast, or a stiff hose stream, and loosened material removed. Sand which rebounds and does not fall clear of the work or which collects on horizontal surfaces shall be blown off from time to time to avoid leaving sand pockets. Concrete shall not be applied to a surface containing frost or ice. Where standing or running water is encountered it shall be removed before applying the concrete. No work shall be done without the permission of the Engineer when the temperature is lower than 35 F. After placing, the concrete shall be protected from freezing or quick drying.

(8) Workmen. Only experienced foremen, gunmen, nozzlemen, and rodmen shall be employed and satisfactory written evidence of such experience shall be furnished the Engineer or his representative upon demand.

431.5. Measurement. Measurement for pneumatically placed concrete will be made by the square foot in place. For encasement of structural steel members and covering portions of structures, the actual contact area shall be the basis for measurement.

431.6. Payment. Pneumatically placed concrete, measured as provided above, will be paid for at the unit price bid per square foot for "Pneumatically Placed Concrete", of the type specified.

The unit price bid per square foot shall be full compensation for all cement, sand, water, reinforcement, furnishing and driving all steel drive pins, for mixing and placing pneumatically placed concrete, and for all labor, tools, equipment, and incidentals necessary to complete the work. Excavation for channel and canal lining will be paid for in accordance with the Item, "Channel Excavation". Shaping and fine grading of channel or canal slopes and floors and excavation required for shaping slopes for headerbanks will not be paid for directly but shall be included in the unit price bid for "Pneumatically Placed Concrete". When headerbanks upon which "Pneumatically Placed Concrete" is to be placed have been built by prior contract, excavation for shaping of slopes will be paid for in accordance with the Item, "Structural Excavation".

ITEM 432

RIPRAP

*432.1. **Description.** This item shall govern the furnishing and placing of riprap of stone or concrete of the type indicated on the plans.

432.2. Materials. Stone for riprap shall consist of field stone or rough unhewn quarry stone as nearly uniform in section as is practicable. The stone shall be dense, resistant to the action of air and water, and suitable in all respects for the purpose intended.

The stone used for Common Mortar Riprap may consist of broken up concrete removed under the contract or obtained from other approved sources. Broken concrete shall be as nearly uniform in section as practicable and of the sizes specified in Article 432.8.

Materials for concrete, grout, and mortar shall conform to the requirements of the Item, "Concrete for Structures". Concrete shall be of the class shown on the plans. Mortar and grout required for the several types of riprap shall consist of one part of Portland cement and three parts of sand, thoroughly mixed with water. Mortar shall have a consistency such that it can be easily handled and spread by trowel. Grout shall have a consistency such that it will flow into and completely fill all joints.

Bar reinforcement shall conform to the requirements of the Item, "Reinforcing Steel".

Wire reinforcement shall consist of welded fabric meeting the requirements of ASTM Designation: A 185.

Premolded expansion joint material shall conform to the requirements of the Item, "Concrete Structures".

432.3. Construction Methods. The slopes and other areas to be protected shall be dressed to the line and grade shown on the plans prior to the placing of riprap. For Dry Riprap, Type A and Type B; Grouted Riprap, Type A and Type B; and Mortar Riprap, the stones shall be so placed that the greater portion of their weight is carried by the earth and not by the adjacent stones.

Mortar or Grouted Riprap shall not be placed on embankment slopes until the embankment has been compacted thoroughly.

Spalls and small stones used to fill open joints and voids in stone riprap shall be driven to a tight fit.

432.4. Dry Riprap, Type A and Type B. Unless otherwise specified, all stones used in these types of riprap shall weigh between 50 and 150 pounds each, and at least 60 percent of the stones shall weigh more than 100 pounds each. The stones shall be placed in a single layer with close joints. The upright axes of the stones shall make an angle of approximately 90 degrees with the embankment slope. The courses shall be placed from the bottom of the embankment upward, the larger stones being placed in the lower courses. Open joints shall be filled with spalls. Stones of greater dimension than the required riprap thickness shall be embedded in the embankment to present a uniform finished top surface such that the variation between tops of adjacent stones shall not exceed 3 inches. Stones that project more than the allowable amount in the finished work shall be replaced, embedded deeper, or chipped.

Dry Riprap, Type B, differs from Dry Riprap, Type A, only in that a toe wall of concrete, having dimensions and reinforcement as shown on the plans, shall be used.

432.5. Dry Riprap, Type C and Type D. Stones having one broad flat surface shall be used when possible; this surface being placed on a horizontal earth bed prepared for it and so placed as to overlap the underlying course,

the intent being to secure a lapped or "shingled" surface. Fifty percent of the mass shall be of stones weighing between 100 and 150 pounds each. These stones shall be placed first and roughly arranged in close contact. The spaces between the large stones then shall be filled with stone of suitable size so placed as to leave the surface evenly stepped, conforming to the contour required, and capable of shedding water to the maximum degree practicable.

Dry Riprap, Type D, differs from Dry Riprap, Type C, only in that a toe wall of concrete, having dimensions and reinforcement as shown on the plans, shall be used.

432.6. Grouted Riprap, Type A and Type B. Stones used in these types of Riprap shall weigh between 40 and 150 pounds each. The stones shall be placed in the same manner as specified above for Dry Riprap, Type A and Type B with care being taken to prevent earth or sand from filling the spaces between the stones. After the stones are in place, the stones shall be wetted thoroughly and the spaces between the stones shall be completely filled with grout. The surface of the Riprap shall be swept with a stiff broom after grouting. No Riprap shall be grouted in freezing weather. The work shall be protected from the sun and kept moist for at least 3 days after grouting.

Grouted Riprap, Type B, shall have a concrete toe wall as specified for Dry Riprap, Type B.

432.7. Mortar Riprap. Stone for this purpose, as far as practicable, shall be selected as to size and shape in order to secure fairly large, flat-surfaced stone which may be laid with a true and even surface and a minimum of voids. Fifty percent of the mass shall be broad flat stones, weighing between 100 and 150 pounds each, placed with the flat surface uppermost and parallel to the slope. The largest stones shall be placed near the base of the slope. The spaces between the larger stones shall be filled with stone of suitable size, leaving the surface smooth, reasonably tight, and conforming to the contour required. In general, the stones shall be placed with a degree of care that will insure for plane surfaces a maximum variation from the true plane of not more than 3 inches in 4 feet. Warped and curved surfaces shall have the same general degree of accuracy as specified for plane surfaces.

Before placing mortar, the stones shall be wetted thoroughly, and as each of the larger stones is placed, it shall be surrounded by fresh mortar and adjacent stones shall be shoved into contact. After the larger stones are in place, all of the spaces or openings between them shall be filled with mortar and the smaller stones then placed by shoving them into position, forcing excess mortar to the surface and insuring that each stone is carefully and firmly embedded laterally. After the work has been completed as described above, all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints then shall be pointed up roughly either with flush joints or with shallow, smooth raked joints.

432.8. Common Dry Riprap and Common Mortar Riprap. The stones for this type shall be not less than one third of a cubic foot in volume and not less than 3 inches in least dimension. The width of the stone shall not be less than twice the thickness.

Prior to placing the stones, a suitable bed shall be excavated for the base course or layer. The material secured by excavation shall be used in dikes or dams around the end of the walls or uniformly spread on embankment slopes. The base course or layer of stone shall be bedded well into the ground with their edges in contact. Each succeeding course or layer shall be well bedded into and placed on even contact with its preceding course or layer. The finished surface shall present an even, tight surface true to line and grades of typical sections.

Sufficient mortar shall be used in Common Mortar Riprap to fill completely all voids in the layers of stone, and surface shall be swept with a stiff broom. Grout may be used in lieu of mortar. Spalls and small stones used to fill open joints and voids in Common Dry Riprap shall be driven to a tight fit.

432.9. Concrete Riprap. Concrete for riprap shall be placed in accordance with the details and to the dimensions shown on the plans or as established by the Engineer. Unless otherwise shown by a note on the plans, concrete riprap shall be reinforced using wire or bar reinforcement.

The class of concrete shall be specified on the plans and shall be in accordance with the Item, "Concrete for Structures".

If wire reinforcement is used, it shall be a 6 by 6 inch No. 6 plain electric welded reinforcing fabric or its equal. A minimum lap of 6 inches shall be used at all splices. At the edge of the Riprap, the wire fabric shall not be less than 1 inch nor more than 3 inches from the edge of the concrete and shall have no wires projecting beyond the last member parallel to the edge of the concrete.

If bar reinforcement is used, the sectional area of steel in each direction shall not be less than the sectional area of the wire fabric described above. The spacing of bar reinforcement shall not exceed 18 inches in each direction and the distance from the edge of concrete to the first parallel bar shall not exceed 6 inches.

Reinforcement shall be supported properly throughout the placement to maintain its position approximately equidistant from the top and bottom surface of the slab.

If the slopes and bottom of the trench for toe walls are dry and not consolidated properly, the Engineer may require the entire area to be sprinkled, or sprinkled and consolidated before the concrete is placed. All surfaces shall be moist when concrete is placed.

After the concrete has been placed, compacted and shaped to conform to the dimensions shown on the plans, and after it has set sufficiently to avoid slumping, the surface shall be finished with a wooden float to secure a reasonably smooth surface.

Immediately following the finishing operation the riprap shall be cured in accordance with the Item, "Concrete Structures".

432.10. Pneumatically Placed Concrete Riprap, Type I and Type II. Pneumatically placed concrete for riprap shall be placed in accordance with

the details and to the dimensions shown on the plans or as established by the Engineer. Pneumatically placed concrete shall conform to the requirements of the Item, "Pneumatically Placed Concrete". Reinforcement shall conform to the details on the plans and with the Item, "Reinforcing Steel". Reinforcement shall be supported properly throughout placement of concrete. All subgrade surfaces shall be moist when concrete is placed.

The surface shall be given a wood float finish or a gun finish as directed by the Engineer.

The strength and design of Pneumatically Placed Concrete Riprap shall be specified on the plans as either Type I or Type II in accordance with the Item, "Pneumatically Placed Concrete".

Immediately following the finishing operation, the riprap shall be cured with membrane curing compound in accordance with the Item, "Concrete Structures".

432.11. Concrete Riprap, Type M and Type N. These classes of riprap shall conform to the requirements of the plans and to the regular concrete riprap specified in Article 432.9. above, with the following exceptions:

The aggregate for this riprap shall be the processed material used on the roadway as flexible base. The processed material and design of the concrete shall be specified by the Engineer.

Any royalty costs for the material to be used as aggregate shall be included in the unit price bid for riprap.

Type M riprap shall be 4 sack concrete.

Type N riprap shall be 3 sack concrete.

Immediately following the finishing operation, the riprap shall be cured in accordance with the Item, "Concrete Structures".

432.12. Stone Riprap for Foundation Protection. Stone for foundation protection shall range in weight up to 300 pounds each, unless otherwise specified or shown on the plans, and shall be graded and so placed as to produce a minimum of voids. The top 6 inches shall be of graded smaller stones and shall be grouted, the grout and grouting to be in conformity with the requirements and methods outlined for Grouted Riprap, Type A and Type B.

432.13. Measurement. Measurement of acceptable riprap complete in place will be made on the basis of the area actually covered, and the volume will be computed on the basis of the measured area and the thickness specified on the plans.

Concrete in toe walls will be measured as riprap of the type with which it is placed.

432.14. Payment. The riprap quantities, measured as provided above, will be paid for at the unit prices bid per cubic yard for riprap of the various classifications shown, which price will be full compensation for furnishing, hauling, and placing all materials including reinforcement and premolded

expansion joint material, and for all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for excavation of toe wall trenches and for all necessary excavation below natural ground or bottom of excavated channel will be included in the unit price bid per cubic yard of riprap.

Payment for excavation required for shaping of slopes for riprap shall be included in the unit price bid per cubic yard for riprap, except that when the header banks upon which the riprap is to be placed are built by prior contract, excavation for shaping of slopes will be paid for in accordance with the Item, "Structural Excavation", or the Item, "Roadway Excavation".

ITEM 434

SLIDING ELASTOMERIC BEARINGS

434.1. Description. This item shall govern for the furnishing and installation of sliding elastomeric bearings in accordance with the details shown on the plans and the requirements of these specifications. These bearings consist of a steel plate with a stainless steel facing bearing on a preformed fabric pad to which is bonded a layer of PTFE material.

434.2. Materials. Steel plates shall be ASTM Designation: A 36, finished to ASA #500 or better on the innerface. Stainless steel sheet shall be Type 304 conforming to ASTM Designation: A 240. The thickness shall not be less than 20 gauge (0.0375 inch nominal). Alternately the steel plate and stainless facing may be Type 304 stainless clad A 36 steel subject to the weldability requirements above. The thickness of cladding shall be no less than 20 gauge (0.375 inch nominal). Whether faced or clad, the finished stainless surface shall be flat to a tolerance of one thirty-second of an inch and shall be polished sufficiently to meet the friction requirements of this item.

Preformed fabric pads shall be manufactured of all new (unused) materials and composed of multiple layers of prestressed cotton duck, 64 plies per inch of finished pad thickness, impregnated and bound with a high quality rubber compound, containing rot and mildew inhibitors and antioxidants, compounded into resilient pads of uniform thickness. The Shore Durometer hardness of the pad shall be not less than 85 nor more than 95. Pads without the PTFE layer shall be capable of withstanding 10,000 psi compressive stress without breakdown. A tolerance of plus or minus five percent will be allowed from the pad thickness shown on the plans.

The PTFE materials shall be pure virgin polytetrafluoroethylene fluorocarbon resin, unfilled, or with a suitable inert filler and/or reinforcement to minimize the cold flow tendencies while maintaining the friction properties of the PTFE fluorocarbon resin. The amount of filler by weight of filled PTFE sheet shall be no less than 10 percent nor more than 35

percent. The finished materials shall exhibit the following physical properties:

Requirement	Test Method	Filled Value	Unfilled Value
Hardness at 78 F	ASTM D 2240, Shore "D"	50-60	50-65
Tensile Strength psi	ASTM D 1457	2,000 min	2,800 min
Elongation, Percent	ASTM D 1457	150 min	200 min
Deformation Under Load Percent—73.4 F-2,000 psi	ASTM D 621, Method A	10 max	15 max
Specific Gravity	ASTM D 1457	2.16 min	2.14 min

The thickness of the finished PTFE sheet shall not be less than one thirty-second of an inch nor more than one-eighth of an inch.

434.3. Manufacturing Processes. The stainless steel sheet shall be attached to the steel plate by epoxy bonding. Extreme care shall be exercised in the preparation of the contact surfaces and control of the bonding operation. The bonding agent shall be a high temperature epoxy meeting the following requirements, or a proven equal:

Requirement	Test Method	Minimum Value
Tensile Strength	ASTM D 638	3,200 psi
Flexural Modulus	ASTM D 790	2×10^4 psi
Safe Operating Temperature		−60 C to 145 C
Linear Expansion Coefficient	ASTM D 696	4.8×10^{-5}
Bond Strength (Tensile Shear 77 F)	ASTM D 1002	1,000 psi

In addition to bonding, the corners of the stainless sheets, and the edges if necessary, shall be secured to the plate with positive mechanical means such as studs, rivets or metal screws, capable of resisting, in shear, .04 times the vertical load capacity of the bearing without interfering with the sliding surface.

Alternatively, if the stainless steel sheet is 16 gauge (0.0625 inch nominal) or greater in thickness it may be secured to the plate by continuous fillet welding all around the edges.

The PTFE material shall be bonded to the preformed fabric pad with extreme care using high temperature bonding agents proven adequate for the purpose. If unfilled PTFE is used the material shall be bonded through a confining substrate which will effectively limit the flow elongation of the PTFE material.

434.4. Testing and Acceptance. One extra bearing of each size (horizontal dimensions) but not less than two nor more than four extra bearings from each project shall be manufactured for testing purposes. As soon as all bearings have been manufactured for a given project, notification shall be given to the Materials and Tests Engineer, 38th and Jackson Streets,

Austin, Texas 78703, who will select the above prescribed test bearings at random from the lot. Testing performed by the Department will be in accordance with procedures published in the Manual of Testing Procedures and/or other applicable test procedures. Manufacturer's certification that the steel, preformed fabric and PTFE material meet the requirements given under "Materials", above, shall be furnished along with notification of fabrication completion.

Test bearings will be cut if necessary to provide load specimens.

Load specimens will consist of a bottom pad at least 4 by 4 inches, but preferably the length of the actual pad in the direction parallel to the girder and at least 4 inches wide with a compatible size of top plate. This specimen will be loaded with 1,000 psi compression and subjected to 100 slow cycles of 1 inch horizontal movement each way from center. The average coefficient of friction shall be .08 or less and the bearing shall show no appreciable signs of bond failure or other defect.

If deemed necessary by the Engineer, check tests will be performed on the steel, preformed fabric pads or PTFE material to verify the properties required under "Materials" and certified by the manufacturer.

Bearings represented by test specimens passing the above requirements will be approved for use in the structure subject to on-site inspection by the Engineer for visible defects.

434.5. Measurement. Sliding elastomeric bearings will be measured by each sliding elastomeric bearing of the type shown on the plans. Unless otherwise shown on the plans, this will include the stainless steel faced plate and the PTFE faced preformed fabric pad, and will include the sole plates and anchor bolts required to connect the bearing between superstructure and substructure.

434.6. Payment. Payment for sliding elastomeric bearings, measured as specified above will be at the unit price bid for each "Sliding Elastomeric Bearing" of the type specified. This price shall be full compensation for all materials, tools, equipment, labor, and for all incidentals necessary to complete the work.

ITEM 435

ELASTOMERIC MATERIALS

435.1. Description. This item shall govern for the materials, testing, fabrication and placement of elastomeric materials, except as otherwise covered in other specifications or on the plans.

435.2. Materials.

(1) Elastomeric Bearings. When specified on the plans, structural members shall be seated on elastomeric bearings.

These bearings may be either "plain" (consisting of elastomer only) or "Laminated" (consisting of alternating individual layers of elastomer and

non-elastic laminates) as shown on the plans. Elastomeric bearings shall be specified on the plans by hardness (durometer), size and configuration and, in the case of laminated bearings, by the thickness of the individual layers of elastomer and the size and position of special connection members, if any, required to be vulcanized with the bearing.

(a) General. Unless otherwise shown on the plans, the elastomer for bearings shall be formulated from previously unvulcanized 100 percent virgin polychloroprene or 100 percent virgin polyisoprene rubber polymers. Rubber-like polymers employed in the elastomer formulation shall be exclusively of the polychloroprene or natural polyisoprene type. Bearings will not be acceptable if the elastomer employed contains previously vulcanized rubber (natural or synthetic) or other synthetic rubber-like polymers.

Non-elastic laminates shall be one-sixteenth of an inch (−0 inch, + 1/16 inch) thick steel strip or sheet. Metal for special connections shall conform to ASTM Designation: A 36, unless otherwise shown on the plans.

(b) Physical Properties of the Elastomer. Elastomer formulated from polychloroprene shall meet the requirements shown in Table A. Elastomer formulated from polyisoprene shall meet the requirements of Table B. Material tests shall be made in accordance with the test methods stipulated except that all tests shall be made on the finished product and standard laboratory test slabs will not be utilized for this purpose. The values shown in Tables A and B pertain to tests performed on samples taken from the finished product. The apparatus employed in preparing test specimens from the finished product shall be in accordance with ASTM Designation: D 15, as pertains to "Sample Preparation for Physical Testing of Rubber Products".

Compression set test specimens shall be taken from the finished product. In bearing thicknesses exceeding one half of an inch or elastomer layers in laminated bearings exceeding one half of an inch, the full thickness of the bearing or elastomer layer shall be utilized. The 25 percent compression shall be employed and obtained through the utilization of appropriate thickness of spacer bars and/or shims. Beveled or wedge shaped bearings of elastomer layers in laminated bearings shall have the compression set specimens selected from sections of the bearings or layers which have been properly cut or ground so that the top and bottom surfaces of the circular compression set specimens will have essentially parallel surfaces. The maximum permissible thickness of such bearings or layers, after rendering the upper and lower surfaces parallel, will be used as a source for the cutting of the cylindrical test specimens employed in the compression set test in accordance with ASTM Designation: D 395, as modified herein.

(c) Formulation Pre-Qualification and Certification. All bearings furnished by the Contractor shall be produced by a bearing manufacturer who has previously submitted the required pre-qualification test samples and certifications and whose elastomer formulation has been initially approved for use by the Engineer. Each elastomer formulation produced by a manufacturer must be approved by the Engineer prior to its first use on Department projects. To pre-qualify and obtain initial approval of a particular

formulation, the bearing manufacturer shall submit to the Engineer, well in advance of anticipated use of his product, certified test results showing actual test values obtained when the physical properties of the elastomer to be furnished were tested for compliance with the pertinent specifications.

In addition, the manufacturer shall forward pre-qualification test samples, freight prepaid, to the Texas Highway Department, Materials and Tests Division, 38th and Jackson Streets, Austin, Texas 78703, for testing and evaluation of compliance with pre-qualification requirements. These pre-qualification samples shall consist of at least two finished bearings typical of the formulation and workmanship intended for use on Departmental projects. When both laminated and plain bearings are required, two samples of each type shall be submitted. Plain sample bearings shall measure 9 inches x 19 inches by 1 inch, 70 Durometer; laminated sample bearings shall be 9 inches x 14 inches x 1½ inches, 60 Durometer, with two steel laminates of commercial grade steel 1/8 inch in thickness. Only elastomer of the type or types to be supplied shall be submitted, (polychloroprene, polyisoprene).

The bearing manufacturer shall certify that all of the samples submitted are of the same basic elastomer formulation and of equivalent cure to that used in the finished products to be furnished on Department projects.

The Producer may be required to perform the complete pre-qualification testing procedure again during later production should the Engineer feel such action appropriate.

(d) Manufacturing Requirements. All components of a "laminated" bearing shall be molded together to form an integral unit free of voids or separations in the elastomer or between the elastomer and the non-elastic laminates or special connections unless specifically required or permitted by the plans or these specifications. The elastomer between the laminates or special connections and on the outer surfaces of the bearing shall be well-vulcanized, uniform and integral such that it is incapable of being separated by any mechanical means into separate, definite, well-defined elastomeric layers. Evidence of this layered construction, either at the outer surfaces or within the bearing, shall be cause for rejection of such laminated bearing shipments.

All edges of non-elastic laminates shall be covered by a minimum of one eighth of an inch of elastomer except that exposure of the laminates will be permitted at approved laminate restraining devices and around holes that will be entirely enclosed in the finished structure. Unless otherwise shown on the plans, all laminates shall be parallel with the bottom surface of the bearing, subject to the tolerances that follow.

Plain bearings may be molded individually, cut from previously molded strips or slabs molded to the full thickness of the finished bearings, or extruded and cut to length. The finished bearings shall have no voids or separations detectable either at the bearing surfaces or within the bearing unless specifically required or permitted by the plans or this specification. Plain elastomeric bearings shall be well-vulcanized, uniform and integral units of such construction that the bearing is incapable of being separated by any mechanical means into separate, definite and well-defined elastomeric layers.

Evidence of layered construction either at the outer surfaces or within the bearing shall be cause for rejection of such bearing shipments.

TABLE A

Interpolate Between Values Shown for Other Hardness Values

Hardness (Durometer)	50	60	70	80	90
ORIGINAL PHYSICAL PROPERTIES					
Hardness ASTM D 2240, Ty A Durometer	50 ±5	60 ±5	70 ±5	80 ±5	90 ±5
Tensile Strength, minimum psi ASTM D 412	2250	2250	2250	1800	1800
Elongation at Break, minimum percent	405	360	270	135	90
ACCELERATED TESTS TO DETERMINE LONG-TERM AGING CHARACTERISTICS OVEN AGED–70 HR AT 212 F ASTM D 573					
Hardness, points change, maximum	0 to +15	0 to +15	0 to +15	0 to +15	0 to +15
Tensile Strength, % change maximum	-15	-15	-15	-15	-15
Elongation at Break, % change maximum	-40	-40	-40	-40	-40
OZONE: 100 PPHM IN AIR BY VOLUME 20% STRAIN AT 100 ±2 F–ASTM D 1149* 100 Hours	No Cracks	No Cracks	No Cracks	No Cracks	No Cracks
COMPRESSION SET–22 HR AT 158 F ASTM D 395 (Method B)** % Maximum	25	25	25	25	25
LOW TEMPERATURE RESISTANCE ASTM D 746, PROCEDURE B Brittleness, at -26 C	No Failure	No Failure	No Failure	No Failure	No Failure
ADHESION (PREQUALIFICATION ONLY) For laminated bearings, bond between the elastomer and laminates will be qualitatively evaluated by the procedure outlined in the THD Manual of Testing Procedures, Test Method Tex-601-J.					

* Samples to be solvent wiped before test to remove traces of surface impurities.

** Modified in that test is performed on specimens of essentially full bearing or layer thickness with the 25 percent compression obtained through the use of appropriate spacer bars and/or shims.

TABLE B

Interpolate Between Values Shown for Other Hardness Values

Hardness (Durometer)	50	60	70	80	90
ORIGINAL PHYSICAL PROPERTIES					
Hardness ASTM D 2240, Ty A Durometer	50 ±5	60 ±5	70 ±5	80 ±5	90 ±5
Tensile Strength, minimum psi ASTM D 412	2250	2250	2250	1800	1800
Elongation at Break, minimum percent	405	360	270	135	90
ACCELERATED TESTS TO DETERMINE LONG-TERM AGING CHARACTERISTICS OVEN AGED–70 HR AT 158 F ASTM D 573					
Hardness, points change, maximum	0 to +10	0 to +10	0 to +10	0 to +10	0 to +10
Tensile Strength, % change, maximum	-25	-25	-25	-25	-25
Elongation at Break, % change maximum	-25	-25	-25	-25	-25
OZONE: 25 PPHM in AIR BY VOLUME 20% STRAIN AT 100 ±2 F–ASTM D 1149* 48 Hours	No Cracks	No Cracks	No Cracks	No Cracks	No Cracks
COMPRESSION SET–22 HR AT 158 F ASTM D 395 (Method B)** % Maximum	25	25	25	25	25
LOW TEMPERATURE RESISTANCE ASTM D 746, PROCEDURE B Brittleness, at -26 C	No Failure	No Failure	No Failure	No Failure	No Failure
ADHESION (PREQUALIFICATION ONLY)					
For laminated bearings, bond between the elastomer and laminates will be qualitatively evaluated by the procedure outlined in the THD Manual of Testing Procedures, Test Method Tex-601-J.					

* Samples to be solvent wiped before test to remove traces of surface impurities.

** Modified in that test is performed on specimens of essentially full bearing or layer thickness with the 25 percent compression obtained through the use of appropriate spacer bars and/or shims.

The finish of cut surfaces shall be ANSI Number 250, or smoother. The batch or lot number and the dimensions or piece mark shall be marked on each bearing and they shall remain legible until placement in the structure.

(e) Appearance and Dimensions. Flash tolerance, finish and appearance shall meet the requirements of the latest edition of the Rubber Handbook as published by the Rubber Manufacturers Association, Inc.; RMA-F3-T.063 for molded bearings and RMA-F2 for extruded bearings.

For both plain and laminated bearings the permissible variation from the dimensions and configuration required by the plans and these specifications shall be as follows:

1. Overall Vertical Dimensions
   Average Total Thickness 1¼" or less ..... -0,+1/8"
   Average Total Thickness Over 1¼" ..... -0,+1/4"
2. Overall Horizontal Dimensions ..... -0,+1/4"
3. Thickness of Individual Layers of
   Elastomer (Laminated Bearings Only) ..... ±1/8"

4. Variation from a Plane Parallel to the Theoretical Surface
   - Top ..... 1/8"
   - Sides ..... 1/4"
   - Individual Non-Elastic Laminates ..... 1/8"
   - (As determined by measurements at the edges of the bearing)
5. Position of Exposed Connection Members ..... 1/8"
6. Edge Cover of Embedded Laminates or Connection Members ..... -0,+1/8"
7. Size of Holes, Slots or Inserts ..... -0,+1/8"
8. Position of Holes, Slots or Inserts ..... -0,+1/8"
9. Thickness of Non-Elastic Laminates ..... -0,+1/16"

(f) Routine Inspection, Sampling and Testing. After pre-qualification approval, the inspection, sampling and testing of actual bearing production will be as outlined below:

Plain Bearings. A minimum of one plain bearing will be taken by a representative of the Materials and Tests Division from each project or from each batch or lot in case the same batch or lot is used for more than one project. Routine tests for compliance with the requirements of Table A or Table B, whichever is applicable, will be performed by the Materials and Tests Division of the Texas Highway Department. Samples will not be returned.

Laminated Bearings. Each laminated bearing shall be subjected, by the manufacturer, to an average compression of 1,000 psi or to lower average compression if so indicated in the plans or approved by the Engineer. This compression test will be performed in the presence of a representative of the Materials and Tests Division who will perform visual inspection and accept or reject the bearings at that time. The performance of each bearing will be considered satisfactory provided there is no visible evidence of bond failure or other damage to the bearing because of this loading and provided the finished bearing meets all other pertinent portions of this specification. Samples of laminated bearings may be taken if the quality of the plant production becomes questionable. If samples are taken, they shall be taken and tested as outlined for plain bearings.

The manufacturer shall furnish certified laboratory test results on the elastomer properties of each batch or lot of compound used in the manufacture of bearings, both plain and laminated.

(2) Waterstops. Waterstops shall be furnished and installed in accordance with the details shown on the plans. Except where otherwise indicated on the plans, waterstops may be manufactured from either natural (plain) or synthetic rubber or from polyvinyl chloride (PVC) as specified below:

(a) Materials.

1. Natural (plain) rubber waterstops shall be manufactured

from a stock composed of a high-grade compound made exclusively from new plantation rubber, reinforcing carbon black, zinc oxide, accelerators, anti-oxidants and softeners. This compound shall contain not less than 72 percent by volume of new plantation rubber.

2. Synthetic rubber waterstops shall be manufactured from a compound made exclusively from neoprene or GRS, reinforcing carbon black, zinc oxide, polymerization agents and softeners. This compound shall contain not less than 70 percent by volume of neoprene or GRS.

3. Physical properties of natural or synthetic rubbers for waterstops shall be as shown in Table C below:

	Natural (Plain) Rubber	Synthetic (Neoprene GRS) Rubber
Original Physical Properties:		
Hardness–ASTM D 676 (Durometer)	60±5	55±5
Tensile Strength, Minimum psi–ASTM D 412	3500	2500
Elongation at Break, Minimum percent	550	425
Accelerated Tests to Determine Aging Characteristics:		
either–after 7 days in air at 158 (±2)F (ASTM D 573)		
or –after 48 hours in oxygen (ASTM D 572) at 158 (±2)F and 300 psi pressure Tensile Strength, % change, Maximum	35	35
Elongation, % change, Maximum	35	--

Table C
Physical Properties for Rubber for Waterstops

4. Polyvinyl Chloride (PVC). Unless otherwise specified on the plans, the material shall conform to the Corps of Engineers Specification Number, CRD-C-572-60.

(b) Manufacturer's Certification. The manufacturer shall furnish certified test results, indicating compliance with this specification, for each batch or lot of waterstop furnished under this contract. In case of doubt of the quality furnished, the burden of proof shall be on the manufacturer, and the decision of the Engineer shall be final.

(c) Manufacturing Requirements.

1. Rubber Waterstops. Waterstops shall be manufactured with an integral cross section which shall be uniform within plus or minus one eighth of an inch in width, and the web thickness or bulb diameter, within plus one sixteenth and minus one thirty second of an inch. No splices will be

permitted in straight strips. Strips and special connection pieces shall be well cured so that any cross sections shall be dense, homogeneous and free from all porosity. All junctions in the special connection pieces shall be full-molded. During the vulcanizing period the joint shall be securely held by suitable clamps.

2. **PVC Waterstops.** Requirements shall be as in 1. above for rubber waterstops except that splicing of PVC shall be done by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not to char the plastic.

(3) Elastomeric Pads. When so specified on the plans, rail posts, rail members, metal shoes or minor structural members shall be insulated, leveled, shimmed or otherwise protected by elastomeric pads, sheets or washers.

Such bearings may be any elastomeric material, plain, fibered or laminated, having a hardness (durometer) between 70 and 100 as certified by the manufacturer to the Engineer.

Acceptance testing will not be required.

(4) Other Elastomeric Products. Other elastomeric products shall be in accordance with the requirements on the plans.

435.3. Construction Methods.

(1) Elastomeric Bearings. Unless otherwise shown on the plans, concrete bearing seats shall be float finished to the required elevation. Variation from a level plane shall not exceed one sixteenth of an inch within the limits of the bearing.

After erection of members on steel structures only, the horizontal distortion of the bearings shall be measured, corrected for temperature and adjusted, if necessary, so that the horizontal displacement between top and bottom of bearing at 70 F does not exceed 15 percent of the elastomer thickness.

Welding in the vicinity of the bearings shall be done with care to avoid injury to the elastomer.

(2) Waterstops. Field splices shall be either vulcanized; mechanical, using stainless steel parts; or made with a rubber splicing union of the same stock as the waterstop, at the option of the Contractor. All finished splices shall have a tensile strength not less than 50 percent of the unspliced material.

435.4. Measurement. Unless otherwise specified on the plans, elastomeric bearings used with prestressed concrete units, and other miscellaneous elastomeric materials will not be measured for payment but will be considered subsidiary to the various pertinent bid items in the contract.

Unless otherwise specified on the plans, elastomeric bearings used in conjunction with steel superstructures will be measured by each elastomeric bearing of the type shown on the plans.

435.5. Payment. Payment for elastomeric bearings, measured as specified above, will be at the unit price bid for each "Elastomeric Bearing" of the type specified. This price shall be full compensation for all materials, tools, equipment, labor, and for all incidentals, including anchor bolts and top plates, necessary to complete the work.

ITEM 436

PREFORMED JOINT SEAL

436.1. Description. This item shall govern for the furnishing and installation of preformed materials, designated on the plans as PJS, to be placed in armored bridge deck joints for the purpose of preventing the passage of water and other materials through the joint.

436.2. Materials. The joint seal shall be an extruded, multi-channeled, elastomeric shape conforming to ASTM Designation: D 2628, modified in accordance with Test Method Tex-613-J, and the requirements of this Item. The size shown on the plans shall be the nominal width of the seal. The actual width of the seal shall not be less than the nominal width. The uncompressed depth of the seal shall be equal to or greater than the width. In addition to the tests prescribed by ASTM Designation: D 2628, the seal shall be subjected to further testing as required.

Unless otherwise shown on the plans, and when tested in accordance with Test Method Tex-613-J, the pressure measured shall be no less than 3 psi at 85 percent, nor more than 100 psi at 50 percent of the nominal width. The configuration of the seal shall be such that there is no outward deflection of the top of the seal and the sides remain in essentially complete contact with the joint faces during the full range of movement.

Lubricant-adhesive may be a one component compound containing only polychloroprene and soluble phenolic resins blended together with anti-oxidants and acid acceptors in an aromatic hydrocarbon solvent mixture and shall have the following physical properties:

Average net weight per gallon	7.84 pounds ±5 percent
Solids content	24-26 percent by weight

Brookfield Viscosity at 77 F, No. 2 Spindle at 10 RPM - 7000-7500 cps
The adhesive shall remain fluid from 5 F to 120 F
Film strength (ASTM D 412) - 2300 psi min tensile strength
- 750% min elongation at break

or may be a one part moisture curing polyurethane and hydrocarbon solvent mixture with the following physical properties:

Average net weight per gallon	8.00 pounds ±10 percent
Solids content	65 - 74 percent by weight
Adhesive to remain fluid from	5 F to 120 F
Film strength (ASTM D 412)	1200 psi
Elongation	350 percent

The Manufacturer shall furnish certification as to the compliance with these physical requirements.

436.3. Pre-qualification. All joint seals installed by the Contractor shall have been pre-qualified for compliance with the requirements of these specifications. Each size and configuration of seal produced by a manufacturer must be approved by the Engineer prior to use on Department projects. For a seal manufacturer to pre-qualify and obtain approval of a seal, he shall submit to the Engineer well in advance of anticipated use of his product, detailed dimensions and configuration of each size of seal and certified test results indicating actual test results in compliance with ASTM Designation: D 2628, and the further requirements of the plans and specifications.

In addition, the manufacturer shall forward pre-qualification test samples, freight prepaid, to the Materials and Tests Engineer, 38th and Jackson Streets, Austin, Texas 78703. Samples shall consist of at least six feet of each size and configuration for which approval is requested.

436.4. Inspection and Testing. After pre-qualification approval, the Engineer shall confirm by visual inspection that the seal proposed for installation is the same size, configuration and manufacture as pre-qualified. In addition, the Engineer shall examine the seal for any undue distortions such as dissymmetry, warping, thick webs or uneven width which are likely to impair the performance of the joint. If the magnitude of the distortions are sufficient to create doubt as to the performance of the seal, the Engineer may direct that the seal be replaced or that samples representing the worst of the lot be subjected to further testing to verify their performance.

In addition, at least one seal of each size furnished for a given project shall be furnished with a minimum of 3 feet extra length. These extra lengths shall be removed at the job site and forwarded to the Materials and Tests Division for confirmation of the physical properties of the elastomer and such other check tests as may be necessary.

436.5. Construction Requirements. Just prior to placing the seal, the joint faces shall be cleaned by abrasive blast and blown out with high pressure air to remove all foreign material and residue. The sides of the seal shall be cleaned with xylol solvent. Lubricant adhesive shall be applied to the joint faces and sides of the seal immediately prior to installing the seal. The seal may be installed with the aid of special compression tools but in no case shall the seal be stretched longitudinally more than 2 percent to aid in installation.

The seal shall be delivered to the job in one continuous length for the full joint, including vertical and horizontal angle changes. One shop splice for each 40 feet of length will be permitted. Failure of a splice will be cause for rejection of the seal. The word "TOP" shall be printed on each seal at intervals not exceeding 25 feet. The back half of the seal may be removed locally by cutting to smooth lines and rounded corners to facilitate vertical bending. In no case shall the top of the seal, after installation, be closer than one half of an inch to the roadway surface.

Uniform joint openings of the proper width and with parallel joint faces shall be provided. Joint openings shall be adjusted for the difference between 70 F and the temperature of the superstructure at the time the opening is set. The amount of adjustment shall be approximately one sixteenth of an inch per 10 F temperature difference per 90 feet of length expanding through the

joint. Adjustments in joint opening shall not be made for reasons other than temperature at setting.

436.6. Measurement. For each size of seal specified, measurement will be made by the linear foot, along the centerline of the joint and at the surface of the roadway, curb, sidewalk and up the roadway surface of required parapet type rail walls to the end of the seal as indicated on the plans.

When field measurement is required by Article 436.7. measurement will be made in place as prescribed above. If no adjustment is required under Article 436.7. no additional measurement or calculations will be made.

In the event of a change in design which either increases or decreases the quantity of seal the variation in quantity will be measured as prescribed above and the quantity shown on the plans and in the proposal will be increased or decreased as the case may be.

436.7. Payment. The quantity to be paid for will be that quantity shown on the contract plans and in the proposal, except as may be modified by the following:

Either party to the contract may request an adjustment of the quantities shown on the contract plan (by each separate bid item), if the quantities, measured as outlined in Article 436.6. vary from those shown on the contract plans by more than 5 percent.

The party to the contract which requests an adjustment shall present to the other, three copies of field measurements and calculations showing the revised lengths for the structure or structures in question. These revised lengths of seal, when proven correct, together with all other seal under the same bid item, shall constitute the final quantity for which payment will be made.

Payment for revised quantities due to a change in design will be paid for at the unit price bid per linear foot measured as provided in Article 436.6.

Adjustments of quantities will be subject to the provisions of Article 4.3.

Payment for preformed joint seal, measured as specified under Article 436.6. shall be full compensation for all materials, (including lubricant-sealer), tools, equipment, labor, and for all incidentals necessary to complete the work.

ITEM 437
CONCRETE ADMIXTURES

437.1. Description. This item shall govern the materials used, methods of tests, and construction methods for the use of admixtures in concrete.

437.2. General.

An "air-entraining admixture" is defined as a material which, when added to a concrete mixture in the correct quantity, will entrain uniformly dispersed microscopic air.

A "water-reducing, retarding admixture" is defined as a material which, when added to a concrete mixture in the correct quantity, will reduce the quantity of mixing water required to produce concrete of a given consistency and will retard the initial set of the concrete.

A "water-reducing admixture" is defined as a material which, when added to a concrete mixture in the correct quantity, will reduce the quantity of mixing water required to produce concrete of a given consistency.

437.3. Retarding and Water Reducing Admixtures. The admixture shall meet the requirements for Type A or Type D admixture as specified in ASTM Designation: C 494, modified as follows:

(1) The water-reducing retarder shall retard the initial set of the concrete a minimum of 2 hours and a maximum of 4 hours, at a specified dosage rate, at a temperature of 90 F.

(2) The cement used in any series of tests shall be either the cement proposed for specific work or a "reference" Type I cement from one mill.

(3) Unless otherwise noted on the plans, the minimum relative durability factor shall be 80.

The air entraining admixture used in the reference and test concrete shall be neutralized Vinsol resin.

437.4. Air Entraining Admixture. The admixture shall meet the requirements of ASTM Designation: C 260 modified as follows:

(1) The cement used in any series of tests shall be either the cement proposed for specific work or a "reference" Type I cement from one mill.

(2) Unless otherwise noted on the plans, the minimum relative durability factor shall be 80.

The air entraining admixture used in the reference concrete shall be neutralized Vinsol resin.

437.5. Approval of Admixtures. The manufacturer shall certify that the material to be furnished meets the requirements of this Item, and of ASTM Designation: C 260 or C 494, as modified herein, and shall furnish test reports from an approved laboratory, as defined by the Item, "Definition of Terms", having prior approval of the Materials and Tests Engineer. At the time of original request for approval of admixture, the manufacturer shall state in writing the chloride content of the admixture. No admixture to which chlorides have been added during manufacture will be permitted to be used.

In addition to the above, the manufacturer shall furnish the following:

(1) At the time of original request for approval of the admixture, the manufacturer shall supply a five gallon sample of the material to the Materials and Tests Division, Austin, Texas, 78703.

(2) Each six months after approval of the material, the manufacturer shall furnish a notarized certification indicating that the material originally

approved has not been changed or altered in any way. Any change in formulation of an admixture shall require retesting, and shall be approved by Materials and Tests Engineer prior to use.

The Engineer may request additional information to be submitted such as infrared spectophotometry scan, solids content, pH value, etc., for further identification. A change in formulation discovered by any of the tests prescribed herein, or other means, and not reported and retested, may be cause to permanently bar the manufacturer from furnishing admixtures for Texas Highway Department work.

A list of pretested and approved admixtures will be maintained by the Materials and Tests Engineer. This list shall specify the approved dosage rate to be used except as modified under Article 437.6.

The Department reserves the right to perform any or all of the tests required by ASTM Designations: C 260 and C 494 as a check on the tests reported by the manufacturer. In case of any variance the Departmental tests will govern.

437.6. Construction Use of Admixtures. When used in construction in conformance with the basic reference specifications and this specification, the Contractor will be allowed to use any admixture which has been approved. The Contractor shall submit to the Engineer three copies of the invoice showing the admixture or admixtures to be used on the project. Prior to using an admixture in the work, trial mixes shall be made and tested in the field using the materials and equipment to be used on the project.

Mix designs from previous or concurrent jobs may be used without trial batches if it is shown that no substantial change in any of the proposed ingredients has been made.

For air entraining admixtures the dosage shown on the approved list is the dosage utilized in approval test of the admixture. This dosage *must* be adjusted as necessary to produce the required air content in the concrete within the specified tolerances.

The normal dosage rate for retarding and water reducing admixtures will be as specified on the approved list. For extended retardation the dosage rate will be established from trial mixes. An approved retarding admixture (for normal hot weather concreting) may not perform satisfactorily for extended retardation, in which case its use will not be permitted.

All admixtures used shall be in the liquid state and shall be dispensed with the mixing water into the concrete. No admixture shall be dispensed onto dry aggregates. Each admixture shall be dispensed separately.

Normally air entraining agents shall be charged into the mixer at the beginning of the batch and retarding or water reducing admixtures shall be charged into the mixer during the last part (approx. 1/3) of the batch when an air entraining agent is used.

For individual placements of concrete of 25 cubic yards or more and for all Ready-Mix concrete, the admixture shall be measured and dispensed by a readily adjustable dispenser. When set to a predetermined volume the dispenser shall fill to the preset amount and hold it positively without leakage

until the operator releases the content into the mixing water, by some positive means. Unless otherwise shown on the plans, completely automatic dispensing will not be required, except for use with a fully automatic plant.

The calibrated container shall be a measuring reservoir of the type where the level of the admixture is visible at all times. A strip gauge with one ounce increments for air-entraining admixtures, ten ounce increments for dispersing admixtures, shall be attached securely to the measuring apparatus. This strip shall be a material possessing weather-resistant qualities. The accuracy required for these systems shall be plus or minus three percent. The equipment shall visibly show the total amount to be dispensed for ready check by the Engineer.

For contract work, with individual placements of less than 25 cubic yards and with the concrete batched on the job site, the Engineer may waive the requirements for mechanical dispensing equipment.

Admixtures shall be agitated as required to prevent separation or sedimentation of solids. Air agitation of neutralized Vinsol resin will not be permitted.

When deemed necessary by the Engineer, the Contractor shall furnish additional quantities of the admixture being used for further testing. Further use of the admixture will not be allowed until the results of such tests are known and the material meets the requirements of this item.

437.7. Measurement and Payment. No additional compensation will be made for the materials, equipment or methods required by this item, but shall be considered subsidiary to the various items included in the contract.

ITEM 440

REINFORCING STEEL

440.1. Description. This item shall govern for the furnishing and placing of reinforcing steel, deformed and smooth, of the size and quantity designated on the plans and in accordance with these specifications.

440.2. Materials. Unless otherwise designated on the plans, all bar reinforcement shall be deformed, and shall conform to ASTM Designation: A 615, Grades 40, 60 or 75, and shall be open hearth, basic oxygen, or electric furnace new billet steel.

Large diameter new billet steel (Nos. 14 and 18), Grade 75, will be permitted for straight bars only.

Where bending of bar sizes No. 14 or No. 18 of Grades 40 or 60 is required, bend testing shall be performed on representative specimens as described for smaller bars in the applicable ASTM Specification. The required bend shall be 90 degrees around a pin having a diameter of 10 times the nominal diameter of the bar.

Spiral reinforcement shall be smooth (not deformed) bars or wire of the minimum diameter shown on the plans, and shall be made by one or more of the following processes: open hearth, basic oxygen, or electric furnace. Bars

shall be rolled from billets reduced from ingots and shall comply with ASTM Designation: A 306, Grade 65 minimum (Reference to ASTM Designation: A 29 is voided. Dimensional tolerances shall be in accordance with ASTM Designation: A 615), or ASTM Designation: A 615, Grade 40 or 60, except for deformations. Wire shall be cold-drawn from rods that have been hot-rolled from billets and shall comply with ASTM Designation: A 82.

Wire for fabric reinforcement shall be cold-drawn from rods hot-rolled from open hearth, basic oxygen, or electric furnace billets. Wire shall conform to the requirements of the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement, ASTM Designation: A 82. Wire fabric, when used as reinforcement, shall conform to ASTM Designation: A 185.

In cases where the provisions of this item are in conflict with the provisions of the ASTM Designation to which reference is made, the provisions of this item shall govern.

Report of chemical analysis, showing the percentages of carbon, manganese, phosphorus and sulphur will be required for all reinforcing steel, when it is to be welded.

The nominal size and area and the theoretical weight of reinforcing steel bars covered by this specification are as follows:

Bar Size Number	Nominal Diameter In.	Nominal Area Sq. In.	Weight Per Linear Foot
2	0.250	0.05	0.167
3	0.375	0.11	0.376
4	0.500	0.20	0.668
5	0.625	0.31	1.043
6	0.750	0.44	1.502
7	0.875	0.60	2.044
8	1.000	0.79	2.670
9	1.128	1.00	3.400
10	1.270	1.27	4.303
11	1.410	1.56	5.313
14	1.693	2.25	7.65
18	2.257	4.00	13.60

Smooth round bars shall be designated by size number through No. 4. Smooth bars above No. 4 shall be designated by diameter in inches.

When wire is ordered by gauge numbers, the following relation between number and diameter, in inches, shall apply unless otherwise specified:

Gauge Number	Equivalent Diameter Inches	Gauge Number	Equivalent Diameter Inches
0	0.3065	8	0.1620
1	0.2830	9	0.1483
2	0.2625	10	0.1350
3	0.2437	11	0.1205
4	0.2253	12	0.1055
5	0.2070	13	0.0915
6	0.1920	14	0.0800
7	0.1770		

440.3. Bending. The reinforcement shall be bent cold, true to the shapes indicated on the plans. Bending shall preferably be done in the shop. Irregularities in bending shall be cause for rejection.

Unless otherwise shown on the plans, the inside diameter of bar bends, in terms of the nominal bar diameter (d), shall be as follows:

Bends of 90° and greater in stirrups, ties and other secondary bars that enclose another bar in the bend.

	Grade 40	Grade 60
#3, #4, #5	3d	4d
#6, #7, #8	4d	5d

All bends in main bars and in secondary bars not covered above.

	Grade 40	Grade 60	Grade 75
#3 thru #8	5d	6d	--
#9, #10	5d	8d	--
#11	5d	8d	8d
#14, #18	10d	10d	--

440.4. Tolerances. Fabricating tolerances for bars shall not be greater than shown in Figure 1.

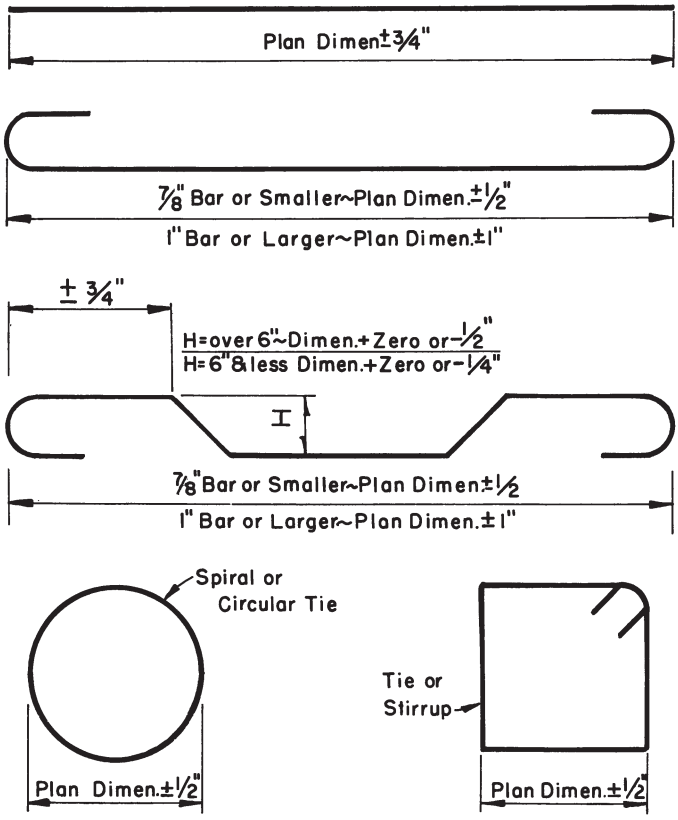


FIGURE 1

440.5. Storing. Steel reinforcement shall be stored above the surface of the ground upon platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, paint, grease, oil, or other foreign materials. Reinforcement shall be free from injurious defects such as cracks and laminations. Rust, surface seams, surface irregularities or mill scale will not be cause for rejection, provided the minimum dimensions, cross-sectional area and tensile properties of a hand wire brushed specimen meets the physical requirements for the size and grade of steel specified.

440.6. Splices. No splicing of bars, except when provided on the plans, or, specified herein, will be permitted without written approval of the Bridge Engineer.

Splices not provided for on the plans will be permitted, but not included for measurement, in Grade 40 bars only, sizes No. 8 and smaller, subject to the following:

For bars exceeding 40 feet in plan length, the distance center to center of splices shall not be less than 40 feet and no individual bar length shall be less than 10 feet. Splices will not be permitted in bars less than 40 feet in plan length. Splices which are not shown on the plans, but permitted hereby, shall be made in accordance with Table 1 below. The specified concrete cover shall be maintained at such splices and the bars placed in contact and securely tied together.

Splices will not be permitted in main reinforcement at points of maximum stress. When permitted in main bars, splices in adjacent bars will be staggered a minimum of two splice lengths.

Horizontal Bars with 12 inches of concrete or less below the bar.	20 Bar Diameters*
Horizontal Bars with more than 12 inches of concrete below the bar.	35 Bar Diameters*
Vertical Bars	30 bar Diameters*

*12 inch Minimum

TABLE 1
Minimum Lap Requirements
(Bar Sizes thru #8, Grade 40 only)

Welding of reinforcing bars may be used only where shown on the plans or as permitted herein. All welding operations, processes, equipment, materials, workmanship, and inspection shall conform to the requirements of the plans and of the Item, "Structural Welding". All splices shall be of such dimension and character as to develop the full strength of the bar being spliced.

End preparation for butt welding reinforcing bars, shall be done in the field. Delivered bars shall be of sufficient length to permit this practice.

For box culvert extensions with less than one foot of fill, the existing longitudinal bars shall have a 20 diameter lap with the new bars. For extensions with more than one foot of fill, a minimum of 6 inch lap will be required.

Unless otherwise shown on the plans, dowel bars transferring tensile stresses, shall have a minimum inbedment equal to the minimum lap requirements shown in Table 1. Shear transfer dowels shall have a minimum inbedment of 12 inches.

440.7. Placing. Reinforcement shall be placed as near as possible in the position shown on the plans. Unless otherwise shown on the plans, dimensions shown for reinforcement are to the centers of the bars. In the plane of the steel parallel to the nearest surface of concrete, bars shall not

vary from plan placement by more than one-twelfth of the spacing between bars. In the plane of the steel perpendicular to the nearest surface of concrete, bars shall not vary from plan placement by more than one-quarter inch. Cover of concrete to the nearest surface of steel shall meet the above requirements but shall never be less than one inch.

Vertical stirrups shall always pass around the main tension members and be attached securely thereto. The reinforcing steel shall be spaced its required distance from the form surface by means of approved galvanized metal spacers, metal spacers with plastic coated tips, stainless steel spacers, plastic spacers, or approved pre-cast mortar or concrete blocks. For approval of plastic spacers on a project, representative samples of the plastic shall show no visible indications of deterioration after immersion in a 5 percent solution of sodium hydroxide for 120 hours.

All reinforcing steel shall be tied at all intersections, except that where spacing is less than one foot in each direction, alternate intersections only, need be tied.

Before any concrete is placed, all mortar shall be cleaned from the reinforcement. Precast mortar or concrete blocks to be used for holding steel in position adjacent to formed surfaces shall be cast in molds meeting the approval of the Engineer and shall be cured by covering with wet burlap or cotton mats for a period of 72 hours.

The blocks shall be cast in the form of a frustrum of a cone or pyramid with the smaller face placed against the forms.

A suitable tie wire shall be provided in each block, to be used for anchoring to the steel. Except in unusual cases, and when specifically otherwise authorized by the Engineer, the size of the surface to be placed adjacent to the forms shall not exceed two and one-half inches square or the equivalent thereof in cases where circular or rectangular areas are provided. Blocks shall be cast accurately to the thickness required, and the surface to be placed adjacent to the forms shall be a true plane free of surface imperfections.

Reinforcement shall be supported and tied in such manner that a sufficiently rigid cage of steel is provided. If the cage is not adequately supported to resist settlement or floating upward of the steel, overturning of truss bars, or movement in any direction during concrete placement, permission to continue concrete placement will be withheld until corrective measures are taken. Sufficient measurements shall be made during concrete placement to insure compliance with the first paragraph of this Article.

Mats of wire fabric shall overlap each other sufficiently to maintain a uniform strength and shall be fastened securely at the ends and edges.

No concrete shall be deposited until the Engineer has inspected the placement of the reinforcing steel and given permission to proceed.

440.8. Measurement. The measurement of quantities of bar reinforcement furnished and placed will be based on the calculated weights of the quantities as shown on the contract plans, with no allowance made for added bar lengths for splices requested by the Contractor, nor for extra metal

used when bars larger than those specified are substituted with the permission of the Engineer. Tie wires and supporting devices will not be included in the calculated weights. The calculated weight for bar reinforcement will be determined using the theoretical bar weights set forth in Article 440.2. and the lengths designated on the plans.

Splices permitted under the second paragraph of Article 440.6. will not be measured for payment. Welded splices will not be measured, but shall be considered subsidiary to this item.

For the quantity measured under this item, adequate calculations have been made in accordance with Article 9.1. If no adjustment is required by Article 440.9., additional measurements or calculations will not be required.

Measurement required by a change in design will be computed as specified herein.

440.9. Payment. The quantity to be paid for, will be that quantity shown on the contract plans and in the proposal, regardless of errors in calculation, except as may be modified by the following:

(1) When a complete structure element has been erroneously included or omitted from the plans, the quantity shown on the plans for that element will be added to or deducted from the plan quantity and included for payment. A complete structure element will be the smallest portion of a total structure for which a corresponding quantity of concrete is included on the plans. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(2) When the plan quantity for a complete structure element is in error by 5 percent or more, a recalculation will be made and the corrected quantity included for payment. Quantities revised in this manner will not be subject to the provisions of Article 4.3.

(3) When quantities are revised by a change in design the 'plan quantity' will be increased or decreased by the amount involved in the design change. Quantities revised in this manner will be subject to the provisions of Article 4.3.

The party to the contract requesting the adjustment shall present to the other, three copies of the description and location, together with calculations of the quantity for the structure element involved. When this quantity is certified correct by the Engineer, it will become the revised plan quantity.

The unit price bid per pound for reinforcing steel, shall be full compensation for furnishing, bending, fabricating, welding and placing the reinforcement, for all clips, blocks, metal spacers, ties, wire, or other materials used for fastening reinforcement in place, and for all tools, labor, equipment, and incidentals necessary to complete the work.

ITEM 441

STEEL STRUCTURES

441.1. Description. This item shall govern for the fabrication and erection of structural steel and other metals used for steel structures or steel portions of structures, except reinforcing and prestressing steel.

441.2. Materials. The metal used for the various portions of the structures shall be as specified and shall conform to the requirements of the Item, "Metal for Structures".

FABRICATION

General

441.3. Shop Drawings. Unless otherwise provided on the plans, the Contractor shall prepare and submit detailed shop drawings for each detail of the general plans requiring the use of Structural Steel, Forgings, Wrought Iron, Castings, or Bearings. Camber and erection diagrams will be required. The drawings shall be prepared on sheets 22 by 36 inches. The margin at the left end shall be 1½ inches wide and the others one-half inch. Each sheet shall have a title in the lower right-hand corner. The title shall include the sheet index data shown on the lower right-hand corner of the project plans, sheet numbering for the shop drawings, name of structure or stream, name of Fabricator and name of Contractor.

All shop drawings shall be checked by the Fabricator before being submitted for approval. Submission shall be made to the Bridge Engineer, Texas Highway Department, Austin, Texas, 78701.

Six copies of shop drawings and seven copies of erection drawings will be required, except that one additional copy of each will be required for Railroad Underpass Structures. Additional sets may be required by note on the plans.

Reproducible tracings of approved shop drawings will be required for railroad underpasses only, upon completion of fabrication.

The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fit and field connections, although the drawings have been approved by the Engineer.

Contract plans indicate details of joints to be used with manual welding. When the use of submerged arc welding, gas metal-arc welding or flux cored arc welding processes are anticipated, the shop drawings shall reflect the correct joint details.

For plate girder units, preliminary erection drawings showing the sequence of erection, the location of falsework, and the location of ground and air splices, to determine any overstress caused by the erection procedure, shall be submitted to the Bridge Division for approval. Five copies will be required.

The Contractor (Fabricator) shall show on the shop drawings the source of supply of the shop coat paint (State stock or outside source).

When structural members are to be fabricated by welding, a Welding Procedure shall be submitted to the Materials and Tests Engineer, Texas Highway Department, Austin, Texas, 78703, in accordance with THD Bulletin C-5. A minimum of five copies of each required procedure shall be submitted on forms furnished by the Department. Upon approval, the welding procedure will be assigned a Welding Procedure Number. The Shop Drawings, when submitted, shall include this Number adjacent to the appropriate welding symbol. The same procedure, when proposed for subsequent projects, will not require resubmission.

When structural members with calculated stress, are fabricated by Welding, Riveting, or Bolting, a fabrication procedure will be required from all fabricators who are new to Department construction and may be required from any fabricator when deemed necessary. A fabrication procedure shall include a list of equipment to be used, sequence of assembly, sequence and detail of connections made, special processes such as planing, facing, etc., detail of heat treating procedures, when applicable, and any other information concerning fabrication, as may be required by the Engineer.

441.4. Notice of Beginning Work. The Contractor shall give the Engineer not less than 24 hours notice of the beginning of work in the shop so inspection may be provided. No work shall be performed in the shop before the Engineer has authorized fabrication. Any purchases of material prior to fabrication authorization shall be at the Contractor's risk.

441.5. Inspection and Testing. The Contractor shall provide facilities for the inspection of material and workmanship in the shop, and furnish the Inspector with as many helpers as he needs to properly inspect the work. The Inspector shall be allowed free access to the necessary parts of the work.

The Inspector will have the authority to reject any material or work which does not meet the requirement of these specifications. In case of dispute, the Contractor may appeal to the Engineer, whose decision will be final.

Prior to beginning fabrication, the Fabricator shall furnish the Engineer with 4 copies of the completed material identification form with supporting mill test reports. These material identification forms will be furnished to the Fabricator by the Department without charge.

The mill test reports shall reflect:

Specification to which material is produced.

Heat number of material.

Chemical and physical properties of the material required by the material specification.

Impact test data when required.

Grain size or statement that fine grain practice was used, when required.

Except as required in Sub-article 442.3.(2).(d), mill test reports will not be required for such items as miscellaneous hardware, bolts, nuts, washers, rivets, screws, etc.

As material is shipped, the Fabricator shall furnish the Engineer with 4 copies of his shipping invoice. The Fabricator's shipping invoice shall reflect:

Member piece mark identification.

Number of pieces shipped.

Total calculated or scale weight for each shipment per bid item.

Final payment for structural steel will not be made until shipping invoices indicating total weight of material used have been received and checked by the Department. *Shipping weights will not be used as measurement for payment.* The acceptance of any material or finished members by the Inspector will not prohibit subsequent rejection if found defective. Rejected material shall be replaced promptly or made good by the Contractor.

441.6. Workmanship, General. For railroad underpass structures, shop workmanship shall be in accordance with the latest American Railway Engineering Association Specification for Steel Railway Bridges for Fixed Spans.

All structural materials, before and after fabrication, shall be stored above the ground upon platforms, skids, blocking, or other supports approved by the Engineer. The material shall be kept free from dirt, grease, and other foreign matter and shall be protected as nearly as practicable from corrosion.

Fabrication and rolling tolerances for rolled shapes, plates, bars, wide flange sections and miscellaneous steel shall be in accordance with ASTM Designation: A 6. Tolerances for fabricated girders shall be in accordance with THD Bulletin C-5.

Maximum deviation from flatness for webs of wide flange sections shall be the same as for built-up girders.

Shoes shall be fabricated with a tolerance not greater than the following:

The top bolster shall have the center 75 percent of the long dimension true to one thirty-second inch, with the remainder true to one-sixteenth inch, and shall be true to one thirty-second inch across its entire width in the short dimension.

For a pin and rocker type expansion shoe, the axis of rotation shall coincide with the central axis of the pin.

When the shoe is completely assembled and the top bolster is moved horizontally simulating the movement of the shoe in the finished structure, no point in the plane of the top bolster shall change elevation by more than one-sixteenth inch for the full possible travel of the rocker both ways from the neutral position, nor shall the top bolster change inclination with respect to the horizontal by more than one degree during this same travel.

I-beams and girders shall be fabricated with a tolerance not greater than the following:

The plane of the bearing area of beams and girders shall be perpendicular to the vertical axis of the beam within one-sixteenth inch.

Correction of bearing areas of shoes, beams and girders to the above tolerances, shall be with heat and/or external pressure. Grinding or milling will be permitted if reduction of required thickness of member is not reduced by more than one-sixteenth inch.

Rolled material must be straight before being laid off or worked.

If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends shall be cause for rejection of the material, unless corrected to the satisfaction of the Engineer. Workmanship and finish shall be equal to the best general practice in modern bridge shops.

Riveted, Bolted and Welded Structures

441.7. Cutting, Planing, Facing and Fit of Members. Sheared edges of plates of more than five-eighths inch thickness and carrying calculated stress shall be planed to a depth of one-fourth inch. Re-entrant cuts shall be filleted to a minimum radius of three-fourths inch, except for the corners of welding access cope holes adjacent to a flange. The fillet and its contiguous cuts shall meet without offset or cutting past the point of tangency. (no gouges, etc.)

Steel and weld metal may be oxygen cut, provided a smooth and regular surface free from cracks and notches is secured and provided an accurate profile is secured by the use of a mechanical guide. Hand cutting shall be done only where approved by the Engineer. (Mill scale and extraneous material shall be removed from the cutting side of A514 steel plates along the lines to be cut.)

Edges of all main members which are sheared or oxygen cut, and all other exposed edges to be painted, shall be rounded or chamfered to an approximate one-sixteenth inch dimension by grinding.

In all oxygen cutting, the flame shall be adjusted and manipulated to avoid cutting inside the prescribed lines. Roughness of the cut surfaces shall not be greater than ANSI surface roughness value of 1000 for material up to 4 inches thick and 1600 for material 4 inches to 8 inches thick, except that member ends not subject to calculated stress shall meet ANSI surface roughness value of 2000. Roughness exceeding these values and occasional notches or gouges not more than three-sixteenths of an inch deep, on otherwise satisfactory surfaces, shall be removed by machining or grinding. Cut surfaces and edges shall be left free of slag. Correction of defects shall be faired to the oxygen cut surfaces with a slope not exceeding one in 10.

Air carbon-arc or oxygen gouging, oxygen cutting, chipping, or grinding may be used for joint preparation or the removal of defective work or material. Oxygen gouging shall not be used on A514 steel.

Oxygen cut edges of ASTM A440 steel one half of an inch or greater in thickness shall be removed to a depth of at least one-eighth of an inch by machining or grinding, except that machine flame cut edges need not be

removed, if they are softened after cutting by heating the cut edge uniformly and progressively to a red heat to a depth of at least one-sixteenth of an inch from the edge (1150 F to 1250 F), or post heated by a torch attached to and following the cutting torch with the tips, gas pressure, speed of travel and the distance of the post heating torch from the cutting torch regulated to the thickness of the steel to accomplish the annealing effect described above. ASTM A242 steel not approved for welded construction requires this treatment of oxygen cut edges in all thicknesses and with bend tests, as applicable, conforming to ASTM A242 for the thickness of material under consideration.

The top and bottom surfaces of steel slabs, base plates and cap plates of columns and pedestals shall be planed or else the steel slabs and base plates hot-straightened. Parts of members in contact with plates shall be faced to fit. For plates over 4 inches thick, top surfaces shall be planed to a ANSI surface roughness value of 250.

Surfaces of bearing plates intended for sliding contact shall have a ANSI surface roughness value of 125.

In planing the surfaces of expansion bearings, the cut of the tool shall be in the direction of expansion.

When stiffeners are required by the plans to be milled, the milled surface shall meet ANSI surface roughness value of 500, and shall provide an even bearing against the flange. Tight-fit, when specified on the plans, shall have at least one point bearing on the flange surface and the remainder with a maximum clearance of one-sixteenth of an inch at any point. Where stiffeners are to be welded to the flange, the opening prior to welding shall not exceed three-sixteenths of an inch, with the fillet weld size increased by the amount of the opening.

Unwelded, cold-bent, load-carrying, rolled-steel plates shall conform to the following:

(1) The bend line shall be at right angles to the direction of rolling.

(2) Bending shall be done so that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in the following table:

THICKNESS IN INCHES

	Up to ½	Over ½ to 1	Over 1 to 1½	Over 1½ to 2½	Over 2½ to 4
Low alloy steel in thicknesses over ½" may require hot bending for small radii	2t	2½t	3t	3½t	4t

Allowance for springback of A514 steel should be about 3 times that for structural carbon steel. For brake press forming the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

If a shorter radius is required, the plates shall be bent hot at a temperature not greater than 1200 F, they must be requenched and tempered in accordance with the producing mill's practice. Hot bent plates shall conform to requirement (1) above.

Plates that will be hot formed shall be ordered to extra length to provide for testing required in ASTM A 514, after requenching and tempering.

(3) Before bending, the corners of the plate shall be rounded to a radius of one-sixteenth of an inch throughout the portion of the plate to be bent.

Finished machining, boring and straightening shall be subsequent to annealing or normalizing structural members. Normalizing and annealing (full annealing) shall be as defined in ASTM E44. The temperatures shall be maintained uniformly throughout the furnace during the heating and cooling so that the temperature at any points on the member will not differ by more than 100 F.

A514 steel shall not be annealed or normalized and shall be stress relieved only with the approval of the Engineer.

The holding temperature for stress relieving A514 steel shall not exceed 1100F, except that 950F shall be maximum for welds and 6 inches surrounding welds.

When required by the plans, bridge shoes, pedestals or other parts which are built up by welding sections of plate together shall be stress relieved in accordance with approved procedures.

441.8. Repair of Defects.

(1) Correction of Defects on Edges to be Welded.

(a) Correction of cutting defects by welding may be made on steel with yield strengths up through 65,000 psi, of occasional notches or gouges less than seven-sixteenths of an inch deep for material up to 4 inches thick, and less than five-eighths of an inch for material over 4 inches thick. Nonmetallic stringers, opening in plate edges which form the faces of groove welds, which will subsequently be fused with the weld, shall be removed to a depth of five-eighths of an inch and repaired by welding. Laminations opening to these edges shall be removed. Weld repairs shall be made after suitably preparing the defect, welding with low hydrogen electrodes not exceeding five-thirty-second inch in diameter, observing the applicable requirements of THD Bulletin C-5, and grinding the completed weld smooth and flush with the adjacent surfaces.

(b) Occasional notches or gouges in edges of A514 steel may be repaired by welding, under the following conditions:

Cutting defects not more than three-sixteenths of an inch deep in plate edges which will form the faces of a groove weld joint, and which will subsequently be completely fused with the weld may be repaired by

welding. Nonmetallic stringers opening to these edges shall be removed to a depth of one-fourth of an inch below the surface by grinding or chipping and the gouge repaired by welding. Laminations opening to these edges shall be removed.

Cutting defects not more than three-sixteenths of an inch deep in plate edges which will form a fillet-welded corner joint shall be repaired by welding only on the part of the edge which will become the faying surface for the joint and the fusion zone of the fillet weld. The part of the defect outside the toe of the completed fillet weld shall be removed by machining or grinding and faired to the oxygen cut surface with a slope not exceeding one in 10. Weld repairs shall be made as specified above using E-11018-M electrodes.

(2) Correction of Defects in Free Running Edges of All Steel.

(a) Roughness exceeding ANSI surface roughness value of 2000 in oxygen cut surfaces and occasional notches or gouges not more than three-sixteenths of an inch deep on otherwise satisfactory surfaces, shall be removed by machining or grinding to a slope not exceeding one in 10.

(b) In the repair and determination of limits of internal defects visually observed on rolled, sheared or oxygen cut edges and caused by entrapped slag or refractory, deoxidation products, gas pocket or blow holes, the metal removed shall be the minimum necessary to remove the defect or to determine that the permissible limit is not exceeded. Plate edges may be at any angle with respect to the rolling direction. All repairs made by welding shall conform to the applicable provisions of THD Bulletin C-5.

The limits of acceptability and the repair of visually observed edge defects in plates 4 inches or less in thickness shall be in accordance with the following table where the length of defect is the visible long dimension on the plate edge and the depth, the distance the defect extends into the plate from the edge.

VISIBLE EDGE IMPERFECTIONS FOR PLATE THICKNESS OF 4 INCHES AND UNDER

Description of discontinuity	Repair required
Any discontinuity 1" in length or less.	None--need not be explored.
Any discontinuity over 1" in length and 1/8" maximum depth.	None - depth should be explored.
Any discontinuity over 1" in length with depth over 1/8" but not greater than ¼".	Remove - need not weld.
Any discontinuity over 1" in length with depth over ¼" but not greater than 1".	Completely remove and weld. Aggregate length of welding not over 20% of plate edge length being repaired.
Any discontinuity over 1" in length with depth greater than 1".	Subject to approval by the Engineer. Gouge out to 1" and block off by welding. Aggregate length of welding not over 20% of plate edge length being repaired unless approved by the Engineer.

Removal of metal by gouging shall be done in a manner assuring adequate width and slope for welding.

(3) Repair of Surface Defects.

The limits of acceptability and repair of surface imperfections for all steels shall be in accordance with ASTM A6.

441.9. Heat Curving. Unless otherwise shown on the plans, horizontally curved welded plate girders may be heat curved provided the specified minimum yield point does not exceed 65,000 psi, and the radius of curvature to the centerline of the web is not less than 400 times the width of the widest flange plate.

Rolled beams required by the plans to be curved may be heat curved.

Camber for rolled beams may be obtained by heating, but girders shall be cambered prior to heat curving by cutting the web to the prescribed arc with proper allowance for shrinkage due to cutting, welding and/or heat curving.

The Contractor shall submit a detailed procedure to the Engineer and obtain his written approval thereof prior to heat curving any beam or girder.

441.10. Color Coding. For each approved steel used, a distinct color code shall be required. The color code shall be as specified in ASTM A6. In addition white shall be required for A36 steel.

The color code used for other steels not specified in ASTM A6 must be submitted to and approved by the Engineer.

The appropriate color(s) shall be placed on the material upon entry into the shop and shall be carried on all pieces to final fabrication. Loss of code marking on any piece and with no other positive identification, shall require testing thereof prior to its use, to re-establish positive identity of the material to the satisfaction of the Engineer.

441.11. Straightening Bent Material. The straightening of plates, angles, other shapes, and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury. Straightening of individual pieces shall be done prior to assembly into a built-up member. Distorted built-up members shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and supervised application of a limited amount of localized heat, except that heat straightening of A514 steel members shall be done only under rigidly controlled procedures, each application subject to the approval of the Engineer. In no case shall the maximum temperature of the A514 steel exceed 1100F, nor shall the temperature exceed 950F at the weld metal or within 6 inches thereof. Heat shall not be applied directly on weld metal. In all other steels the temperature of the heated area shall not exceed 1200F (a dull red). In all cases the temperature of the steel shall be controlled by approved temperature indicating devices, such as crayons, liquids, or bimetal thermometers.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

Correction of errors in camber in welded beams and girders of A514 material shall be done only under rigidly controlled procedures, each application subject to approval of the Engineer.

441.12. Pins, Pinholes and Rockers. Pinholes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member, and parallel with each other, unless otherwise required. Pins and pinholes shall be finished to ANSI surface roughness value of 125.

The diameter of the pinhole shall not exceed that of the pin by more than one-fiftieth of an inch for pins, five inches or less in diameter, or one thirty-second of an inch for larger pins. Rockers shall be finished to ANSI surface roughness value of 250.

441.13. Shop Painting. The application of shop paint shall conform to the requirements of the Item, "Paint and Painting".

441.14. Marking and Shipping. All structural members shall be marked in accordance with the erection diagram. The markings shall be over the painted surface. In no case shall shop paint be left off in order to preserve

markings on unpainted steel. Match-marks shall be made with paint in addition to the requirements of Articles 441.20 and 441.27.

Members weighing more than 3 tons shall have the weight marked theron. Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, small parts, and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels. A list and description of the contents shall be plainly marked on the outside of each package. The loading, transportation, unloading and storing of material shall be conducted so it will be kept clean and free from injury.

Riveted and Bolted Structures

441.15. Rivets and High Strength Bolts. Unless prohibited by the plans, High Strength Bolts may be used where rivets are designated. Where these specifications refer to pitch, edge distance, preparation of holes, etc., for rivets, the same criteria shall govern for High Strength Bolts.

441.16. Pitch and Edge Distance of Rivets. Pitch and edge distance not shown on the plans shall be in accordance with the latest edition of AASHO Standard and Interim Specifications for Highway Bridges.

441.17. Rivet Holes. All holes for rivets shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched one-sixteenth inch larger than the nominal diameter of the rivets if the thickness of the metal is not greater than three-fourths inch for carbon steel or five-eights inch for HS or one-half inch for XHS steel. For more than five thicknesses or when any of the main material is thicker than shown herein or when required under Article 441.18, all the holes shall be subpunched or subdrilled three-sixteenths inch smaller, and after assembling, reamed one-sixteenth inch larger, or drilled from the solid to one-sixteenth inch larger than the nominal diameter of the rivets.

For punched holes, the diameter of the die shall not exceed that of the punch by more than one-sixteenth inch. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes shall be clean cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

Reamed, punched and drilled holes shall be cylindrical, perpendicular to the member and one-sixteenth inch larger than the nominal diameter of the rivets. Reamers and drills shall be guided by mechanical means. Only for holes not accessible to mechanically guided equipment shall the guiding be by hand. Reaming and drilling shall be done with twist drills, except that for poorly aligned holes, tapered reamers shall be used in conjunction with a template so placed, and held, to force the reaming to the best center of holes for that group. Connecting parts shall be assembled and held securely during reaming or drilling operations and match-marked before disassembling.

441.18. Preparation of Holes for Field Rivets. Holes in all field splices of main truss members, continuous I-beams, and plate girders shall be subpunched (or subdrilled, if required by Article 441.17) and reamed while assembled, or drilled full size with all parts assembled, taking into account their relative position in the finished structure due to grade, camber and

curvature. Tack welding may be used for assembly of field splices to be drilled full size, except as otherwise noted, provided the tack welds are held to a minimum and conform to the requirements of the Item, "Structural Welding". The assembly, including camber, alignment, accuracy of holes and milled joints, shall be approved by the Engineer before reaming or drilling full size is started.

All holes for floor beams and stringer end connections shall be subpunched and reamed to a steel template of not less than one inch thickness or reamed while assembled.

Holes for secondary members such as diaframs, laterals, sway bracing, etc., may be punched full size unless subdrilling and reaming is required by Article 441.17.

441.19. Accuracy of Holes. Accuracy of all holes punched full size, subpunched or subdrilled, shall be such that a cylindrical pin one-eighth inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the adjoining holes in the same plane after assembling and prior to any reaming. Pieces not meeting this requirement will be rejected. Any hole which will not pass a pin three-sixteenths inch smaller in diameter than the nominal size of the punched hole will be cause for rejection.

After reaming or drilling, 85 percent of the holes in any adjoining group shall show no offset greater than one thirty-second inch between adjacent thicknesses of metal.

Layout of shop work shall be done so that gauge lines for rivets shall not vary from plan dimensions more than one-sixteenth inch. Full size holes in any adjoining group or line shall not vary more than the following:

At least 80 percent of the holes shall be within one-sixteenth inch of plan gauge.

Not more than 10 percent of the holes may vary as much as one-eighth inch from plan gauge.

Holes varying more than one-eighth inch from plan gauge will not be accepted.

441.20. Shop Assembling. Each truss section shall be assembled in its relative position in the shop before reaming is started. Match marks shall be stamped in the metal at all field connections, in accordance with erection diagrams, at the time reaming is done.

Rigid bolting or clamping shall hold surfaces of assembled parts or members in close contact before reaming is started.

Adjacent sections of beam and girder units shall be assembled in the proper relative positions each will take in the structure before reaming is started. Match-marks shall be stamped in the metal in accordance with erection diagrams at the time reaming is done.

Surfaces of metal in contact shall be cleaned before assembling.

Disassembling after reaming will be required to remove shavings, burrs, tack welds, etc.

Tack welding for the purpose of eliminating bolts for assembling will not be permitted, except as provided in Article 441.18 for drilling holes full size. In no case shall tack welding be used in assembly for riveting. The member shall be free from twists, bends and other deformations.

If necessary, the rivet holes shall be spear-reamed for the admission of rivets preparatory to the shop riveting of full-sized punched material. The spear reamer used for this purpose shall be not more than one-sixteenth inch larger than the nominal diameter of the rivets.

End connection angles, stiffener angles and similar parts shall be adjusted to correct position and bolted or clamped firmly in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts, insofar as practicable, to prevent damage in shipment and handling.

The drifting done during assembling shall be only that required to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit rivets, they shall be reamed.

441.21. Shop Rivets and Riveting. Rivets, before heating, shall be of diameter specified and shall be free from furnace scale.

Rivets shall be heated uniformly to a light "cherry red" color and shall be driven while hot. When heated and ready for driving, they shall be free from slag, scale and other adhering matter, and they shall completely fill the holes when driven. The heads shall be of approved shape, full size, neatly formed, concentric with the shank, free from fins and in full contact with the surface of the member after driving.

Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal, and, if necessary, the rivets shall be drilled out. Caulking or recupping will not be permitted.

Rivets shall be driven by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed. If rivets are driven with a pneumatic hammer, a pneumatic bucker shall be used.

441.22. Bolted Connections. When High-Strength Bolts are required or permitted, the bolts shall be in conformance with the Item, "Metal for Structures", and the Item, "Structural Bolting".

441.23. Preparation and Fit of Members. When specified on the plans, abutting joints shall be milled and brought to an even bearing. Where joints are not milled the openings shall not exceed one-fourth of an inch.

Floor beams and girders with end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angles shall be not less than that shown on the detail plans.

The ends of lacing bars shall be rounded neatly unless otherwise shown on the plans. Lacing bars with a single rivet connection shall have ends rounded to a radius equal to half the width of the bar.

For girders without cover plates, not to be encased in concrete, the top edge of the web shall be one-eighth inch or less below the backs of the flange angles of any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of them. Web plates of girders having cover plates may be one-half inch less in width than the distance back to back of flange angles.

At web splices, the clearance between the ends of the web plates shall not exceed three-eighths inch. The clearance at the top and bottom ends of web splice plates shall not exceed one-fourth inch.

Surfaces to be in contact after shop riveting is completed shall be cleaned but shall not be painted.

Welded Structures

441.24. Welding. All welding operations, processes, equipment, materials, qualifications of welders, workmanship and inspection shall be in accordance with THD Bulletin C-5, except as provided in Article 441.34.

Nondestructive testing and inspection as herein described will be required for welding performed in the fabricating shop.

Unless otherwise shown on the plans, nondestructive testing (magnetic particle and radiographic) required in the shop will be done by the Contractor and at his expense. This will include furnishing all materials, equipment, tools, labor and incidentals necessary to perform the required testing. The Department may require further tests as necessary in accordance with Article 5.9. In addition, the Department may perform additional testing, including other types.

All magnetic particle inspection and all radiographic inspection shall be done in the presence of and at the locations selected by the Engineer or his authorized representative. The Engineer shall examine and interpret all tests made.

Magnetic particle inspection shall be in accordance with ASTM Designation E109, "Dry Powder Magnetic Particle Inspection".

Unless otherwise shown on the plans for built-up members (plate girders, floor beams and stringers), magnetic particle inspection will be required on 100 percent of the web to flange and bearing stiffener fillet welds on not less than one fabricated piece (as designated by individual piece marks) for each 15 pieces or fraction thereof when the maximum flange thickness is less than two and one half inches and on not less than one piece for each 10 pieces or fraction thereof when the maximum flange thickness is two and one half inches and over. No magnetic particle inspection will be required for rolled sections. Welds requiring repairs shall be retested by magnetic particle inspection after the repairs are made.

Radiographic equipment, procedure, resulting radiographs, identification marks, penetrameters, examination, report, disposition of radiograph and weld surface preparation shall be in accordance with Appendix B of the latest AWS Standard Specifications for Welded Highway and Railroad Bridges, and THD Bulletin, C-5.

For shop welds of material 65,000 psi yield strength and less, radiographic inspection will be made of the full flange width of 35 percent of all flange splices where the plate thickness at the weld is 2 inches or less and of 50 percent of all flange splices where it is thicker than 2 inches and of 1/5 the depth of the web of 50 percent of the web splices on each structure. If unacceptable work is found, additional radiographs will be made on sections welded by the same equipment and/or operator just prior to and just after the section containing the defect.

For shop welds, radiographic inspection shall be made of all groove welds containing steel over 65,000 psi yield strength. These welds shall be inspected not less than 48 hours after they are completed.

Welds requiring repairs shall be retested by radiography after repairs are made. All radiographic inspection and necessary repairs shall be done prior to assembly.

When radiographic inspection of particular welds is required by the plans, this shall be in addition to the radiographic inspection required herein.

The acceptability of welds by radiographic and/or magnetic particle inspection shall comply with Article 203, "Quality of Welds", and repairs will be in accordance with Article 204, "Corrections", of THD Bulletin C-5.

441.25. Preparation of Material for Welding. Dimensional tolerances, straightness and flatness of structural shapes and plates shall be within the limits prescribed by Article 441.6.

Surfaces to be welded shall be smooth, uniform and free from fins, tears and other defects which would adversely affect the quality of the weld. Surfaces to be welded shall be free from loose scale, slag, rust, grease, or other material. Mill scale that withstands vigorous wire brushing or a light film of drying oil or rust inhibitive coating may remain. Finish of bevels of groove welds shall be milled or ground. Oxygen cut bevels without grinding will not be allowed.

When a zinc rich paint system is specified, surfaces within 4 inches of a groove weld joining main stress carrying members and within 2 inches of fillet welds joining diaframs or lateral bracing to stiffeners or gusset plates shall be sandblast cleaned and coated with linseed oil. After welding is completed, the areas shall be sand-blast cleaned and painted as required for the specified paint system.

For other paint systems, surfaces within 2 inches of any weld joining main stress carrying members shall be free from any paint or other material that would prevent proper welding.

Sheared plates for webs of built-up members shall be wide enough to allow for trimming of edges where built-in camber is required. Plates with rolled edges used for webs, shall be trimmed by oxygen cutting.

Preparation of edges by oxygen cutting shall be in accordance with Article 441.7.

The faying surfaces of the web and flange plates and the adjacent surfaces that are to be fillet welded shall be cleaned by grinding prior to assembly and welding of web to flange.

441.26. Assembly of Parts. The parts to be joined by fillet welds shall be brought into as close contact as possible, with a maximum separation of three-sixteenths inch. If the separation is one-sixteenth inch or greater, the leg of the fillet weld shall be increased by an equivalent amount. The separation between faying surfaces of lap joints and of butt joints landing on a backing strip shall not exceed one-sixteenth inch. The fit of joints not sealed by welds throughout their length shall be close enough to exclude water after painting. Where irregularities in rolled shapes or plates, after straightening, prevents this, the procedure necessary to bring them within the above limits shall be subject to the approval of the Engineer. The use of fillers is prohibited, except as specified on the drawings or as approved by the Engineer.

Members to be welded shall be brought into correct alignment and held in position by clamping, welding, or tacking until the joint has been welded. Adequate clamps must be provided to prevent cupping or warping of the flanges when welding them to the web. The clamping devices must be designed to not interfere with the operation or guiding of the automatic welding equipment.

Temporary stiffeners used for jigs and/or warpage control shall not be tack welded to the flange material. Tacking to the web is permissible if the welds are at least d/6 distance away from the flange where "d" is the web depth. The tack weld shall be removed by grinding flush with the parent metal prior to acceptance.

Suitable allowance shall be made for shrinkage, and the joint shall never be restrained on both sides when welding.

Abutting parts to be joined by groove welds shall be aligned carefully. Regardless of the range of stress, all shop groove welds in flange plates shall be ground smooth and flush with the base metal on all surfaces. This shall apply to both parts of equal thickness and parts of unequal thickness.

The surfaces shall be ground so that the radii at the points of transition will be 4 inches minimum.

When groove welds are used to join materials of different thickness or width, there shall be a smooth transition between offset surfaces with a slope of not greater than 1 in 4 in thickness transition, and to the proper radii in the case of width transition (See Figures 1 and 2).

Groove welds in web plates need not be ground unless shown on the plans.

Grinding shall be done in the direction of stress, and in a manner that keeps the metal below the blue brittle range.

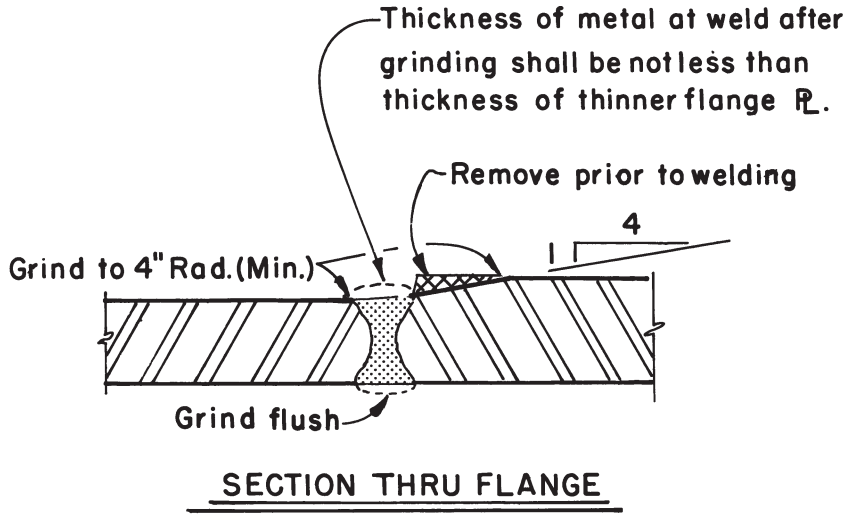


FIGURE 1

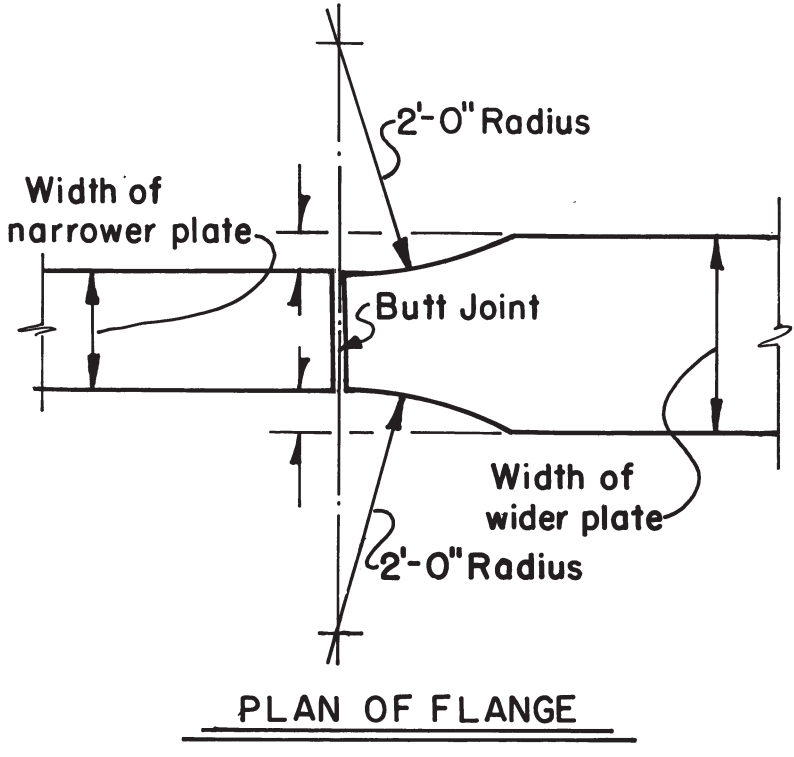


FIGURE 2

Intermediate stiffeners within 12 inches of a splice point shall be shipped tack welded in place. The welding shall be done in the field after the splice is made.

441.27. End Preparation and Shop Assembly for Field Welds. Ends of beams and girders shall be prepared in accordance with Figure 3 and the requirements herein or as shown on the plans. The centerline of the land of opposing web and flange bevels shall not deviate from each other by more than one-sixteenth of an inch.

For Shop Assembly, members should be brought into abutting contact in accordance with the blocking diagram. Root faces shall not vary in excess of one-sixteenth of an inch from contact. Corrections by additional cutting and/or grinding shall be made to bring the splice within this tolerance. Finish of bevels for groove welds shall be milled or ground. Oxygen cut bevels without grinding will not be allowed.

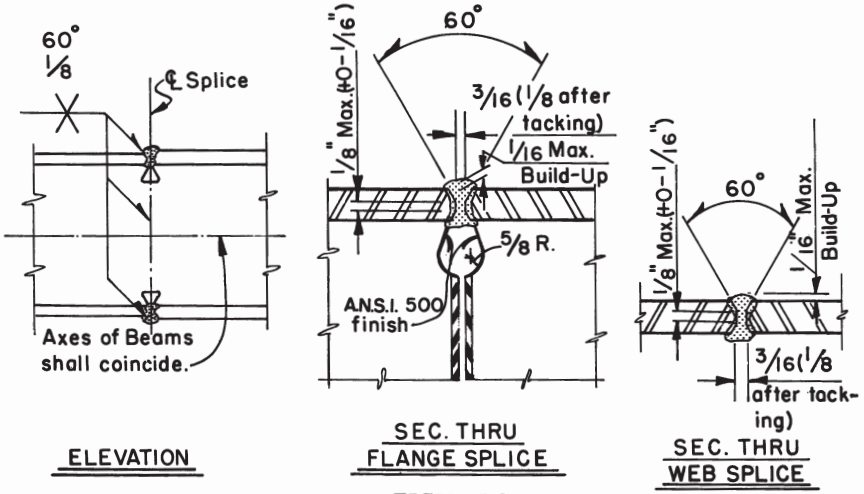


FIGURE 3

End preparation, backing and tolerances for single V groove welds for framing beams or girders shall conform to the details shown on the plans or as permitted by C-5.

Ends of beams or girders to be welded shall be prepared in the shop taking into account their relative positions in the finished structure due to grade, camber and curvature. Each splice shall be completely shop assembled, checked and while assembled, match-marked and the ASTM Designation and grade of the steel stamped in the metal adjacent to the splice.

FIELD ERECTION

441.28. Methods and Equipment. Before starting work, the Contractor shall inform the Engineer fully of the method of erection he proposes to follow and the amount and character of the equipment he proposes to use;

the adequacy of which shall be subject to the approval of the Engineer. Such approval shall not relieve the Contractor of the responsibility for the safety or adequacy of his methods or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done without the sanction of the Engineer.

The Contractor shall prepare and submit detailed erection plans for plate girders (riveted, bolted, or welded), trusses, and for all railroad underpass structures showing procedures, sequence of work, equipment to be used, falsework, etc., so that a check can be made of the adequacy of the proposed procedure. This detailed procedure shall follow the preliminary procedure previously submitted. Field erection plans for I-beam units will not be required unless specified on the plans.

Spot welding for the purpose of eliminating field erection bolts or for holding steel parts together while riveting will not be permitted.

The Contractor shall provide the falsework and all tools, machinery and applicances, including drift pins and fitting-up bolts, necessary for the expeditious handling of the work. Drift pins sufficient to fill at least one-fourth of the field holes for main connections shall be provided.

All steel beams or girders placed over a traveled roadway or a railroad, shall be securely tied and/or braced to prevent overturning immediately after erection, and until diaframs are permanently in place. The methods to be used shall be submitted on the erection drawings. When railroad or roadway traffic must be maintained beneath girders or beams already placed, traffic shall be protected against falling objects during the erection of diaframs and other structural members, during the placing of cast-in-place concrete and during the erection and dismantling of forms therefor. The protection shall consist of safety nets (1 inch mesh maximum) or a flooring with openings not larger than 1 inch.

441.29. Storing Materials. All material shall be handled in a manner that prevents injury to it. Stored material shall be placed on skids above the ground and kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns, shall be supported on skids placed closely enough to prevent excess deflection.

441.30. Falsework. The falsework shall be properly designed for the loads to be supported and shall be substantially constructed and properly maintained. The Contractor shall prepare and submit plans for falsework to the Engineer with the erection drawings.

The falsework plans shall be complete in all details of members, connections, equipment, etc., so that a structural check can be made of them.

Approval of the Contractor's plans shall not be considered as relieving him of any responsibility.

441.31. Straightening Bent Material. Straightening of structural members shall be in accordance with Article 441.11.

441.32. Handling and Assembling Material. The parts shall be assembled accurately as shown on the plans and match-marks shall be followed. The

material shall be handled carefully so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled.

Unless erected by the cantilever method, truss spans shall be erected on blocking so located as to provide proper camber. The blocking shall be left in place until the tension chord splices are fully connected and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in rail connections shall not be driven until the span has been swung. Main connections shall have one-half of the holes filled with bolts and erection pins (half bolts and half pins) before swinging the span. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the rivets or bolts. Erection pins shall be one thirty-second inch larger.

There shall be no temporary welds for transportation, erection or other purposes on main members, except at approved locations more than one-sixth the depth of the web from the flanges of beams and girders, unless otherwise approved by the Engineer.

441.33. Field Riveting. Pneumatic hammers shall be used for field riveting. Cupfaced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be fitted up accurately and securely before the rivets are driven. Drifting shall be used only to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light "cherry red" color and driven while hot. Rivets shall not be overheated or burned and heads shall be full and symmetrical, concentric with the shank and with full bearing all around. Rivet heads shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, the rivets shall be drilled out.

Rivets for field driving shall be furnished in excess of the nominal number required by 10 percent or 10 rivets for each diameter and length whichever is the largest. Payment for extra rivets will not be made.

441.34. Field Welding. Welding shall be in accordance with the Item, "Structural Welding".

Unless otherwise shown on the plans or specified herein, nondestructive testing required in the field will be done by the Department. This will include furnishing all materials, equipment, tools, labor and incidentals necessary to perform the required testing. Tests in addition to those required herein, may be made by the Department in accordance with Article 5.9.

No magnetic particle inspection will be required for welds made in the field.

Radiographic equipment, procedure, resulting radiographs, identification marks, penetrameters, examination, report, disposition of radiograph and

weld surface preparation shall be in accordance with Appendix B of the latest AWS Standard Specifications for Welded Highway and Railroad Bridges.

Radiography shall be done within the time interval specified by the Engineer.

For field welds, radiographic inspection will be made of the full flange width of 25 percent of all flange splices and of 1/3 the depth of the web of 25 percent of all web splices on each structure (17 inches minimum length). If unacceptable work is found, an additional radiograph (penalty shot) shall be made on a section welded by the same operator just prior to and just following the section containing the defect. Welds requiring repairs shall be retested by radiography after repairs are made. Necessary repairs shall be made prior to any further work being done.

All radiography (penalty shots and retakes), required because of unacceptable welding, shall be performed by a commercial laboratory at the expense of the Contractor.

When radiographic inspection of particular welds is required by the plans, this shall be in addition to the radiographic inspection required herein.

Upon completion of welding of beam and girder splices, distorted bearing pads shall be restored to an equivalent vertical position at 70F. This shall be done by any approved method of temporarily relieving the load on them.

441.35. Bearing and Anchorage. Castings, bearing plates, or shoes shall not be placed upon improperly finished bridge seat bearing areas, but shall have a full and even bearing upon the concrete. Castings, bearing plates, or shoes shall be placed on preformed fabric pads manufactured of all new (unused) materials and composed of multiple layers of prestressed cotton duck, 64 plies per inch of finished pad thickness, impregnated and bound with a high quality rubber compound, containing rot and mildew inhibitors and antioxidants, compounded into resilient pads of uniform thickness. The Shore Durometer hardness of the pad shall be not less than 85 nor more than 95. Pads shall be capable of withstanding 10,000 psi compressive stress without breakdown. A tolerance of ±5% will be allowed from the required pad thickness. Unless otherwise shown on the plans the required thickness of pads will be one fourth of an inch. Anchor bolt holes shall be not more than one fourth of an inch larger than the bolt diameter.

When the concrete is placed below grade, castings, or bearing plates or shoes may be raised to grade on beds of Portland cement mortar consisting of one part cement and two parts sand. The minimum thickness of mortar bed shall be one-eighth inch and the maximum thickness shall be three-eighths inch. Adequate curing shall be provided.

When it is necessary to raise the castings or bearing plates higher above the concrete than provided by the allowable thickness of the above described materials, the area under the built-up portion shall be prepared in accordance with the specification requirements for construction joints and the build-up placed using an approved latex based grout mixed in accordance with the manufacturer's recommendations. Steel shims or other approved material shall be used in conjunction with one of the specified materials.

Beams and girders shall have practically full bearing on shoes and base plates. Field corrections shall be made to provide a minimum of 75 percent contact of flange to shoe with no separation greater than one thirty-second of an inch.

Corrections by heat and pressure or through the use of tapered steel shims or layers of steel sheets shall be made to provide bearings to the tolerances given above. Small irregularities may be ground off, but care must be taken not to destroy the finish. The shims used shall be galvanized.

Care shall be taken to set expansion shoes normal to the direction of movement of the unit. Full line bearing of the rocker plate to the base plate shall be provided, and shall be interpreted to mean full bearing on a minimum of 85 percent of the contact surfaces.

All foreign matter shall be removed from machine-finished surfaces immediately prior to placing in the structure. Surfaces designed for sliding movement, one upon the other, shall be given a field coat of graphite spring lubricant when placed in the structure. The rolling surface of rocker shoes shall be painted.

Anchor bolts may be set to the exact location in the concrete when it is placed. Accurately cut and placed templates will be required for positioning the bolts.

In lieu of the above, anchor bolt holes shall be drilled in the exact location or may be formed by insertion of oiled and tapered wooden plugs or tapered metal sleeves into the plastic concrete. The bolts shall be set accurately and fixed in position with non-shrink grout completely filling the holes.

The location of the slotted holes in the expansion shoes in relation to the anchor bolts shall be varied with the prevailing temperature. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span and either lock nuts shall be provided or the threads of the anchor bolts burred.

In setting shoes or bearing plates for steel truss spans, proper allowance shall be made for bottom chord elongation due to dead load.

All shoes and rockers shall be set to be vertical at 70F.

441.36. Grading Deck on Continuous Units. Forms shall not be erected until after all welding, bolting, or riveting is complete, the unit positioned, and bearings properly set.

An accurate measurement shall be made of the elevations of girder or beam flanges at all grading control points as shown on the plans.

Subsequent grading of forms and placing and finishing of concrete shall be governed by these measurements only, taking into account the dead load deflections of the slab and rail as shown on the dead load deflection diagram.

441.37. Misfits. Corrections of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets will be considered a legitimate part of the operation. Any error in shop work which prevents the proper

assembling and fitting-up of parts by the moderate use of drift pins or a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Engineer for his approval of the method of correction.

The correction shall be made in the presence of the Engineer, who will check the material. Such work is to be done at the entire expense of the Contractor.

441.38. Paint and Painting. Unless otherwise provided, the application of field paints shall conform to the requirements of the Item, "Paint and Painting".

For railroad structures, which require that the steel be erected and assembled on falsework and moved into place as a unit, all field paint, except the final coat, shall be applied to the steel while on the falsework and prior to moving into final position. Surfaces inaccessible for painting in the final position shall have the final paint coat applied prior to move-in. Touch up of paint damaged due to move-in to final position will be done, and the final field coat applied.

441.39. Measurement and Payment. No direct compensation will be made for "Steel Structures". Measurement and payment for quantities of structural metal, concrete, reinforcement, railing and other proposal items which constitute the completed and accepted structures will be made in accordance with the provisions of pertinent specifications.

ITEM 442

METAL FOR STRUCTURES

442.1. Description. This item shall govern for the materials, such as structural steels, alloy steels, rivet steel, high strength bolts, forgings, steel castings, iron castings, wrought iron, bronze, steel pipe and tubing, aluminum castings and tubing, and other miscellaneous metals used in structures, except reinforcing steel and metal culvert pipe.

442.2. Process. All ferrous metals furnished for use under these specifications shall be made by one or more of the following processes only: Open-hearth, basic oxygen, or electric furnace.

442.3. Structural Steel.

(1) Steel for Main Members.

(a) Carbon Steel. When shown on the plans and in the proposal as Structural Steel-HYC, the material shall conform to the requirements of ASTM Designation: A36.

(b) High Strength Steel (HS). High strength steel will be specified on the plans by minimum required yield strength (Example - HS-42, 42,000 psi minimum yield) and will be tabulated on the plans and in the proposal as Structural Steel-HS.

When so specified, the steel shall conform to one of the following ASTM Steels subject to thickness and physical requirements of the pertinent ASTM Specification, or to ASTM Steels shown on the plans.

1. ASTM Designation: A441, High-Strength Low-Alloy Structural Manganese Vanadium Steel.

2. ASTM Designation: A572, High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, maximum Grade 50.

3. ASTM Designation: A588, High-Strength Low-Alloy Structural Steel With 50,000 psi Minimum Yield Point To 4 Inch Thickness.

Unless otherwise noted on the plans, and when used in welded construction, ASTM Designations: A572 and A588 shall be modified as follows:

a. A572 steel shall be limited to shapes in ASTM groups 1, 2 and 3, and for plates and bars up to a maximum thickness of 1½ inches. For plates over 3/4 of an inch through 1½ inches, "killed, fine grain practice" will be required.

b. For A572 and A588 steels, the producer shall make and report one impact test* from the thickest material in each lot furnished. This test shall be the longitudinal Charpy V-notch at +40F, conforming to ASTM Designation: A370, paragraph 23.

A lot, for purposes of impact testing, shall consist of 50 tons or fraction thereof of finished material from a single heat which is rolled on the same mill and is the same grade, type of product (plate, bar, wideflange, I, H, angle, etc.) and which is within one of the following thickness classifications:

Differing not more tnan three-eights of an inch in thickness when the least thickness of the lot does not exceed 2 inches.

Differing not more than one inch in thickness when the least thickness in the lot exceeds 2 inches.

The governing thickness for wide-flange, I, H and T sections shall be the average thickness of the flange. Test specimens for shapes shall be taken at a point one-third the distance from the outer edge of the flange or leg to the web or heel of the section.

*(*Prior to furnishing either A572 or A588 Steel, the producer may furnish to the Bridge Engineer, Texas Highway Department, Austin, Texas, impact test data on previously produced steel from the mill from which the steel is to be furnished. The tests shall represent the range of plate thicknesses and shape sizes required by the contract. These data shall indicate that longitudinal Charpy V-notch values of at least 15 foot-pounds at +40F are consistently obtained. If these data are satisfactory, impact test data will still be required, but will be for informational purposes only and will not be used for acceptance or rejection of the steel.*

If prequalified data are not submitted, or the data submitted is not acceptable, impact data required will be used for acceptance or

rejection of the steel. In this case 95% of the tests shall indicate values of not less than 15 foot-pounds at +40F.)

(c) Extra High Strength Steel (XHS). Extra high strength steel will be specified on the plans by minimum required yield strength (Example-XHS-90, 90,000 psi minimum yield) and will be tabulated on the plans and in the proposal as Structural Steel-XHS. When so specified, the steel shall conform to the following:

ASTM Designation: A 514, High-Yield Strength, Quenched and Tempered Alloy Steel Plate.

The steel furnished shall be suitable for welding. Structural shapes and seamless tubing, meeting the other requirements of A514 steels, will be permitted a maximum tensile strength of 140,000 psi for structural shapes and 145,000 psi for seamless tubing.

(d) High Strength Steel for Riveted or Bolted Construction (HSR).

High strength steel for riveted or bolted construction will be specified on the plans by minimum required yield strength (Example - HSR - 65, 65,000 psi minimum yield) and will be tabulated on the plans and in the proposal as Structural Steel-HSR.

When so specified, the steel furnished shall meet the requirements of ASTM Designation: A242, A440, A441, A572, A588, or A514 subject to thickness and stress requirements of the pertinent ASTM Specification and of the plans. Other ASTM Types and grades may be permitted when specified on the plans.

When used for bolted or riveted construction (no welding required), impact requirements will not be required for ASTM Designations: A572 or A588.

(2) Miscellaneous Steel.

Unless otherwise noted on the plans, items noted below shall conform to the following:

(a) Structural steel for members such as shoes, diaframs, stiffeners (including bearing stiffeners), lateral bracing, diagonals, armor joints and finger joints shall conform to ASTM Designation: A36 or A500, Grade B.

(When A572 or A588 steel is used for secondary or nonstress-carrying members the impact requirements will be waived.)

(b) Rivet Steel shall conform to ASTM Designation: A502, Grade 1 or 2.

(c) Stud shear connectors, slab anchors and anchors on armor joints and finger joints shall conform to the requirements of ASTM Designation: A108, cold drawn bars, Grades 1015, 1017, or 1020, either semi- or fully-killed.

Tensile properties as determined by tests of bar stock after drawing or

finishing shall conform to the following:

Tensile Strength (Min.)	60,000 psi
Yield Strength (Min.)	50,000 psi
Elongation (Min.)	20% in 2 inches
Reduction of Area (Min.)	50%

Tensile properties shall be determined in accordance with the applicable section of ASTM Designation: A370.

The manufacturer shall certify that the studs as delivered conform with the material requirements of this section.

(d) High strength bolts shall conform to the requirements of ASTM Designation: A325 or A490, unless otherwise shown on the plans. A mill test report or certification will be required indicating that the bolts conform to these requirements.

(e) Steel piling shall conform to the following:

Type	ASTM Designation
Steel H Piling	A36
Metal Shell Piling (heavier than 10 gauge)	A252* Grade 2 or A36
Sheet Piling (Rolled)	A328* Grade A
Sheet Piling (Formed)	A570* Grade A

*A mill certificate shall be furnished by the manufacturer certifying to the results of tests required by the governing specifications.

Sheet piling of a different configuration than that required by the plans may be used provided the section modulus and weight per foot furnished is equal to or greater than required by the plans.

(f) Deck Plates. Material for deck plates shall conform to one of the following:

1. Wrought Iron conforming to ASTM Designation: A42. Where bent plates are required, the Contractor shall notify the producer that plates must be furnished with proper ductility to allow bending in accordance with plan details without damage to the material.

2. Corrosive resistant structural steel conforming to ASTM Designation: A242. The material must be of weldable quality, and shall contain alloying elements that furnishes corrosion resistance at least twice that of copper bearing structural steel. The type of material to be used and the trade name shall be stated on the shop plans.

442.4. Steel Forgings. Steel forgings from which pins, rollers, trunnions, or other forged parts are to be fabricated, shall conform to the requirements of the Standard Specifications for Carbon-Steel Forgings for General

Industrial Use, ASTM Designation: A235, Class C1. The above will govern for all Railroad underpass structures.

For other structures, for pins 9 inches in diameter or less, material conforming to ASTM Designation: A108, Grades 1016 to 1030 may be used. The material shall have a minimum Rockwell Scale B Hardness of 80 or shall have a minimum tensile strength and yield point of 66,000 psi and 33,000 psi respectively. All forgings shall be thoroughly annealed prior to being machined to form finished parts. Material for pins over 9 inches in diameter shall be as shown on the plans.

442.5. Steel Castings. Steel castings shall conform to the specifications for Mild to Medium Strength Carbon Steel Castings for General Application, ASTM Designation: A27, Grade 70-36.

When specified on the plans as Class 70, Class 90, or Class 120, the steel castings shall conform to the specified class of ASTM Designation: A 486.

442.6. Iron Castings. All iron castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended.

The castings specified shall conform to the following ASTM Designations:

Material	ASTM Designation	Grade
Gray-Iron Castings	A48	Class 30
Malleable Castings	A47	35018
Ductile Iron Castings	A536	60-40-18

442.7. Wrought Iron. Wrought iron shall conform to the requirements of the Standard Specifications for Wrought Iron Plates or Welded Wrought Iron Pipe, ASTM Designations: A42 and A72, respectively. Transverse ductility of wrought iron plates shall not be less than 3 nor more than 8 percent.

442.8. Bronze. Bronze castings for bearings, trunnions, gears, and shafts shall conform to the requirements of the Specifications for Bronze Castings for Turn-Tables and Movable Bridges, ASTM Designation: B22. Alloy B shall be furnished, unless otherwise specified on the plans.

Bronze bearings and expansion plates shall conform to the requirements of the Specifications for Wrought Phosphor Bronze Bearings and Expansion Plates for Bridges and Structures, ASTM Designation: B100. Alloy 510 shall be furnished, unless otherwise specified on the plans.

442.9. Lead. Sheet lead shall conform to the requirements of the Specifications for Pig Lead, ASTM Designation: B29.

442.10. Copper. Sheet copper shall conform to ASTM Designation: B152.

442.11. Anchor Bolts. Unless otherwise specified on the plans, plain and threaded bars used for anchorage purposes shall conform to requirements of ASTM Designation: A36, or ASTM Designation: A306, Grade 65. Headed bolts and nuts shall conform to requirements of ASTM Designation: A307, Grade A. Anchor bolts shall not be galvanized unless otherwise noted on the plans.

A mill test report or certification will be required indicating that the material conforms to these requirements. When heat treated material is specified or required, the test report for certification shall include the necessary certification relative to the heat treating process.

442.12. Steel Pipe. Steel pipe shall conform to the material requirements shown on the plans.

442.13. Steel Tubing. Steel tubing shall conform to ASTM Designation: A500 Gr. B, unless otherwise shown on the plans or herein. Tubing conforming to API Standard 5LX, Grade 52, except as noted herein, may be used if produced by a mill recognized as "authorized to produce pipe with the API monogram" and listed as such in the standard API specifications.

The following exceptions to the requirements of API 5LX, Grade 52, will be allowed:

Hydrostatic tests will not be required.

In lieu of a mill test report, a certificate from the manufacturer will be required for each lot or shipment, certifying that the tubing meets the requirements stated above.

442.14. Pipe Rail. Pipe shall be construed to include special extruded and bent shapes and shall be of the section indicated on the plans. Pipe may be rolled or extruded to the shape shown on the plans or may be cold pressed from a round pipe or flat plate.

If cold pressed, the design of the press and dies shall result in a pipe of uniform section and free from die marks. After the pipe has been formed to the required section, it shall be cut to the lengths required. The end cuts and notches shall be made at such angles with the axis of the pipe as required to produce vertical end faces and plumb posts when required by the plans. Cutting and notching of pipe shall be done with a saw or machine guided torch or other means that will insure a neat and workmanlike finish.

442.15. Steel Deep Beam Rail. The rail element shall be formed from steel complying with Article 442.2. The rail element shall be either 10 gauge (0.1345 inches nominal thickness) or 12 gauge (0.1046 inches nominal thickness), exclusive of protective coating, as required by the plans. Minimum tensile strength of the rail element and joint, when tested in tension, parallel to the axis of the rail, shall be not less than 100,000 pounds for 10 gauge nor 60,000 pounds for 12 gauge.

The terminal section shall be of the same material, but shall not be less than 12 gauge.

442.16. Aluminum.

(1) Aluminum materials, other than castings, shall conform to the ASTM Designations shown on the plans.

Unless otherwise shown on the plans, aluminum castings shall conform to ASTM Designation: B108, Alloy S7A-T4.

Test specimens shall be cut, either vertically or horizontally, from the lower 14 inches of the tension flange but not at the junction of the rib or base. The curved surfaces shall be flattened prior to machining. Test specimens shall conform to ASTM Designation: E8, Figure 8.

(2) Aluminum Deep Beam Rail. The rail element shall conform to the following ASTM Designation:

Material	ASTM Designation	Alloy
Beam Section	B209	2024-T3
Terminal Section	B209	2024-T3

The minimum thickness of the rail element shall be 0.156 inches (nominal) or 0.105 inches (nominal) as required by the plans. Minimum tensile strength of the rail element and joint, when tested in tension parallel to the axis of the rail, shall be not less than 100,000 pounds for 0.156 inch thickness rail nor 60,000 pounds for 0.105 inch thickness rail.

442.17. Fabrication, Erection, and Painting. Fabrication, welding, and erection of structural metal shall be in accordance with the Item, "Steel Structures", the Item, "Structural Welding", and THD Bulletin C-5. Paint and painting shall be in accordance with the Item, "Paint and Painting". Aluminum or galvanized steel members shall not require painting.

442.18. Galvanizing. Galvanizing of metal fabricated from rolled, pressed, or forged steel shapes, plates, pipe and bars, shall conform to ASTM Designation: A123. Galvanizing of steel or iron castings shall conform to ASTM Designation: A153, Class A. Galvanizing of bolts, nuts, screws, washers, and other miscellaneous hardware, shall conform to ASTM Designation: A153, Class C or D.

Galvanizing will not be required for any material unless specified on the plans.

442.19. Measurement. Measurement of the quantity of structural metal furnished and placed will be based on the weight of metal in the fabricated structure. The weight of erection bolts, paint, or weld metal shall be excluded.

When increases in size or weights of members have been made which were not ordered but approved by the Engineer, the measurement will be made on the sizes or weights shown on the contract plans.

In determining the weight of structural metal in steel or concrete structures, such items as castings, bearing plates, anchor bolts, drains, deck plates, armor joints, finger joints, and all other metal for which no separate

measurement is specified, will be considered as Structural Steel.

The weights of rolled shapes and of plates shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop plans. The weight of castings will be computed from the dimensions shown on the approved shop drawings. Shoes will be measured by the weights shown on the contract plans, or as specified for castings, if weights are not shown.

Deductions will be made for all cuts, copes, perforations, and all holes except rivet or bolt holes.

When computed, the weight of metal will be based on the following:

	Pay Weights-Lbs per Cu In.				
Material	Steel	Cast Iron	Wrought Iron	Bronze	Lead
Weight	0.2833	0.2604	0.2777	0.3150	0.4085

Rivets and High Strength Bolts-Weight per Hundred Units							
Diameter	1/2"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/4"
Rivet Heads	4	7	12	18	26	36	48
Bolt Heads			15	25	36	52	73
Nuts			19	28	41	56	73
Washers			12	12	18	21	27

Splices will be measured as follows:

(1) No additional weight will be allowed for weld metal in a welded splice.

(2) Where a riveted or bolted splice is permitted as an alternate for a welded splice, measurement will be made on the basis of a welded splice.

(3) Where a riveted splice is required, the weight of splice material and rivet heads, with no deduction for holes, will be measured.

(4) Where a bolted splice is permitted as an alternate to a riveted splice, measurement will be on the basis of a riveted splice.

(5) Where a bolted splice is required, the weight of splice material, bolt heads, washers, and nuts, with no deduction for holes, will be measured.

A change in design concept which either increases or reduces the quantity of metal going into the structure or structures, will be measured by actual computed weights of the metal, and the quantity as shown on the plans and in the contract, will be increased or decreased by the revised weights, as the case may be.

442.20. Payment. Structural metal will be paid for at the unit price bid per pound for "Structural Steel, HYC", "Structural Steel, HS", or for such other classifications of metal as shown on the plans and in the proposal.

Shipping invoice or acceptance slip weights will not be used as basis for payment.

The quantity to be paid for will be that quantity shown on the contract plans and in the proposal, except as may be modified by the following:

(1) Either party to the contract may request an adjustment of the quantities shown on the contract plans (by each separate bid item), if the weights, calculated as outlined in Article 442.19, vary from those shown on the contract plans by more than the following:

(a) Over 500 tons—one-half of one percent.

(b) 50 tons through 500 tons—one percent.

(c) Less than 50 tons—1½ percent.

When adjustment is required, the Contractor shall furnish the Engineer three sets of shop bills showing the calculated weights of all parts of the structure. The weights shall be computed from the approved shop drawings, except as noted in paragraph two of Article 442.19.

(2) Payment for revised quantities due to a change in design will be paid for at the unit price bid per pound adjusted as provided in Article 442.19.

(3) Adjustments of quantities will be subject to the provisions of Article 4.3.

This price shall be full compensation for furnishing all materials and for all fabrication, shopwork, transportation, erection, paint, painting, galvanizing, and for furnishing all equipment, tools, labor, and incidentals necessary to complete the work.

ITEM 446

PAINT AND PAINTING

446.1. Description. This item shall govern for the type, quality and testing of paints; their source; surface cleaning and preparation; for the application of the paint; protection of all traffic, property and/or persons upon, underneath, or near the structure; and, the protection of all parts of the structure against disfigurement from any and all of the painting operations.

Surface conditions and application requirements are specified with the intent to obtain full adhesion of coatings to clean, dry metal and to

previously applied coats. This will require careful attention to preparation of surfaces; to prevention of contamination and marring of coatings during and after drying; and to uniform, skillful application of each coat of paint.

446.2. Paint Systems.

(1) Prime Coat. This Item provides for two basic paint systems for the prime coating of structural steel, as follows:

(a) Protection System I will require 'brush-off-blast' cleaning, with a minimum of 4 mil dry film thickness of prime coat paint.

(b) Protection System II will require 'near-white blast' cleaning, with a minimum 3.5 mil dry film thickness and a maximum 10 mil dry film thickness of prime coat paint.

(c) A Special Protection System will sometimes be specified and will require the type of cleaning, the type and thickness of prime coat and other coats, as shown on the plans or in Special Provisions to this Item.

(d) For members, which cannot be given a prime coat prior to installation, such as steel piling, regular cleaning will be permitted when Protection System I is specified. Unless otherwise shown on the plans, the cleaning system required for Protection System II or Special Protection System will be required for these members when pertinent.

(2) Appearance Coat. The final appearance coating for any of the prime coat systems may be aluminum, green, gray or brown as specified on the plans, with a minimum 1.5 mil dry film thickness. Appearance coats of other colors, when required, will have the type of paint, color and mil coverage designated on the plans or in Special Provisions to this Item.

446.3. Paint Designation. The complete system and color required by a particular contract will be shown on the plans as:

"Protection System I–Gray"

"Protection System II–Green"

"Protection System II–Aluminum" or Aluminum (Fast Dry)

"Special Protection System–Brown"

Note: Any of these colors may be designated with a particular system.

With specific written approval of the Engineer, the Contractor may substitute System II for a specified System I.

When the paint system is not shown on the plans, Protection System I–Aluminum will be required.

All primary structural steel including diaframs, laterals, finger joints and shoes shall receive cleaning and painting in accordance with the Paint System shown. Bearing plates, exposed surfaces of steel H, sheet or metal shell piling, and other miscellaneous structural steel items, except for armor joints, shall

be painted in accordance with Protection System I—Aluminum, unless otherwise specified. Armor joints shall be given a prime coat and field touch up prime coat only; an appearance coat will not be required.

446.4. Paint Requirements.

(1) General. Paints for System I, System II, and appearance coats for these systems will be in accordance with Department D-9-1 specifications.

Additional information about paint characteristics, thinner requirements, etc., and copies of Specification D-9-1 are available from the Texas Highway Department, Materials and Tests Division, 38th and Jackson St., Austin, Texas 78703.

(2) Prime Coat Paints. The prime coat for Protection System I is an oleoresinous type paint having a moderately slow drying rate. One gallon of unthinned paint, theoretically, will coat 1,000 square feet with a one mil dry film thickness.

The prime coat for Protection System II is an organic, Zinc-rich type paint. It is supplied in a two container kit. One combined kit of paint, theoretically, will coat 1,000 square feet with a one mil dry film thickness. Characteristics such as fast dry, high pigmentation and heavy weight make mandatory the use of good application technique and agitation of the paint during application.

(3) Appearance Coat Paints. The aluminum appearance coat (slow dry) is a standard, oil base, aluminum paint. One gallon of unthinned paint, theoretically, will coat 900 square feet with a one mil dry film thickness.

The aluminum appearance coat (fast dry) is a standard, laquer base, aluminum paint, for spray application only. One gallon of unthinned paint, theoretically, will coat 350 square feet with a one mil dry film thickness.

The color appearance coats (Green, Gray or Brown) are resin type, flat paints. These paints need to be thinned in accordance with the application conditions. They may be slow dry or fast dry according to the thinner selected. One gallon of unthinned paint, theoretically, will coat 775 square feet with a one mil dry film thickness.

(4) Condition. Paints being applied shall be mixed thoroughly and strained. They shall be completely homogeneous mixtures free of lumps, skins, or agglomerates, and shall contain all pigments, vehicle solids, and thinners required in the original formulation. Paint containers shall be kept tightly covered and protected from the weather when not in use.

(5) Thinning. Paint may be adjusted to the correct application consistency by the use of properly applied heat not to exceed 150 F, or by use of suitable thinners.

446.5. Source of Supply. All paint required to comply with Federal Specifications shall be purchased on the open market.

The contractor may purchase paints required to comply with D-9-1 specifications either from the Department or on the open market. All costs of

testing paint purchased on the open market, whether performed directly by the Department, or by commercial laboratories designated by the Department, will be charged to the Contractor.

All paints purchased from the Department will be charged to the Contractor at prices in accordance with the plans. The cost of testing of paints purchased from the Department is included in the price of the paint. Reimbursement to the State will be accomplished by making deductions from the Contractor's estimate for the actual cost of paints purchased.

Paint is stored by the Department in warehouses located at Seguin, Athens and Post, Texas. Paint will usually be shipped from the warehouse nearest the destination; however, the right is reserved to ship from any warehouse or delay shipment up to 30 days in case of necessity. Shipments will be made direct to the Contractor at the location he designates, with transportation charges to be paid by him. The Contractor shall place his order for paint through the District Engineer.

The Contractor shall not use any of these paints on any work which is not required by, or which does not constitute a part of his contract. Paints in unopened containers, which were purchased from the Department shall be returned promptly to the District Warehouse upon completion of the contract and credit will be given for the original cost of the paint.

Paints purchased on the open market shall not be used unless they have been inspected and tested as required. It is the Contractor's responsibility to place orders sufficiently in advance of work to insure delivery of paints meeting specification and inspection requirements.

The Contractor shall advise the Engineer, within 30 days after issuance of the work order, the source of supply of both shop coat and field coat (State stock or outside source).

446.6. Responsibility for Hazards. Some paints are harmful to the health. The Contractor is warned that he is responsible for the safety of his operations. This warning shall absolve the State from blame in the event of harm to persons or property from the Contractor's cleaning and painting operations.

446.7. Place of Application. Unless otherwise provided in the contract, the initial cleaning and application of required prime coat paint shall be done by the Fabricator, prior to shipment of the steel to the job site.

446.8. Cleaning and Preparation of Surfaces.

(1) General. Surfaces to be painted, whether in the shop or field, shall be completely free of oil, grease, moisture, dirt, sand, overspray, welding contamination, loose or flaking mill scale, rust or paint, and free of any other conditions that will prevent the paint from forming a continuous, uniform, tightly adhering film.

Loose mill scale, rust or paint shall be defined as follows:

Mill scale, rust and paint are classified as "loose mill scale", "loose and non-adherent rust" and "loose" or "removeable paint", if they can be

removed from a steel surface by power wirebrushing using a commercial air or electric wirebrushing machine operated at a speed under load of 3450 RPM and equipped with a 6-inch diameter cup brush, of double row knotted construction, made of No. 20 gauge music wire (Osborn Manufacturing Company, Cleveland, Ohio, Brush No. 4503 or equal). The brush shall be held against the steel surface with a force of sixteen pounds, and the rate of cleaning shall be two square feet per minute. This test must be conducted on an area not previously brushed, scraped, or sanded, but from which all detrimental stratified rust (rust-scale), oil and grease, if present, have been removed. This test establishes a standard for surface preparation and shall not be considered as establishing the production rate of cleaning.

Unless otherwise provided, the inside surfaces of box members *to be* completely sealed, shall be cleaned in accordance with regular cleaning, but shall not require painting. After all fabrication of the member is completed; its inside surfaces shall be cleaned by whatever methods necessary to remove dirt and other foreign substance which may have accumulated during assembly prior to closure. All surfaces that will not be completely enclosed shall be cleaned and painted in accordance with the required Protection System. Contact surfaces to be riveted or bolted shall not be painted.

For either shop or field painting, before other cleaning operations begin, grease-like contaminants shall be completely removed with clean petroleum solvents, such as cleaning naphtha, applied with clean rags so that the oil substance is actually removed and not simply diluted or spread out over a greater area. The same general requirements for painting over a clean, dry, firm surface shall be applicable to all coats.

All welds shall be flushed thoroughly with clean water and allowed to become thoroughly dry before cleaning.

(2) Regular Cleaning. Unless a particular cleaning method is specified, any effective method for removal of rust, scale and dirt, such as the use of blast-cleaning, hand or rotating metal brushes, scrapers, chisels, hammers, flamecleaning, or other means, will be acceptable.

(3) Required Blast-Cleaning. When blast-cleaning is required, the following shall apply:

(a) Near White Blast-Cleaning. When near white, blast-cleaning is required, the surface shall be cleaned to meet the following requirements:

A Near White Blast-Cleaned Surface Finish is defined as one from which all oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint or other foreign matter have been completely removed from the surface. Very light shadows, very slight streaks, or slight discolorations caused by rust stain, mill scale oxides or residues of paint or coating may remain. At least 95 percent of each square inch of surface area shall be free of all visible residues, and the remainder shall be limited to the light discoloration mentioned above.

(b) Brush-Off-Blast-Cleaning. When brush-off-blast-cleaning is required, the surface shall be cleaned to meet the following requirements:

A Brush-Off-Blast-Cleaned Surface Finish is defined as one from which all

oil, grease, dirt, rust-scale, loose mill scale, loose rust and loose paint or coatings are removed completely, but tight mill scale and tightly-adhered rust, paint and coatings are permitted to remain provided that all surface areas to be cleaned have been exposed to the abrasive blast pattern sufficiently to expose numerous flecks of the underlying metal fairly uniformly distributed over the entire surface.

(4) Field Cleaning and Spot Painting. When the erection or maintenance work is complete, including all riveting, bolting, welding, straightening of material, and the Engineer has examined and approved the work, all adhering rust, scale, dirt, grease or other foreign material shall be removed and the unpainted areas cleaned in accordance with the method required under the paint system specified and painted with the required prime coat. Any surfaces from which the prime coat of paint has become worn off or in any way fails to meet specification requirements, shall be cleaned and re-painted. All small cracks and cavities which were not sealed in a watertight manner by the prime coat shall be filled with a pasty mixture of the paint before the second coat is applied.

For field touch up coating on edges of plates or shapes, rivet heads, bolt heads, or nuts and other parts subjected to special wear, the edges shall first be striped with a longitudinal motion and the rivet heads, bolt heads or nuts, with a rotary motion of the brush, followed immediately by the general painting of the whole surface, including the edges and rivet heads.

The coating of white lead and tallow specified in Article 446.9 shall be completely removed as directed for removal of grease and oil herein.

446.9. Painting.

(1) General. Paint shall not be applied to any surface containing moisture discernible with the eye or by the following test:

> If temperature and humidity conditions are such that moisture is likely to condense upon the surface, a small area thereon shall be moistened with a damp cloth to apply a clearly defined, thin film of water. If this thin film evaporates within fifteen minutes, the surface shall be considered safe to paint from the standpoint of continued condensation at that particular time.

Paint shall not be applied at air temperature below 40 F; nor when there is likelihood of change in weather conditions within 2 hours after application which would result in air temperatures below 40 F, or deposition of moisture in the form of rain, snow, condensation, etc., upon the surface. The Engineer reserves the right to require that no paint be applied when impending weather conditions might result in injury to fresh paint.

If, in the opinion of the Engineer, traffic produces an objectionable amount of dust, the Contractor shall, at his own expense, allay the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before the paint is applied.

Paint shall not be applied closer than 12 inches to a surface which is to be cleaned.

(2) Application. Each coat of paint shall be applied so that it will dry to form a smooth, continuous, tightly adhering film of uniform thickness and appearance, free of brush marks, sags, runs, holidays and overspray. For all systems the dry film thickness shall be measured according to Test Method Tex-728-I.

Spray application of the first coat of prime coat will be permitted only when the surfaces are cleaned by blasting. Except for this limitation or inability to achieve other specification requirements, all coats may be applied by roller, spray, brush or a combination thereof. Any method of application approved by the Engineer may be used to paint inaccessible areas.

All equipment used for paint application shall meet with the approval of the Engineer. Brushes shall not exceed 4 inches in width; shall be springy and not flabby; and, shall be kept free of contaminants. Equipment used for spray painting shall have adequate provision for separation of moisture from any air stream in contact with the paint; and all spray guns shall be adequate for the type of paint being used and shall be equipped with spray heads adequate to provide a smooth, uniform coat of paint.

All painting shall be done by skilled workmen. Application of modern specialized coatings requires workmen knowledgeable about the characteristics of the various coating, solvents and substrates. They also must be capable of adjusting equipment and application techniques as dictated by the type paint, weather conditions, environment, size and shape of surface being painted.

(3) Prime Coat. After all fabrication work is completed and has been tentatively accepted, all surfaces to be painted shall be cleaned and painted with the required prime coat. Pieces shall not be loaded for shipment until coatings are thoroughly dry. No painting shall be done after material is loaded for shipment. Erection marks for field identification of members shall be painted upon previously painted surfaces. Surfaces to be in contact after shop riveting or bolting shall be cleaned but not painted. Unless otherwise noted on the plans, the top flanges of girders and I-beams shall be painted.

When field rivets or high-strength bolts are required, paint shall be omitted from surfaces to be in contact after erection.

Machine finished surfaces which are in sliding contact in the structure shall be clean and coated with a hot mixture of white lead and tallow before being shipped. This refers particularly to pins and pinholes. The composition used for coating these machine finished surfaces shall be mixed in the following proportions:

4 lbs. pure tallow

2 lbs. pure white lead

1 quart pure raw linseed oil

When Protection System II is used, surfaces within 4 inches of a weld that joins main stress carrying members and within 2 inches of fillet welds, including the far side, joining diaframs or lateral bracing to stiffeners or gusset plates shall be free of paint. These unpainted surfaces shall be blast-cleaned

and coated with raw linseed oil. After welding is completed, the areas shall be cleaned and painted in accordance with the required system.

When Protection System I is used, surfaces within 2 inches of a weld that joins the main stress carrying members shall be free of paint. These unpainted surfaces shall be cleaned and coated with raw linseed oil. After welding is completed, the areas shall be cleaned and painted in accordance with the required system.

All surfaces, other than those mentioned, shall be painted, whether or not the surface in question will be in direct contact with concrete.

Unless otherwise shown on the plans, or exempted above, the surfaces to be shop painted will include the rolling faces of rockers and base plates, all surfaces of bearing plates and all surfaces of iron or steel castings, whether or not such surfaces are milled.

(4) Appearance Coat. After all concrete has been placed and other work has progressed to the extent that marring of the appearance coat is unlikely, and all other previous paint coats, including any necessary corrective painting, has hardened completely, the required final or appearance coat may be applied. Previously applied paint film including field touch up requires a minimum of eight days cure prior to application of appearance coat.

If concreting operations have damaged the paint, the surface shall be recleaned and repainted. Prime coated surfaces shall be cleaned to remove dirt, grease or other foreign material prior to the application of the appearance coat. Paint that has become defective shall be removed, the metal properly cleaned and the required prime coat reapplied. Excessive amounts of paint that fails to properly dry or produces blisters in the paint shall be removed and replaced in accordance with the requirements of the specified system. In no case shall a succeeding coat be applied until the previous coat, and all touch up paint has dried throughout the full thickness of the paint film. At the time of acceptance of the structure, the painted portion thereof shall present an even and uniform appearance throughout.

(5) Paint Improperly Applied. To uncover evidence of improperly applied paint, the Engineer may, at any time during construction, explore underneath the surface of any paint coats already applied. Whenever unsatisfactory conditions are found beneath applied coating films, the Engineer shall require any and all necessary remedial measures.

All paint which has been applied improperly, applied to improperly cleaned surfaces, fails to dry and harden properly, fails to adhere tightly to underlying metal or other paint film, or does not evidence a normal, workmanlike appearance in conformance with these specifications, shall be repaired or completely removed and replaced at the expense of the Contractor. When the final field coat does not have a uniform color and appearance throughout the structure, it shall be corrected by the use of whatever additional coats or other corrective measures found to be necessary. Freshly applied paint which has not yet set, shall be removed with the use of suitable solvents. Removal of dried paint films shall be either by means of blast-cleaning, scraping, or flame torches meeting the approval of the Engineer.

446.10. Cleaning and Painting Existing Structures. Unless otherwise provided for on the plans, existing steel structures to be cleaned and painted shall receive the same paint schedule as that required for new structural steel. If the paint schedule for the existing structure is to be different from the new, or if there is no new structural steel on the project, paint requirements will be shown as "Special Protection System" and the requirements for cleaning and painting will be listed.

446.11. Measurement and Payment. Unless otherwise provided on the plans or specifications, the furnishing of all materials, equipment, supervision, labor, scaffolding, protection of traffic and incidentals necessary to complete the work required by this Item, will not be measured for payment but will be included in the unit price bid for the Item or Items receiving the paint. Painting of existing structures will be paid for at the lump sum bid for, "Painting Existing Structures".

ITEM 447

STRUCTURAL BOLTING

447.1. Description. This item shall govern for the materials to be used, and for the method of installation of high strength bolts used in structural joints.

Unless otherwise specified on the plans, high strength bolts may be used in lieu of rivets.

447.2. Material.

(1) Bolts, nuts, and washers shall conform to the requirements of the Specifications for "High Strength Bolts for Structural Steel Joints, Including Suitable Nuts and Plain Hardened Washers", ASTM Designation: A325, except as hereinafter provided.

(2) Bolts shall conform to the requirements for regular semi-finished hexagon bolts or heavy semi-finished hexagon bolts of the ANSI Standard B18.2.1.

(3) When specified on the plans, interference-body bolts, with heads conforming to the dimensions for driven button heads of the ANSI Standard B18.4 for large rivets of the same nominal diameter will be required. The head may be flattened to the same height as the head of the regular semi-finished hexagon bolt at the Contractor's option only when permitted by the Engineer. (Bolts of the interference-body type may not be substituted for the regular bolt, except as shown on the plans.)

(4) Nuts shall conform to the requirements for heavy semi-finished hexagon nuts or to the requirements for finished hexagon nuts of the ANSI Standard B18.2 and meeting the requirements of ASTM Designation: A194, Grade 2H.

(5) Circular washers shall be flat and smooth and their nominal dimensions shall be not less than those given in Table 3 of this Specification with ANSI Standard B27.2 Type A washer tolerances applied to these nominal dimensions. Beveled washers shall be square or rectangular, taper in thickness, and conform to the dimensions given in Table 3.

Where necessary, washers may be clipped on one side to a point not closer than seven eighths of the bolt diameter from the center of the washer.

(6) Bolts and nuts of any of the types specified above may be furnished except that all bolts and nuts shall be the same for any one structure.

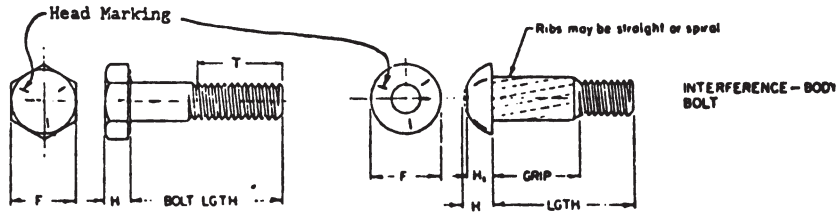
447.3. General.

(1) Surfaces of bolted parts in contact with the bolt head and nut shall not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Holes shall be punched, sub-punched and reamed, or drilled as required by the Item, "Steel Structures". Holes shall be of a nominal diameter not more than one sixteenth of an inch in excess of the nominal bolt diameter. Field erection and fit-up of joints and splices shall conform to the requirements of the Item, "Steel Structures."

(2) When assembled, all joint surfaces, including those adjacent to the washers, shall be free of dirt, rust, loose scale, burrs, and other defects that would prevent solid seating of the parts.

(3) Contact surfaces shall be free of oil, paint, lacquer, or galvanizing.

447.4. Identification and Dimensions. Bolts manufactured to ASTM Designation: A325 shall be identified on the top of the head by three radial lines and the manufacturer's mark. Heavy semi-finished hexagon nuts manufactured to ASTM Designation: A325 shall be identified on at least one face by 3 circumferential marks, or by the number "2" and the manufacturer's mark. Finished hexagon nuts shall be identified by the symbol "2H" and the manufacturer's mark.



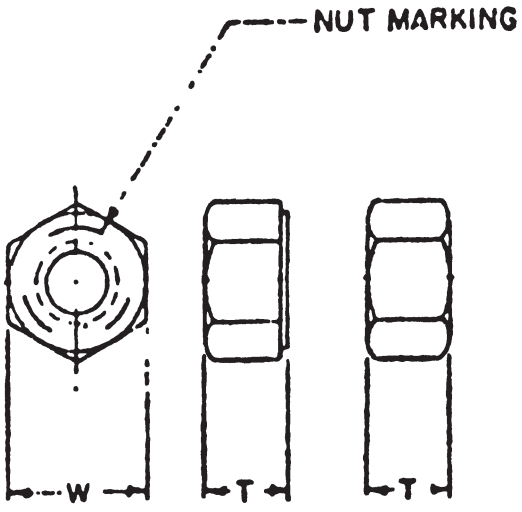
Nominal Bolt Size	Column 1		Column 2		Column 3			
	Regular Semifinished Hexagon		Heavy Semifinished Hexagon		Thread Length	Interference-body		
D	Width Across Flats	Height H	Width Across Flats	Height H	T†	F	H_1*	H
1/2	3/4	5/16	7/8	5/16	1	59/64	5/16	11/32
5/8	15/16	25/64	1 1/16	25/64	1 1/4	1 9/64	25/64	7/16
3/4	1 1/8	15/32	1 1/4	15/32	1 3/8	1 3/8	15/32	33/64
7/8	1 5/16	35/64	1 7/16	35/64	1 1/2	1 19/32	35/64	39/64
1	1 1/2	39/64	1 5/8	39/64	1 3/4	1 53/64	39/64	11/16
1 1/8	1 11/16	11/16	1 13/16	11/16	2	2 1/16	11/16	25/32
1 1/4	1 7/8	25/32	2	25/32	2	2 9/32	25/32	55/64
1 3/8	2 1/16	27/32	2 3/16	27/32	2 1/4	2 33/64	27/32	61/64
1 1/2	2 1/4	15/16	2 3/8	15/16	2 1/4	2 47/64	15/16	1 1/32

*Flattened height furnished at manufacturer's option.

†Thread lengths for hexagon head products up to 5 inches in length are shown; for bolts over 5 inches in length, thread lengths increase by ¼ inch.

TABLE 1

Bolt Dimensions
(inches)



Nominal Bolt Size	Column 1		Column 2	
	Finished Hexagon		Heavy Semifinished Hexagon	
	Width Across Flats	Height T	Width Across Flats	Height T
1/2	3/4	7/16	7/8	31/64
5/8	15/16	35/64	1 1/16	39/64
3/4	1 1/8	41/64	1 1/4	47/64
7/8	1 5/16	3/4	1 7/16	55/64
1	1 1/2	55/64	1 5/8	63/64
1 1/8	1 11/16	31/32	1 13/16	1 7/64
1 1/4	1 7/8	1 1/16	2	1 7/32
1 3/8	2 1/16	1 11/64	2 3/16	1 11/32
1 1/2	2 1/4	1 9/32	2 3/8	1 15/16

TABLE 2

Nut Dimensions
(inches)

		Circular Washers Flat Surfaces			Square or Rectangular Washers for American Standard Beams and Channels Beveled Surfaces†		
Bolt Size	Inside Dia*	Minimum Nominal Outside Dia.	Nom. Thick. Gauge No.	Nom. Thick. In.	Minimum Width	Mean Thick.	Slope or Taper in Thickness
1/2	9/16	1-3/8	12	0.109	1-3/4	5/16	1:6
5/8	11/16	1-1/2	10	0.134	1-3/4	5/16	1:6
3/4	13/16	1-3/4	9	0.148	1-3/4	5/16	1:6
7/8	15/16	2	8	0.165	1-3/4	5/16	1:6
1	1-1/16	2-1/4	8	0.165	1-3/4	5/16	1:6
1-1/8	1-1/4	2-1/2	8	0.165	2-1/4	5/16	1:6
1-1/4	1-3/8	2-3/4	8	0.165	2-1/4	5/16	1:6
1-3/8	1-1/2	3	7	0.180	2-1/4	5/16	1:6
1-1/2	1-5/8	3-1/4	7	0.180	2-1/4	5/16	1:6

*Not to be increased if larger washers are used.

†For slopes greater than 1:20

TABLE 3

Washer Dimensions
(inches)

447.5. Determination of Grip. To determine the required hexagon head bolt length, the value shown in the following table will be added to the grip, i.e., (the total thickness of all connected material, exclusive of washers).

Bolt Size (inches)	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
*To determine required bolt length add to grip (inches)	13/16	1-1/16	1-3/16	1-5/16	1-9/16	1-13/16	1-13/16	2-1/16	2-1/16

*The total length of bolt shall be adjusted to the next 1/4 inch increment up to 5 inches in length and to the next 1/2 inch increment for lengths over 5 inches.

TABLE 4

Determination of Grip

The above values allow for manufacturing tolerances, provide for the inclusion of either one or two flat circular washers, and the use of either a heavy or finished nut, with adequate "Stick-through" at the end of the bolt. For each required beveled washer, add an additional one eighth of an inch.

To determine the required length of interference-body bolts the value shown in the above table, less one eighth of an inch will be added to the grip.

447.6. Installation.

(1) Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening. A hardened washer shall also be used under the head of regular semi-finished hexagon bolts (Table 1, Column 1) and under finished hexagon nuts, (Table 2, Column 1), even when these are not the elements turned in tightening. The washer may be omitted under the head of heavy semi-finished hexagon bolts, (Table 1, Column 2), interference-body bolts, (Table 1, Column 3), and under heavy semi-finished hexagon nuts, (Table 2, Column 2), when these are not the elements turned.

(2) All fasteners shall be tightened to give at least the required minimum bolt tension values shown in Table 5 on completion of the joint.

Bolt Size (in.)	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Required Minimum Bolt Tension* (lb.)	12,050	19,200	28,400	36,050	47,250	56,450	71,700	85,450	103,950

*Equal to the proof load of bolt given in ASTM A325.

TABLE 5

Bolt Tension

(3) Tightening shall be done by one of the following methods:

(a) The Turn-of-the-Nut Method;

(b) The Calibrated-Power-Wrench Method.

447.7. Construction.

(1) Prior to the actual tightening of the bolts, the following procedure shall be followed:

(a) A minimum of 20 percent of the holes at a connection point will be filled with erection pins to "fair-up" all holes.

(b) Install bolts in all remaining holes.

(c) Tighten a minimum of 20 percent of the bolts, following a pattern of progression from the center, or most rigid part of the joint toward the free edges, making sure that all plies of the metal in the connection are properly fitted and in contact.

(d) Mark those bolts used for fit-up bolts.

(e) Tighten all the remaining bolts the required amount, then remove the erection pins.

(f) Fill the remaining holes with bolts, and loosen all bolts used for fit-up.

(g) Tighten the rest of the bolts by the required amount.

(2) Turn-of-the-Nut Method.

(a) Tighten all bolts not used as fit-up bolts to a "snug-tight" condition. (A snug-tight condition is indicated by the wrench when it ceases to spin and just begins to impact, or with a spud wrench by tightening with slight pressure.)

(b) Tighten the nuts by the amount specified in Table 6 below.

Bolt diameter in inches	From snug tight rotate nut*	
	1/2 turn for grips	3/4 turn for grips
3/4	up to 5 in.	above 5 in.
7/8	up to 5 in.	above 5 in.
1	up to 8 in.	above 8 in.
1-1/8	up to 8 in.	above 8 in.
1-1/4	up to 8 in.	above 8 in.

*Permissible tolerance: 1/4 turn over, nothing under.

TABLE 6

Turns for Specified Grip

Impact wrenches shall be of adequate capacity and sufficiently supplied with air to perform the required tightening in approximately 10 seconds.

(c) Follow steps (f) and (g) shown in Subarticle 447.7.(1) above.

(d) Tightening crew to mark finished work with identifying symbol.

(e) Inspector mark accepted work.

(3) Calibrated-Power-Wrench Method. When calibrated wrenches are used to provide the bolt tension specified in Table 5, their setting shall be such as to induce a bolt tension slightly in excess of the value shown. The wrenches shall be calibrated by tightening not less than three typical bolts of each size from the lot to be installed, in a device capable of indicating actual bolt tension.

Power wrenches shall be adjusted to stall-out or cut-out completely at the selected tension.

When using calibrated wrenches to install bolts, the operator should return to "touch-up" bolts previously tightened, until all bolts are tightened to the prescribed tension.

After proper calibration, the following procedures shall be followed:

(a) Tighten all bolts not used as fit-up bolts to the tension required in Table 5.

(b) Follow steps (f) and (g) shown in Subarticle 447.7.(1) above.

(c) Follow steps (d) and (e) shown in Subarticle 447.7.(2) above.

Impact wrenches shall be of adequate capacity and sufficiently supplied with air to perform the required tightening in approximately 10 seconds.

447.8. Inspection. The Engineer will approve the procedures for calibration of wrenches and installation of bolts. The inspector will further observe the filed installation to determine that these procedures are followed.

Bolts, nuts, and washers are normally shipped with a light residual coating of oil. This coating is not detrimental to friction type connections and need not be removed. Heavy coatings of oil shall be removed.

Bolts tightened by the turn-of-the-nut method shall have the outer face of the nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks shall be made by the operator with a keel, crayon, or spot of paint, after the bolts have been brought up to snug-tight.

A torque wrench will be used to check bolts for tightness when the calibrated-power-wrench method is used. The following procedure will be used to calibrate the torque wrench.

Three bolts of the type, size, and condition of thread as those to be inspected, will be tightened with the impact wrench, in a device capable of measuring actual bolt tension, to the required minimum bolt tension required in Table 5.

In this tightened condition, the inspector's torque wrench will be used to rotate the nut slowly in the tightening direction to just move the nut. The amount required to move the nut will be used for the inspection torque. (Use the average of the three torque values.)

When inspecting the bolts installed in the structure, the torque wrench will be used to tighten the nut, and the torque read just as the nut is set in motion.

Readings higher than the required minimum tension required will not be cause for rejection. Bolts giving values lower than the required value shall be further tightened. If the bolts cannot be tightened further, they shall be removed and replaced.

One or two bolts of each size in every connection, and a minimum of 10 percent of the bolts in large connections shall be checked. If one or more bolts in a connection are below the required value, all the bolts shall be re-impacted with the calibrated power wrench.

When the interference-body type of bolt is allowed and used, close inspection will be made to insure that the bolts are a tight drive-fit, and that there is no movement of the rivet-type head in the tightening operation.

When the calibrated-wrench-method of tightening is used the Contractor shall furnish the calibration equipment (Skidmore Wilhelm Bolt Calibrator or equal).

For the turn-of-the-nut method, the Contractor will not be required to

furnish equipment or make tests for establishing bolt tension. Such tests, if required, will be performed by the Engineer. However, the Contractor will not be relieved of the responsibility for re-tightening bolts in case that tests indicate that the required tension is not being obtained.

447.9. Measurement and Payment. No direct compensation will be made for the installation of bolts. Payment will be subsidiary to the pertinent Item requiring the use of High Strength Bolts.

Measurement and payment for the bolts required will be in accordance with the Item, "Metal for Structures".

ITEM 448

STRUCTURAL WELDING

448.1. Description. This item shall govern for the field welding of structural steel and reinforcing steel.

Provisions are made herein for the welding of the types of steel listed in Table 1, using the manual shielded metal-arc process, semi-automatic (manual) gas metal-arc welding and flux cored arc welding processes. Other welding processes may be permitted with the specific approval of the Engineer and with qualification of the welding procedure.

Shop fabrication and welding shall be in accordance with the Item, "Steel Structures", and THD Bulletin C-5.

448.2. General. Final welds including tack welds to be incorporated therein shall be made by a certified welder with electrodes meeting the mechanical requirements of the final welds and shall be of sound quality except that miscellaneous welds may be made by a qualified welder in accordance with Article 448.16. Certification shall be in conformance with the requirements of THD Construction Bulletin C-6. Tack welds shall be cleaned and fused thoroughly with the final weld. Defective, cracked or broken tack welds shall be removed.

Welds shall be as required by the contract or erection drawings. The location or size shall not be changed without approval of the Engineer.

The welder shall place his identification mark with crayon or paint near the groove welds made by him.

No welding will be allowed when the air temperature is lower than 20 F, when surfaces are wet or exposed to rain, snow, or wind, or when operators are exposed to inclement conditions that will hamper good workmanship.

Any moisture present at the point of welding shall be driven off by heat before welding commences. Wind breaks shall be required for the protection of all welding operations.

There shall be no temporary welds for transportation, erection or other purposes on main members, except at locations more than one-sixth the depth of the web from the flanges of beams and girders, as approved by the Engineer.

On A514 steel, all groove welds in main members and in flanges of beams

and girders subject to tensile stress or reversals of stress shall be finished smooth and flush on all surfaces, including edges, by grinding in the direction of applied stress, leaving the surfaces free from depressions. Chipping may be used provided it is followed by such grinding. Parts joined by groove welds connecting plates of unequal thickness or width shall have a smooth transition between offset surfaces at a slope not greater than one in four with the surface of either part. The surfaces shall be ground so that the radii at the points of transition will be 4 inches minimum.

All groove welds, except when produced with the aid of backing, shall have the root of the initial weld gouged, chipped or otherwise removed to sound metal before welding is started from the second side, except that back gouging will not be required when welding steel piling or armor joints with E 6010 electrodes. The back side shall be thoroughly cleaned before placing back-up pass.

When backing for welds is left in place to become a part of the structure, it shall be a single length insofar as possible. Where more than a single length is needed, they shall be joined by full penetration butt welds. The surfaces of this butt weld shall be ground flush as necessary to obtain proper fit-up in the weld joint.

Before welding over previously deposited metal, all slag shall be removed, and the weld and adjacent base metal shall be cleaned. This requirement shall apply equally to successive layers, successive beads and the crater area.

Arc strikes outside the area of permanent welds must be avoided on all steels. Where they do occur, resulting cracks and blemishes shall be ground out to a smooth contour and checked to insure soundness.

Stringer bead technique shall be used where possible for groove welds on all types of steel. Weaving will not be permitted for A514 steel except in welding vertically upward, when a weave not exceeding two electrode diameters is permissible for manual shielded metal-arc welding.

In all welding processes, the progression for all passes in vertical welding shall be upward using a back step sequence.

Groove welds shall begin and terminate at the ends of a joint on extension bars. Edge preparation and thickness of extension bars shall be the same as that of the member being welded and shall extend a minimum of three-fourths inch beyond the joint. Extension bars shall be removed with a cutting torch upon completion and cooling of the weld, and the flange edges shall be smooth.

Any defects exposed by the grinding shall be cleaned, filled with weld metal, and reground to a uniform finish. All grinding shall be parallel to the flange. Excess grinding of the parent metal shall be avoided.

448.3. Filler Metal. Electrodes for manual shielded metal-arc welding shall conform to the requirements of the latest edition of "Specifications for Mild Steel Covered Arc-Welding Electrodes", AWS A5.1, or to the requirements of the latest edition of "Specifications for Low Alloy Steel Covered Arc-Welding Electrodes", AWS A5.5.

All electrodes and combination of electrode and shielding for gas metal-arc welding for producing weld metal with a minimum specified yield point not exceeding 60,000 psi shall conform to the requirements in the latest edition, "Specification for Mild Steel Electrodes for Gas Metal-Arc Welding", AWS A5.18, or "Specification for Mild Steel Electrodes for Flux Cored Arc Welding", AWS A5.20, applicable for the classifications producing weld metal having a minimum impact strength of 20 ft -lb, Charpy V-notch, at a temperature of 0 F or below.

For weld metal with a minimum specified yield strength exceeding 60,000 psi, the Contractor shall demonstrate that each electrode and flux or combination of electrode and shielding medium proposed for use will produce low alloy weld metal having the mechanical properties listed in Table A.

The mechanical properties shall be determined from a multiple pass weld made in accordance with the test requirements of the latest edition of AWS A5.18 or AWS A5.20 as applicable.

Required Mechanical Properties

GMAW Grade	FCAW Grade	Tensile Strength psi – Min	Yield Strength psi – Min	Elongation, % in 2 inches Min	Impact Strength ft-lb @0F-Min
E80S	E80T	80,000	65,000	18	20
E90S	E90T	90,000	78,000	17	20
E100S	E100T	100,000	90,000	16	20
E110S	E110T	110,000	98,000	15	20

TABLE A

The mechanical property tests for Grades E100S, E110S, E100T and E110T shall be made using ASTM A 514 base metal.

A list of approved electrodes and flux electrode combinations will be maintained by the State Highway Engineer, Austin, Texas. All electrodes used on Department projects must be on the approved list. For approval of electrodes, the manufacturer shall submit to the Materials and Tests Division, Austin, Texas, certified copies of all test required by the pertinent AWS Specifications. Tests shall be made on electrodes of the same class, size and brand which were manufactured by the same process and with the same materials as the electrodes to be furnished. Tests must be made and approval renewed every 12 months.

For sizes of electrodes not requiring tests by AWS Specifications, test reports shall be furnished for electrodes of the nearest size and of the same classification. The request for approval shall include the manufacturer's certification that the process and material requirements were the same for manufacturing the tested electrodes and those to be furnished, and new test reports shall be submitted if any changes are made in process or materials during the effective period.

Class of electrode required will be as shown in Table 1. Electrodes shall be used with the type of current, the polarity and in the positions permitted by AWS A5.1 and A5.5 for manual shielded metal-arc welding. AWS A5.18 and A5.20 Specifications shall govern for gas metal-arc welding and flux cored arc welding.

Type of Steel	Main Members		Secondary Members	
	Groove & Fillet Welds		Groove & Fillet Welds	
Steel Piling	E6010	E60T-8	E60XX	E70S-6
	E6011	E70S-1B	E70XX	E70U-1
A53 Pipe, A500,	E7015	E70S-2	E70S-1B	E60T-8
A501	E7016	E70S-3	E70S-2	
	E7018	E70S-6	E70S-3	
Armor Joints		E70U-1		
A36	E7015	E70S-1B	E7015	E70S-1B
A441	E7016	E70S-2	E7016	E70S-2
A572-Grades 42	E7018	E70S-3	E7018	E70S-3
thru 50	E70U-1	E70S-6	E70T-1	E70S-6
A588	E70T-5	E70T-6	E70T-5	E70U-1
A242 (Deck Plates)			E70T-6	
API Pipe				
A514	E11018M		E11018M	
	E110S	E110T	E110S	E110T
Reinforcing Steel	E7015	E7016	E7018	
A572 Grades 60 and	E8015	E8016	E8018 Grades E80S or E80T	
65 for Light Towers				

(1) Use of the same type electrode with the next higher mechanical properties, in accordance with AWS A5.1 or A5.5, than those listed will be permitted.

(2) In joints involving base metals of different yield points or strengths, low hydrogen electrodes applicable to the lower strength base metal may be used.

Table 1
CLASSIFICATIONS OF ELECTRODES PERMITTED

Before use, all electrodes with low hydrogen coverings conforming to AWS A5.1 shall be dried for not less than two hours between 450 and 500 F and electrodes with low hydrogen coverings conforming to AWS A5.5 for not less than one hour at a temperature between 700 and 800 F. Immediately after drying, electrodes shall be stored in ovens held at a temperature of at least 250 F. E70 electrodes not used within four hours, E80 within two hours and E110 within one-half hour after removal from the storage oven shall be redried before use. Electrodes which have been wet or with cracked or otherwise damaged flux shall not be used. When used for welding A514 steel, electrodes shall be dried at least one hour at temperatures between 700 and 800 F before being used. Electrodes shall be redried only once.

Suitable facilities for drying and storage of electrodes shall be furnished at the job site, along with thermometers for checking and controlling the oven temperature.

In humid atmospheres, the times allowed for use without redrying may be reduced.

When a gas or gas mixture is used for gas metal-arc or flux cored arc welding, it shall be of a welding grade having a dew point of -40 F or lower. The gas manufacturer shall furnish certification to the Engineer that the gas or gas mixture is suitable for the intended application and will meet the dew point requirements.

Welding wire coils removed from the original package, shall be protected or stored to keep their characteristics or welding properties intact. Rusty coils, or portions of coils that are rusty shall not be used.

448.4. Assembly and Fit-Up. For any welding process, the parts to be joined by fillet welds shall be brought into as close contact as possible, and shall not be separated more than three-sixteenths inch. If the separation is one-sixteenth inch or greater, the leg of the fillet weld shall be increased by the amount of the separation. The separation between faying surfaces of lap joints and of butt joints landing on backing strips shall not exceed one-sixteenth inch.

Splices of beams and girders joined by groove welds shall be carefully aligned with the center of gravity of both members coinciding or each flange offset equally. Beams and girders with offset webs shall be fit with the webs aligned and the flanges offset.

When flanges are offset, or parts abutting edge to edge differ in thickness by more than one-eighth inch, the joint shall be made with the slope of either surface through the transition not exceeding one in four.

Suitable allowance shall be made for shrinkage and the joint shall never be restrained on both sides in any welding process.

All butt splices shall be made before welding of diaframs or sway bracing in a particular section of a unit. Diaframs and sway bracing may be welded in a unit behind the splice welding to provide stability except where such welding interferes with butt splice adjustments such as at a drop-in segment of a continuous unit. All splices shall be made before welding of beams or girders to shoes.

For manual shielded metal-arc welding, the fit-up procedure listed below shall be used for manual shielded metal-arc welding of groove welds for butt joints:

Members shall be spaced to provide a three-sixteenth inch root opening at the nearest point. When, at other points of the joint, this spacing provides up to and including a seven-sixteenth inch opening, correction may be made by buildup not exceeding one-eighth inch on each bevel nose. Opening exceeding seven-sixteenth inch shall require rebeveling of the joint to bring it within the maximum buildup limits prescribed above. Buildups must be allowed to cool before proceeding with the welding.

All members shall be brought into correct alignment and held in position by acceptable clamps while being welded.

The sequence used in welding of splices in all I-beams shall be to first place four tacks (1-1/2" to 2") in the web.

For I-beams or for built-up girders, place passes one, two and three in the top flange, followed by passes four, five and six in the bottom flange (See Figure 1).

Gouge out and replace passes one and four, which always are placed in the overhead position, before welding on the web. Next, place passes seven and eight in the web after aligning girder webs with short tacks at approximately 8 inches on centers. (I-beam web is already tacked at this stage).

Alignment clamps may be removed when sufficient weld has been placed to hold the members together, and welding is completed using the sequence shown in Figure 1.

When welding the root passes of beam and girder splices, E7010 electrodes may be used, provided the work is preheated to 400 F. After the root passes are backed up, the E7010 electrode pass shall be completely removed by arc-air gouging and replaced using low hydrogen electrode.

When this procedure is used, it shall be a continuous operation and back gouging and rewelding shall be completed on each splice before starting on another one. The use of E7010 electrodes will not be permitted for welding A514 steel.

Deviations from the above electrode designation, sequence of weld passes or fit-up procedures shall be approved by the Bridge Division.

448.5. Procedure. Shrinkage and distortion shall be controlled through the use of an approved procedure. Passes shall be made symmetrically and shall alternate between both sides of the joint.

For manual shielded metal-arc welding, beam and girder splices shall be made using the sequences shown in Figure 1, except that some members will require fewer or more passes than shown. Welds shall be alternated from side to side to prevent heat buildups on one flange edge. The passes must be arranged between the top and bottom flange to maintain balance and symmetry.

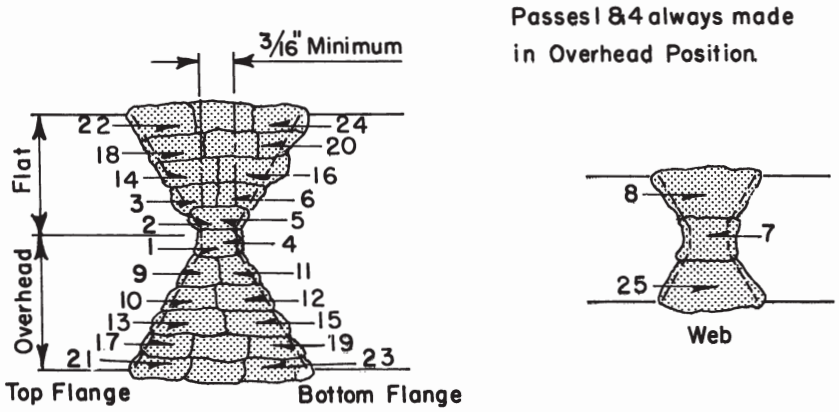


FIGURE 1

WELDING PROCEDURE FOR SPLICES FOR MATERIAL UP TO 50,000 PSI YIELD STRENGTH USING MANUAL SHIELDED METAL-ARC PROCESS

Welding procedures for any special connections shall be approved by the Bridge Division.

Procedures for all gas metal-arc and flux cored arc welding shall be submitted to the Bridge Division for approval and shall be qualified prior to any field welding.

All Gas Metal-Arc and Flux Cored Arc Welding procedures shall be qualified in accordance with Sections 5 and 7 of THD Bulletin C-5. For each joint to be used in construction, the joint details, electrode classification or grade, electrode diameter, voltage, amperage, travel speed, order and relative position of passes, number and thickness of layers, gas flow, dew point of gas, back gouging, method of cleaning and other pertinent information shall be clearly presented in the Procedure Specification. Fillet welds shall conform to details shown in Figure 2.

Procedures for welding on ASTM A 514 steel shall be submitted to the Bridge Division for approval and qualified in accordance with the C-5 prior to starting work. Variables to be reported shall include welding process, plate thickness, grade of steel, weld position, joint details, type and size of electrode, number and location of passes, welding sequence, back gouging, current and voltage per pass, welding speed, heat input, preheat and maximum interpass temperature. The heat input and maximum interpass temperature shall not exceed the recommendations of the Steel Producer.

The classification and size of electrode, arc length, voltage and amperage shall be suitable for the thickness of the material, type of groove, welding positions, and other circumstances attending the work.

(1) Manual shielded metal-arc welding process.

(a) The maximum size of electrode shall be as follows provided the welder has been certified for its use by the Department:

1. 5/16 inch for all welds made in the flat position, except root passes.

2. 1/4 inch for horizontal fillet welds.

3. 1/4 inch for root passes of fillet welds made in the flat position and of groove welds made in the flat position with backing and with a root opening of 1/4 inch or more.

4. 5/32 inch for welds made with EXX14 and low hydrogen electrodes in the vertical and overhead positions.

5. 3/16 inch for root passes of groove welds and for all other welds not included under 1, 2, 3 and 4 above.

(b) The root pass size shall be large enough to prevent cracking. The maximum thickness of layers subsequent to the root pass in fillet welds and of all layers in groove welds shall be:

1. 1/4 inch for root passes of groove welds.

2. 1/8 inch for subsequent layers of welds made in the flat position.

3. 3/16 inch for subsequent layers of welds made in the vertical, overhead and horizontal positions.

(c) The maximum size fillet weld which may be made in one pass shall be:

1. 3/8 inch in the flat position.

2. 5/16 inch in horizontal or overhead positions.

3. 1/2 inch in the vertical position.

(2) Manual (semi-automatic) gas metal-arc welding and flux cored arc welding process.

(a) The maximum size electrode used shall be as follows:

1. 5/32 inch for the flat and horizontal positions.

2. 5/64 inch for the vertical and overhead positions.

(b) The thickness of weld layers, except root and surface layers shall not exceed 1/4 inch. The split-layer technique shall be used in making all multiple pass welds when the width of the layer exceeds 5/8 inch. When the root opening of a groove weld is 1/2 inch or greater, a multiple pass split-layer technique shall be used.

(c) The welding current, arc voltage, gas flow, mode of metal transfer and speed of travel shall be such that each pass will have complete fusion with adjacent base metal and weld metal, and there will be no overlap, excessive porosity or undercutting.

(d) Gas metal-arc welding or flux cored arc welding with external gas shielding shall not be done in a draft or wind. An approved shelter of a

material and shape capable of reducing the wind velocity in the vicinity of the weld to an approved minimum must be used.

(e) The maximum size of a fillet weld made in one pass shall be:

1. 1/2 inch for the flat and vertical position.

2. 3/8 inch for the horizontal position.

3. 5/16 inch for the overhead position.

(3) Preheat.

Preheat ahead of welding both groove and fillet welds (including tack welding) will be required as shown in Table 2. Any moisture present at the point of welding shall be driven off by preheating before welding begins. When the base metal is below the required temperature, it shall be preheated so the parts being welded are not less than the specified temperature within 3 inches of the point of welding.

Preheat and interpass temperatures must be sufficient to prevent crack formation. The preheat temperatures shown are minimums and higher preheats may be necessary in highly restrained welds.

Preheating equipment shall be adequate to maintain the entire joint at or above the specified temperature. When possible, a joint shall be completely welded before it is allowed to cool below the specified temperature but shall always be welded sufficiently to prevent cracking before cooling is permitted.

Usually preheat and interpass temperatures shall not exceed 400 F for thickness up to 1½ inches and 450 F for greater thickness. These temperatures shall never be exceeded on A514 steel.

The welder shall have and use approved equipment for checking preheat and interpass temperatures at all times while welding is in progress.

For all groove welds, preheat temperature shall be measured on the side opposite to which the heat is applied at points about three inches away from the joint.

Thickness of Thickest Part at Point of Welding	MANUAL OR SEMI-AUTOMATIC GAS METAL-ARC WELDING, FLUX CORED ARC WELDING OR MANUAL SHIELDED METAL-ARC WELDING With Low Hydrogen Electrodes	
	ASTM A 36; A 242; A 441; A 572 Grades 42, 45, and 50; A 588	ASTM A 514
To ¾, incl.	50F	50F
Over ¾ to 1½, incl.	70F	125F
Over 1½ to 2½, incl.	150F	175F
Over 2½	225F	225F

(1) These temperatures are the minimum required for the thinner material shown for each increment and higher preheat on a step basis will be required for the thicker material within each increment. Preheat and interpass temperatures must be sufficient to prevent crack formation. Temperature above those shown may be required for highly restrained welds.

(2) When E7010 electrodes are permitted for tacking or temporary root pass, the material shall be preheated to 400 F.

(3) When joining steels of different strengths or thickness with groove welds, the preheat and interpass temperature for the higher strength steel and the average plate thickness shall be used. For fillet welds, the preheat shall be used for the higher strength steel and the thickest plate being welded.

(4) When the base metal temperature is below 32 F preheat to at least 70 F and maintain this minimum temperature during welding.

(5) Heat input when welding A514 steel shall not exceed the steel producers' recommendations.

TABLE 2

MINIMUM PREHEAT AND INTERPASS TEMPERATURE FOR MANUAL SHIELDED METAL-ARC WELDING, FLUX CORED ARC WELDING OR GAS METAL-ARC WELDING

448.6. Quality of Welds. Weld metal shall be sound throughout.

There shall be no cracks in any weld or weld pass.

There shall be complete fusion between the weld metal and the base metal and between successive passes throughout the joint.

Welds shall be free from overlap and the base metal free from undercut more than one one-hundredth inch deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall not be more than one thirty-second inch deep when its direction is parallel to the primary stress in the part that is undercut.

All craters shall be filled to the full cross section of the welds.

All welds on A514 steel shall be visually examined for longitudinal or transverse cracks not less than 48 hours after completion of welding.

448.7. Corrections. When welding is unsatisfactory or indicates inferior workmanship, the following corrective measures will be required by the Engineer whose specific approval shall be obtained for making each correction.

When requirements prescribe the removal of part of the weld or a portion of the base metal, removal shall be by oxygen gouging or arc-air gouging.

Oxygen gouging shall not be used on A514 steel. All surfaces shall be ground after arc-air gouging.

Backgouging of splices in beams and girders or cutouts of defective welds shall be done by a welder qualified to make beam and girder splices.

Where corrections require the deposition of additional weld metal, the sides of the area to be welded shall have sufficient slope to permit depositing new metal.

Defective or unsound welds shall be corrected either by removing and replacing the entire weld, or as follows:

Excessive convexity. Reduce to size by grinding off the excess weld metal.

Shrinkage cracks, cracks in base metal, craters and excessive porosity. Remove defective portions of base and weld metal down to sound metal and replace with additional sound weld metal.

Undercutting, undersize, and excessive concavity. Clean and deposit additional weld metal.

Overlapping and incomplete fusion. Remove and replace the defective portion of weld.

Slag inclusions. Remove the parts of the weld containing slag and replace with sound weld metal.

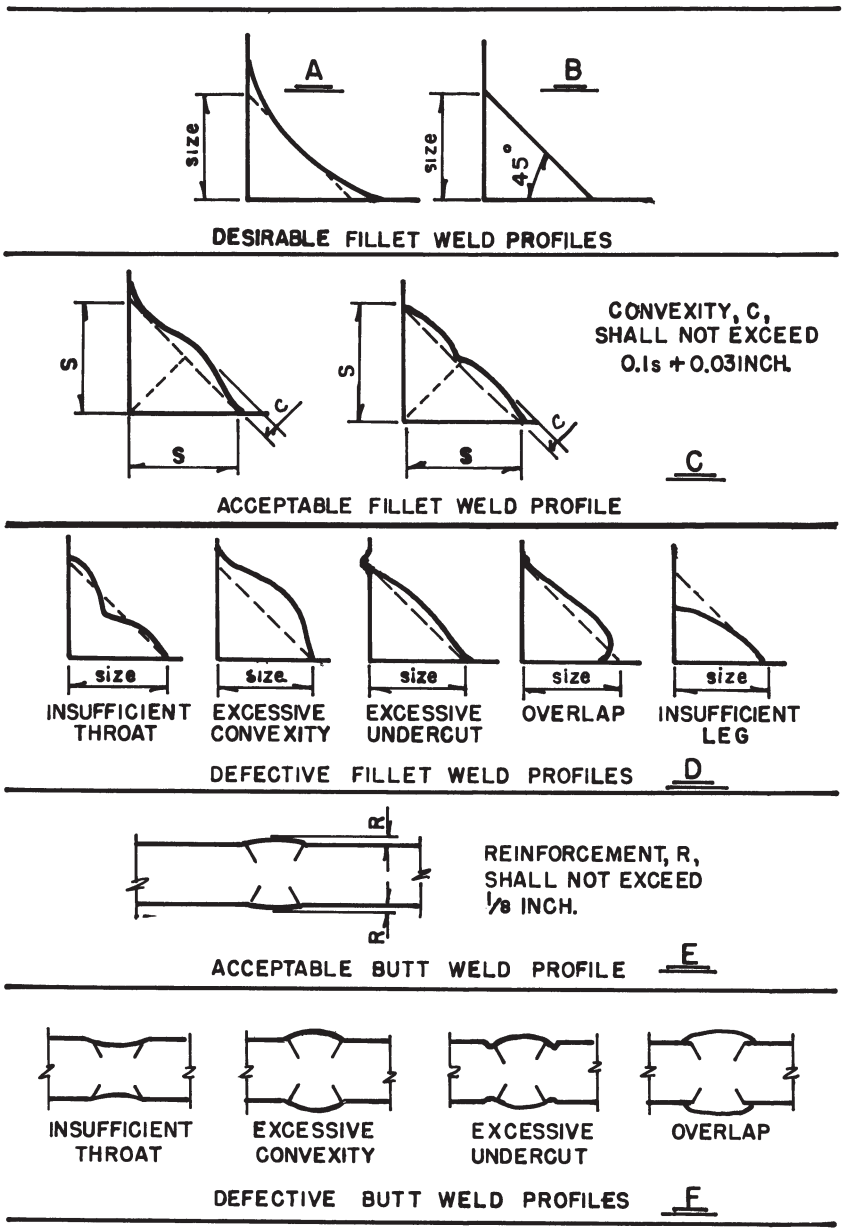


FIGURE 2
Weld Profiles

Removal of adjacent base metal during welding. Clean and form full size by depositing additional weld metal.

Where corrections require the deposition of additional weld metal, the electrode used shall be smaller than that used for making the original weld. Surfaces shall be cleaned thoroughly before rewelding.

A cracked weld shall be removed throughout its length, unless the extent of the crack can be ascertained to be limited, in which case the weld metal shall be removed 2 inches beyond each end of the crack and repairs made.

Where work performed after the making of a deficient weld has made the weld inaccessible or has caused new conditions making the correction of the deficiency dangerous or ineffectual, the original conditions shall be restored by removal of welds or members, or both, before making the necessary corrections, or else the deficiency shall be compensated by additional work according to a revised design approved by the Engineer.

Improperly fitted and misaligned parts shall be cut apart and rewelded.

Members distorted by the heat of welding shall be straightened by mechanical means or by the carefully supervised application of a limited amount of localized heat. Heated areas shall not exceed 1200 F as measured by Tempil-sticks or other approved methods for steel up to 65,000 psi yield strength. Parts to be heat straightened shall be substantially free of stress from external forces, except when mechanical means are used in conjunction with the application of heat.

Heat straightening of A514 steel shall be done only under rigidly controlled procedures, subject to the approval of the Engineer. In no case shall the maximum temperature of the steel exceed 1100 F. Sharp kinks and bends shall be cause for rejection of the material.

448.8. Radiographic Inspection. In addition to the requirements of this Article, radiographic and other nondestructive testing shall be in accordance with the requirements of Article 441.34.

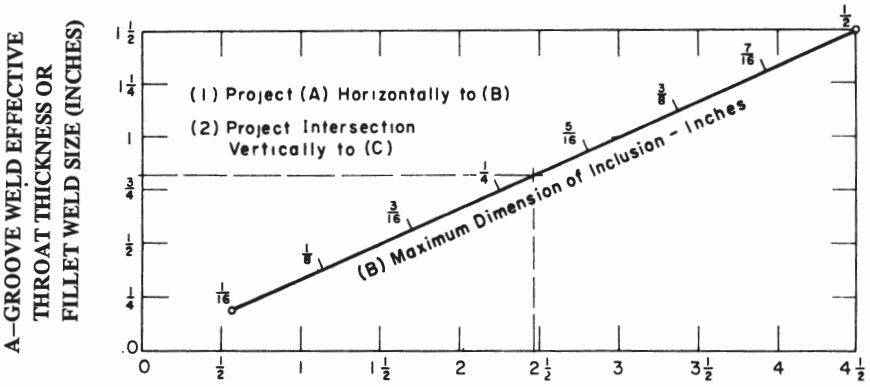
All groove welds designed to carry primary stresses shall be subject to radiographic inspection. When subjected to such inspections, the presence of any of the following defects in excess of the limits indicated will result in rejection of the defective weld until corrected.

(1) Sections of welds shown to have any cracking, regardless of length or location, incomplete fusion, overlapping, or inadequate penetration shall be judged unacceptable.

(2) Inclusions less than one-sixteenth inch in greatest dimension including slag, porosity and other deleterious material, shall be permitted if well dispersed so that the sum of the greatest dimensions of the inclusions in any linear inch of welded joint shall not exceed three eighths inch.

(3) Inclusions one-sixteenth inch or larger in greatest dimension shall be permitted provided such defects do not exceed the limits shown on Figure 3 or in paragraph (2) above.

(4) There shall be no inclusion greater than one-sixteenth inch within one inch of the edge of part or member at the joint or point of restraint.



C–MINIMUM CLEARANCE MEASURED ALONG THE LONGITUDINAL AXIS OF THE WELD BETWEEN EDGES OF POROSITY OR FUSION-TYPE DEFECTS (INCHES).
(Larger of Adjacent Defects Governs)

NOTES:

(1) The distance from the edge of an inclusion to the edge of a plate or to any intersecting weld shall be equal to or greater than the clearance between inclusion.

(2) Inclusions with any dimension greater than 1/2 inch are not acceptable.

(3) For joint thickness greater than 1-1/2 inches, the minimum allowable dimension and spacing of inclusions shall be the same as for 1-1/2 inch joints.

(4) Values of (B) obtained by projecting horizontally from (A) are maximum value. Any value of (B) smaller than the maximum is satisfactory.

(5) Values of (C) obtained by projecting vertically from (B) are minimum values. Any value of (C) larger than the minimum is satisfactory.

FIGURE 3
STANDARDS FOR ALLOWABLE INCLUSIONS

Radiographic inspection shall be made of A514 steel not less than 48 hours following the completion of welding. For other steels, nondestructive inspection may begin immediately after welding and cleaning or grinding is completed.

Definitions:

Porosity signifies gas pockets or any similar generally globular type voids.

Fusion-type defect signifies slag inclusions and similar elongated defects.

REINFORCING STEEL

448.9. General. Provisions are made herein for the welding of reinforcing steel by the manual shielded metal-arc process. Other processes may be permitted with the specific approval of the Engineer or may be specified on the plans.

Splicing of reinforcing steel by welding shall be done only at locations shown on the plans.

448.10. Base Metal. Reinforcing steel to be welded shall be new billet steel conforming to ASTM Designation: A 615, and shall also conform to the following chemical composition.

Maximum Carbon	0.40 Percent
Maximum Manganese	1.30 Percent

Mill test reports will be required in accordance with the Item, "Reinforcing Steel".

448.11. Filler Metal. Low hydrogen electrodes as specified in Table 1 will be required for all welding of reinforcing steel. Drying of electrodes shall be as specified in Article 448.3.

448.12. Preheat and Interpass Temperature. Minimum preheat and interpass temperatures shall be as shown in Table 3.

Carbon Range	No. 7 & Smaller	No. 8 & Larger
Up to and including 0.30	None	100
0.31 to 0.35 inclusive	None	150
0.36 to 0.40 inclusive	100	250
Unknown	250	400

TABLE 3

For widening projects, use carbon content and bar size of new steel to determine preheat required.

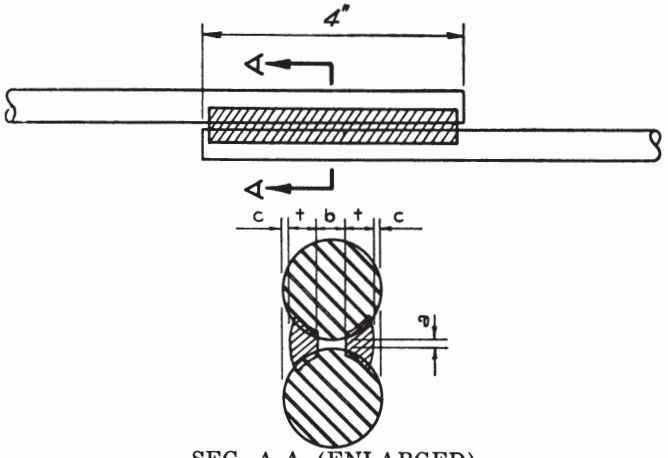
448.13. Joint Types. For all bars No. 8 and larger, butt splices will be required. For No. 7 bars and smaller, lap splices will be required.

Fillet welds in lap splices shall be a minimum of 4 inches in length and shall be welded on each side of the lap joint. For bars No. 5 and smaller, welding from one side of the lap will be permitted by the Engineer, when it is impractical to weld from both sides of the joint, and the weld shall be a minimum of 6 inches in length.

Lap welds shall meet the requirements specified in Table 4.

Where possible, all butt splices shall be made in the flat position. All butt splices, except ~~horizonta~~l, shall be as shown in Figure 4 with the back-up strip required. ~~Horizontal~~ splices shall be as shown in Figure 5.

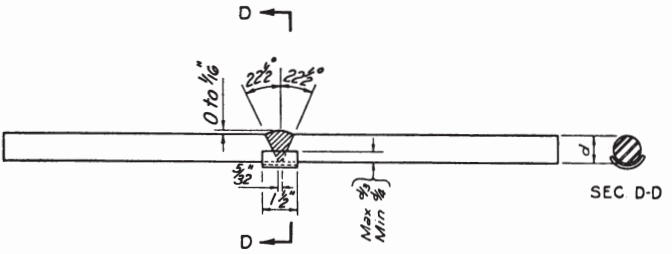
Bar Size	"a"	"b" (Max.)	"t" (Min.)	"c" (Max.)	Electrode Size
No. 4	.04 in.	1/8 in.	1/8 in.	1/16 in.	1/8 in.
No. 5	.05 in.	1/8 in.	3/16 in.	1/16 in.	5/32 in.
No. 6	.06 in.	1/8 in.	1/4 in.	1/16 in.	5/32 in.
No. 7	.07 in.	3/16 in.	5/16 in.	1/16 in.	5/32 in.



SEC. A-A (ENLARGED)

TABLE 4

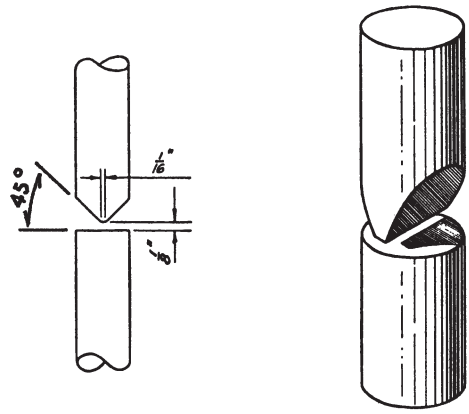
Required Dimensions for Lap Splices



Butt weld in flat position

BUTT WELD WITH BAR IN HORIZONTAL POSITION

FIGURE 4



BUTT WELD WITH BAR IN VERTICAL POSITION

FIGURE 5

448.14. Widening Projects. In general, the new reinforcing steel shall be either lap or butt spliced directly to the bar to be extended. When the reinforcement in the old portion of a structure is found to be of the wrong spacing, dowel bars long enough to develop the welded lap or butt splice and also develop the bar in bond, as required in the Item, "Reinforcing Steel", shall be welded to the old steel, and the new reinforcement placed at the correct spacing without welding to the old steel. No measurement or payment will be made for the dowels but will be subsidiary to the other items in the contract.

Both old and new reinforcement shall be cleaned thoroughly prior to the preparation of the joint.

448.15. Radiographic Inspection. When so designated on the plans, welded butt splices shall be radiographed. Weld quality shall be as follows: There shall be no cracks and the sum of the greatest dimensions of porosity and fusion-type defects shall not exceed one-tenth of the nominal bar diameter in inches.

STRUCTURAL AND REINFORCING STEEL

448.16. Welder Qualification. All welders who weld on permanent load carrying members shall be certified before working on any material which is to be incorporated into a Department project. Each welder must have certification papers showing the type of work for which he is certified and will not be permitted to do any type of work not covered by such papers.

Miscellaneous welds of the following types may be made by a welder that is certified for structural or reinforcing steel, or a qualified welder:

Armor joints and their supports, Screed Rail and Form Hanger Supports where permitted on Steel units, Reinforcing Steel to R-Bars for lateral stability between Prestressed Beams, Spirals or Bands to

Reinforcing Bars in Drilled Shaft cages and other similar miscellaneous members that have no load carrying capacity in the completed structure.

A qualified welder is an experienced welder who is capable of making welds of sound quality, but does not have certification papers. Prior to welding operations, the Resident Engineer's personnel shall check the welder's ability by a job site Miscellaneous Weld Qualification Test. The Contractor shall furnish all of the material and equipment necessary for this test.

The Miscellaneous Weld Qualification Test shall consist of the following:

The welder shall make a single pass fillet weld 1/4 inch maximum size approximately 2 inches long on one half inch plate using 5/32 inch low hydrogen electrodes in the position shown in Figure 6.

The specimen shall be visually examined and the fillet weld shall present a reasonably uniform appearance free of cracks, overlap and undercut. (See Figure 2). There shall be no porosity visible on the surface of the weld.

The specimen shall be ruptured as shown in Figure 7 by the application of a force or by striking with a hammer.

The fractured surface of the weld shall show complete penetration into the root of the joint and shall exhibit no incomplete fusion to the base metal nor any inclusion or porosity larger than 3/32 inch in its greatest dimension.

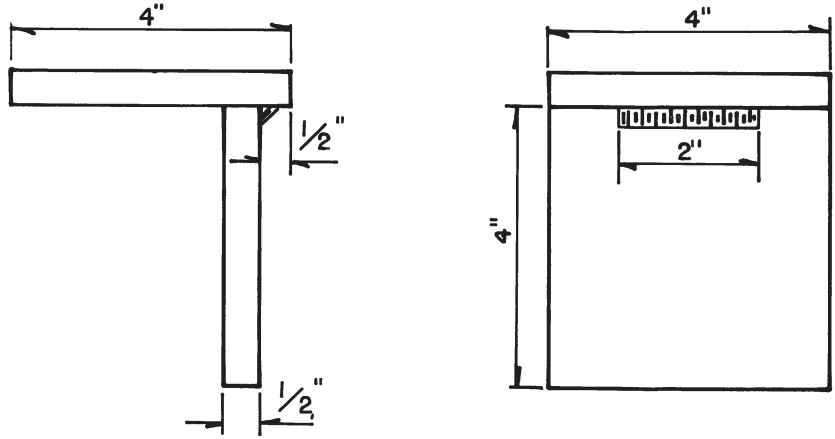


FIGURE 6
Fillet Weld-Break Specimen
Miscellaneous Qualification

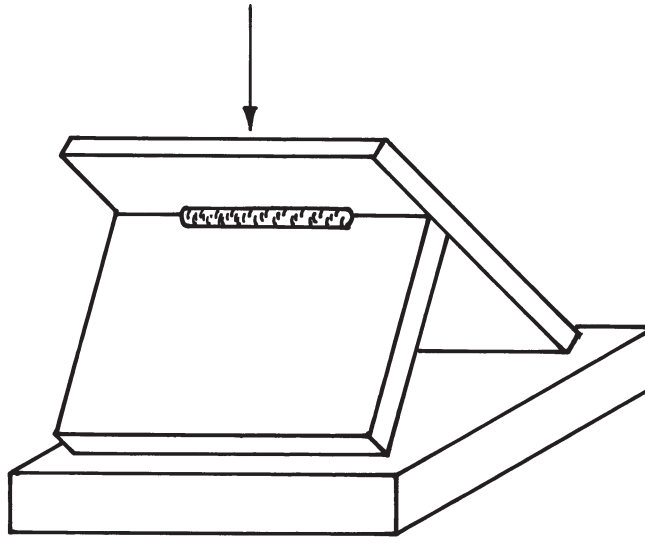


FIGURE 7

Method of Rupturing Specimen-Miscellaneous Qualification

If a welder fails to meet the requirements of this test, a retest may be allowed under the following conditions:

(1) An immediate retest may be made consisting of two test welds, as described above, and both test specimens shall meet all of the requirements specified.

(2) A retest may be made after thirty days, provided there is evidence that the welder has had further training or practice. In this case the test shall be a single specimen.

The qualification test herein specified shall be effective immediately upon satisfactory completion thereof and shall remain in effect for the duration of the project.

Before welding on A514 steel, each welder must present evidence, satisfactory to the Engineer, that he has had at least three months satisfactory experience welding this type of steel over one inch thick. In lieu of such experience, each welder, providing he has previously qualified for welding with low-hydrogen electrodes or has used the proposed welding process, shall have completed a training course in welding A514 steel prior to taking the welder qualification test.

Tests for certification of welders for manual shielded metal-arc welding shall be as prescribed by THD Bulletin C-6. Tests shall be given by an approved laboratory. For field welding, certification by an approved laboratory will be accepted for a period of one month from the time of certification. During this period, the welder will be permitted

to work on Department projects provided his work is satisfactory. If his work is satisfactory during this period, the Department will issue him certification papers which will permit the welder to work on Department projects as long as he continues to do satisfactory work.

A welder must have passed the Basic Qualification Test for Structural Welding in the vertical and overhead position in accordance with THD Bulletin C-6. Also, he must demonstrate to a Department welding inspector a thorough knowledge of the required welding procedures together with his ability and desire to follow them and make welds of sound quality and good appearance. Quality of the weld will be checked by radiography.

To work on field splices of beams and girders, a welder must be certified for and be capable of making groove welds in both the vertical and overhead position when using the manual shielded metal-arc process.

For manual (semi-automatic) gas metal-arc welding or flux cored arc welding, welder qualification tests for certification shall qualify using an approved procedure in accordance with THD Bulletin C-5 and tested in accordance with THD Bulletin C-6 as follows:

(1) Basic Test—Certification for groove welds for unlimited thickness material will also qualify a welder for any equal or lower strength steel or for fillet welding in the position in which he is certified using the same electrode and combination of shielding used for the test.

(2) Welders shall be certified in the vertical and overhead position to work on field splices of beams or girders.

(3) Tests for certification shall be given by an approved laboratory. Certification papers for gas metal-arc welding or flux cored arc welding issued by an approved laboratory will be handled in a manner similar to that used for the manual shielded metal-arc process.

(4) Welders shall be qualified for each process to be used. Qualification for flux cored arc welding will not qualify a welder for gas metal-arc welding or vice versa.

(5) Qualification for welding with any grade electrode will automatically qualify a welder for the use of lower grades of electrodes using the same process, i.e., qualification with grade E80S electrode will qualify for Grade E70S, but not vice versa.

The certification papers issued by the Department are the property of the Department and may be cancelled at any time.

For A514 steel, radiographic inspection shall be made of all qualification test plates for groove welds. If this inspection indicates any lack of fusion, incomplete penetration, and defects one-sixteenth of an inch or larger in greatest dimension, or if the sum of the greatest dimensions of defects less than one-sixteenth of an inch in greatest dimension exceeds three-eights of an inch in any linear inch of weld, the weld shall be considered as failing the soundness test. This radiographic

inspection shall apply only to that portion of the welds between the discard strips of the specimens as indicated in Figures 13 and 14 of Appendix B of THD Bulletin C-6. The specimen plates shall be wide enough to provide a minimum of six inches of effective weld length for radiographic testing.

448.17. Measurement and Payment. No measurement or payment will be made under this item for the work prescribed but shall be considered subsidiary to the various other bid items called for in the contract.

ITEM 450

RAILING

450.1. Description. This item shall govern for the construction of concrete, steel, aluminum, or pipe railing, or a combination of these materials on bridges, walls, or incidental structures as designated on the plans.

In general, railing shall include that portion of the structure erected on and above the roadway curb or along the edges of walks, curbs, and/or slabs for the protection of traffic and pedestrians, and shall include the tie-in anchorage to the approach railing erected on the embankment.

Railing, including the necessary anchorage, shall be constructed in accordance with the details shown on the plans.

450.2. Materials. All materials shall conform to the requirements of the Item, "Concrete for Structures", "Lightweight Concrete for Structures", "Reinforcing Steel", and "Metal for Structures", as the case may be.

450.3. Construction.

(1) General. Railing shall be of the classification and type specified conforming with the requirements herein and shall be constructed in accordance with details shown on the plans. It shall be constructed to the alignment, grade and camber designated on the plans. Shop fabricated railing shall be uniform to insure good joints and continuous lines after erection on the structure. Any appreciable amount of cutting, bending or filling required during erection to produce a reasonable fit will be cause for rejection of the rail. Unless otherwise provided, railing shall not be placed until falsework, if any, for the span has been released. During construction, care shall be exercised to insure proper functioning of expansion joints.

Unless otherwise shown on the plans, rail posts shall be vertical. Fabrication and erection of metal for railing shall conform to the pertinent provisions of the Item, "Steel Structures", and to the requirements of this specification.

Splicing of members will be permitted only as provided by contract plans. In general, splices shall be at rail posts. All splice locations and details shall be shown on the shop drawings.

For metal railings, shop drawings shall be prepared and forwarded for approval in accordance with the requirements of the Item, "Steel Structures".

Welding shall be in accordance with the Item, "Structural Welding", and THD Bulletin C-5.

Railing materials shall be stored above the ground on platforms, skids, or other supports and kept free from grease, dirt and contact with dissimilar metals. Care shall be taken at all times to avoid scratching, marring, denting, discoloring, or otherwise damaging the railing. Unpacking and storing of rail members at the job site shall be in accordance with manufacturer's recommendations.

To facilitate bending or straightening, aluminum materials other than castings may be heated not to exceed 400 F for a period not exceeding 30 minutes.

Welding of aluminum materials shall be done by an inert gas shielded, electric arc welding process using no welding flux. Torch or flame cutting of aluminum will not be permitted.

(2) Concrete Railing. For concrete portions of railings, the construction and removal of forms and the placing, curing and surface finishing shall conform to provisions of the Item, "Concrete Structures", and to the requirements herein. Provision shall be made in constructing forms to provide for checking and correction of railing lines and grades after concrete has been placed, but before initial set, and the finish floating of the railing tops shall not disturb the form alignment after the final check. Particular care shall be exercised in other construction operations to avoid disturbing or vibrating the span with the newly placed railing. Construction joints at the bottom of rail posts or rail parapet shall be treated in accordance with Article 420.6. For precast members, care shall be taken to preserve true and even edges and corners. Any member which becomes marred or cracked will be rejected and shall be removed from the work.

All storing, splicing, bending and placing of reinforcing steel for railing shall conform to the pertinent provisions of the Item, "Reinforcing Steel".

(3) Pipe Railing. Pipe shall be fabricated from the material and to the shape and dimensions shown on the plans and governing specifications.

Pipe rail and posts shop fabricated into panels shall be mounted in a jig clamped in their true relative position, accurately spaced with respect to each other and while assembled shall be completely welded or bolted, as the case may be. When required by the plans, as each rail section is completely assembled and connected, the adjacent section shall be set in its proper

relative position with the ends engaged and remain in this position until completely connected. Each pair of sections shall be matchmarked so they may be erected in the same order in which they were fabricated.

(4) Metal Rail. The fabricated elements shall conform to the dimensions and cross section shown on the plans. The rail shall be straight and free from warp. Maximum deviation from straightness of either edge of a full length section shall be one-half of an inch.

Rail elements shall be jointed and connected to the rail posts as shown on the plans. Lapped elements shall have the lap in the direction of traffic in the adjacent lane.

(5) Cast Rail Posts. Castings shall be true to pattern in form and dimensions and shall be of the materials specified on the plans and governing specifications.

Castings shall be permanent mold castings of uniform quality and condition, free from cracks, and shall be free of defects such as blow holes, porosity, hard spots or shrinkage effects which are extensive enough to materially affect their suitability for the intended use. The castings shall be free of all burrs, fins, discoloration and mold marks, and shall, when finished, have a smooth and uniform appearance and texture.

Castings shall be produced under radiographic control, consisting of a radiographic examination of them, until proper foundry technique is established for each mold to produce a product free from harmful internal defects. Radiographic examination of production castings will be made as necessary to insure maintenance of satisfactory quality.

Mill test reports shall be furnished showing the chemical composition, tensile strength, elongation and number of pieces for each lot.

When required, the castings shall be heat-treated to produce material with the utmost uniformity conforming to the properties specified. The whole casting shall be heat-treated and never a portion only.

All castings shall be permanently marked on the web or top of base with the lot number and with heat treat lot identification. Such markings shall be sufficient to correlate the castings with the mill test reports.

To provide more uniform materials and to reduce the number of samples required to establish material compliance, the entire number of acceptable posts cast from each lot shall be furnished to the project, except where less than the complete lot is required or where a portion of a lot is required to complete the shipment. The mill test report shall indicate the number of posts represented by each lot and furnished to the project.

For aluminum, a lot of castings shall consist of not more than 1,000 pounds of trimmed castings when produced from batch type furnaces, or 2,000 pounds when produced from a continuous furnace during a period not exceeding 8 consecutive hours.

Minor defects in aluminum castings may be repaired by an approved inert gas welding process.

450.4. Tests. One post from each cast aluminum post lot shall be selected by the Engineer for test purposes and shall meet the requirements of Subarticle 442.16.(1).

For Metal Beam Rail, a sample of the rail and terminal section may be taken from each project or from each shipment to a project. Samples of bolts and nuts may be required also. A test coupon cut from the material and tested in the Department Laboratory as specified in ASTM Designation: E 8, Figure 6, shall elongate not less than 12 percent in a 2 inch gauge length.

450.5. Protective Coating. Unless otherwise noted on the plans, all portions of steel railing may be either painted or galvanized. When painted, the type and coating thickness shall be in accordance with the paint system shown on the Specification Data Sheet and conforming to the Item, "Paint and Painting".

Galvanized railing shall be hot dip galvanized after fabrication in accordance with ASTM Designation: A 123 and A 153, except that, unless otherwise specified on the plans, any deep beam rail element may be galvanized before fabrication with a coating designation G 210 in accordance with ASTM Designation: A 525.

Aluminum railing and galvanized steel railing shall not require field painting. Prior to acceptance, extrusion marks, grease, dirt and grime shall be cleaned from the railing.

After erection, galvanizing on all parts of steel posts and rail elements which has become scratched, chipped or otherwise damaged shall be thoroughly cleaned and the cleaned area painted with two coats of zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641b or repaired by the application of repair compounds meeting Federal Specification 0-G-93 (Stick only) in accordance with manufacturer's recommendations.

Where fabrication is done after galvanizing, and when specifically required by the plans, the cut edges and bolt holes shall be cleaned by brushing and the cleaned area shall be painted with two coats of zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641b or shall be repaired by application of galvanizing repair compounds meeting Federal Specification 0-G-93 (Stick only) in accordance with the manufacturer's recommendations.

450.6. Designation of Railing. Railing shall be designated by the general classification and type shown on the plans. If the plans include details of both steel and aluminum designs for the same type of railing, the Contractor has the option of furnishing either type. The option chosen (steel or aluminum) shall be furnished for *all* railing of that type in the entire contract.

450.7. Measurement. Railing of the classification and type designated will be measured by the linear foot, complete in place, in accordance with the dimensions and details as shown on the plans.

450.8. Payment. Payment will be made at the unit price bid per linear foot for railing of the classification and type indicated on the plans, complete in place, measured as herein provided; which price shall be full compensation for furnishing, preparing and placing of all concrete, expansion joint material, reinforcing steel, structural steel, aluminum, cast steel, pipe, anchor bolts, anchorage device for attaching Metal Beam Guard Fence, and all other materials required in the finished railing, and for all labor, tools, hardware, equipment, paint and painting, galvanizing and incidentals necessary to complete the work in the manner and in accordance with the details specified in the contract.

ITEM 451

REMOVING AND REPLACING RAILING

451.1. Description. This item shall govern for the removal of existing railing, modified as indicated on the plans, and replacing on finished bridges at locations indicated on the plans in accordance with these specifications and the details shown on the plans.

451.2. Construction Methods. Existing railing shall be removed in such a manner that it will not be damaged and shall be placed carefully on adequate blocking along the right of way so that it will not interfere with traffic or construction. Any of the materials of the railing that are lost, damaged beyond repair, or broken by the Contractor shall be replaced at his expense.

Railing shall be replaced as shown on the plans, and as directed by the Engineer. New anchor bolts and washers, repairing, etc., shall be provided where necessary to place the railing in the new position.

After erection, painted steel railing shall be cleaned thoroughly of loose scale, rust, dirt and other foreign matter, spot painted, and repainted in accordance with the Item, "Paint and Painting".

Galvanized steel railing shall be cleaned thoroughly to an acceptably uniform color. Galvanizing damaged in removal or replacement or galvanizing which has been damaged previously shall be cleaned thoroughly of rust or other foreign matter and the cleaned area shall be painted with two coats of zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641b, or shall be repaired by application of galvanizing repair compounds meeting Federal Specification 0-G-93 (Stick only) in accordance with the manufacturer's recommendations.

When designated on the plans, galvanized railing shall be cleaned, a wash primer applied to a dry film thickness of 2 to 5 mils, and painted in accordance with the Item, "Paint and Painting". The wash primer shall comply with Federal Specification MIL-C-14504.

Aluminum railing shall be cleaned to a uniform color, but will not require painting.

451.3. Measurement. Removing and replacing railing will be measured by the linear foot of railing, complete in place. Measurement will be made upon the face of the rail in place in accordance with dimensions as shown on the plans.

451.4. Payment. The work performed as prescribed by this item, measured as provided above, will be paid for at the unit price bid for "Removing and Replacing Railing", of the type specified, which price shall be full compensation for salvaging the existing railing and rebuilding complete in place as shown on the plans, for furnishing all additional materials, paint and painting, and for all labor, tools, hardware, equipment, and incidentals necessary to complete the work.

ITEM 452

REMOVING RAILING

452.1. Description. This item shall govern for the removal and disposal of railing which is not to be reused on the structure, but is to be completely replaced with other railing. The removal may be on one side only, or on both sides of the structure. All railing considered salvable shall become the property of the Texas Highway Department and shall be stockpiled as directed by the Engineer.

452.2. Construction Methods. The existing railing shall be removed to the lines and grades as shown on the plans by the use of air driven equipment or other suitable means. The use of explosives will not be permitted. Care shall be taken to avoid damage to that portion of the concrete that is to remain in place. Any concrete removed beyond the neat lines, or lines established by the Engineer, shall be replaced at the Contractor's expense.

Existing reinforcing steel in concrete posts, not to be used as dowels, shall be cut off a minimum of 1 inch below the surface of the concrete. The concrete removed in making the cut-off shall be replaced in a manner satisfactory to the Engineer.

The top of the concrete where railing is removed shall be refinished in such a manner as to leave a neat surface.

Old concrete which is removed shall be loaded, hauled, and neatly stored at pre-designated sites, or otherwise disposed of as directed by the Engineer.

Work performed under this specification shall be performed at such time, and prosecuted in such manner that will cause a minimum of inconvenience to traffic.

452.3. Measurement. Existing railing removed as prescribed above will be measured by the linear foot in its original position.

Railing to be removed on the side of the structures to be widened will not be measured under this item, but will be measured under the Item, "Extending Concrete Structures".

452.4. Payment. The work performed as prescribed by this item and measured as provided under "Measurement" above, will be paid for at the contract unit price bid for "Removing Railing", of the type specified, which price shall be full compensation for removing all materials, loading, hauling, unloading and satisfactorily disposing of the material, for cutting back old post reinforcing bars, for refinishing the top and roadway face of the old curb and for all labor, tools, equipment, manipulations and incidentals necessary to complete the work.

ITEM 453

TEMPORARY RAILING

453.1. Description. This item shall govern for the installation of temporary railing, at the locations shown on the plans, in conformity with plan details and the requirements of this item.

453.2. Material. Timber posts, wheel guards, rail members etc. shall be commercial grade lumber in satisfactory condition for the use intended on the basis of field inspection. Used timber will be acceptable if approved by the Engineer.

Steel shapes, plates and deep-beam members shall be in satisfactory condition for the use intended. Portions of permanent railing to be used later on the permanent structures may be used subject to the requirements of this item.

Paint for portions of the temporary railing which are to be later used in the permanent railing shall conform to the Item, "Paint and Painting."

When a portion of the temporary railing is to be furnished by the Department, such portions to be furnished will be shown on the plans.

453.3. Construction. The temporary railing shall be erected on that side of the existing structure where widening operations are to begin prior to the removal of the existing railing, curb and portion of the slab. The rail and posts shall be constructed in accordance with the details shown on the plans.

After erection, all parts not galvanized shall be thoroughly cleaned and painted. Portions of the railing which are to become a part of the permanent rail shall receive paint in accordance with the paint system shown in the plans for the permanent rail. Other portions of the rail shall be painted with one coat of commercial grade aluminum paint unless otherwise specified on the plans.

After completion of the widening on one side of bridges to be widened on both sides, the temporary railing shall be moved to the other side and erected, prior to the removal of the existing railing and curb.

Any railing material furnished by the State will be delivered free of charge to the bridge site or stored at a site designated on the plans.

The Contractor shall maintain the temporary railing in a first class condition until all work on the structure has been completed.

All holes drilled through or into existing concrete for erection of temporary railing shall be filled with mortar and finished in an acceptable manner.

Upon removal of the railing, materials furnished by the State shall be stored near the bridge site as directed by the Engineer for subsequent removal by State Forces.

Prior to installation of railing used as temporary railing, in the permanent structure, it shall be reworked, if necessary, to provide railing as intended by the plans and specifications for the new structure. Portions of the railing damaged beyond reasonable repair shall be replaced at the Contractor's expense.

453.4. Measurement. Temporary railing will be measured by the linear foot, constructed complete and maintained, measurement being made of the railing on one side of the bridge only.

453.5. Payment. The work performed as prescribed by this item measured as provided above, will be paid for at the unit contract price bid per linear foot for "Temporary Railing," which price shall be full compensation for furnishing all materials except those designated on the plans to be furnished by others, for all preparation, hauling and erection, painting, maintaining, moving the railing from one side of the bridge to the other and for removing the railing and for all labor, tools, equipment, and incidentals necessary to complete the work.

ITEM 458

WATERPROOFING

458.1. Description. This item consists of the furnishing and placing of the type waterproofing shown on the plans for structure decks, walkway surfaces, backs of abutments and retaining walls and for substructure footings in accordance with these specifications.

Type 1 waterproofing shall consist of a butyl rubber membrane with a protective course of asphalt plank or asphalt mat of the specified thickness, furnished and placed in accordance with the plans and these specifications.

Type 2 waterproofing shall consist of one asphaltic primer coat and one mopping of asphalt.

Type 3 waterproofing shall consist of one asphaltic primer coat and two moppings of asphalt. At construction joints of foundation structures when so indicated on the plans, the primer and two moppings of asphalt shall be supplemented by two layers of treated cotton fabric 15 inches wide with a third mopping of asphalt placed over the outer layer of fabric.

Type 4 waterproofing shall be as specified on the plans.

458.2. Materials.

(1) Asphalt for Mopping Above Ground. Asphalt for mopping above ground shall be homogeneous and free from water. It shall be the product

obtained by the distillation of crude asphaltic base petroleum with steam agitation, supplemented if necessary with oxidation by air, but without the addition, during any stage of the process of manufacture, of any fluxing material other than a native asphalt or a straight steam refined asphaltic residual. It shall meet the following requirements:

Softening point (ring and ball Method)—145 to 170 F (62.8 to 76.7C)

Penetration: at 115 F (46.1 C), 50 g, 5 sec—not more than 110.

at 77 F (25 C), 100 g, 5 sec—25 to 40.
at 32 F (0 C), 200 g, 60 sec—not less than 10.

Flash point (open cup)—not less than 400 F (204.4C)

Loss on heating at 325 F (163 C), 50 g, 5 hr—not more than 0.5 percent.

Penetration at 77 F (25 C), 100 g, 5 sec of residue after heating at 325 F (163 C), as compared with penetration of asphalt before heating—not less than 80 percent.

Ductility: at 77 F (25 C) elongated at rate of 5 cm per min not less than 10 cm.

Solubility in trichlorethylene—min 99 percent.

(2) Asphalt for Mopping Below Ground. Asphalt for mopping below ground shall be a petroleum asphalt obtained as a residue of an asphaltic petroleum by straight steam-refining without oxidation. It shall be free from admixtures of blown or oxidized residuals, cracked residuals, sludge asphalt, or their derivatives. It shall have the following properties:

Penetration at 77 F, 100 gr, 5 sec	80 to 100
Softening point (ring and ball Method)	110 to 125 F
Ductility of pure bitumen at 77 F (25 C) elongated at rate of 5 cm per min	Min 70 cm
Flash point	Min 450 F
Loss on heating at 325 F, 50 gr, 5 hr	Max 1.0%
Penetration at 77 F, 100 gr, 5 sec of residue after heating at 325 F as compared with penetration of asphalt before heating	Min 50%
Pure bitumen soluble in trichlorethylene	Min 99.0%

(3) Asphaltic Primer. Asphaltic primer shall be composed of asphalt conforming to the foregoing requirements for asphalt for mopping above ground and a solvent. It shall meet the following requirements:

Water	None
Asphaltic Base: Percent asphalt of primer by weight	30 to 45
Solvent (hydrocarbon distillate): End point on distillation	Max 500 F (260 C)
Percent which shall distill under 248 F (120 C)	Max 20
Sediment	Max 1%

(4) Plastic Cement. Plastic cement shall be composed of semi-solid asphalt dissolved in a suitable volatile solvent and stiffened with a mineral filler consisting essentially of short fiber asbestos.

The asphalt forming the base of plastic cement shall be a petroleum asphalt, the pure bitumen of which shall meet the following minimum requirements:

Penetration at 77 F, 100 gr, 5 sec	30
Ductility at 77 F, 5 cm per min	100 cm

It shall be free from water, oxidized petroleum, residuals from the cracking process, sludge asphalt, tar or pitch products, or derivatives thereof.

Plastic cement shall meet the following requirements:

	By Weight
Petroleum asphalt, not less than	38%
Short Fiber Asbestos, not less than	25%
Petroleum Solvent, not more than	25%

The consistency of plastic cement shall permit ready spreading with a trowel without drawing or pulling, or extrusion through a suitable nozzle under a pressure of 50 lbs or more per square inch.

When applied in a layer one-sixteenth to one-eighth of an inch thick, plastic cement shall set within 24 hours to a tough, plastic coat, free from blisters.

After drying for 72 hours a patch of plastic cement one-sixteenth to one-eighth of an inch thick, applied to the material it is to be used upon, shall not blister or sag more than one-fourth inch upon exposure at a temperature of 140 F for 5 hours.

After drying for 72 hours and exposure at a temperature of 140 F for 5 hours, a patch of the cement one-sixteenth to one-eighth of an inch thick shall be plastic and adhere well to metal or concrete upon exposure at a temperature of 32 F for one hour.

After drying for 24 hours and exposure at a temperature of 140 F for 24 hours and then cooling to a temperature of 70 to 77 F, a patch of the cement one-sixteenth to one-eighth of an inch thick shall not crack or break from the metal, when bent over a mandrel one inch in diameter.

(5) Mineral Filler. Mineral filler shall be finely ground limestone or silica meeting the following requirements:

Passing a 200 mesh sieve ..... Not less than 75 percent
Passing a 30 mesh sieve .....Not less than 100 percent

(6) Butyl Rubber Membrane.

(a) Membrane. Butyl rubber membrane shall be furnished in rolls of sufficient length and width to cover the area shown on the plans with a

minimum of splices and shall conform to the following requirements:

Thickness—nominal	1/16", unless otherwise noted on plans	
Color	Black	
Specific Gravity	1.20 ±0.05	ASTM D 297
Tensile Strength	1200 psi (Min)	ASTM D 412
Modulus @ 300% Elongation	650 psi (Min)	ASTM D 412
Elongation	300 % (Min)	ASTM D 412
Tear Resistance, Die B	150 lbs. per inch (Min)	ASTM D 624
Shore A Hardness (Durometer)	55 ±5 with 5 sec interval before reading	ASTM D 2240
Heat Aging (accelerated)		ASTM D 573
Tensile Retension	75% of original @ 7 days/250 F	
Elongation Retention		
Butyl Identification		ASTM D 471
(Tricresyl Phosphate Immersion—General Purpose Grade)	Max Volume swell 10% @ 70 hrs/212 F	

Manufacturer's certification will be required for ozone resistance showing no cracks @ 70 hrs/50 pphm/100 F/20% Ext. in accordance with ASTM Designation: D 1149.

(b) Adhesive. Adhesive for butyl rubber shall be as recommended by the manufacturer of the butyl rubber membrane. It shall remain elastic at temperatures above minus 40 F and shall be compatible with the materials to which it is bonded.

(c) Splicing Cement. Cement for splicing shall be a butyl compound as recommended by the manufacturer of the butyl rubber membrane. It shall be of self-vulcanizing butyl rubber conforming to the following requirements:

Viscosity, No. 3 Zahn Cup (77 F) . . . . . 100 to 150 seconds
Total Solids . . . . . 30 % Minimum
Coverage of cement application (Min) shall be 50 sq ft per gallon.

(7) Asphalt Plank. Asphalt plank shall be a mixture of asphalt, mineral matter and organic fiber, but not wood fiber, and shall meet all requirements of ASTM Designation: D 517 for plain asphalt plank.

The plank shall be of uniform width and thickness with sides straight and all edges square.

The standard width and length of plank for the thickness specified shall normally be as follows:

Thickness	Width	Length
½ inch	12 inches	48 inches
1 inch	8 inches	72 inches
1 inch	10 inches	60 inches

Shorter lengths for one inch thickness may be acceptable provided no length shipped is less than 36 inches.

Shipments of asphalt plank shall be loaded so that deformation caused by irregular supports is avoided and blocking shall be used if necessary to prevent shifting while in transit.

Finished thickness of asphalt plank shall not be less than one inch when used as protective course.

(8) Asphalt Mat. Asphalt mat shall consist of a core of blended airblown asphalt, organic fibers and mineral fillers, a covering of asphalt-saturated felts and an exterior coating of weather resistant oxidized asphalt. The mats shall be furnished in widths of 4 feet and not less than 8 feet long except for end pieces cut to length required. They shall be uniform in thickness and free from imperfections which may affect serviceability. The mat surfaces shall be dusted with mica, talc or similar materials to prevent sticking or damage to them during shipment or handling. The thickness of the mats shall be one half of an inch or one inch.

Finished thickness of asphalt mat shall not be less than one inch when used as protective course.

(9) Treated Cotton Fabric.

(a) Fabric. Fabric shall consist of high-grade cotton cloth saturated thoroughly and uniformly with coal-tar pitch, which conforms to the following specifications:

> In the process of manufacture, the dry cotton fabric shall be treated thoroughly and uniformly at a temperature and speed that will not injure the fabric. This shall be accomplished by passing the fabric through the saturant and then calendering it in the presence of heat, after which it shall be cooled and wound into rolls.

(b) Saturant. Coal-tar pitch for saturant shall be homogeneous and free from water. It shall meet the following requirements:

Specific gravity at 77/77 F (25/25 C)	1.21 to 1.30
Softening point (cube in water method)	110 to 140 F
Distillation Test; Total distillate by weight 32 to 572 F (0 to 300 C)	Max 15%
Residue by weight	Min 85%
Specific gravity, at 100/77 F (38/25 C) of total distillate to 572 F (300 C)	Min 1.03
Ductility at 77 F (25 C)	Min 50 cm
Solubility in trichlorethylene	75% to 90%

(c) Treated Fabric. Treated cotton fabric shall meet the following requirements:

Width of roll: Min 30 in; Max 38 in.

Gross weight of roll: Min 35 lbs.; Max 80 lbs.

Average weight per square yard: Not less than 10 ounces.

Moisture content: Not more than four percent of net weight.

Tensile strength at 70 F in either direction (grab method):Not less than 50 lbs. per linear inch.

Elongation without fracture: When measured by rule or scale, not less than 10 percent; when measured by autographic recording device, not less than 8 percent.

Pliability at 32 F: Shall not crack when bent over a 1/16 inch mandrel through an arc of 180 degrees in one direction and then through 360 degrees over the same mandrel in the opposite direction.

Average loss on heating asphalt treated fabric (exclusive of moisture): Not more than 4 percent.

Weight of saturant in square yard of treated fabric: Not less than one and three-fourth times the weight of a square yard of untreated moisture-free fabric.

(10) Cold Asphalt-Base Emulsion. Cold asphalt-base emulsion shall consist of a nonvolatile organic base asphalt mixed with mineral fillers, asbestos fiber or other suitable materials, to form a quick setting mastic material capable of being applied and bonded to asphalt plank surfaces at temperatures of 50 F or above and meeting the following requirements:

Net weight per gallon, lb	8.4	ASTM D 1010
Nonvolatile Matter (24 hrs at 105± 5 C) Min, Percent by Weight	50	ASTM D 1010
Water, Max, Percent by Weight	50	ASTM D 244
Final Set, Hour	Within 24	ASTM D 1010
Flexibility at 25 ± 2 C Over a ½-inch mandrel through an arc of 180 degrees:		ASTM D 1010
Cracking, flaking or loss of adhesive	None	
Water Resistance:		ASTM D 1010
Blistering	None	
Reemulsification	None	
Loss of Adhesive	None	

Except as otherwise provided, materials shall be sampled and tested for the specified properties by the current method recommended by the American Society for Testing Materials.

The acceptance of any materials by the Engineer shall not prevent their subsequent rejection if found defective. Any material not meeting the specification requirements shall immediately be removed from the work at the Contractor's expense.

All materials to be furnished by the Contractor shall be delivered on the work not less than 3 weeks before they are to be applied, so they may be tested and analyzed. No materials shall be used until they have been accepted by the Engineer.

458.3. Construction Methods. Type 1 waterproofing shall not be applied in wet weather, or when the ambient temperature is below 50 F, without written permission of the Engineer. The rubber membrane shall be free from punctures, pockets or folds.

Surface to be waterproofed shall be dry and clean. Projections that might injure the membrane shall be removed. There shall be no depressions or pockets in horizontal surfaces of finished waterproofing. Concrete shall be cured before waterproofing is applied.

The membrane shall be turned into drainage castings without break. Special care shall be taken to make the waterproofing effective along the sides and ends of girders and at stiffeners, gussets, etc. Grooves shall be filled with plastic cement.

Expansion joints shall be filled with plastic cement conforming to these specifications. Joints shall be dried and cleaned immediately before they are filled. They shall be over-filled slightly to allow for shrinkage in drying.

The butyl membrane shall be installed by first applying the adhesive as recommended by the butyl rubber membrane manufacturer to ballast retainers, ends of deck and at necessary splices in a solid area extending from the edges back about 36 inches. Apply the butyl rubber membrane. Press the membrane firmly and uniformly in place against the previously applied adhesive. Avoid wrinkles and buckles. All splices, laps and flashing shall be made in accordance with the butyl rubber manufacturer's recommended procedures.

As soon as practicable after membrane placement, its protective cover shall be placed. The membrane surface shall be cleaned of all dirt and other foreign material just prior to placing the cover material. A coating of cold Asphalt-Base Emulsion shall be applied over the butyl rubber membrane at the minimum rate of 4 gallons per 100 square feet of surface and place the asphalt plank or mat thereon.

The minimum thickness of protection shall be one inch and shall consist of asphalt plank or asphalt mat laid as provided hereafter. As successive planks are laid, the edges and ends of adjacent planks already laid shall be coated heavily with cold asphalt emulsion. The planks shall be laid tight against those previously laid so that the emulsion will completely fill the joints and be squeezed out the top. After all planks have been laid, any joints not completely full shall be filled with emulsion. When two layers of planks are used to obtain the required one inch cover thickness, the vertical joints of the second layer shall be offset not less than 4 inches transversely and one foot longitudinally from the joints in the lower layer.

Asphalt mat protection shall be applied in the same manner, except that the longitudinal butt joints in a single layer shall be staggered approximately 2 feet. When more than one thickness of asphalt mat is required, the same

procedure shall be followed with all vertical joints offset at least one foot. A follow-up coating of asphalt emulsion approximately 6 inches in width shall be placed over all joints of the top layer.

Where deck waterproofing is carried over the back wall and down the back of the abutment for only several feet for the purpose of providing a proper flashing for the deck waterproofing, "Above Ground" moppings of asphalt as provided herein shall be used.

Where waterproofing is required by the plans as a protection for back of abutments, retaining walls or footings, "Below Ground" moppings of asphalt as provided herein shall be used.

When Type 2 waterproofing is specified, the asphalt primer shall be in place at least 24 hours and shall be dry prior to the asphalt mopping. The primer shall be well worked in to give a uniform coating. The asphalt for mopping shall be heated in kettles equipped with armored thermometers to permit uniform covering, but shall not be heated above 350 F. While being heated the asphalt shall be stirred frequently. The mop coating shall require not less than 4 gallons per 100 square feet of surface. If imperfections appear in the coating, additional coatings shall be applied until the imperfections are corrected.

When Type 3 waterproofing is specified, the asphalt primer shall be in place at least 24 hours and shall be dry prior to the first asphalt mopping. The primer shall be well worked in to give a uniform coating. The asphalt for mopping shall be heated in kettles equipped with armored thermometers to permit uniform covering, but shall not be heated above 350 F. While being heated the asphalt shall be stirred frequently. Minimum coverage for each mop coating shall be 4 gallons per 100 square feet of surface. If imperfections appear in the coating, additional coatings shall be applied until the imperfections are corrected.

At construction joints, the surfaces to be waterproofed shall be mopped in sections. While the first mopping of asphalt is still hot, a strip of cotton fabric shall be laid on the mopping and pressed into place. Each mopping thereafter shall be so applied that it will completely cover and seal the cotton fabric. End laps of the cotton fabric shall be not less than 12 inches.

458.4. Measurement. Measurement of waterproofing of the type specified on the plans will be made by the square yard of the waterproofing complete in place.

458.5. Payment. Payment for waterproofing will be made at the contract unit price bid per square yard for "Waterproofing" of the type specified on the plans measured as prescribed above. Such payment shall be full compensation for furnishing all materials, equipment, tools, labor and incidentals necessary to complete the work.

ITEM 460

CORRUGATED GALVANIZED METAL PIPE

460.1. Description. This item shall govern for furnishing corrugated metal pipe conforming to these specifications, of the sizes and dimensions required on the plans; installing such pipe as designated on the plans or by the Engineer in conformity with the lines and grades given. This item shall include the furnishing and construction of such joints, and such connections to new or existing pipes, catch basins, endwalls, etc., as may be required to complete the work as shown on the plans. Pipe shall be full circle or pipe arch type as shown on the plans. The location of private driveway and side road pipe may be varied as deemed necessary by the Engineer.

460.2. Materials. The zinc coated iron or steel sheets shall conform to Zinc Coated (Galvanized) Iron or Steel Sheets for Culverts and Underdrains (AASHO Designation: M 218). All material shall meet the requirements of Zinc Coated (Galvanized) Corrugated Iron or Steel Culverts and Underdrains (AASHO Designation: M 36) as to accepted brands, certified analysis, guarantee and rivets.

Where reference is made to "gauge" of metal, the reference is to U.S. Standard Gauge for uncoated sheets prior to galvanizing. Tables in AASHO Designation: M 36 and M 218 list thicknesses for the coated sheets in inches.

Sampling, testing and inspection of metal sheets and coils used for Corrugated Metal Pipe shall be in accordance with Test Method Tex-708-I.

Damaged spelter coating shall be repaired by thoroughly wire brushing the damaged area and removing all loose, cracked or weld-burned spelter coating. The cleaned area shall be painted with a zinc dust-zinc oxide paint conforming to Federal Specifications TT-P-641 b.

460.3. Fabrication. Pipe shall be full circle or arch pipe as designated on the plans. It may be fabricated with circumferential corrugations, lap joint construction with riveted or spot welded seams, or may be fabricated with helical corrugations and a continuous lock or welded seam.

Arch pipe shall be full circle pipe which has been re-formed to multi-circle pipe having arch shaped tops with slightly outwardly centered integral bottoms.

Pipe shall conform to AASHO Designation: M 36 as to corrugations, dimensions, riveted seams, resistance spot welded seams, end finish, size, permissible variations, workmanship and finish.

Helically corrugated pipe shall further conform to the following: Seams shall consist of a continuous lock or welded seam extending from end to end of each length of pipe section and shall be fabricated in such a manner that they will develop the full strength of the pipe and not affect the shape or nominal diameter of the pipe.

Folded lock seams or ultrahigh frequency resistance butt-welded seams shall be used. Folded lock seams shall be formed with sufficient pressure to prevent any seam slippage that would appreciably affect the load carrying

capacity of the pipe but without damaging the metal to such an extent that a plane of weakness is created.

Welded seams shall be controlled so that the combined width of the weld and adjacent spelter coating burned by welding does not exceed three times the metal thickness. If the spelter coating is damaged by the welding outside the above specified area, the weld and damaged spelter adjacent to the weld shall be cleaned and painted as specified in Article 460.2.

The manufacturer shall certify that during manufacture the weld was tested for quality and found satisfactory at the beginning of each shift, and when a change in thickness of pipe material was made. Any indication of cracks, skips or deficient welds found through normal visual inspection will be cause for rejection. A coating of rust on the bare metal portion of the weld will not be considered as a defect.

460.4. Selection of Gauges. Plans will provide a Summary of Culverts which will include at least the following information for each culvert: location, diameter, length of pipe, and maximum height of fill over pipe measured from top of pipe to finished grade elevation. By entering the appropriate Tables 1, 2, 3 or 4 with this information the required gauge may be determined. Unless otherwise noted on the plans, this gauge shall be provided for the entire culvert. Pipes designed for special purposes, under railroad tracks, or for fills in excess of the fills shown in the following tables shall be of the gauge shown on the plans.

TABLE 1

2 2/3-inch by 1/2-inch Corrugations
H-20 Loading
Full Circle Pipe

Pipe Diameter	Min. Cover, Top of Pipe To Top of Subgrade	0.064 In. 16 Gage	0.079 In. 14 Gage	0.109 In. 12 Gage	0.138 In. 10 Gage	0.168 In. 8 Gage
Inches		Maximum Fill Height Above Top of Pipe in Feet				
12	12	83	90	--	--	--
15	12	67	73	93	98	--
18	12	47	55	70	82	86
24	12	30	33	40	48	54
30	12	24	25	29	33	37
36	12	21	22	24	26	28
42	12	--	20	21	23	24
48	12	--	19	20	21	22
54	12	--	18	19	20	21
60	12	--	--	18	19	20
66	12	--	--	18	18	19
72	12	--	--	--	18	18
78	12	--	--	--	--	18
84	12	--	--	--	--	18

Note: Thickness in inches, as shown above, refers to the coated metal after galvanizing.

TABLE 2

3-inch by 1-inch Corrugations
H-20 Loading
Full Circle Pipe

Pipe Diameter	Min. Cover, Top of Pipe To Top of Subgrade	0.064 In. 16 Gage	0.079 In. 14 Gage	0.109 In. 12 Gage	0.138 In. 10 Gage	0.168 In. 8 Gage
Inches		Maximum Fill Height Above Top of Pipe in Feet				
36	12	34	38	48	56	63
42	12	28	30	37	42	48
48	12	24	27	30	34	38
54	12	22	24	26	29	32
60	12	21	22	24	26	28
66	12	20	20	22	23	25
72	12	19	20	21	22	23
78	12	18	19	20	21	22
84	12	--	19	19	20	21
90	12	--	18	19	19	20
96	12	--	--	18	19	20
102	24	--	--	18	19	19
108	24	--	--	18	19	19
114	24	--	--	--	18	19
120	24	--	--	--	18	19

Note: Thickness in inches, as shown above, refers to the coated metal after galvanizing.

TABLE 3

2 2/3-inch by 1/2-inch Corrugations
H-20 Loading
Pipe Arch

Design Size	Area Square Feet	*Span Inches	*Rise Inches	Minimum Gage Required	Coated Thickness Inches	Equivalent Diameter Full Circle Pipe Inches
1	1.1	18	11	16	0.064	15
2	1.6	22	13	16	0.064	18
3	2.8	29	18	16	0.064	24
4	4.4	36	22	16	0.064	30
5	6.4	43	27	16	0.064	36
6	8.7	50	31	14	0.079	42
7	11.4	58	36	12	0.109	48
8	14.3	65	40	12	0.109	54
9	17.6	72	44	10	0.138	60

*All dimensions are measured from the inside crests of the corrugations. A tolerance of plus or minus 1-inch will be permissible in span and rise.

The fill heights for all sizes of pipe arches are limited to a minimum of 12-inches and a maximum of 7 feet.

TABLE 4

3-inch by 1-inch Corrugations
H-20 Loading
Pipe Arch

Design Size	Area Square Feet	*Span Inches	*Rise Inches	Minimum Gage Required	Coated Thickness Inches	Equivalent Diameter Full Circle Pipe Inches
5	6.4	43	27	16	0.064	36
6	8.7	50	31	16	0.064	42
7	11.4	58	36	16	0.064	48
8	14.3	65	40	16	0.064	54
9	17.6	72	44	16	0.064	60
10	22	73	55	16	0.064	66
11	26	81	59	14	0.079	72
12	31	87	63	14	0.079	78
13	35	95	66	12	0.109	84
14	40	103	71	12	0.109	90
15	46	112	75	12	0.109	96
16	52	117	79	12	0.109	102
17	58	128	83	10	0.138	108

*All dimensions are measured from the inside crests of the corrugations. A tolerance of plus or minus 1 inch will be permissible in span and rise.

The fill heights for all sizes of pipe arches are limited to a minimum of 12-inches and a maximum of 10 feet.

460.5. Coupling Bands. Coupling bands for full circle pipe and pipe arches shall be made of the same base metal as the pipe and shall be similarly zinc coated. The coupling bands shall be 16 gauge minimum for pipes through 54 inch diameter and 14 gauge minimum for pipes above 54 inch diameter.

Pipes furnished with circumferential corrugations shall be field jointed with locking bands. The corrugated bands shall be not less than 7 inches wide for pipes through 30 inch diameter, not less than 12 inches wide for pipes through 60 inch diameter, and not less than 24 inches wide for pipes greater than 60 inch diameter.

Pipes furnished with helical corrugations shall be field jointed preferably with bands with projections. The bands for pipe diameters of 12 inches to 54 inches shall be at least 10-1/2 inches wide and for pipe diameters 60 inches and greater, 16-1/2 inches wide.

The bands shall be connected in a manner approved by the Engineer with a suitable fastening device such as galvanized 2 inch by 2 inch by 3/16 inch angles, or integrally or separately formed and attached flanges bolted with one-half inch diameter galvanized bolts, or a wedge lock constructed of the same gauge as the band itself.

460.6. Protective Coating.

(1) General. Where conditions warrant, protective coatings shall be applied to corrugated galvanized metal pipe and pipe arches. The protective coatings shall be indicated on the plans by the use of one of the following descriptions, whichever is applicable:

Corrugated Galvanized Metal Pipe or Pipe Arch (Bituminous Coated)

Corrugated Galvanized Metal Pipe or Pipe Arch (Bituminous Coated, Paved Invert)

Corrugated Galvanized Metal Pipe or Pipe Arch (Asbestos Bonded)

Corrugated Galvanized Metal Pipe or Pipe Arch (Asbestos Bonded, Paved Invert)

(2) Bituminous Coated. Bituminous Coated pipe or pipe arch shall conform to this specification both as to base metal and fabrication; and in addition shall be coated inside and out with a bituminous coating which shall meet the performance requirements set forth herein. The bituminous coating shall be 99.5 percent soluble in carbon bisulphide. The pipe shall be uniformly coated inside and out to a minimum thickness of 0.05 inch, measured on the crests of the corrugations.

The bituminous coating shall adhere to the metal tenaciously; shall not chip off in handling; and shall protect the pipe from deterioration as evidenced by samples prepared from the coating material successfully meeting the Shock Test and Flow Test in accordance with Test Method Tex-522-C.

(3) Paved Invert. Where a paved invert is specified, the pipe, or pipe arch, in addition to the fully coated treatment described above, shall receive additional bituminous material, of the same specification as above, applied to the bottom quarter of the circumference to form a smooth pavement with a minimum thickness of one-eighth of an inch above the crests of the corrugations.

(4) Asbestos Bonded. Where asbestos bonded pipe is specified, the pipe or pipe arch shall be formed from sheets whose base metal shall conform to this specification. In addition, the sheets shall have been coated with a layer of asbestos fibers, applied in sheet form by pressing them into a molten metallic bonding medium. The pipe shall be bituminous coated inside and out as specified above. If a paved invert is specified, it shall be in accordance with the procedure outlined above. The test for spelter coating required by this specification is waived for asbestos bonded pipe.

460.7. Construction Methods. Corrugated galvanized metal pipe culverts shall be constructed from the specified materials in accordance with the following method and procedure.

(1) Excavation. All excavation shall be in accordance with the requirements of the Item, "Structural Excavation", except where tunneling or jacking methods are shown on the plans or permitted by the Engineer. When pipes are laid in a trench, the trench when completed and shaped to receive the pipe, shall be of sufficient width to provide free working space for

satisfactory bedding and jointing and thorough tamping of the backfill and bedding material under and around the pipe. The Contractor shall make such temporary provision as may be necessary to insure adequate drainage of the trench and bedding during the construction operation.

(2) Foundation. The pipe shall be bedded in a foundation of stable earth material carefully and accurately shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height. When requested by the Engineer, the Contractor shall furnish a simple template for each size and shape of pipe to be placed for use in checking the shaping of bedding. The template shall consist of a thin plate or board cut to match the lower half of the cross section of the pipe.

Where rock, in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such manner as to provide a compacted earth cushion having a thickness under the pipe of not less than one half inch per foot height of fill over the top of the pipe, with the minimum allowable thickness of 12 inches and a maximum of 0.75 D, where D is the diameter of the pipe. Where the soil encountered at the established grade is a quicksand, muck or similar unstable material, unless other special construction methods are called for on the plans or in special provision, such unstable soil shall be removed and replaced in accordance with the requirements of the Item, "Structural Excavation".

(3) Laying Pipe. Unless otherwise authorized by the Engineer, the laying of pipes on the prepared foundation shall be started at the outlet end with the separate sections firmly joined together, with outside laps of circumferential joints pointing upstream and with longitudinal laps on the sides. Any metal in joints which is not protected by galvanizing shall be coated with a suitable asphaltum paint. Proper facilities shall be provided for hoisting and lowering the sections of pipe into the trench without damaging the pipe or disturbing the prepared foundation and the sides of the trench. Any pipe which is not in alignment or which shows any undue settlement after laying, or is damaged, shall be taken up and relaid without extra compensation.

Multiple installations of corrugated galvanized steel pipe and pipe arches shall be laid with the center lines of individual barrels parallel. When not otherwise indicated on the plans, the following clear distances between outer surfaces of adjacent pipes shall be maintained:

Diameter of Pipe	Clear Distance Between Pipes Full Circle and Pipe Arch	Pipe Arch Design No.
18"	1'-2"	2
24"	1'-5"	3
30"	1'-8"	4
36"	1'-11"	5
42"	2'-2"	6
48"	2'-5"	7
54"	2'-10"	8
60"-84"	3'-2"	9
90"-120"	3'-5"	10 & Over

(4) Connections. Where new culverts are constructed as extensions to culverts in place or are jointed to existing structures, the construction shall include all work necessary to provide a proper connection between the new structure and the old, as indicated on the plans.

(5) Reuse of Existing Headwalls. When existing headwalls and aprons are specified on the plans for reuse, the portion to be reused shall be severed from the culvert, and moved to the new position previously prepared, by hoisting with a crane, rolling, or other approved methods. Connections shall conform to the requirements for joining sections of pipes as indicated herein or as shown on the plans. Any portion of headwalls, aprons or pipe attached to headwall damaged during the moving operations by the Contractor shall be restored to their original condition at his entire expense. The Contractor, if he so desires, may remove and dispose of the existing headwalls and aprons and construct new headwalls at his own expense, in accordance with the pertinent specifications and design indicated on the plans or as furnished by the Engineer.

(6) Backfilling. Backfilling for the metal pipe structure is a critical phase of the construction, and strict adherence to construction methods is required. After the metal pipe structure has been completely assembled on the proper line and grade and headwalls constructed when required by the plan details, selected material from excavation or borrow shall be placed along both sides of the completed structures equally, in uniform layers not exceeding 6 inches in depth (loose measurement), wetted if required and thoroughly compacted between adjacent structures and between the structures and the sides of the trench or, for a distance each side of the structures equal to the diameter of the pipe. Backfill material shall be compacted to the same density requirements as specified for the adjoining sections of embankment in accordance with the governing specifications therefor. Above the three-fourths point of the structure, the fill shall be placed uniformly on each side of the pipe in layers not to exceed 12 inches.

For backfilling, until a minimum cover of 12 inches is obtained, only hand operated tamping equipment will be allowed within vertical planes 2 feet beyond the horizontal projection of the outside surfaces of the structure.

Unless otherwise shown on the plans or permitted in writing by the Engineer, no heavy earth moving equipment will be permitted to haul over the structure until a minimum of 4 feet of permanent or temporary, compacted fill has been placed thereon. Pipe damaged by the Contractor's equipment shall be removed and replaced by the Contractor at no additional cost.

During the backfilling operations, special emphasis is placed upon the need for obtaining uniform backfill material and uniform compacted density throughout the length of the structure so that unequal pressure will be avoided. Extreme care is to be taken to insure proper backfill under the structure.

Prior to adding each new layer of loose backfill material, until a minimum of 12 inches of cover is obtained, an inspection will be made of the inside periphery of the structure to determine any local or unequal deformation caused by improper construction methods.

460.8. Measurement. Corrugated Galvanized Metal Pipe will be measured by the linear foot. Such measurements will be made between the ends of the barrel along its central axis. Where spurs or branches, or connections to existing pipe lines are involved, measurement of the spur or new connecting pipe will be made from the intersection of its central axis with the outside surface of the pipe into which it connects. Where inlets, headwalls, catch basins, manholes, junction chambers, or other structures are included in lines of pipe, that length of pipe tieing into the structure wall will be included for measurement but no other portion of the structure length or width will be so included.

For multiple pipes, the measured length will be the sum of the lengths of the barrels, measured as prescribed above.

When actual field measurement is required by Article 460.9, measurement will be made by the linear foot of pipe in place between the ends of the pipe along the central axis as installed. If no adjustment is required under Article 460.9, no additional measurement or calculations will be made.

In the event of a change in design which either increases or decreases the quantity of pipe, the variation in quantity will be measured as prescribed above and the quantity shown on the plans and in the proposal will be increased or decreased as the case may be.

460.9. Payment. Payment for corrugated galvanized metal pipe culverts, measured as prescribed above will be made at the contract unit price bid per linear foot for the various sizes and gauges of the Items of "Corrugated Galvanized Metal Pipe" or "Corrugated Galvanized Metal Pipe Arch", with or without protective coating as indicated in the proposal.

The quantity to be paid for will be that quantity shown on the contract plans and in the proposal, except as may be modified by the following:

Either party to the contract may request an adjustment of the quantities shown on the contract plans (by each separate bid item) if the quantities calculated as outlined in Article 460.8., vary from those shown on the contract plans by more than 5 percent.

The party to the contract which requests an adjustment shall present, to the other, two copies of field measurements and calculations showing the revised length for the structure or structures in question. These revised lengths of pipe, when proven correct, together with all other pipe under the same bid item, shall constitute the final quantity for which payment will be made.

Payment for revised quantities due to a change in design will be paid for at the unit price bid per linear foot measured as provided in Article 460.8.

Adjustments of quantities will be subject to the provisions of Article 4.3.

Payment shall be full compensation for furnishing and transporting the pipe; for all bituminous coating, asbestos bonding and invert paving; hauling and placing of select material where required for bedding pipe in rock

excavation; the preparation and shaping of beds; hauling, placing and joining of pipes; for all connections to existing structures; for moving and reusing headwalls where required by the plans, and for all other items of materials, labor, equipment, tools and incidentals necessary to complete the culvert in accordance with the plans and these specifications, except excavation and backfill which will be paid for in accordance with the Item, "Structural Excavation". Where pipes are laid on a skew or where pipe ends are cut to fill slope, full compensation for cutting the ends parallel with the centerline of the highway or the fill slope shall be considered as included in the price bid per linear foot for the designated item of pipe and no additional allowance will be made therefor.

ITEM 461

STRUCTURAL PLATE PIPES, PIPE ARCHES, ARCHES, AND UNDERPASSES

461.1. Description. This item shall consist of furnishing and installing structural plate pipes, pipe arches, arches and underpasses conforming to these specifications, of the sizes and dimensions required by the plans, at the places designated on the plans or by the Engineer, in conformity with established lines and grades. Structural plate pipes shall be furnished round or elongated, as indicated on the plans.

461.2. Materials and Manufacture.

(1) The iron or steel plates used for construction of structural plate pipes, pipe arches, arches or underpasses shall conform to Structural Plate for Pipe, Pipe-Arches, and Arches (AASHO Designation: M 167) as to Base Metal, Corrugations, Gauge Determination Tolerance, Spelter Coating, Galvanized Sheets, Identification and Bolts and Nuts for Connecting Plates. The Manufacturer's Certified Analysis and Guarantee, Accepted Brands of Metal, Fabricator's Certificate of Compliance, and Sampling shall be in accordance with Test Method Tex-708-1.

(2) Description of Plates. Plates shall consist of structural units of galvanized corrugated metal. Single plates shall be furnished in standard sizes to permit structure length increments of 2 feet. (Plates will have approximately a 2 inch lip beyond each end crest, which results in the actual length of a given structure being approximately 4 inches longer than the nominal length, except when skewed or beveled. In constructing footings for arches this additional length must be provided for.) The plates at longitudinal and circumferential seams shall be connected by bolts.

(3) Fabrication of Plates. Plates shall be formed to provide lap joints. The bolt holes shall be so punched that all plates having like dimensions, curvature, and the same number of bolts per foot of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross-sectional dimensions of the finished structure will be as indicated on the plans or as specified. Unless otherwise specified, bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be staggered in rows 2 inches apart, with one row in the valley and one in the

crest of the corrugations. Bolt holes along those edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 12 inches. The minimum distance from center of hole to edge of the plate shall be not less than 1-3/4 times the diameter of the bolt. The diameter of the bolt holes in the longitudinal seams shall not exceed the diameter of the bolt by more than one-eighth inch. Plates for forming skewed or sloped ends shall be cut so as to give the angle of skew or slope specified. Burnt edges shall be free from oxide and burrs, shall present a workmanlike finish, and legible identification numerals shall be placed on each part plate to designate its proper position in the finished structure.

(4) Workmanship. It is the essence of these specifications that in addition to compliance with the details of construction the completed structure shall show careful, finished workmanship in all particulars. Structures on which the spelter coating has been damaged, either in the shop or in shipping, or which shows defective workmanship, shall be rejected, except that damaged areas deemed by the Engineer to be of a minor nature may be repaired by painting with a zinc dust-zinc oxide paint conforming to Federal Specification TT-P-641 b. The requirement applies not only to the individual plates but to the shipment as a whole. The following defects are considered to be poor workmanship. The presence of any or all of them in any individual culvert plate or in any shipment will be cause for rejection:

(a) Uneven laps,

(b) Elliptical shaping (unless specified),

(c) Variation from a straight center line,

(d) Ragged edges,

(e) Loose,uneven lined or spaced bolts,

(f) Illegible brand,

(g) Bruised, scaled or broken spelter coating, or

(h) Dents or bends in the metal itself.

(5) Visual Inspection. The Contractor shall furnish an itemized statement of the number and length of plates in each shipment. This inspection shall include an examination of the plates for deficiency in size, radius of curvature specified, and any evidence of poor workmanship as outlined above. The inspection may include the taking of samples for chemical analysis and determination of weight of spelter coating. The plates making up the shipment shall fully meet the requirements of these specifications and if 25 percent, of the plates in any shipment fails to do so, the entire shipment may be rejected.

(6) Mill and Factory Inspection. If the Engineer so elects, he may have the material inspected and sampled in the rolling mill or in the shop where fabricated. He may require from the mill the chemical analysis of any plate. The inspection, either in the mill or in the shop, shall be under the direction of the Engineer. The Engineer or his representative shall have free access to the mill or shop for inspection and every facility shall be extended to him for this purpose. Any material which has been previously rejected at the mill or

shop and included in a later lot will be considered sufficient cause for the rejection of the entire lot.

461.3. Design.

(1) Gauge for Structural Plate. The gauge of metal plates to be furnished for each structure will be shown on the plans.

(2) Skewed Structures. The end skew shall not exceed 45 degrees. When the skew of arches is more than 15 degrees, the length of the structure shall be such that no portion of the live load will be carried by the cut portion of the arch end. Where right of way or other conditions do not permit the required length, the cut end shall be supported by a rigid headwall designed to meet the conditions. When the skew angle of pipes exceeds 20 degrees, and the structure has the ends cut to fit a slope, the ends shall be reinforced with concrete riprap or other suitable end protection as indicated on the plans or as directed by the Engineer. The plates shall be anchored to the headwall with not less than three-fourths of an inch by 6 inch bolts, at not over 19 inch centers. If structures are to have skewed ends, bevels, step-bevels or other special end treatment, this information will be shown on the plans.

(3) Multiple Structures Installed in Parallel Lines. Where multiple lines of pipes or pipe-arches greater than 48 inches in diameter or span are used, they shall be spaced so that adjacent sides of the pipe shall be at least one-half diameter or three feet apart, whichever is less, to permit adequate compaction of backfill material. For diameters up to 48 inches, the minimum spacing shall be not less than 24 inches.

(4) Substructure for Arches. The substructure for structural plate arches shall be detailed on the plans.

461.4. Construction Methods. Structural plate pipe, pipe arches, arches and underpasses shall be constructed from the specified materials in accordance with the following method and procedure:

(1) Excavation. All excavation shall be in accordance with the requirements of the Item, "Structural Excavation". Trenches for pipes, pipe arches or underpasses shall be of sufficient width to provide free working space for erection and thorough tamping of the backfill and bedding material under and around the structure. The Contractor shall make such temporary provisions as may be necessary to insure adequate drainage of the trench and bedding during the construction operation.

(2) Foundations, Structural Plate Pipes, Pipe Arches and Underpasses. The pipe shall be bedded in a foundation of sandy earth material carefully and accurately shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height, except that the length of bedding arc need not exceed the width of the bottom plate. The sandy material shall be at least three inches in thickness so as to obtain uniform seating of the corrugations on the pipe bed.

Where rock, in either ledge or boulder formation, is encountered, it shall be removed below grade and replaced with suitable materials in such manner

as to provide a compacted earth cushion having a thickness under the pipe of not less than one-half inch per foot height of fill over the top of the pipe, with the minimum allowable thickness of 12 inches and a maximum of 24 inches under the bottom of the pipe. Where the soil encountered at the established grade is a quicksand, muck or similar unstable material, unless other special construction methods are called for on the plans or in special provision, such unstable soil shall be removed and replaced in accordance with the requirements of the Item, "Structural Excavation".

(3) Foundations, Structural Plate Arches. Substructure units for structural plate arches shall be formed and finished to true lines and grades as established by the Engineer. Anchors shall be set to true line and grade when placing concrete for each substructure unit. The work of placing substructure units shall conform to the requirements of the Item, "Concrete Structures", the Item, "Concrete for Structures", and the Item, "Reinforcing Steel".

(4) Erection. Any metal in joints which is not protected by galvanizing shall be coated with suitable asphaltum paint. Plates shall be assembled in a workmanlike manner to produce structures of the dimensions shown on the plans. Joints shall be staggered so that not more than three plates are jointed at any one point. Not less than four bolts shall be used per foot of longitudinal seam. Where anchor bolts are required, three-fourths of an inch by six inch minimum bolts on not more than 19 inch centers shall be used to anchor plates to headwall. No plates for arch structures shall be placed until the substructure has been placed for a minimum of three days. Wherever practicable, plates shall be assembled in accordance with manufacturer's recommendations.

When all plates are in position, all bolts not already in place shall be inserted and all nuts tightened progressively and uniformly, beginning at one end of the structure. All nuts shall be tightened a second time to a torque of not less than 150 ft-lbs nor more than 300 ft-lbs. It is essential that bolts be well tightened. If an impact wrench is used, a sufficient number of bolts should be checked with a long-handled, structural or socket wrench or a torque wrench to insure that they are properly tightened. All service bolts used in drawing the plates together shall be replaced with standard high strength bolts.

Where circular structural plate pipe is used and plans require elongated pipe, the pipe shall be erected such that the elongated axis is vertical.

(5) Backfilling. Backfilling and/or construction of the embankment around and over the pipe is a critical phase of the construction and strict adherence to these construction methods is required. Backfilling and/or embankment construction around the pipe shall be performed in accordance with the Item, "Structural Excavation", except as modified herein.

Within vertical planes two feet beyond the horizontal limits of the structure and until a minimum of two feet of cover has been compacted over the structure, only hand operated, mechanical tamping equipment will be permitted.

Unless otherwise shown on the plans or permitted in writing by the

Engineer, no heavy earth moving equipment will be permitted to haul over the structure until a minimum of 4 feet of permanent or temporary, compacted fill has been placed thereon. Pipe damaged by the Contractor's equipment shall be removed and replaced by the Contractor at no additional cost.

During the backfilling operations, special emphasis is placed upon the need for obtaining uniform backfill material and uniform compacted density throughout the length of the structure so that unequal pressure will be avoided. Extreme care is to be taken to insure proper backfill under the structure.

Prior to adding each new layer of loose backfill material, until a minimum two feet of cover is obtained, an inspection will be made of the inside periphery of the structure to determine any local or unequal deformation caused by improper construction methods.

The structure shall be backfilled so that when two feet of cover is obtained the inside dimensions shall be within 2 percent of the specified dimension. After backfill has been completed, the inside dimension shall be within 5 percent of the specified dimension. In the case of elongated pipe, the specified dimension is considered to be the dimensions of the elongated pipe prior to backfill. In the case of arches (does not apply to pipe arches) when backfilling is completed before headwalls are placed, the first material shall be placed midway between the ends of the arch, forming as narrow a ramp as possible until the top of the arch is reached. The ramp shall be constructed evenly from both sides, and the backfilling material shall be thoroughly compacted as it is placed. After the two ramps have been constructed to the top of the arch, the remainder of the backfill shall be deposited from the top of the arch both ways from the center to the ends and as evenly as possible on both sides of the arch. If the headwalls are built before the arch is backfilled, the filling material shall be placed first adjacent to one headwall until the top of the arch has been reached, after which the fill shall be dumped from the top of the arch toward the other headwall, with care being taken to deposit the material evenly on both sides of the arch.

In multiple installations the procedure specified above shall be followed, but extreme care shall be used to bring the backfill up evenly on each side of each structure so that unequal pressure will be avoided.

461.5. Measurement. Structural plate pipe, pipe arch, arch and underpass will be measured by the linear foot of each structure, or of a series of structures, by the sum of the linear feet in the series, in place. The measurement will be made as follows:

Structural Plate Pipe	The average of top and bottom center line lengths.
Structural Plate Pipe Arch	The bottom center line length.
Structural Plate Arch	The average of the springing line lengths.
Structural Plate Underpass	The bottom center line length.

461.6. Payment. Payment for structural plate pipes, pipe arches, arches, and underpasses, measured as prescribed above, will be made at the contract unit price bid for the various size and gauges of the Items of "Structural Plate Pipe", "Structural Plate Pipe Arch", "Structural Plate Arch", and "Structural Plate Underpass", in place, which payment shall be full compensation for furnishing, transporting and erecting; for handling and placing of select fill material; for all bolts, nuts, washers, anchor bolts and anchor channels or angles; and for all other items of material, labor, equipment, tools and incidentals necessary to complete the various installations in accordance with these specifications.

ITEM 464

REINFORCED CONCRETE PIPE CULVERTS

464.1. Description. This item shall govern for the furnishing and placing of reinforced concrete pipe culverts and for the material and incidental construction requirements for reinforced concrete pipe sewers. The culvert pipe shall be installed in accordance with the requirements of these specifications, to the lines and grades shown on the plans, and shall be of the classes, sizes and dimensions shown thereon. The installation of pipe shall include all joints or connections to new or existing pipe, headwalls, etc., as may be required to complete the work. The location of private driveway and side road pipe may be varied as deemed necessary by the Engineer.

464.2. Materials.

(1) General. Except as modified herein, materials, manufacture and design of pipe shall conform to ASTM Designation: C 76 for Circular Pipe; ASTM Designation: C 506 for Arch Pipe, or ASTM Designation: C 507 for Elliptical Pipe. All pipe shall be machine made or cast by a process which will provide for uniform placement of the concrete in the form and compaction by mechanical devices which will assure a dense concrete. Concrete shall be mixed in a central batch plant or other approved batching facility from which the quality and uniformity of the concrete can be assured. Transit mixed concrete will not be acceptable for use in precast concrete pipe.

(2) Design. The pipe shall be of the Class specified on the plans. The shell thickness, the amount of circumferential reinforcement and the strength of the pipe shall conform to the specified Class as summarized in ASTM Designation: C 76 for Circular Pipe; C 506 for Arch Pipe or C 507 for Elliptical Pipe.

(3) Physical Test Requirements. The acceptability of the pipe shall be determined by the results of the three-edge-bearing test for the load to produce the 0.01 inch crack and the ultimate load; by the appropriate material tests required in ASTM Designations: C 76, C 506 or C 507; by absorption tests on selected samples from the wall of the pipe; and by inspection of the finished pipe to determine its conformance with the design prescribed in these specifications and its freedom from defects. Three-edge-bearing tests for both the 0.01 inch crack and the ultimate load shall be

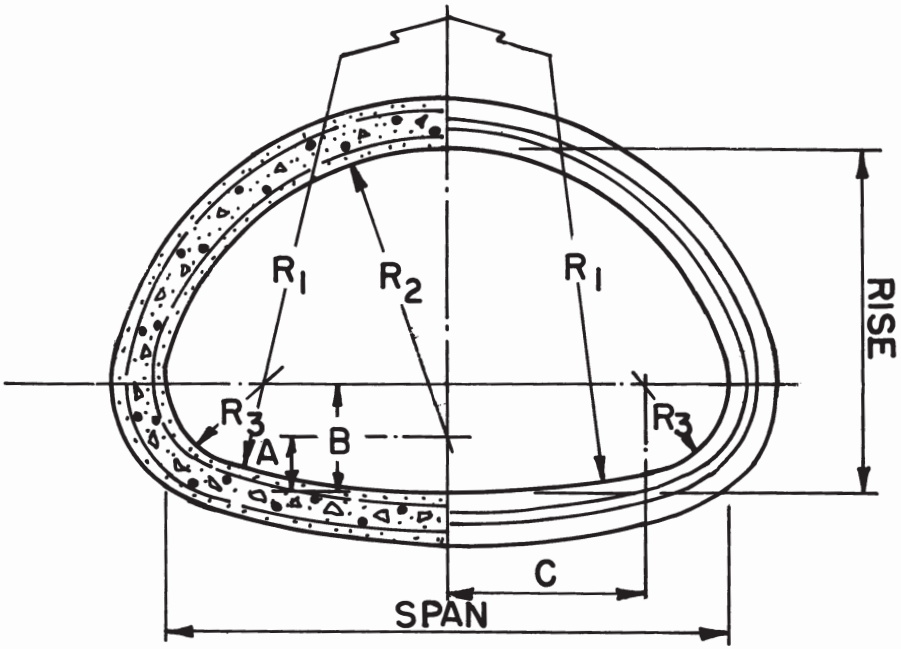
performed on one pipe for each 100 pipe, or fraction thereof, for each type, size and class. The methods of testing shall conform to ASTM Designations: C 76, C 506 or C 507, whichever is applicable.

As an alternate to the three-edge-bearing test, concrete pipe 60 inches in diameter and over may be accepted, at the option of the manufacturer, on the basis of material tests and inspection of the completed product. Acceptability of pipe on this basis shall be determined by the results of material tests as required in ASTM Designation: C 76, C 506 or C 507; by crushing tests on cores taken from the barrel of the completed and cured pipe; by absorption tests on samples from the wall of the pipe; and by inspection of the finished pipe including amount and placement of reinforcement, to determine its conformance with the design prescribed in these specifications and its freedom from defects. The manufacturer shall furnish facilities and personnel for taking the cores from the pipe barrel and for determining the compressive strength of the samples. When the cores cut from a section of pipe successfully meet the strength requirement, the coreholes shall be plugged and sealed by the manufacturer in a manner such that the pipe section will meet all of the test requirements of ASTM Designation: C 76, C 506 or C 507. Pipe sections, so sealed, will be accepted for use.

(4) Sizes and Permissible Variations.

(a) Variations in diameter, size, shape, wall thickness, reinforcement, placement of reinforcement, laying length and the permissible underrun of length shall be in accordance with the applicable ASTM Specification for each type of pipe as referred to previously.

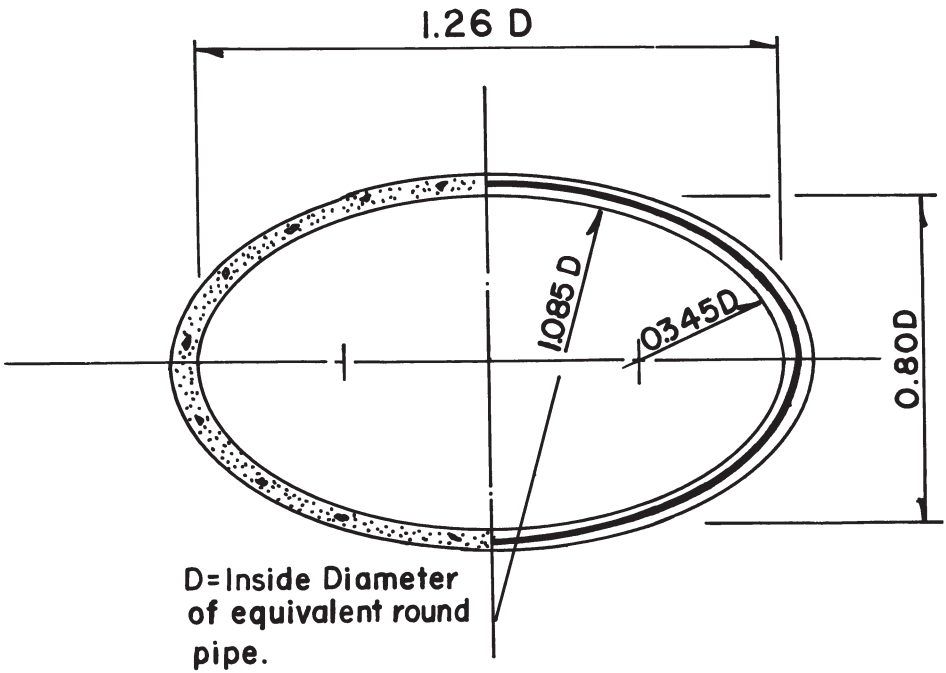
For convenience, the design sizes and dimensions for Arch and Elliptical Pipe are shown in the following tables:



Dsgn. Size	Size, In.	Water Area, sq ft	Rise, in.	Span, in.	A, in.	B, in.	C, in.	R_1, in.	R_2, in.	R_3, in.
1	15	1.1	11	18	3/8	4-11/16	4-31/32	22-7/8	10-5/8	4-1/32
2	18	1.65	13-1/2	22	1/4	6	5-3/4	27-1/2	13-3/4	5-1/4
3	21	2.2	15-1/2	26	3/4	6-1/4	7-3/4	35-1/2	14-3/4	5-1/4
4	24	2.8	18	28-1/2	3-7/16	5-29/32	9-21/32	40-11/16	14-9/16	4-19/32
5	30	4.4	22-1/2	36-1/4	3-3/4	7-11/16	12-3/32	51	18-3/4	6-1/32
6	36	6.4	26-5/8	43-3/4	4-1/8	8-9/16	15-1/2	62	22-1/2	6-3/8
7	42	8.8	31-5/16	51-1/8	5-1/16	10-1/16	18	73	26-1/4	7-9/16
8	48	11.4	36	58-1/2	6	11-19/32	20-1/2	84	30	8-3/4
9	54	14.3	40	65	6-1/2	13	22-11/16	92-1/2	33-1/2	9-13/16
10	60	17.7	45	73	7-1/2	14-11/16	25-9/32	105	37-1/2	11-7/32
11	72	25.6	54	88	9	17	31-7/16	126	45	12-9/16
12	84	34.6	62	102	10	18-21/32	37-1/32	162-1/2	52	13-31/32
13	90	44.5	72	115	13	23-13/16	38-7/32	183	59	19-9/32
14	96	51.7	77-1/4	122	15-1/4	24-11/32	40-15/16	218	62	20-1/16
15	108	66.0	87-1/8	138	17-1/8	26-27/32	46-5/8	269	70	22-3/8

FIGURE 1

Cross-Sectional Shape of Arch Pipe



Design Size	Equiv. Round Size (In)	Rise (In) X Span (In)	Min. Wall Thick. (In)	Design Size	Equiv. Round Size (In)	Rise (In) X Span (In)	Min. W all Thick. (In)
1	18	14 x 23	2-3/4	11	60	48 x 76	6-1/2
2	24	19 x 30	3-1/4	12	66	53 x 83	7
3	27	22 x 34	3-1/2	13	72	58 x 91	7-1/2
4	30	24 x 38	3-3/4	14	78	63 x 98	8
5	33	27 x 52	3-3/4	15	84	68 x 106	8-1/2
6	36	29 x 45	4-1/2	16	90	72 x 113	9
7	39	32 x 49	4-3/4	17	96	77 x 121	9-1/2
8	42	34 x 53	5	18	102	82 x 128	9-3/4
9	48	38 x 60	5-1/2	19	108	87 x 136	10
10	54	43 x 68	6				

FIGURE 2

Cross-Sectional Shape of Elliptical Pipe

(b) Where rubber gasket pipe joints are to be used the. Design of the Joints and Permissible Variations in Dimensions shall be in accordance with ASTM Designation: C 443.

(5) Workmanship and Finish. Pipe shall be substantially free from fractures, large or deep cracks and surface roughness. The ends of the pipe shall be normal to the walls and centerline of the pipe within the limits of variations allowed under Subarticle 464.2.(4).(a) above.

(6) Curing. Pipe shall be cured in accordance with the applicable ASTM Specification for each type of pipe as referred to above.

(7) Marking. The following information shall be clearly marked on each section of pipe:

(a) The class of pipe.

(b) The date of manufacture.

(c) The name or trade mark of the manufacturer.

(d) One end of each section of pipe with elliptical reinforcement shall be clearly marked during the process of manufacture or immediately thereafter on the inside and the outside of opposite walls to show the location of the "top" or "bottom" of the pipe as it should be installed, unless the external shape of the pipe is such that the correct position of the top and bottom is obvious. Marking shall be indented on the pipe section or painted thereon with waterproof paint.

(8) Minimum Age for Shipment. Pipe shall be considered ready for shipment when it conforms to the requirements of the tests specified herein.

(9) Inspection. The quality of materials, the process of manufacture, and the finished pipe shall be subject to inspection and approval by the Engineer at the pipe manufacturing plant. In addition, the finished pipe shall be subject to further inspection by the Engineer at the project site prior to and during installation.

(10) Causes for Rejection. Pipe shall be subject to rejection on account of failure to conform to any of the specification requirements. Individual sections of pipe may be rejected because of any of the following:

(a) Fractures or cracks passing through the shell, except for a single end crack that does not exceed the depth of the joint.

(b) Defects that indicate imperfect proportioning, mixing and molding.

(c) Surface defects indicating honeycombed or open texture.

(d) Damaged ends, where such damage would prevent making a satisfactory joint.

(11) Repairs. Pipe may be repaired if necessary, because of occasional imperfections in manufacture or accidental injury during handling and will be acceptable if, in the opinion of the Engineer, the repairs are sound and

properly finished and cured and the repaired pipe conforms to the requirements of the specifications.

(12) Rejections. All rejected pipe shall be plainly marked by the Engineer and shall be replaced by the Contractor with pipe which meets the requirements of these specifications. Such rejected pipe shall be removed immediately from the site of work.

(13) Jointing Materials. Unless otherwise specified on the plans the Contractor shall have the option of making the joints by any of the following methods:

(a) Mortar for joints shall be in accordance with the Item, "Concrete for Structures".

(b) Cold Applied, Plastic Asphalt Sewer Joint Compound shall be suitable for jointing concrete pipe. It shall consist essentially of natural and/or processed asphalt base, suitable volatile solvents, and inert filler, a portion of which shall be asbestos fiber. The consistency is to be such that the ends of the pipe can be coated with a layer of the compound up to one-half inch thick by means of a trowel. It shall cure to a firm, stiff plastic condition after application. The material shall be of a uniform mixture and any small separation occuring in the container before use must be readily stirred back to form a uniform mix.

Detailed Requirements: The material shall meet the following requirements when tested according to Test Method Tex-526-C:

Asphalt Base, 100–(% Volatiles + % Ash), % by wt	28-45
Volatiles by 212 F Evaporation, 24 hrs, % by wt	10-26
Mineral Matter determined as Ash, % by wt	30-55
Consistency, Cone Penetration, 150 g, 5 sec, 77 F	150-275

(c) Rubber Gaskets shall conform to ASTM Designation: C 361 or C 443, with the provision that the Contractor shall furnish the Engineer the Manufacturer's Certificate of Analysis.

(d) Cold Applied Preformed Plastic Gaskets shall be suitable for sealing joints of tongue and groove concrete pipe. The gasket sealing the joint shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler and shall contain no solvents, irritating fumes or obnoxious odors. The gasket joint sealer shall not depend on oxidizing, evaporating, or chemical action for its adhesive or cohesive strength, and shall be supplied in extruded rope-form of suitable cross-section. The size of the plastic gasket joint sealer shall be in accordance with the manufacturer's recommendations and sufficient to obtain the squeeze-out as described under Article 464.3. The gasket joint sealer shall be protected by a suitable removable two-piece wrapper. The two-piece wrapper shall be so designed that one-half may be removed longitudinally without disturbing the other half to facilitate application as noted below.

The chemical composition of the gasket joint sealing compound as shipped shall meet the following requirements when tested in accordance with the test methods shown.

Composition	Test Method	Typical Analysis
Bitumen (petroleum plastic content) (% by weight)	ASTM-D-4-52	50 – 70
Ash-Inert Mineral Matter (% by weight)	Tex – 526-C	30 – 50
Volatile Matter (@ 325 F) (% by weight)	Tex – 506-C	2.0 Max.

The gasket joint sealing compound when immersed for 30 days at ambient room temperature separately in 5 percent solution of caustic potash, a mixture of 5 percent hydrochloric acid, a 5 percent solution of sulfuric acid, and a saturated H_2S solution shall show no visible deterioration.

The physical properties of the gasket joint sealing compound as shipped shall meet the following requirements:

Property	Test Method	Typical Analysis	
Specific Gravity @ 77 F	ASTM D-71-52	1.20 Min	1.35 Max
Ductility @ 77 F (cm) Min	Tex – 503-C	5.0 Min	
Softening point @ 77 F Min	Tex – 505-C	320 F Min	
Penetration			
32 F (300 g) 60 Sec	Tex – 502-C	75 Min	
77 F (150 g) 5 Sec	Tex – 502-C	50 Min	120 Max
115 F (150 g) 5 Sec	Tex – 502-C		150 Max
Flashpoint C.O.C. F	Tex – 504-C	600 F	
Fire Point C.O.C. F	Tex – 504-C	625 F	

For jointing materials (b), (c) and (d) as described above, the Contractor shall furnish the Engineer the Manufacturer's Certificate of Compliance.

464.3 Construction Methods. Reinforced concrete pipe culverts shall be constructed from the specified materials in accordance with the following methods and procedure:

(1) Excavation. All excavation shall be in accordance with the requirements of the Item, "Structural Excavation", except where tunneling or jacking methods are shown on the plans or permitted by the Engineer. When pipe is laid in a trench, the trench when completed and shaped to receive the pipe, shall be of sufficient width to provide free working space for satisfactory bedding and jointing and thorough tamping of the backfill and bedding material under and around the pipe. The Contractor shall make such temporary provisions as may be necessary to insure adequate drainage of the trench and bedding during the construction operation.

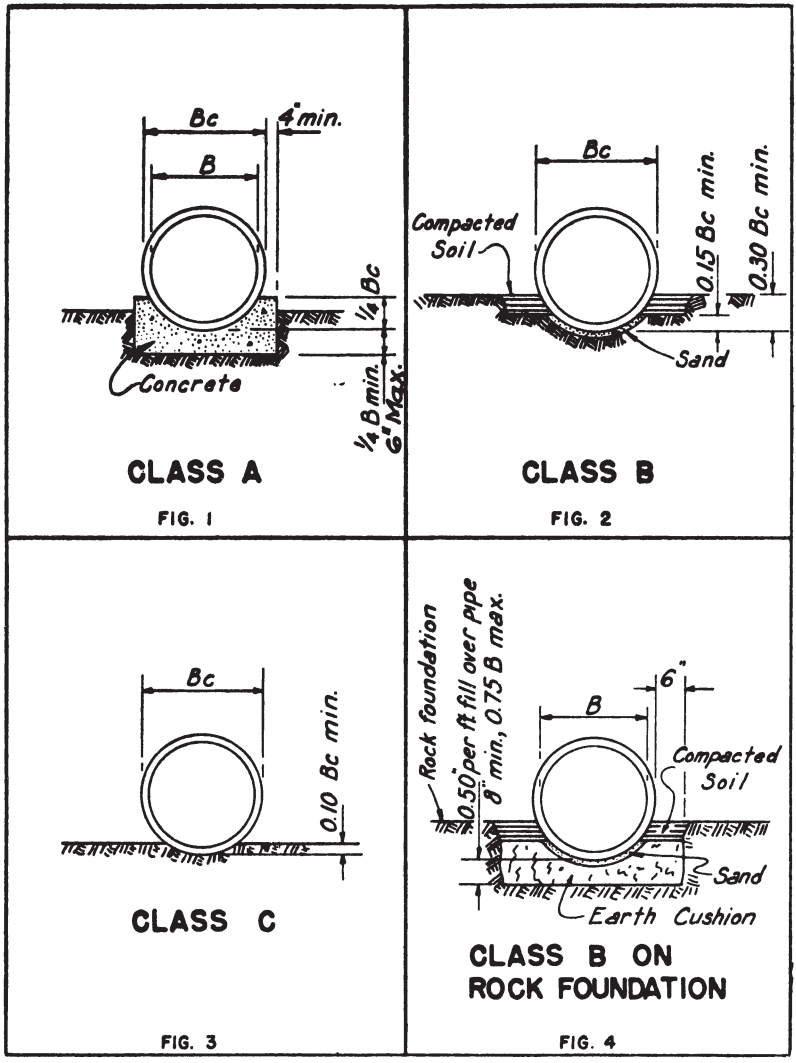
(2) Bedding. The pipe shall be bedded in accordance with the classification shown on the plans. In the absence of plan requirement for specific bedding classification, the pipe shall be bedded in accordance with the requirements for Class C Bedding. The various classes of bedding shall be prepared as follows:

(a) Class A (Concrete Cradle) Bedding. In this class of bedding the lower part of the pipe exterior, as shown in Figure 1, shall be bedded in a continuous cradle constructed of Class B concrete, in accordance with the Item, "Concrete for Structures", having a minimum thickness under the pipe of one fourth the nominal inside diameter or a thickness of 6 inches whichever is less, and extending up the sides of the pipe for a height equal to one fourth of the outside diameter. The cradle shall have a width at least equal to the outside diameter of the barrel of the pipe plus 8 inches and shall be constructed monolithically without horizontal construction joints. The pipe shall be placed in the concrete cradle before the concrete has taken its initial set.

(b) Class B Bedding. The pipe shall be bedded, as shown in Figure 2, on fine granular materials over an earth foundation, accurately shaped by means of a template to fit the lower part of the pipe exterior for at least 15 percent of its overall height. Selected materials from excavation or borrow shall then be placed along both sides of the pipe equally in layers not more than 6 inches thick and compacted by mechanical tamps or rammers for the remainder of the lower 30 percent of the overall height of the pipe.

(c) Class C Bedding. The pipe shall be bedded, as shown in Figure 3, in a foundation of stable earth material accurately shaped to fit the lower part of the pipe exterior for at least 10 percent of its overall height. The Engineer may require use of a template if necessary to secure reasonably accurate shaping of the foundation material.

(d) Rock or Other Incompressible Foundation. Where ledge rock, rocky or gravelly soil, hard pan, or other unyielding material is encountered at the structure site, such materials shall be removed prior to bedding the pipe. Where Class A bedding is specified, these materials shall be excavated to the bottom of the concrete cradle. Where Class B or Class C bedding is specified, the hard materials shall be excavated as illustrated in Figure 4 for a minimum of 8 inches below the bottom of the pipe or one half of an inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three fourths of the nominal diameter of the pipe. The width of the excavation shall be one foot greater than the outside diameter of the pipe. It shall be replaced with suitable granular materials and lightly compacted and shaped as required for the specified class of bedding.



(e) Unstable Materials. Where the soil encountered at the established grade is quicksand, muck, or similar unstable material, unless special construction methods are called for on the plans or in the special provisions, such unstable soil shall be removed and replaced in accordance with the requirements of the Item, "Structural Excavation".

(f) Flat Bottom Pipe. If the pipe is shaped such that the bottom is flat for a width equal to at least 40 percent of its external diameter, the circular shaping of the trench as required for Class B and Class C bedding will not be required and the pipe may be bedded on sand (Class B) or on natural earth (Class C) which has been shaped flat to receive the pipe, with uniform bearing under the entire length of each joint. For Class B bedding the sand cushion shall extend a minimum of 6 inches on each side beyond the flat bottom.

(3) Laying Pipe. Unless otherwise authorized by the Engineer, the laying of pipe on the prepared foundation shall be started at the outlet end with the spigot or tongue end pointing downstream and shall proceed toward the inlet end with the abutting sections properly matched, true to the established lines and grades. Where bell and spigot pipe are used, cross trenches shall be cut in the foundation to allow the barrel of the pipe to rest firmly upon the prepared bed. These cross trenches shall be not more than two inches larger than the bell ends of the pipe. Proper facilities shall be provided for hoisting and lowering the sections of pipe into the trench without disturbing the prepared foundation and the sides of the trench. The ends of the pipe shall be carefully cleaned before the pipe is placed. As each length of pipe is laid, the mouth of the pipe shall be protected to prevent the entrance of earth or bedding material. The pipe shall be fitted and matched so that when laid in the bed it shall form a smooth, uniform conduit. When elliptical pipe with circular reinforcing or circular pipe with elliptical reinforcing is used, the pipe shall be laid in the trench in such position that the markings "Top" or "Bottom", shall not be more than 5 degrees from the vertical plane through the longitudinal axis of the pipe.

For pipe over 42 inches in diameter the Contractor may drill two holes not larger than 2 inches in diameter, in the top of each section of the pipe, to aid in lifting and placing.

The holes shall be neatly drilled, without spalling of the concrete, and shall be done without the cutting of any reinforcement. After the pipe is laid, the holes shall be filled with mortar and cured.

Multiple installations of reinforced concrete pipe shall be laid with the center lines of individual barrels parallel. When not otherwise indicated on plans, the following clear distances between outer surfaces of adjacent pipe shall be used.

Diameter of Pipe	18"	24"	30"	36"	42"	48"	54"	60" to 84"
Clear Distance Between Pipes	0'-9"	0'-11"	1'-1"	1'-3"	1'-5"	1'-7"	1'-11"	2'-0"

(4) Jointing. If the Contractor elects to use Portland cement mortar joints, all pipe shall be jointed tight and sealed with stiff mortar, composed of one part Portland cement and two parts sand, so placed as to form a durable water-tight joint. The ends of the pipe shall be cleaned thoroughly and wetted before making the joint. After any section of pipe is laid and before any succeeding section is laid the lower half of the bell or groove of the pipe last laid shall be plastered thoroughly by troweling on an even layer of mortar. Next, mortar shall be applied to the upper portion of the tongue or spigot of the pipe section being laid.

The spigot or tongue end of the next section of pipe shall then be inserted and the joint pulled up tight, taking care that the inner surfaces of the abutting pipe sections are flush and even. After the section is laid and uniformly matched and the sections have been fitted as close as the construction of the pipe will permit, the lower half of the inner circumference of the joints of pipe over 18 inches in diameter shall be sealed and packed with mortar and finished smooth and even with the adjacent section of pipe. Before this mortar has attained initial set, additional mortar then shall be applied from the outside and forced into the unfilled portion of the bell or groove to fill completely the annular space around the spigot or tongue. For bell and spigot pipe, a bead shall be formed on the outside by troweling on mortar downward at an angle of 45 degrees from the outer edge of the bell to the spigot of the last laid section. For tongue and groove pipe, a bead shall be formed extending at least 1 inch on either side of the joint and of approximately semicircular cross-section or triangular cross-section. If the triangular cross-section is used, it shall be formed by placing the mortar approximately 45 degrees outward from the extreme edges of the bead. For pipe too small to permit finishing of the inside surface of the joint, a tight stopper of burlap or other equivalent materials shall be dragged through the pipe past the new joint to remove any fins of mortar. Special care shall be exercised in placing adjacent pipe sections to avoid movement of the pipe in place and the breaking of the mortar bond at completed joints. After the initial set, the mortar on the outside shall be protected from air and sun with a thoroughly wetted earth or burlap cover or acceptable equivalent which shall be kept wet for a minimum of 48 hours or until the backfill has been completed. No jointing shall be done when the atmospheric temperature is at or below 40 F, and when necessary, because of a sudden drop in temperature, joints shall be protected against freezing for at least 24 hours. After placing, any pipe which is not in true alignment or which shows any undue settlement after laying or is damaged, shall be taken up and relaid or replaced without extra compensation.

At the Contractor's option, and with the approval of the Engineer for pipes which are large enough for a man to enter and perform the required work efficiently, pipe may be furnished with the groove not less than one-half of an inch and not more than three-fourths of an inch longer than the tongue. Such pipe may be laid without mortar joints and backfilled. Care shall be exercised to avoid displacing the joints during the backfilling operations. After the backfilling has been completed, the space between the end of the tongue and the groove shall be cleaned of all foreign material, thoroughly wetted and filled with mortar around the entire circumference of the pipe. Mortar for this use shall be of such consistency that it can be packed in the joint completely filling the space between adjacent pipes. The Engineer will inspect this process to ascertain that the joints are being completely filled. If the Engineer finds that this is not being accomplished, he may void this process and require that for the remainder of the project the pipe be jointed and backfilled in accordance with the provisions of the first paragraph of this section.

The Contractor shall make available for the use of the Engineer an

appropriate rolling device similar to an automobile mechanic's "Creeper" for conveyance through the small size pipe structures.

No mortar banding on the outside of pipe will be required for side drain culverts. No joint material will be required for temporary culverts.

Mortar joints will be required for irrigation wells, vents and similar vertical structures.

Joints using Cold Applied, Plastic Asphalt Sewer joint compound shall be made as follows:

Both ends of the pipes shall be clean and dry and shall be coated with a suitable primer of the type recommended by the manufacturer where they will be in contact with the joint material. Under no circumstances shall this type of joint be attempted on wet pipe. After the pipe has been set to proper line and grade in the trench, a one-half of an inch thick layer of the compound shall be troweled or otherwise placed on the groove end of the pipe covering not less than two-thirds of the joint face around the entire circumference. Next the tongue end of the next pipe shall be shoved home with sufficient pressure to make a tight joint. After the joint is made any excess mastic projecting into the pipe shall be removed. Backfilling of pipe laid with asphalt mastic joints may proceed as soon as the joint has been inspected and approved by the Engineer. Special precautions shall be taken in placing and compacting backfill to avoid damage to the joints.

Joints using Rubber Gaskets: Where rubber gasket pipe joints are required by the plans the joint assembly shall be made according to the recommendations of the gasket manufacturer. Water tight joints will be required when using rubber gaskets.

Joints using Cold Applied Preformed Plastic Gaskets shall be made as follows:

A suitable primer of the type recommended by the manufacturer of the gasket joint sealer shall be brush applied to the tongue and groove joint surfaces and the end surfaces and allowed to dry and harden. No primer shall be applied over mud, sand or dirt or sharp cement protrusions. The surface to be primed must be clean and dry when primer is applied.

Before laying the pipe in the trench, the plastic gasket sealer shall be attached around the tapered tongue or tapered groove near the shoulder or hub of each pipe joint. The paper wrapper shall be removed from one side only of the two-piece wrapper on the gasket and pressed firmly to the clean, dry pipe joint surface. The outside wrapper shall not be removed until immediately before pushing the pipe into its final position.

When the tongue is correctly aligned with the flare of the groove, the outside wrapper on the gasket shall be removed and the pipe shall be pulled or pushed home with sufficient force and power (Back Hoe shovel, chain hoist, ratchet hoist or winch) to cause the evidence of squeeze-out of the gasket material on the inside or outside around the complete pipe joint circumference. Any joint material pushed out into the interior of the pipe that would tend to obstruct the flow shall be removed. (Pipe shall be pulled home in a straight line with all parts of the pipe on line and grade at all

times.) Backfilling of pipe laid with plastic gasket joints may proceed as soon as the joint has been inspected and approved by the Engineer. Special precautions shall be taken in placing and compacting backfill to avoid damage to the joints.

When the atmospheric temperature is below 60 F, plastic joint seal gaskets shall either be stored in an area warmed to above 70 F, or artifically warmed to this temperature in a manner satisfactory to the Engineer. Gaskets shall then be applied to pipe joints immediately prior to placing pipe in trench, followed by connection to previously laid pipe.

(5) After the pipe has been placed, bedded and jointed as specified, filling and/or backfilling shall be done in accordance with the applicable requirements of the Item, "Structural Excavation". When mortar joints are specified, no fill or backfill shall be placed until the jointing material has been cured for at least six hours. Special precautions shall be taken in placing and compacting the backfill to avoid any movement of the pipe or damage to the joints. For side drain culverts and all other culverts where joints consist of materials other than mortar, immediate backfilling will be permitted.

(6) When existing headwalls and aprons are specified on the plans for reuse, the portion to be reused shall be severed from the culvert and moved to the new position previously prepared by hoisting with a crane, rolling, or other approved methods. Connections shall conform to the requirements for joining sections of pipes as designated herein or as shown on the plans. Any portion of the headwalls, aprons or pipe attached to headwall damaged during the moving operations by the Contractor shall be restored to their original condition at his entire expense. The Contractor, if he so desires, may remove and dispose of the existing headwalls and construct new headwalls at his expense in accordance with the pertinent specifications and design indicated on the plans or as furnished by the Engineer.

(7) Unless otherwise shown on the plans or permitted in writing by the Engineer, no heavy earth moving equipment will be permitted to haul over the structure until a minimum of 4 feet of permanent or temporary, compacted fill has been placed thereon. Pipe damaged by the Contractor's equipment shall be removed and replaced by the Contractor at no additional cost.

464.4. Measurement. Reinforced concrete pipe will be measured by the linear foot. Such measurement will be made between the ends of the pipe barrel along its central axis. Where spurs or branches, or connections to existing pipe lines are involved, measurement of the spur or new connecting pipe will be made from the intersection of its central axis with the outside surfaces of the pipe into which it connects. Where inlets, headwalls, catch basins, manholes, junction chambers, or other structures are included in lines of pipe, that length of pipe tieing into the structure wall will be included for measurement but no other portion of the structure length or width will be so included.

For multiple pipes, the measured length will be the sum of the lengths of the barrels measured as prescribed above.

When actual field measurement is required by Article 464.5., measurement will be made by the linear foot of pipe in place as prescribed above. If no adjustment as required under Article 464.5. is necessary, no additional measurement or calculation will be made.

In the event of a change in design which either increases or decreases the quantity of pipe, the variation in quantity will be based on revised plan dimensions and the quantity shown on the plans and in the proposal will be increased or decreased as the case may be.

464.5. Payment. Payment for concrete pipe measured as prescribed above will be made at the contract unit price bid for the various sizes of "Reinforced Concrete Pipe", "Reinforced Concrete Pipe, Arch" and "Reinforced Concrete Pipe, Elliptical" of the class specified.

The quantity to be paid for will be that quantity shown on the contract plans and in the proposal, except as may be modified by the following:

Either party to the contract may request an adjustment of the quantities shown on the contract plans (by each separate bid item) if the quantities, measured as outlined in Article 464.4., vary from those shown on the contract plans by more than 5 percent.

The party to the contract which requests an adjustment shall present, to the other, two copies of field measurements and calculations showing the revised length for the structure or structures in question. These revised lengths of pipe, when proven correct, together with all other pipe under the same bid item, shall constitute the final quantity for which payment will be made.

Payment for revised quantities due to a change in design will be paid for at the unit price bid per linear foot measured as provided in Article 464.4.

Adjustments of quantities will be subject to the provisions of Article 4.3.

Payment shall be full compensation for furnishing and transporting the pipe; hauling and placing of earth cushion material where required for bedding pipe in rock excavation; for the preparation and shaping of beds; for hauling, placing and jointing of pipes; for end finish; for moving and reusing headwalls; for all connections to existing structures and for all other items of materials, labor, equipment, tools, and incidentals necessary to complete the culvert or storm sewer in accordance with the plans and these specifications, except excavation and backfill, which will be paid for in accordance with the Item, "Structural Excavation". The excavation of rock or other incompressible materials, as may be required by Subarticle 464.3.(2).(d). will be measured and paid for as "Structural Excavation". Where pipes are laid on a skew, or where pipe ends are cut to fill slope, full compensation for cutting the ends parallel with the centerline of the highway or the fill slope shall be considered as included in the price paid per linear foot for the designated item of pipe and no additional allowance will be made therefor.

ITEM 465

PIPE SEWERS

465.1. Description.

(1) General. This item shall consist of furnishing all pipe and/or materials for and constructing precast concrete or monolithic concrete pipe sewer mains, laterals, stubs, and inlet leads including all applicable work such as excavating, bedding, jointing, materials, tests, etc., prescribed under the Item, "Excavation and Backfill for Sewers", and the Item, "Reinforced Concrete Pipe Culverts". The sewers shall be of the sizes, types, and dimensions shown on the plans or as designated by the Engineer, and shall include all joints or connections to new or existing pipes, sewers, manholes, inlets, etc., as may be required to complete the work. Pipe used in the construction of pipe sewers shall be of the classes provided herein for the various units of work.

(2) Types. Pipe sewers shall be of the sizes shown on the plans. Sewers less than 36 inches in size and portions of sewers constructed in paved streets where traffic is to be maintained, shall be constructed of precast concrete pipe. With these exceptions and except where the plans designate that cast-in-place monolithic reinforced concrete pipe shall be used, the Contractor shall have the option of constructing pipe sewers from precast pipe of the classes specified herein or from cast-in-place monolithic reinforced concrete pipe conforming to the details shown on the plans.

465.2. Materials.

(1) Pipe. Concrete pipe 12 inches diameter and over shall conform to the class specified on the plans and in accordance with the Item, "Reinforced Concrete Pipe Culverts".

Concrete pipe smaller than 12 inches diameter shall conform to the requirements of ASTM Designation: C 14.

After delivery along the trenches, the pipe and specials will be subjected to a rigid inspection for transportation and handling damages incurred after acceptance at the source of manufacture. Pipe may be repaired if necessary and will be acceptable if, in the opinion of the Engineer, the repairs are sound and properly finished and cured and the repaired pipe conforms to the requirements of these specifications.

(2) Concrete. All concrete other than materials for pipe shall be Class "C" concrete conforming to the requirements of the Item, "Concrete Structures", and the Item, "Concrete for Structures".

(3) Mortar. Mortar shall be composed of one part Portland cement and two parts sharp, clean mortar sand suitably graded for the purpose, but conforming in other respects to the provisions of the Item, "Concrete for Structures", for fine aggregate. Hydrated lime or lime putty may be added to the mix but in no case shall it exceed ten percent by weight of the total dry mix.

(4) Reinforcing Steel.

(a) Reinforcing steel and the placing thereof shall conform to the requirements of the Item, "Reinforcing Steel".

(b) Circumferential reinforcing hoops for monolithic reinforced concrete pipe sewers shall conform to the details shown on the plans. Unless indicated otherwise on the plans, the longitudinal reinforcement shall be continuous throughout the length of the sewer and all bar splices shall be a minimum of twenty bar diameters length.

465.3. Construction of Precast Concrete Pipe Sewers.

(1) Installation of Pipe. No pipe shall be installed in the trench until the excavation has been completed as required on the plans, the bottom of the trench shaped, and the trench approved for condition, line, and grade by the Engineer.

The Contractor shall furnish, at his own expense, and place in position as directed by the Engineer all necessary batter boards for controlling the work. The batter boards shall be of such size timber as the Engineer directs and be supported substantially. The boards and all location stakes must be protected from possible injury or change of location. The Contractor shall be required to furnish at his own expense, good, sound, twilled lines for use in achieving lines and grades, and the necessary plummets and graduated poles made of a form approved by the Engineer.

All pipes shall be laid and jointed in the dry, regardless of the joint material used and the trench shall be kept dry until the mortar in the joints has attained final set.

The pipes and specials shall be laid in the trench such that after the sewer is completed the interior surface thereof shall conform accurately to the grades and alignments fixed and given by the Engineer.

The pipe shall be laid accurately to line and grade, with the tongue end downstream entering the groove to full depth and in such manner as not to drag earth into the annular space for the sealing of the joints. Pipes shall be fitted together and matched so that when laid in the work, they shall form a sewer with a smooth and uniform invert.

(2) Joints. All joints shall conform to the requirements of the Item, "Reinforced Concrete Pipe Culverts".

(3) Connections. Where pipe sewers are connected to new manholes, inlets, or headwalls, the end of the connecting pipe shall be framed into the structure as shown on the plans and the concrete or brick masonry shall be placed or laid around the pipe for the full thickness of the structure wall.

Where pipe sewers are connected to existing inlets or manholes, the connection shall be made by cutting an opening into the wall of the structure, inserting the end of the pipe until it is flush with the inside face of the structure and completely filling the space between the pipe and structure with concrete or mortar. The bottom of the existing structure shall be

mortared or concreted to eliminate any drainage pockets created by the new connection, and in general accord with details for the new structure as shown on the plans. Where such connections involve the setting back of inlets and connecting the sewer line through the old inlet to the new, the old inlet, or portions thereof, shall be removed as is required to provide a full circle pipe connection through the limits of the old structure. Where abrupt angles are involved, vitrified clay specials set in concrete or mortar to a depth of 3 inches over the top of the pipe shall be employed and such connections shall be classified as pipe sewers. Where the sewer is connected into old structures which are to remain in service, any damage to the structure resulting from the work of making the connection shall be restored by the Contractor to the satisfaction of the Engineer.

Where pipe sewers are connected directly into other pipe sewers, unless otherwise shown on the plans, the connection shall be effected by cutting a hole into the larger sewer equal to the external diameter of the smaller and thereafter connecting the two with a smooth mortared joint constructed in a manner satisfactory to the Engineer.

Where pipe sewers are connected directly to the sides of monolithic sewer mains or box sewer mains, the connection shall be made, preferably, by framing the pipe end into the form of the main and placing the concrete of the main in direct contact with the pipe end. It will be permissible, in making connections into box sewers, to cast or cut an opening in the side of the main some six inches greater in diameter than the outside of pipe and subsequently mortaring the pipe to form a smooth connection, with end of the pipe flush with the inside face of the main.

(4) Stub Ends. Stubs, for connection to future work not covered by plans, shall be finished by building a watertight two course brick plug into the free end of the pipe, or with a precast concrete plug.

(5) Control of Ground Water. Sewers shall be built in the dry. If it becomes necessary to employ additional sheathing or to provide concrete bedding below sub-grade to accomplish this objective, such additional provisions shall be approved by the Engineer, and shall be provided by the Contractor without additional compensation.

465.4. Construction of Monolithic Pipe Sewers.

(1) Forms. There shall be provided suitable collapsible centers or forms with smooth surfaces rigidly braced for strength. The bracing shall be adequate to prevent deviations from the correct lines during construction. All steel forms shall be made accurately and neatly. Similar parts in each longitudinal section of form shall be interchangeable. Bent plates requiring close fit shall be rolled and fabricated to the correct curves prior to assembling. Suitable forms shall be provided for bends in the sewer. Steel filler plates shall be furnished as required. All steel center forms or "pans" must be approved by the Engineer prior to use in construction. If, during construction, any forms become dented or warped or in any other manner unsuitable for use, such forms may be rejected by the Engineer until such time that the Contractor reconditions the forms making them suitable for further use.

All wooden forms shall be built of clean, sound, cured lumber, reasonably free from knots, dressed on all sides, and neatly fitted. Forms for interior surfaces of sewers shall be lined or faced with 1 inch x 4 inch S4S timber. The form surface shall be watertight and fastened securely to the ribs or supports. No forms built up in the trench or ribs with separate pieces of wooden lagging will be allowed except for specials or curves. No center or form shall be used which is not clean and of proper shape and strength. Before placing concrete or reinforcement, the forms shall be coated with lubricants to prevent adherence to the concrete.

Circular forms shall be set on concrete blocks of proper thickness with dimensions approximately 6 inch x 6 inch and spread on about 5-foot centers along the sewer and shall have a groove of size and depth to provide for proper supports and cover of reinforcement.

(2) Concrete Placement and Control. After the trench has been excavated in accordance with the Item, "Excavation and Backfill for Sewers", that portion of the sides of the trench that will be in contact with the concrete shall be hand trimmed and shaped to conform to the section of the sewer to be constructed. The bottom of the trench shall be fine graded to the grade established. Below the grade line so established, backfill will not be permitted. When timber sheathing or flooring is employed, proper allowances for timber thickness shall be made.

Upon completion of the trench and following inspection and approval by the Engineer, the Contractor shall place the reinforcing steel and forms (adequately braced in proper position) and place concrete. The top of the sewer shall be finished by hand with a wooden float. The thickness of the top shall be checked with a wire gauge.

The Contractor shall furnish at his own expense and place in position as directed by the Engineer, all necessary batter boards for controlling the work. The batter boards shall be of such size timber as the Engineer directs and shall be supported substantially. The boards and all location stakes must be protected from possible injury or change of location. Also, the Contractor shall be required to furnish at his own expense, good, sound twilled lines for use in achieving lines and grades, and the necessary plummets and graduated poles made of a form approved by the Engineer.

Horizontal joints will not be permitted unless shown on the plans. Each run of concrete shall end against a vertical header which shall remain in place for a minimum period of eight hours. Longitudinal reinforcement shall continue through the header for a minimum distance of twenty bar diameters.

(3) Special Foundations. Concrete in monolithic sewers shall be placed in the dry under conditions of full control of any ground water which may be encountered. If it is found necessary to employ additional sheathing, concrete section or a working platform below sub-grade of concrete or concrete and timber in order to accomplish this objective, such additional provisions shall be approved by the Engineer and shall be provided by the Contractor without additional compensation.

(4) Junctions. Unless special structures are provided, junctions of monolithic sewers shall be made by fitting the form of the branch sewer to the side of the larger diameter.

(5) Stubs. Stubs for monolithic sewers shall be as shown on the plans. Stub ends shall be blocked with a watertight two course brick header.

465.5. Measurement. Longitudinal measurement of pipe sewers will be made along the centerline of the sewer by the linear foot of the various sizes of sewers, in place, in accordance with these specifications, complete and accepted by the Engineer.

The lengths of sewer mains and laterals will be measured between inside faces of manholes where the installation involves connection of the sewer into a manhole at each end of the line being measured.

Where the installation involves a connection to an existing stub, the measurement will be made from the end of the stub to the inside face of the manhole on the work being measured. Sewer stubs will be measured from the end of the stub to the inside face of manhole to which the stub is connected.

Where pipe sewers, sewer laterals, leads, or stubs are connected directly to other pipe sewers, measurement will be to the inside face of the sewer into which connection is made. Where such connection is directly into a box sewer main, measurement will be made to the inside face of the box sewer on the side where the connection is made.

Storm sewer leads connecting an inlet to the sewer system will be measured from the inside face of the inlet to the inside face of the manhole or inlet or pipe sewer or the inside face of the box sewer where the lead terminates.

All pipe sewer mains, laterals, leads, and stubs will be measured as prescribed above and classified as pipe sewers for the purposes of payment.

465.6. Payment. Payment for pipe sewers, measured as prescribed above, will be made at the unit price bid per linear foot for the various sizes of "Pipe Sewers", of the class specified, complete in place except that excavation shall be paid for as required under the Item, "Excavation and Backfill for Sewers".

Such payment shall be full compensation for furnishing all concrete materials, reinforcing steel, precast concrete pipe, mortar, and for all other materials, tools, labor, equipment, and incidentals required to perform the applicable work prescribed herein.

ITEM 470

MANHOLES AND INLETS

470.1. Description. This item shall govern for the construction of manholes and inlets complete in place or to the stage detailed on the plans and the materials used therein, including the installation, and when required, the furnishing of frames, grates, rings and covers. Junction boxes shall be classified as manholes.

470.2. Types. The various types of manholes and inlets are designated on the plans by letters or by numbers indicating the particular design of each. Each type shall be constructed in accordance with the details shown on the plans and to the depth required by the profiles and schedules given.

470.3. Stages of Construction. All types of manholes and inlets may be built either complete in one stage or in two stages hereinafter described as Stage I Construction and Stage II Construction.

Stage I Construction shall consist of that portion of manholes and inlets designated as such on the plans. Stage I Construction shall include the furnishing and installation of a temporary wooden cover for both manholes and inlets and the required manhole steps in accordance with the details shown on the plans. Only that portion of the total depth included in Stage I Construction as designated on the plans shall be constructed under Stage I Construction.

For Inlet Units, Stage I Construction shall consist of furnishing and installing the sewer pipe from the storm sewer to a point below the top of curb as indicated on the plans including the furnishing and installation of a temporary precast concrete plug for the exposed end of the sewer pipe.

Stage II Construction shall consist of that portion of the complete manhole or inlet not covered under Stage I. This shall include the remaining wall height and top of manhole or inlet including the installation of frames, grates, rings and covers, the furnishing and installation of manhole steps, curb beams and/or collecting basins in accordance with the plans and specifications.

470.4. Materials.

(1) Concrete. Concrete for manholes and inlets shall be Class "A" concrete when used with precast pipe sewer construction and Class "C" concrete when used with monolithic pipe sewer construction conforming to the requirements of the Item, "Concrete Structures", and the Item, "Concrete for Structures", except as otherwise provided on the plans.

(2) Mortar. Mortar shall be composed of one part Portland cement and two parts clean, sharp mortar sand suitably graded for the purpose by conforming in other respects to the provisions of the Item, "Concrete for Structures" for fine aggregate. Hydrated lime or lime putty may be added to the mix but in no case shall it exceed 10 percent by weight of the total dry mix.

(3) Reinforcing Steel. Reinforcing Steel shall conform to the requirements of the Item, "Reinforcing Steel".

(4) Structural Steel. Structural steel shall conform to the requirements of the Item, "Steel Structures" and the Item, "Metal for Structures".

(5) Brick. Bricks shall be of first quality, sound, hard-burned, perfectly shaped brick. Shale bricks, if used, shall be homogeneous, thoroughly and uniformly burned. Bricks shall not absorb more than 16 percent of water by weight when submerged in water for 24 hours, having been in a completely

dry state prior to placing in water. Clay brick shall conform to the requirements of ASTM Designation: C 32, Grade NA or equal. Concrete brick meeting the requirements of ASTM Designation: C 55, Grade A, shall be acceptable.

(6) Concrete Blocks. Concrete blocks when shown on the plans shall conform to the requirements of ASTM Designation: C 139.

(7) Frames, Grates, Rings and Covers. Frames, grates, rings and covers shall conform to the requirements of the Item, "Frames, Grates, Rings and Covers".

(8) Cast Iron. Cast iron for supports, steps and inlet units shall conform to the shape and dimensions shown on the plans. The castings shall be clean and perfect, free from sand or blow holes, or other defects. Cast iron castings shall conform to the requirements of "Gray Iron Castings" ASTM Designation: A 48, Class 30.

(9) Timber. Timber for temporary covers when used with Stage I Construction shall be sound, new or used timber of minimum 3 inch nominal thickness, reasonably free of knots and warps.

470.5. Construction Methods.

(1) General. All concrete work shall be performed in accordance with the requirements of the Item, "Concrete Structures", unless otherwise specified. Forms will be required for all concrete walls, except where the nature of the surrounding material is such that it can be trimmed to a smooth vertical face (the outside form for concrete bases supporting brick walls may be omitted with approval by the Engineer). Where brick is used in wall construction, cast iron steps shall be mortared into the joints as shown on the plans. Where concrete is used in wall construction, the steps shall be cast into the wall when the concrete is placed. All brick work shall be laid with one half of an inch "shoved" joints. Plastered or buttered joints are prohibited. Every fifth course of brick shall be a header course or bond course with the long axis of such course laid perpendicular to the long axis of the preceding four courses.

(2) Manholes and Inlets for Precast Concrete Pipe Sewers. The construction of manholes and inlets for precast concrete pipe sewers shall be done as soon as is practicable after sewer lines into or through the manhole or inlet locations are completed. All sewers shall be cut neatly at the inside face of the walls of the manhole or inlet and pointed up with mortar.

(3) Manholes and Inlets for Monolithic Pipe Sewers. Bases for manholes and inlets on monolithic pipe sewers may be placed monolithic with the sewer or, at the Contractor's option, may be placed after the sewer is constructed.

(4) Manholes for Box Sewers. Bases for manholes for box sewers shall be cast as an integral part of the sewer. The manholes may be constructed prior to backfilling or, if the Contractor so elects, the manhole opening may be

covered temporarily with timber to facilitate the compaction of backfill for the sewer as a whole with tractor equipment. Thereafter, required excavation for the manhole shall be made and the manhole constructed and backfilled in accordance with the plans. Manholes for box sewers shall include all manhole steps required in the wall of the sewer.

(5) Inverts. The inverts passing out or through the manhole or inlet shall be shaped and routed across the floor of the manhole or inlet as shown on the plans. This shaping may be accomplished by adding and shaping mortar or concrete after the base is cast or by placing the required additional material with the base.

(6) Finishing Complete Manholes and Inlets. Manholes and inlets shall be completed in accordance with the plans. Backfilling to original ground elevation shall be in accordance with the provisions of the Item, "Structural Excavation" or the Item, "Excavation and Backfill for Sewers".

(7) Finishing Stage I Construction. Stage I Construction shall be completed by constructing the walls to the elevations shown on the plans and backfilling to required elevations in accordance with the requirements of the Item, "Structural Excavation" or the Item, "Excavation and Backfill for Sewers".

(8) Stage II Construction. Subgrade and base course construction shall be completed over manholes constructed as provided for Stage I. Stage II Construction of manholes or inlets shall consist therefore of excavating to expose the top of Stage I Construction and completing the manhole or inlet in accordance with the plans and these specifications, including backfill and cleaning of all debris from the bottom of the manhole or inlet.

(9) Inlet Units. Cast iron or steel inlet units shall be installed in conjunction with the construction of concrete curb and gutter. Prior to placing concrete for curb and gutter, the inlet units shall be set securely in position. Openings for the inlets and recesses in curb and gutter, as indicated on the plans, shall be formed in conjunction with the curb and gutter forms. Concrete for curb and gutter adjacent to the inlets shall be placed using care to secure thoroughly compacted concrete around the inlet castings and formed openings and recesses without displacement of the inlet units in the forms.

470.6. Measurement.

All manholes and inlets satisfactorily completed in accordance with the plans and specifications will be measured by each manhole or inlet, complete, or by each manhole or inlet completed to the stage of construction required by the plans.

Extension to inlets will be measured by each extention separately from the inlet.

Excavation and backfill will not be measured under this item but will be measured as required by the Item, "Structural Excavation", or the Item, "Excavation and Backfill for Sewers", as the case may be.

Frames, grates, rings and covers will be measured and paid for as required under the Item, "Frames, Grates, Rings and Covers".

470.7. Payment.

(1) Manholes, Complete. Payment for complete manholes of the type shown on the plans in place and in accordance with these specifications and measured as prescribed above will be made at the unit price bid for each "Manhole, Complete", of the type specified.

(2) Inlets, Complete. Payment for Inlets of the type shown on the plans in place in accordance with these specifications and measured as prescribed above will be made at the unit price bid for each "Inlet, Complete", or "Inlet Unit", of the type specified. Payment for inlets with extensions of the length shown on the plans and measured as prescribed above shall be made at the unit price bid for each "Inlet Extension".

(3) Manholes, Stage I. Payment for Manholes, Stage I in place in accordance with these specifications and measured as prescribed above will be made at the unit price bid for each "Manhole, Stage I", of the type specified.

(4) Manholes, Stage II. Payment for Manholes, Stage II in place in accordance with these specifications and measured as prescribed above will be made at the unit price bid for each "Manhole, Stage II", of the type specified.

(5) Inlets, Stage I. Payment for Inlets, Stage I in place in accordance with these specifications and measured as prescribed above will be made at the unit price bid for each "Inlet, Stage I", of the type specified.

(6) Inlets, Stage II. Payment for Inlets, Stage II in place in accordance with these specifications and measured as prescribed above will be made at the unit price bid for each "Inlet, Stage II", of the type specified.

Payments as provided under the methods above shall be full compensation for furnishing all concrete, reinforcing steel, brick, mortar and castings, for all other materials, tools, equipment and incidentals required to perform the applicable work prescribed above. Frames, grates, rings and covers will be paid for separately as required under the Item, "Frames, Grates, Rings and Covers".

ITEM 471

FRAMES, GRATES, RINGS AND COVERS

471.1. Description. This item shall govern for the furnishing and installation of frames, grates, rings and covers for inlets, manholes and other structures in accordance with the plans and specifications.

471.2. Materials. Welded steel grates and frames shall conform to the member size, dimensions and details shown on the plans and shall be welded into an assembly in accordance with those details. Steel shall conform to the requirements of ASTM Designation: A 36.

Castings, whether Carbon-Steel, Gray Cast Iron or Ductile Iron shall conform to the shape and dimensions shown on the plans and shall be clean substantial castings, free from sand or blow holes or other defects. Surfaces of the castings shall be free from burnt-on sand and shall be reasonably smooth. Runners, risers, fins, and other cast-on pieces shall be removed from the castings and such areas ground smooth. Bearing surfaces between manhole rings and covers or grates and frames shall be cast or machined with such precision that uniform bearing shall be provided throughout the perimeter area of contact. Pairs of machined castings shall be matchmarked to facilitate subsequent identification at installation.

Steel castings shall conform to the requirements of the specifications for "Mild to Medium Strength Carbon Steel Castings for General Application", ASTM Designation: A 27. Grade 70-36 shall be furnished unless otherwise specified.

Cast iron castings shall conform to the requirements of "Gray Iron Castings", ASTM Designation: A 48, Class 30.

Ductile iron castings shall conform to the requirements of "Ductile Iron Castings" ASTM Designation: A 536. Grade 60-40-18 shall be used unless otherwise specified.

471.3. Construction Methods. Frames, grates, rings and covers shall be constructed of the materials as specified and in accordance with the details shown on the plans and shall be placed carefully to the lines or grades indicated on the plans or as directed by the Engineer.

All welding shall conform to the requirements of the Item,"Structural Welding". Frames, grates, rings and covers shall be given one coat of a commercial grade red lead and oil paint and two coats of commercial grade aluminum paint. Painting of gray iron castings will not be required, except when used in conjunction with structural steel shapes.

Commercial grade galvanized bolts and nuts shall be used. The zinc coating shall be uniform in thickness, smooth and continuous.

471.4. Measurement. Frames, grates, rings and covers shall be measured by the unit of each "Grate", "Frame", "Grate and Frame", "Frame and Cover", or "Ring and Cover", complete in place.

471.5. Payment. Payment for frames, grates, rings and covers will be made at the unit price bid for each "Grate", "Frame", "Grate and Frame", "Frame and Cover", or "Ring and Cover" as the case may be, unless otherwise shown on the plans, which price shall be full compensation for furnishing all materials, tools, equipment, labor and incidentals necessary to complete the work.

ITEM 472

RELAYING CULVERT PIPE

472.1. Description. This item shall govern for the removal and reinstallation of existing culvert pipe or pipe sewer. Pipe in place and designated for use in new work, shall be removed from the existing locations,

transported to the new locations, cleaned, and installed as noted on the plans and in accordance with this specification, in such manner as to prevent damage to the pipe and fittings. Unless otherwise provided on the plans, any culvert pipe or fittings and concrete headwalls designated for reuse, damaged by the Contractor shall be replaced by the Contractor at his own expense and without additional compensation.

472.2. Construction Methods. The installation of all pipes shall conform to the requirements of the specification for the type or kind of pipe to be relaid. Connections shall be made to existing structures as called for on the plans, and when the connection is to an existing pipe of the same type as that to be relaid, the connection shall conform to the requirements for jointing sections of pipe as described in the pertinent pipe specifications. The connection between reinforced concrete pipe and corrugated metal pipe shall be made with a suitable concrete collar having a minimum thickness of 4 inches.

The top and bottom of reinforced concrete pipe shall be marked prior to being moved and when relaid shall be placed in the same position with reference to top and bottom as before it was removed.

When headwalls and aprons are specified on the plans for reuse, the portion to be reused shall be severed from the culvert and moved to the new position previously prepared by hoisting with a crane, rolling, or other approved methods. Connections shall conform to the requirements for joining sections of pipes as designated herein. Any portion of the headwalls and aprons damaged during the moving operations by the Contractor shall be restored to their original condition at his entire expense. The Contractor, if he so desires, may remove and dispose of the existing headwalls and construct new headwalls at his expense in accordance with the pertinent specifications and design indicated on the plans or as furnished by the Engineer.

472.3. Measurement. Relaid pipe shall be measured by the linear foot of complete and accepted pipe in place in accordance with these specifications. Such measurements shall be made between the ends of the pipe barrel along the central axis as installed. Where spurs or branches, or connections to existing pipe lines are involved, measurement of the spur or connecting pipe shall be made from the intersection at its central axis with the outside surface of the pipe into which it connects. Where inlets, catch basins, manholes, or other structures are included in lines of pipe, that length of pipe provided for tie into the structure wall shall be included for measurement but no other portion of the structure length or width shall be so included.

Excavation for taking up existing pipes for relaying or moving is considered incidental to the pay items involved and will not be measured for payment. Excavation in natural ground for installing culvert pipe or pipe sewer to be relaid will be measured as prescribed in the Item, "Structural Excavation", or the Item, "Excavation and Backfill for Sewers".

472.4. Payment. Payment for relaying culvert pipe measured as prescribed above will be made at the contract unit price bid for "Relaying Culvert Pipe 18 inch Diameter and Under", "Relaying Culvert Pipe Over 18

inch Diameter", or "Relaying Pipe Sewer", of the size specified, as the case may be, which payment shall be full compensation for excavating and removing the pipe from its original location; excavation, hauling and placing of select material where required for bedding pipe in rock excavation; the preparation and shaping of beds; hauling, placing and joining of pipe; for moving and reusing headwalls; for all connections to existing structures and for all other items of materials, labor, equipment, tools, and incidentals necessary to complete the work in accordance with the plans and these specifications, except excavation and backfill for relaying which will be paid for in accordance with the Item, "Structural Excavation", or the Item, "Excavation and Backfill for Sewers". Where pipes are laid on a skew, or where pipe ends are cut to fit the fill slopes, full compensation for cutting the ends parallel with the centerline of the highway, or to the fill slopes, shall be considered as included in the price paid per linear foot for the designated item of pipe relaid and no additional allowance will be made therefor.

ITEM 473

LAYING CULVERT PIPE

473.1. Description. This item shall govern for the installation of culvert pipe, furnished by the Department, at the locations and to the line and grades shown on the plans or as designated by the Engineer. Pipe furnished the Contractor may be salvaged or new pipe or a combination of both. Any pipe damaged by the Contractor shall be replaced at his own expense and without additional compensation.

473.2. Construction Methods. The installation of concrete pipe shall conform to the requirements of the Item, "Reinforced Concrete Pipe Culverts" and corrugated galvanized metal pipe shall be installed in accordance with the requirements of the Item, "Corrugated Galvanized Metal Pipe". Connections shall be made to existing structures as called for on the plans, and when the connection is to an existing pipe of the same type as that to be laid, the connection shall conform to the requirements for jointing sections of pipe as described in the pertinent pipe specifications. The connection between reinforced concrete pipe and corrugated metal pipe shall be made with a suitable concrete collar having a minimum thickness of 4 inches.

473.3. Measurement. Pipe laid under these specifications will be measured by the linear foot of complete and accepted pipe in place. Such measurement will be made between the ends of the pipe barrel along the central axis as installed. Where spurs or branches, or connections to existing pipe lines are involved, measurement of the spur or connecting pipe will be made from the intersection of its central axis with the inside surface of the pipe into which it connects. Where inlets, manholes, or other structures are included in lines of pipe, that length of pipe provided for tie into the structure wall will be included for measurement but no other portion of the structure length or width will be so included.

Excavation in natural ground for installing culvert pipe will be measured as prescribed in the Item, "Structural Excavation."

473.4. Payment. Payment for laying culvert pipe measured as prescribed above will be made at the contract unit price bid for "Laying Culvert Pipe", which payment shall be full compensation for excavating, hauling, and placing of select material where required for bedding pipe in rock excavation; the preparation and shaping of beds; hauling, placing and joining of pipe; for all connections to existing structures, cutting pipe to proper length, and for all other items of materials, labor, equipment, tools, and incidentals necessary to complete the work in accordance with the plans and these specifications, except excavation and backfill for laying which will be paid for in accordance with the Item, "Structural Excavation". Where pipes are laid on a skew, or where pipe ends are cut to fit the fill slopes, full compensation for cutting the ends parallel with the centerline of the highway, or to the fill slopes, shall be considered as included in the price paid per linear foot for the designated item of pipe laid and no additional allowance will be made therefor.

ITEM 476

JACKING, BORING OR TUNNELING PIPE

476.1. Description. This item shall govern for the furnishing and installation of pipe by the methods of jacking, boring or tunneling as shown on the plans and in conformity with this specification.

476.2. Materials. Pipe may be either corrugated galvanized metal pipe conforming to the Item, "Corrugated Galvanized Metal Pipe", or reinforced concrete pipe, conforming to the Item, "Reinforced Concrete Pipe Culverts", and of the size, type, and class specified on the plans, or other types as may be specified by the Engineer or designated on the plans.

476.3. Construction.

(1) Jacking. If the grade of the pipe at the jacking end is below the ground surface, suitable pits or trenches shall be excavated for the purpose of conducting the jacking operations and for placing end joints of the pipe. Wherever end trenches are cut in the sides of the embankment or beyond it, such work shall be sheeted securely and braced in a manner satisfactory to the Engineer to prevent earth caving.

Where pipe is required to be installed under railroad embankments or under highways, streets, or other facilities by jacking or boring methods, construction shall be made in such a manner that will not interfere with the operation of the railroad, street, highway, or other facility, and shall not weaken or damage any embankment or structure. During construction operations, barricades and lights to safeguard traffic and pedestrians shall be furnished and maintained, as directed by the Engineer, until such time as the backfill has been completed and then shall be removed from the site.

Heavy duty jacks suitable for forcing the pipe through the embankment shall be provided. In operating jacks, even pressure shall be applied to all jacks

used. A suitable jacking head, usually of timber, and suitable bracing between jacks and jacking head shall be provided so that pressure will be applied to the pipe uniformly around the ring of the pipe. A suitable jacking frame or back stop shall be provided. The pipe to be jacked shall be set on guides, properly braced together, to support the section of the pipe and to direct it in the proper line and grade. The whole jacking assembly shall be placed so as to line up with the direction and grade of the pipe. In general, embankment material shall be excavated just ahead of the pipe and material removed through the pipe, and the pipe forced through the embankment with jacks, into the space thus provided.

The Contractor shall furnish for the Engineer's approval, a plan showing his proposed method of handling, including the design for the jacking head, jacking support or back stop, arrangement and position of jacks, pipe guides, etc., complete in assembled position. The approval of this plan by the Engineer will not relieve the Contractor from his responsibility to obtain the specified results.

The excavation for the underside of the pipe, for at least one third of the circumference of the pipe, shall conform to the contour and grade of the pipe. A clearance of not more than 2 inches may be provided for the upper half of the pipe. This clearance is to be tapered off to zero at the point where the excavation conforms to the contour of the pipe.

The distance that the excavation shall extend beyond the end of the pipe depends on the character of the material, but it shall not exceed 2 feet in any case. This distance shall be decreased on instructions from the Engineer, if the character of the material being excavated makes it desirable to keep the advance excavation closer to the end of the pipe.

The pipe, preferably, shall be jacked from the low or downstream end. Lateral or vertical variation in the final position of the pipe from the line and grade established by the Engineer will be permitted only to the extent of 1 inch in 10 feet, provided that such variation shall be regular and only in one direction and that the final grade of flow line shall be in the direction indicated on the plans.

If the Contractor desires, he may use a cutting edge of steel plate around the head end of the pipe extending a short distance beyond the end of the pipe with inside angles or lugs to keep the cutting edge from slipping back onto pipe.

When jacking of pipe is once begun, the operation shall be carried on without interruption, insofar as practicable, to prevent the pipe from becoming firmly set in the embankment.

Any pipe damaged in jacking operations shall be removed and replaced by the Contractor at his entire expense.

The pits or trenches excavated to facilitate jacking operations shall be backfilled immediately after the jacking of the pipe has been completed.

(2) Boring. The boring shall proceed from a pit provided for the boring equipment and workmen. Excavation for pits and installation of shoring shall be as outlined above under "Jacking". The location of the pit shall meet the

approval of the Engineer. The holes are to be bored mechanically. The boring shall be done using a pilot hole. By this method an approximate 2 inch pilot hole shall be bored the entire length of the crossing and shall be checked for line and grade on the opposite end of the bore from the work pit. This pilot hole shall serve as the centerline of the larger diameter hole to be bored. Excavated material will be placed near the top of the working pit and disposed of as required. The use of water or other fluids in connection with the boring operation will be permitted only to the extent to lubricate cuttings. Jetting will not be permitted.

In unconsolidated soil formations, a gel-forming colloidal drilling fluid consisting of at least 10 percent of high grade carefully processed bentonite may be used to consolidate cuttings of the bit, seal the walls of the hole, and furnish lubrication for subsequent removal of cuttings and installation of the pipe immediately thereafter.

Allowable variation from line and grade shall be as specified under "Jacking". Overcutting in excess of one inch shall be remedied by pressure grouting the entire length of the installation.

(3) Tunneling. Where the characteristics of the soil, the size of the proposed pipe, or the use of monolithic sewer, would make the use of tunneling more satisfactory than jacking or boring, or where called for on the plans, a tunneling method may be used.

The excavation for pits and the installation of shoring shall be as outlined above under "Jacking".

The lining of the tunnel shall be of steel of sufficient strength to support the overburden. The Contractor shall submit his proposed liner method to the Engineer for approval. Approval by the Engineer shall not relieve the Contractor of the responsibility for the adequacy of the liner method.

The space between the liner plate and the limits of excavation shall be pressure-grouted or mud-jacked.

Access holes for placing concrete shall be spaced at maximum intervals of 10 feet.

(4) Joints. If corrugated galvanized metal pipe is used, joints may be made by field bolting or by connecting bands, whichever is feasible. If reinforced concrete pipe is used, the joints shall be mortared from the inside, after installation as specified in the Item, "Reinforced Concrete Pipe Culverts".

476.4. Measurement. Jacking, boring or tunneling pipe will be measured by the linear foot of pipe complete in place. Such measurement will be made between the ends of the pipe along the central axis as installed.

476.5. Payment. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit price bid per linear foot for "Jacking or Boring Pipe" or "Jacking, Boring or Tunneling Pipe" as the case may be, of the type, size, and class specified on the plans, which price shall be full compensation for furnishing all materials, pipe, liner materials required for tunnel operations,

for all preparation, hauling and installing of same, and for all labor, tools, equipment, and incidentals necessary to complete the work, including excavation, backfilling and disposal of surplus material.

ITEM 479

ADJUSTING MANHOLES AND INLETS

479.1. Description. This item shall govern for the furnishing of materials and for adjusting, abandoning or capping existing sewer manholes or inlets, where required by the plans. Manholes and inlets shall be adjusted to positions and/or elevations as shown on the plans or as ordered by the Engineer and in accordance with these specifications.

479.2. Materials. Manholes or inlet rings, plates, grates and covers, and brick in good condition, removed from the manholes and inlets in the process of abandonment, capping or adjustment, may be re-used. Additional materials required shall conform to the pertinent provisions for those materials of the Item, "Manholes and Inlets".

479.3. Construction. Manholes or inlet rings, covers, plates, and grates shall be removed carefully and the contact areas shall be cleaned of all mortar and grease. Rings, covers, plates, or grates broken in the process of removal and cleaning shall be replaced in kind by the Contractor at his expense.

If the adjustment involves lowering the top of a manhole or inlet, a sufficient depth of brick courses or concrete shall be removed to permit reconstruction on a batter not exceeding 1 inch horizontal to 2 inches vertical. In the case of brickwork, the mortar shall be cleaned from the top course of brick remaining in place and from all brick to be re-used and the manhole or inlet rebuilt to the original top dimensions. The manhole or inlet ring, cover, plate, or grate shall then be installed with top conforming to the proposed new surface of street or grading as the case may be.

If the adjustment involves raising the elevation of the top of manhole or inlet, the top course of brick shall be cleaned of mortar and built up vertically to the new elevation using new brick, brick salvaged from other manhole or inlet adjustments, or Class "A" Concrete, and the ring, cover, plate, or grate installed with top conforming to the proposed new surface of street or grading as the case may be.

If abandonment of an inlet or manhole is required, it shall be removed to an elevation a minimum of one foot below subgrade elevation or as otherwise indicated on the plans, and capped or backfilled from the flow line to subgrade with special sewer backfill as specified in the Item, "Excavation and Backfill for Sewers".

If capping of an inlet or manhole is required by the plans, the capping shall be in accordance with the details shown on the plans.

All workmanship and finish shall be in accordance with the applicable provisions of the Item, "Manholes and Inlets".

Excavation and backfill shall conform to the requirements of the Item, "Excavation and Backfill for Sewers".

479.4. Measurement. Manholes or inlets completely adjusted, abandoned, or capped as prescribed above, will be measured by the unit of each manhole or inlet adjusted. The excavation and backfill involved will not be measured for payment.

479.5. Payment. Each manhole or inlet adjusted, measured as prescribed above, complete in accordance with these specifications, will be paid for at the unit price bid for "Adjusting Manholes", "Adjusting Inlets", or "Adjusting Manholes and Inlets", as the case may be, which price shall be full compensation for furnishing all required materials, including backfill as required, excavation, tools, labor, equipment, and incidentals required to complete the work.

ITEM 490

TIMBER STRUCTURES

490.1. Description. This item shall govern for the construction of all culverts, bridges, bulkheads, retaining walls, piers, bents, fenders, or any portion thereof which involves the use of timber materials whether treated or untreated. This item shall not include temporary timber construction which is not a part of the finished work.

490.2. Materials. All materials used in the construction of timber structures shall conform to the requirements of the Item, "Timber for Structures", or other pertinent specifications.

490.3. Preservative Treatment. Lumber and piling for Timber Structures shall be "Treated" or "Untreated" as shown on the plans. "Treated" lumber and piling shall be impregnated with the quantity of preservative and in the manner and by one of the processes specified in the Item, "Timber Preservative and Treatment", unless otherwise specified on the plans.

490.4. Storage of Materials. Lumber and timber at the site of the work shall be stored in piles.

Untreated material shall be open-stacked at least 12 inches above the ground surface and arranged to shed water and prevent warping. It shall be protected from the weather by suitable covering.

Treated timber shall be close-stacked, and arranged to shed water and prevent warping. It shall be protected from weather and sun by a suitable covering.

The ground underneath and in the vicinity of all material piles shall be cleared of weeds and rubbish.

490.5. Handling. Timber shall be handled carefully without sudden dropping, breaking of outer fibers, or bruising. The surface of treated timbers shall not be penetrated with tools. Treated timbers shall be handled with rope slings or other approved methods. Use of cant dogs, hooks, or pike poles will not be permitted.

490.6. Workmanship. Workmanship shall be first class throughout. None but competent bridge carpenters shall be employed and all framing shall be true and exact. Nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for removal of the workman causing them.

All lumber and timber shall be accurately cut and framed to a close fit so that the joints will have even bearing over the entire contact surface. Mortises shall be true to size for their full depth and tenons shall make snug fit therein.

Countersinking shall be done wherever smooth faces are required.

490.7. Framed Bents. Mud sills of treated or untreated timber shall be of durable material as shown on the plans. They shall be bedded firmly and evenly to solid bearing and carefully tamped in place.

Concrete pedestals for the support of framed bents shall be finished carefully so that the sills or posts will take even bearing on them.

490.8. Sills. Sills shall have true and even bearing on piling or pedestals. When possible, all earth shall be removed from around sills so that there will be free air circulation around them.

490.9. Post Covers. The tops of posts in framed bents, if untreated material, shall be given a thick coat of red lead and oil, hot tar, hot asphaltum, or hot coal-tar and covered with a sheet of 20 gauge galvanized metal as indicated on the plans. The cover shall measure at least 6 inches more in each dimension than the diameter or side of the post. The edges shall be bent down over the post and fastened with largeheaded galvanized nails or secured by binding with galvanized wire as indicated on the plans.

For treated materials, the tops shall be saturated thoroughly with hot creosote oil. These shall be covered with a coat of hot tar pitch over which shall be placed a cover as specified for untreated material above.

490.10. Caps. Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piling and to secure an even alignment of their ends. All caps shall be secured to the posts or piling in accordance with the details shown on the plans. No shimming on tops of piling or posts will be permitted.

490.11. Bracing. Sway bracing shall be placed diagonally on bents and connected to the cap and all piling or posts as shown on the plans.

Sash bracing and longitudinal bracing shall be placed and fastened to the piling or posts as shown on the plans.

Bracing shall be fitted to the bents in a satisfactory manner without dapping or cutting the posts or piling.

490.12. Stringers. Stringers shall be sized to uniform depth at bearings and shall be placed in a position so that knots near the edges will be in the top portion of the stringers.

Stringers may have butt joints or lapped joints as shown on the plans.

The lapped ends of untreated stringers shall be separated at least one-half of an inch to permit the circulation of air. When stringers are two panels in length, adjacent stringers shall be lapped at alternate bents. All stringers shall be fastened securely by bolts where shown on plans.

490.13. Bridging. Cross bridging or diaphragms between stringers shall be framed neatly and accurately and securely toenailed with at least two nails in each end.

Treated bridging need not be framed before treating, but the framed ends shall be given two coats of hot creosote oil before placing.

490.14. Flooring. Plank for single plank floors shall be placed with the heart side down with one-fourth of an inch openings between them for seasoned materials and with tight joints for unseasoned material. Unless otherwise provided, each plank shall be spiked to each stringer or nailing strip with not less than two spikes, the length of which shall be at least 3 inches greater than the thickness of the plank. The ends of the plank shall be cut off on a straight line parallel with the center line of the roadway. The planks shall be selected carefully according to thickness and so laid that no two adjacent planks shall vary in thickness more than one-eighth of an inch.

Where double plank floors are indicated on the plans, the top course shall be laid diagonal or parallel to the center line of the roadway as shown and, unless otherwise provided, each plank shall be spiked to the lower course at intervals of not more than 2 feet with two spikes, the length of which shall be at least 3 inches greater than the thickness of the plank. Joints shall be staggered at least 3 feet. Where the planks are placed parallel to or diagonally with the center line of the roadway, special care shall be exercised to securely fasten the ends, and at the ends of the bridge, the ends of all planks shall be cut to a straight line parallel to the end of the bridge.

For laminated floors, the strips shall be placed on edge and at right angles to the center line of roadway. The strips shall be full length. Random lengths will not be permitted. Unless otherwise provided, each strip shall be spiked to the adjacent strip at intervals of 2 feet; the spikes being staggered 8 inches in adjacent strips. The spikes shall be of sufficient length to pass completely through two adjacent strips and approximately half way through the third strip. In addition, unless otherwise provided, the strips shall be toenailed to the stringer with spikes not less than 4 inches in length. The toenailing of successive strips shall be staggered so that the spacing of spikes along each stringer shall be not less than 6 inches. For strips 3 inches in thickness, spikes driven vertically through the strips and extending into the stringer not less than 3 inches may be substituted for toenailing, with the approval of the Engineer. Strips on steel stringers shall be secured to the stringers by one-eighth of an inch thick floor plates, slotted to fit the flange of the stringer and punched for two nails.

490.15. Wheel Guards. Wheel guards, as shown on the plans, shall be constructed on each side of the roadway.

490.16. Railings. Railings shall be constructed as shown on the plans. All connections shall be bolted wherever possible. Railings shall be so constructed

that no two butt joints occur on the same post.

490.17. Cutting, Framing Holes for Bolts, Dowels, Rods, and Lag Screws. All cutting, framing, and boring of treated timbers shall be done before treatment insofar as is practicable.

Holes for round drift bolts and dowels shall be bored with a bit one-sixteenth of an inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit of the same diameter as the bolt.

Holes for rods shall be bored with a bit one-sixteenth of an inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit no larger than the root of the thread and shall be one-half of an inch deeper than the penetration of the lag screws.

All cuts, and drilled holes, in treated piling or timbers and all abrasions, after having been trimmed carefully, shall receive treatment as specified under Article 492.5.

490.18. Hardware. Machine bolts, drift bolts, and dowels may be either wrought iron or medium steel; washers may be O-gee cast or malleable iron, or they may be cut from medium steel or wrought iron plate, as specified.

Machine bolts shall have square heads and nuts unless otherwise specified. Wire nails and spikes shall be of steel, of circular cross section without taper, with a head and point, and of good quality. Boat spikes shall be of steel or wrought iron with forged heads and wedge-shaped points.

Washers of the size and type specified shall be used at all points where bolt heads and nuts would otherwise come in contact with wood. Cast washers shall have a thickness equal to the diameter of the bolt and a diameter of four times the thickness. For plate washers, the thickness shall be equal to one-half the diameter of the bolt, and the sides of the square shall be equal to four times the diameter of the bolt.

All bolt threads shall be properly checked after the final adjustment of the nuts. All bolt stock projecting beyond one-fourth of an inch from the top of the nut shall be removed.

All hardware, including nails, except cast iron washers, shall be galvanized by the hot dip method in accordance with ASTM Designation: A 153.

490.19. Painting. After completion of the structure, all bolt heads, threads, nuts, washers, and exposed portions of bolts shall be given a thorough coating of hot asphalt.

Railings shall be painted as provided in the plans. The materials and application shall conform to the requirements of the Item, "Paint and Painting".

For untreated timber structures, the following surfaces shall be coated thoroughly with a thick coat of red lead and oil, hot tar, hot asphaltum, or hot coal-tar creosote before assembling: the ends, tops, and all contact surfaces of pile caps; floor beam and stringer ends; joints and all contact surfaces of truss members; and laterals and braces. The back face of bulkheads and all other timber in contact with earth shall be coated thoroughly with one of the materials specified above.

All bolts passing through non-resinous wood shall be painted with two coats of commercial grade red lead and oil.

490.20. Measurement and Payment. No direct compensation will be made for "Timber Structures". Measurement and payment for quantities of timber, piling, excavation, and other proposal items which constitute the completed and accepted structures will be made in accordance with the provisions of pertinent specifications.

ITEM 491

TIMBER FOR STRUCTURES

491.1. Description. This item shall govern for the materials for treated or untreated timber used in the construction of timber structures or portions of structures, as shown on the plans. This item shall not include temporary timber construction which is not a part of the finished work.

491.2. Materials. Unless specified on the plans, the material shall be either Southern Pine or Douglas Fir, of the grades shown below. (Timber Grade designations refer to standard designations of the Southern Pine Inspection Bureau and the West Coast Lumber Association.)

Group (1)

Stringers, Caps, Flooring, Posts, Railing, Wheel Guards and Fender Timbers

Species	Size of Member	Grade
Southern Pine	2" thickness	No. 1 Dense – 1850f
Southern Pine	2-1/2" and thicker	Dense Str. 72 – 1850f
Douglas Fir	2" to 4" thick	Select Str. – 1900f
Douglas Fir	5" and thicker	Select Str. – 1900f

Group (2)

Nailing Strips, Sway Bracing, Bulkhead Plank, Bridging, Edging Strips, Cleats and Blocks

Species	Size of Member	Grade
Southern Pine	2" thickness	No. 1 – 1600f
Southern Pine	2-1/2" and thicker	Dense Str. 65 – 1650f
Douglas Fir	2" to 4" thick	Dense Construction – 1750f
Douglas Fir	5" and thicker	Dense Construction – 1750f

The dressing of all timber shall be as indicated on plans or bills of material. Unless otherwise indicated, all strip flooring from 2 by 4 inches to 3 by 6 inches in size, shall be dressed S1S1E, full size, hit or miss. Under this requirement all pieces which are more than one-eighth inch in excess of full nominal width or thickness, or more than one-quarter inch scant of full nominal width or thickness at any point, will be rejected.

491.3. Grading Requirements. Methods of grading and general requirements shall be in accordance with the "General Requirements for Stress Grades" as set forth in ASTM Designation: D 245 except as otherwise provided herein. In addition the following specific requirements for the specified grades of timber shall govern:

GROUP (1) GRADES

Southern Pine – 2" Thickness, No. 1 Dense – 1850f

Must be dense grain and admits: Compression wood–prohibited if in readily identifiable and damaging form; Grain deviation–slope limited to one in 10. Firm red heart–not limited; Holes–occasional, limited to one-quarter inch through opening; Knots–sound, firm, encased and pitch knots but must be tight, and in the nominal rough size shall occupy not more than one-quarter cross section at edge of wide face, or one-third cross section along the centerline of wide face; decayed and hollow knots, but must be tight, and may occupy not more than one-sixth cross section at any point with hollow knots limited to one-quarter inch through opening; Manufacture–standard E manufacture except heavy raised grain allowed. Occasional full length hit or miss, on narrow surface limited to one-thirty-second of an inch scant width; Pitch, pitch pockets and pitch streaks–heavy pitch; large closed pitch pockets, large pitch streaks; Pitch–not limited; Shakes, checks and splits–check and medium shakes if penetrate not deeper than three-quarters of an inch, except through shakes, through checks and splits allowed if not longer than width of piece; Stain–medium; Wane–averaging one-quarter inch thickness by one-quarter length, but not to exceed either one-third width or one-third length, and to provide at least five-eighths inch nailing edge throughout length of both narrow faces; and, Warp–one-half medium.

Southern Pine – 2-1/2" and Thicker, Dense Structural 72 – 1850f

Slope of grain: not greater than 1" in 14"

Maximum permissible size of knots, shakes, checks and splits, and wane:

SIZE OF KNOTS
FULL LENGTH OF PIECE

Nominal Width Of Face	On Narrow Face	At Edge Of Wide Face	Along Center Line Of Wide Face	Shakes And Checks	Wane At Any Point On Any Face
2"	1/2"*	1/4"	1/4"	1/2"	5/32"
3"	3/4"*	1/2"	1/2"	1"	1/4"
4"	1-1/8"	5/8"	1-1/8"	1-1/4"	11/32"
5"	1-3/8"	3/4"	1-3/8"	1-5/8"	13/32"
6"	1-5/8"	15/16"	1-5/8"	1-7/8"	1/2"
8"	2"	1-1/4"	2-1/4"	2-1/2"	5/8"
10"	2-1/4"	1-1/2"	2-3/4"	3"	13/16"
12"	2-3/8"	1-7/8"	3-3/8"	3-3/4"	1"
14"	2-5/8"	2"	3-5/8"	4-1/2"	1-3/16"
16"	2-3/4"	2-1/8"	3-7/8"	5"	1-3/8"
18"	3"	2-1/4"	4"	5-1/2"	1-1/2"
20"	3-1/4"	2-3/8"	4-1/4"	6"	1-5/8"

Douglas Fir – 2" to 4" Thick Select Structural – 1900f

Characteristics and limiting provisions are: Stained sapwood; Very short splits; Seasoning checks–single or opposite each other with a sum total equal to approximately one-fourth the thickness; Medium torn grain; Close grain; Slope of grain in middle one-third of length not to exceed one in 12, balance of piece may be one in 10; Pitch streaks; Occasional small skips; Medium pitch pockets; and, Wane approximately one-eighth of any face.

Knots, sound, tight and well spaced, may be present in the following approximate sizes.

ON NARROW FACES:

Face Width	In Middle 1/3 Of Length	At Ends
2"	5/8"	3/4"
3"	3/4"	1-1/4"
4"	1"	1-3/4"

The size of knots on a narrow face may increase proportionately from the limited size shown from the middle one-third of the length of the piece to the size shown at the ends.

ON WIDE FACES:

Face Width	At Edges In Middle 1/3 Of Length	Elsewhere* On Wide Face
4"	3/4"	1-3/8"
6"	1-1/8"	1-5/8"
8"	1-1/2"	2"
10"	1-7/8"	2-3/8"
12"	2-1/4"	2-3/4"
14" and wider	2-1/2"	3"

*On the edges of the wide face immediately outside the middle one-third of the length, knot sizes may be increased proportionately for a distance equal to one-half of the remaining length, to the size permitted elsewhere on the face. The remaining portion of the length may contain knots equal to the largest knot permitted elsewhere. Knots away from edges outside of the critical areas may be of the largest size permitted.

Spike knots are permitted if judged to have no more effect than other knots.

Holes from any cause have no more effect than knots, but for the sake of appearance are limited to one-half inch in 6 inch widths and three-fourths inch in 8 inch and wider widths. Two holes or unsound or not firmly fixed knots of the same size, or their equivalent, are permitted to 12 foot pieces. Also, proportionately fewer or more are permitted in shorter or longer lengths.

Larger knots could be permitted in this grade without reducing the strength, but are excluded to improve appearance.

Douglas Fir — 5" and Thicker Select Structural — 1900f

Characteristics and limiting provisions are: Stained sapwood; Splits approximately one-half of the width; Seasoning checks—single or opposite each other with a sum total equal to approximately one-fourth the thickness; Heavy torn grain; Pitch streaks; Close grain; Slope of grain in middle one-third of length not to exceed one in 15, balance of piece may be one in 12; Occasional skips one-sixteenth inch by 2 feet; Medium pitch pockets; Wane approximately one-eighth of any face; and, Shake approximately one-sixth the thickness.

Knots, sound, tight and well spaced, may be present in the following approximate sizes:

Size of Piece	On narrow face and edge of wide face in middle 1/3 of length (A)	On narrow face and edge of wide face at end of piece (B)	At center line of wide face (C)
5"x8"	1-1/4"	2"	2"
10"	1-1/4"	2-1/2"	2-1/2"
12"	1-1/4"	2-1/2"	3"
14" and wider	1-1/4"	2-1/2"	3-1/4"
6"x10"	1-1/2"	2-1/2"	2-1/2"
12"	1-1/2"	3"	3"
14" and wider	1-1/2"	3-1/4"	3-1/4"
8"x12"	1-3/4"	3"	3"
14" and wider	1-3/4"	3-1/4"	3-1/4"
10"x14" and wider	2"	3-1/4"	3-1/4"
12"x16" and wider	2-1/4"	3-1/2"	3-1/2"
14" and up x 18" and up	2-1/4"	3-1/2"	3-1/2"

The size of knots permitted on the narrow face and at the edge of the wide face are the same. These sizes may increase proportionately from that permitted in the middle one-third of the length to that permitted at the ends.

GROUP (2) GRADES

Southern Pine — 2" Thickness No. 1 — 1600f

Must be medium grain and admits: Compression wood—prohibited if in readily identifiable and damaging form; Grain deviation—slope limited to one to 10; Firm red heart—not limited; Holes—occasional, limited to one-fourth inch through opening; Knots—sound, firm, encased and pitch knots but must be tight, and in the nominal rough size shall occupy not more than one-fourth cross section at edge of wide face, or one-third cross section along the centerline of wide face; decayed and hollow knots, but must be tight, and may occupy not more than one-sixth cross section at any point with hollow knots limited to one-fourth inch through opening; Manufacture—standard E manufacture except heavy raised grain allowed, and occasional full length H or M on narrow surface limited to one-thirty-second inch scant width; Pitch, pitch pockets and pitch streaks—heavy pitch; large closed pitch pockets, large pitch streaks; Pitch—not limited; Shakes, checks and splits—checks and medium shakes if penetrate not deeper than three-fourths inch, except

through shakes, through checks and splits allowed if not longer than width of piece; Stain—medium; Wane—averaging one-fourth thickness by one-fourth length, but not to exceed either one-third width or one-third length, and to provide at least five-eighths inch nailing edge throughout length of both narrow faces; and Warp—one-half medium.

Southern Pine – 2-1/2" and Thicker Dense Structural 65 – 1650f

Slope of grain: not greater than 1" in 12"
Maximum permissible size of knots, shakes, checks and splits, and wane:

SIZE OF KNOTS
FULL LENGTH OF PIECE:

Nominal Width Of Face	On Narrow Face	At Edge Of Wide Face	Along Center Line Of Wide Face	Shakes And Checks	Wane At Any Point On Any Face
2"	5/8"*	5/16"	5/16"	5/8"	1/4"
3"	15/16"*	5/8"	5/8"	1-1/4"	3/8"
4"	1-3/8"	13/16"	1-3/8"	1-5/8"	1/2"
5"	1-3/4"	1"	1-3/4"	2"	5/8"
6"	2"	1-1/8"	2-1/8"	2-3/8"	3/4"
8"	2-1/2"	1-1/2"	2-3/4"	3-1/8"	1"
10"	2-3/4"	2"	3-1/2"	4"	1-1/4"
12"	3"	2-3/8"	4-1/4"	4-3/4"	1-1/2"
14"	3-1/4"	2-1/2"	4-5/8"	5-1/2"	1-3/4"
16"	3-1/2"	2-3/4"	4-7/8"	6-1/4"	2"
18"	3-3/4"	2-7/8"	5"	7"	2-1/4"
20"	4"	3"	5-1/2"	7-3/4"	2-1/2"

Douglas Fir – 2" to 4" Thick Dense Construction – 1750f

Must be dense grain.

Characteristics and limiting provisions are: Stained sapwood; Stained heartwood in 25 percent of area; Short splits; Seasoning check-single or opposite each other with a sum total equal to approximately one-fourth the thickness; Pin holes, limited; Medium torn grain; Slope of grain in middle one-third of length not to exceed one in 10, balance of piece may be one in 8; Pitch streaks; Occasional skips one-sixteenth inch deep, approximately two feet in length; Medium pitch pockets; and, Wane approximately one-fourth of any face.

Knots, sound, tight and well spaced, may be present in the following approximate sizes:

ON NARROW FACES:

Face Width	In Middle 1/3 Of Length	At Ends
2"	7/8"	1-1/8"
3"	1-1/4"	1-1/2"
4"	1-1/2"	2"

The sizes of knots on a narrow face may increase proportionately from the limited size shown for the middle one-third of the length of the piece to the size shown at the ends.

ON WIDE FACES:

Face Width	At Edges In Middle 1/3 Of Length	Elsewhere* On Wide Face
6"	1-1/2"	2-1/4"
8"	2"	2-3/4"
10"	2-1/2"	3-1/4"
12"	3"	3-3/4"
14" and wider	3-1/4"	4"

*On the edges of the wide face immediately outside the middle one-third of the length, knot sizes may be increased proportionately for a distance equal to one-half of the remaining length, to the size permitted elsewhere on the face. The remaining portion of the length may contain knots equal to the largest knot permitted elsewhere. Knots away from edges outside of the critical areas may be of the largest size permitted.

Spike knots are permitted if judged to have no more effect than other knots.

Knots which are unsound or not firmly fixed may be two-thirds the size of allowable tight knots.

Holes from any cause have no more effect than knots, but for the sake of appearance are limited to approximately three-fourth inch in 6 inch widths, one inch in 8 inch and wider widths and to two or their equivalent in each 12 feet of length.

Larger knots could be permitted in this grade without reducing the strength, but are excluded to improve appearance.

All or nearly all of the permissible characteristics of the grade are never present in maximum size or number in any one piece. Any piece with an unusual combination of characteristics which seriously affects normal serviceability is excluded from the grade.

Douglas Fir – 5" and Thicker Dense Construction – 1750f

Must be dense grain.

Characteristics and limiting provisions are: Stained sapwood; Stained heartwood in 25 percent of the piece; Splits approximately equal to the width; Seasoning checks–single or opposite each other with a sum total equal to approximately one-fourth the thickness; Heavy torn grain, Slope of grain in middle of one-third of length not to exceed one in 10, balance of piece may be one in 8; Pitch streaks; Occasional skips one-sixteenth inch by 2 feet; Medium pitch pockets; Wane approximately one-fourth of any face, and Shake approximately one-sixth the thickness.

Knots, sound, tight and well spaced, may be present in the following approximate sizes:

Size of Piece	On narrow face and edge of wide face in middle 1/3 of length (A)	On narrow face and edge of wide face at end of piece (B)	At center line of wide face (C)
5"x8"	2"	3"	3"
10"	2"	3-3/4"	3-3/4"
12"	2"	3-3/4"	4-1/2"
14" and wider	2"	3-3/4"	4-3/4"
6"x10"	2-1/4"	3-3/4"	3-3/4"
12"	2-1/4"	4-1/2"	4-1/2"
14" and wider	2-1/4"	4-1/2"	4-3/4"
8"x12"	2-1/2"	4-1/2"	4-1/2"
14" and wider	2-1/2"	4-3/4"	4-3/4"
10"x14" and wider	2-3/4"	4-3/4"	4-3/4"
12"x16" and wider	3-1/4"	4-3/4"	4-3/4"
14" and up x 18" and up	3-1/2"	4-3/4"	4-3/4"

The size of knots permitted on the narrow face and at the edge of the wide face are the same. These sizes may increase proportionately from that permitted in the middle one-third of the length to that permitted at the ends.

491.4. Treated Timber. Treated timber shall be impregnated with the kind and amount of preservative specified, and by the process designated in the Item, "Timber Preservative and Treatment".

491.5. Workmanship. Timber structures, whether treated or untreated, shall be constructed in accordance with the requirements of the Item, "Timber Structures".

491.6. Timber for Sign Posts. Lumber for sign posts shall be Southern Pine, number 1 small timbers, medium grain, air-dried, or kiln-dried before treatment. Compression wood is prohibited on any face. Such wood will be permitted if wholly enclosed in the piece, not less than six annual rings from the surface, and not over one-fourth inch wide in its maximum dimension. Sign posts shall have a preservative treatment as specified on the plans in accordance with the Item, "Timber Preservative and Treatment".

491.7. Measurement. The quantities of timber of the various classifications used in the completion of the structure in accordance with the plans and specifications, shall be computed in feet board measure on nominal sizes and the shortest commercial lengths practicable of use. The measurement shall not include timber used for erection purposes such as form, falsework and/or temporary bracing.

491.8. Payment. The timber quantities as measured above shall be paid for at the unit price bid per thousand feet board measure, (MFBM) for "Treated Timber" or "Untreated Timber", as the case may be, which prices shall be full compensation for all materials, hardware, equipment, tools, labor, painting, preservative treatment and incidentals necessary to complete the work.

The payment provided herein shall not be interpreted to include payment for timber piling, bituminous or concrete wearing surfaces, or other portions of the completed structures for which payment is provided elsewhere in the contract.

ITEM 492

TIMBER PRESERVATIVE AND TREATMENT

492.1. Description. This item shall govern for the preservative, and for the seasoning, preparation and treatment of piles, posts, timbers, lumber and service poles when treatment is specified on the plans or called for in the specifications. Unless otherwise specified on the plans, the preservative and retention shall be as shown in Table 1 of this item.

Product	Creosote (AWPA P1) Lbs. Per Cu. Ft.	Creosote-Coal Tar Solution (AWPA P12) Lbs. Per Cu. Ft.	Pentachlorophenol (AWPA P8 & P9) Lbs. Per Cu. Ft.	(1) ACA CCA – Type A CCA – Type B CCA – Type C (AWPA P5) Lbs. Per Cu. Ft.	Treating Specification (AWPA Standard Specification Number)
TIMBER PILING					C3
For Land or Fresh Water Use (Including Foundation Piles)					
Southern Pine	12 by Assay (0 to 3.0" zone)		0.6 Dry Penta By Assay (0 to 3.0" zone)		
Douglas Fir	17 by Assay (0 to 1.0" zone)		0.85 Dry Penta By Assay (0 to 1.0" zone)		
For Use in Coastal Waters					
Southern Pine		20 By Assay (0 to 3.0" zone)			
West Coast Douglas Fir		15 By Assay (0 to 2.0" zone)			
GUARD FENCE POSTS-ROUND					C5
Southern Pine	8 by Assay (0.5 to 2.0" zone)		0.4 Dry Penta By Assay (0.5 to 2.0" zone)	0.4 by Assay (0.5 to 2.0" zone)	
POSTS FOR WIRE FENCE-ROUND					C5
Southern Pine	8 by Assay (0 to 1.0" zone)		0.4 Dry Penta By Assay (0 to 1.0" zone)	0.4 by Assay (0 to 1.0" zone)	
TIMBER DELINEATOR POSTS-ROUND					C5
Southern Pine	8 by Assay (0 to 1.0" zone)		0.4 Dry Penta By Assay (0 to 1.0" zone)	0.4 by Assay (0 to 1.0" zone)	
TIMBER FOR SIGN POSTS					C5
	8		0.4	0.4	
BRIDGE TIMBERS & FENDER TIMBERS					C2
Southern Pine	12		0.6	0.4	
Douglas Fir	8		0.4	0.4	
LUMBER OTHER THAN BRIDGE TIMBERS & FENDER TIMBERS					C2
Southern Pine	8		0.4	0.4	
Douglas Fir	8		0.4	0.4	
SERVICE POLES					C4
Southern Pine	8 by Gauge or weight		0.4 by Gauge or weight	0.6 by Gauge or weight	

Note: (1) ACA: Ammoniacal Copper Arsenite.
CCA: Chromated Copper Arsenate

TABLE 1

MINIMUM NET RETENTION OF PRESERVATIVE

492.2. Materials. Except as otherwise provided herein, American Wood-Preservers' Association (AWPA) Standard Specification shall govern for materials and methods of treatment, including seasoning, incising, preservatives, treatment and inspection for treatment. Pretreated stock will not be accepted by the Inspector except in emergencies. In such case, special permission must be obtained from the Engineer.

492.3. Storage. Timber Posts for Guard Fence, Timber Delineator Posts, and Timber Milepost Marker Posts stored or otherwise not installed for a period longer than six months following initial treatment shall be reinspected prior to use in a highway project. Such reinspection will be at no cost to the State.

492.4. Paintability. All guard posts and sign posts shall be steam cleaned after treatment to assure paintability. Timber other than guard posts and sign posts shall be cleaned for paintability when so required by the plans.

492.5. Treatment of Cuts. When it is necessary to bore holes or to cut pressure treated materials after treatment, or when any treated surface is badly scarred, the hole, cut or scarred surface shall be given a multi-application of a concentrated solution of the same type preservative as that used in the original treatment, as specified in AWPA Standard M4. The supplier of the timber products shall furnish suitable liquid preservative for field treatment upon request from the Engineer. Heating of the preservative and method of application to the damaged or cut areas shall be as specified in AWPA Standard M4.

492.6. Inspection. Inspectors representing the Department shall have access to all parts and facilities of plants used in the conditioning and treating of forest products. The supplier shall provide the necessary assistance for the proper inspection of the materials being furnished.

492.7. Identification. Each piece or bundle of treated timber products shall bear a legible brand mark or tag indicating the name of the treater, date of treatment and the specification symbol to which the treatment conforms.

492.8. Measurement and Payment. Payment for all work prescribed herein will be included in the unit prices bid for "Timber for Structures", "Timber Piling", "Timber Post Guard Fence", or other Timber Products, as the case may be.

ITEM 496

REMOVING OLD STRUCTURES

496.1. Description. This item shall provide for the removal and disposal of old structures or portions of old structures, as noted on the plans, and shall include all excavation and backfilling necessary to complete the removal. The work shall be done in accordance with the provisions of these specifications.

496.2. Method of Removal.

Culverts or Sewers. Pipe shall be removed by careful excavation of all

dirt on top and the sides in such manner that the pipe will not be damaged. Removal of sewer appurtenances shall be included for removal with the pipe. Those pipe which are deemed unsatisfactory for reuse by the Engineer may be removed in any manner the Contractor may select.

Concrete Structures. Concrete structures or concrete portions of structures shall be removed by blasting and/or sledging the concrete into sizes not larger than one cubic foot.

When an existing concrete structure is to remain in use, the removal of any portions thereof shall be in accordance with Article 430.3.

Concrete portions of structures below the permanent ground line, which will not interfere in any manner with the proposed construction, may be left in place, but removal shall be carried at least 2 feet below the permanent ground line and neatly squared off. Reinforcement shall be cut off close to the concrete.

Steel Structures. Steel structures or steel portions of structures shall be dismantled in sections as determined by the Engineer. The sections shall be of such weight and dimensions as will permit convenient handling, hauling, and storing. Rivets and bolts connecting steel railing members, steel beams of beam spans and steel stringers of truss spans shall be removed by cutting the heads with a "cold cut" and punching or drilling from the hole, or by such other method as will not injure the members for re-use and will meet the approval of the Engineer. The removal of rivets and bolts from connections of truss members, bracing members, and other similar members in the structure will not be required unless specifically called for on the plans or special provisions and the Contractor shall have the option of dismantling these members by flame-cutting the members immediately adjacent to the connections. Flame-cutting will not be permitted, however, when plans or special provisions call for the structure unit to be salvaged in such manner as to permit re-erection. In such case, all members shall be carefully matchmarked with paint in accordance with diagram furnished by the Engineer prior to dismantling, and all rivets and bolts shall be removed from the connections in the manner specified in the first portion of this paragraph.

Timber Structures. Timber structures or timber portions of structures shall be removed in such manner as to damage the timber for further use as little as possible. All bolts and nails shall be removed from such lumber as deemed salvable by the Engineer.

Unless otherwise specified on the plans, timber piles shall be either pulled or cut off at a point not less than 2 feet below ground line, with the choice between these two methods resting with the Contractor.

Brick or Stone Structures. Brick or stone structures or stone portions of structures shall be removed by blasting and/or sledging the masonry into sizes not larger than one cubic foot.

Portions of such structures below the permanent ground line, which will not in any manner interfere with the proposed construction, may be left in place, but removal shall be carried at least 2 feet below the permanent ground line and neatly squared off.

Salvage. All material such as pipe, timbers, railings, etc., which the Engineer deems as salvable for reuse, and all structural steel shall be carefully placed in neat piles along the right of way at convenient loading points which will not interfere with traffic or construction. All of these materials shall be the property of the Texas Highway Department.

The I–beams, stringers, etc., which are specified to be dismantled without damage for reuse, and all steel members when matchmarked and dismantled for reuse, shall be blocked off the ground in an upright position to protect the members against further damage.

Materials, other than structural steel, which are not deemed salvable by the Engineer, shall become the property of the Contractor and shall be removed to suitable disposal sites off of the right of way arranged for by the Contractor, or otherwise disposed of in a manner satisfactory to the Engineer.

Where temporary structures are necessary for a detour adjacent to the present structure, the Contractor will be permitted to use the material in the old structure for the detour structure, but he shall dismantle and stack or dispose of the material as required above as soon as the new structure is opened for traffic.

The bidder's attention is called to Article 7.9 regarding responsibility in the use of explosives.

Backfill. All excavation made in connection with this item and all openings below the natural ground line caused by the removal of old structures or portions thereof shall be backfilled to the level of the original ground line, unless otherwise provided on the plans.

That portion of the backfill which will support any portion of the roadbed or embankment shall be placed in layers of the same depth as those required for placing embankment. Material in each layer shall be wetted uniformly if required and shall be compacted to the density required in the adjoining embankment. In places inaccessible to blading and rolling equipment, mechanical or hand tamps or rammers shall be used to obtain the required compaction.

That portion of the backfill which will not support any portion of the roadbed or embankment shall be placed as directed by the Engineer in such manner and to such state of compaction as will preclude objectionable amounts of settlement.

496.3. Measurement. The work as provided for by this item shall be measured as each individual structure to be removed, except that pipe sewers may be measured as each structure, or may be measured by the linear foot. When measured by either method, removal shall include all appurtenances thereto.

496.4. Payment. The work as prescribed for in this item shall be paid for at the unit price bid each for "Removing Old Structures, Large", "Removing Old Structures, Small", or "Removing Old Structures (Pipe)", per linear foot, which price shall be full compensation for all work, labor, tools, equipment, excavation, backfilling, materials, and incidentals necessary to complete the work.

ITEM 498

PLANT INSPECTION LABORATORY
(Equipped)

498.1. Description. This item shall govern for the furnishing of an inspection laboratory. A commercial fabricating plant from which the Contractor proposes to obtain prestressed concrete products, and any job site prestressing plant (pretensioning or post-tensioning), shall provide an inspection laboratory, available for the use of the State, equipped as specified herein.

498.2. General Requirements. The laboratory shall be provided prior to beginning the casting of any prestressed concrete units required by the contract.

The building and equipment shall be maintained so that it will continue to function properly for its intended use.

Department personnel and the Contractor's personnel shall not be housed in the same office or laboratory space.

498.3. Laboratory Building.

(1) Commercial Fabricating Plants. The building furnished shall be approved by the Engineer. It shall be partitioned to provide a separate laboratory and office. Laboratory and office space for plant operations requiring two inspection personnel shall be not less than 400 square feet. For operations requiring three or more inspection personnel, the laboratory and office space shall be not less than 600 square feet. The building shall be water tight, adequately lighted, heated and ventilated with restroom facilities incorporated. Curing, capping and testing facilities for concrete cylinders may be housed in the same building but partitioned off from the laboratory and office space, or contained in space convenient to the office and laboratory. If curing, capping and testing facilities are housed in the same building the space required for these facilities will be in addition to the above requirements for laboratory and office space. The building shall be situated to give visibility to plant operations unless otherwise approved by the Engineer.

(2) Job Site Plant. A laboratory building shall be furnished for inspection of prestressing operations. The building shall be a Type C structure as described in the Item, "Structure for Field Office and Laboratory", and shall be approved by the Engineer. It shall be water tight; well lighted, heated and ventilated; equipped with restroom facilities, and situated so the plant operations are visible therefrom, unless otherwise approved by the Engineer.

498.4. Equipment.

(1) Commercial Fabricating Plants. Equipment furnished shall be as follows:

(a) A sink with running water and adequate work tables.

(b) A compression machine for new installations or replacement, shall be in accordance with ASTM Designation: C39.

(c) A scale or balance as required by Test Method Tex-401-A.

(d) For moisture and specific gravity determination, a gas pressure moisture content tester, a supply of 1 and 2 quart glass jars, pycnometer tops, wide spout funnel and siphon bulb.

(e) A complete set of sieves as required by Test Method Tex-401-A.

(f) A mechanical sieve shaker.

(g) A thermostatically controlled electric or gas oven capable of maintaining a temperature of 230 F ± 9 F at loaded capacity.

(h) A minimum of 12 permanent cylinder molds for each line to be produced for each day's run. Molds shall be 6 inches by 12 inches, made of cast iron, sheet iron, or tubing, a minimum of one-fourth of an inch thick, and equipped with quick acting clamps, or heavy thumb screws, for assembling and disassembling. Steel base plates shall be provided with means for securing to the mold. Either glass or steel top plates will be required. The assembled mold and base plate shall be mortar tight. The molds shall not vary from the prescribed diameter by more than 1/16 inch nor from the prescribed height by more than 1/4 inch.

(i) One small shovel and trowel for making concrete cylinders.

(j) Six round aggregate pans.

(k) Capping equipment meeting the requirements of ASTM Designation: C617.

(l) A thermostatically controlled curing tank, capable of maintaining water temperature between 70 F and 90 F, and large enough to accommodate a minimum of six cylinders for each placement for at least 14 days of consecutive run.

In lieu of a curing tank, a moist cabinet and/or room meeting the requirements of ASTM Designation: C511.

(m) Equipment as required by Test Method Tex-404-A for running unit weight.

(n) A slump mold and tamping rod as required by Test Method Tex-415-A.

(o) All of the equipment required for performing the sand equivalent test in Test Method Tex-203-F.

(p) If elevated temperature curing is used, one remote reading thermometer and one recording thermometer will be required for each 100-foot length of casting bed in simultaneous use. At least one standby thermometer of each type will be required for emergency use. The same equipment shall be used from November 1 thru March 31 for any kind of curing method.

(2) **Job Site Operations.** Equipment items, (a), (b), (h), (k), (l), and (p), as required above for Commercial Fabricating Plants shall be furnished by the

Contractor. Other items required shall be furnished by the State. In lieu of providing a compression testing machine as described above, the Contractor may provide, at his expense, to have test cylinders tested by an approved Commerical Laboratory. Moisture content of the aggregate may be determined by the pycnometer method.

(3) General. All equipment furnished shall be subject to the approval of the Engineer. In lieu of the above and with written permission of the Engineer, the Contractor may provide other suitable equipment and/or facilities for testing.

All equipment shall be calibrated properly and housed in a weatherproof enclosure. Recalibrations of any equipment furnished by the Contractor shall be done when directed by the Engineer at the expense of the Contractor.

498.5. Measurement and Payment. No payment will be made to the Contractor for the work, materials or equipment involved in providing the "Plant Inspection Laboratory (Equipped)" for Central Fabricating Plants or for Job Site Operations, but will be considered subsidiary to the various bid items in the contract.

PART II, CONSTRUCTION DETAILS

DIVISION V,
INCIDENTAL CONSTRUCTION

ITEM 500

WEIGHIN G AND MEASURING EQUIPMENT

500.1. Description. "Weighing and Measuring Equipment" shall govern for the weighing and measuring equipment utilized where materials are specified to be measured or proportioned by weight or volume.

500.2. General Requirements. All scales and scale installations shall meet the requirements of the latest revision of the National Bureau of Standards Handbook 44 (published by the U.S. Department of Commerce and available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402) except that accuracy to within 0.4 percent of the load being weighed will be satisfactory. The Contractor shall provide personnel, facilities and equipment for checking the scales to the satisfaction of the Engineer.

All scales shall be checked prior to beginning of operations, after each move and at such other times when in the opinion of the Engineer there is a question as to their accuracy or adequacy. Plant operations shall cease during the checking operation and when inaccuracy or inadequacy is discovered and will not be resumed until corrective measures have been completed and/or scales certified as provided by this item.

For use of State inspection forces in checking the scales during operation, the Contractor shall furnish four 50-pound weights. In addition the Contractor shall furnish four 5-pound weights and four 2-pound weights to be used in checking cement, asphalt and small platform scales. All weights shall be checked and certified by the Texas Department of Agriculture, Weights and Measures Section as meeting the Maintenance Tolerances for Avoirdupois Weights specified in Handbook 44. All scales shall be satisfactorily insulated against shock, vibrations or movement of other operating equipment in the plant.

In lieu of the above specified weights for checking the scales, the Contractor may furnish a letter from a recognized commercial scale company, certifying that the scales meet the requirements of this Item. This certification will be required at least once each six (6) months.

The weighing containers shall be sufficiently tight to prevent leakage of the contents and shall be of sufficient capacity to hold a complete batch without wasting or leveling by hand and shall be so designed that the entire batch will discharge quickly into the mixer. The weighing containers shall be so constructed that if in charging, an excess is introduced into the weighing containers, it may be removed by the operator. The weighing containers shall be provided with a close fitting and quick operating cut-off gate, so that there

will be no leakage of the contents into the mixer, and shall be satisfactorily attached to the batching scales.

500.3. Equipment.

(1) Truck Scales. Truck scales shall consist of a set of standard platform truck scales capable of weighing the load as a single draft; that is, the total weight of the truck or truck-trailer combination shall not be determined by adding together the weights obtained by separately weighing each end of such truck or by weighing individual elements of such truck or coupled combination. The Contractor shall provide a weather-tight building of sufficient size to house the Contractor's weigher and the State's checker.

(2) Aggregate Batching Scales. The scales used for weighing aggregate shall be equipped with a quick adjustment at zero to provide for any change in tare. The scales shall be provided with pointers or "tell-tale" indicators of the springless dial type to indicate full load for each aggregate. The dial or "tell-tale" device shall be in full view of operator while charging the weigh box and he shall have convenient access to all controls.

(3) Portable Platform Scales. Portable platform scales shall conform to the general requirements of this specification, except that they will not be required to be checked after each move or set-up within a given project, unless directed by the Engineer.

Type A. This type shall consist of a portable platform scale having a container fastened securely to the platform.

The capacity of this type of scale shall be not less than 500 pounds. The weighing capacity may be obtained by means of a weigh beam and loose weights.

When this type of scale is used, the Contractor shall provide a container of approximately the same size as the platform for weighing the aggregate, or he may provide an elevated hopper, the base of which is approximately the size of the platform from which the aggregates may be discharged.

If the hopper is provided, it shall be of such design that the aggregates will be completely and quickly discharged and shall be of such construction that the position of the aggregates while being weighed will not affect the accuracy of the weights.

The Contractor will not be permitted to increase the size of the original platform by constructing another platform on top of the original unless provision is made to set the tare weight of the container or hopper separately from the batch weight. Separate scales for fine and coarse aggregate will be required.

Type B. This type shall consist of a portable platform scale having a platform sufficiently large to permit the weighing of loaded wheelbarrows or carts.

The capacity of this type of scale shall be not less than 800 pounds. The weighing capacity may be obtained by means of a weigh beam and loose

weights. The scale shall preferably be equipped with a double weigh beam, in order that the tare weight of the wheelbarrow or other vehicle for transporting the aggregates may be set off on the weigh beam separately from the batch weights. When the scale is equipped with a single beam or a single beam and a tare beam, separate scales shall be provided for fine and coarse aggregates.

When this type of equipment is designed to weigh more than one kind of material on the same scale, it shall be equipped with separate charging beams and a tare beam. Each charging beam shall be equipped with a release lever to throw the beam in and out of service. This type of scale may also be equipped with a "tell-tale" dial meeting the requirements of these specifications.

(4) Suspended Hopper. This type shall consist of a weighing container or hopper completely suspended from the scale equipment. Suitable provisions shall be made for leveling the scale equipment.

The appliances used for placing materials within or upon the weighing equipment shall so regulate and control the quantity supply that accurate adjustment to the weights required can be secured with little expenditure of time and labor. A convenient means shall be provided for the addition or the removal of small amounts of material to adjust the quantity to the exact weight per batch.

(5) Cement Weighing Equipment. Where bulk cement is used it shall be batched by weight, and scales shall be of rugged construction. Provision shall be made for indicating to the operator that the required load in the weigh box or container is being approached, which device shall indicate at least the last 50 pounds of load. Where a closed type cement weigh box is used, the cement weighing scales shall be provided with a springless dial to indicate when the weigh box is empty. This indicator for the empty condition of the weigh box shall be in continuous operation. The weigh box shall be fitted with an approved vent, a tightly covered inspection opening of not less than 12 inches by 12 inches, and the box and scales shall be maintained in a condition to meet the requirements for accuracy of weight.

Where portland cement to be mixed with subgrade, subbase or base material is not batched by weight and bulk cement is furnished, each truck shall have the weight of cement certified by a bonded public weigher or the Contractor shall place a set of standard platform truck scales or hopper scales at a location approved by the Engineer.

(6) Automatic Proportioning Devices.

(a) Portland Cement Concrete. When required by the plans or special provisions, batching plants shall be equipped to proportion by weight, aggregates, bulk cement, as the case may be, by means of automatic proportioning devices of approved type conforming to the following requirements.

The scales shall be automatic to the extent that the only manual operation required for porportioning the aggregates for one batch shall be a single operation of a switch or a starter.

The bulk cement batcher and aggregate batcher shall be so interlocked that a new batch cannot be started until all weigh hoppers are empty, the scale at zero and the discharge gates closed. The interlock shall permit no part of the batch to be discharged until all aggregate hoppers and the cement hopper have been filled with the correct charge. The discharge gate on the cement hopper shall be so designed as to permit regulating the flow of the material into the aggregate as directed by the Engineer.

Material discharged from the several bins shall be controlled by gates or by mechanical conveyors. The means of withdrawal from the several bins and of discharge from the weigh box shall be so interlocked that not more than one bin can discharge at a time; that the order of discharge can be changed as directed by the Engineer; and that the weigh box cannot be tripped until the required quantity from each of the several bins has been deposited therein. Should a separate weigh box be used for each size aggregate, all may be operated and discharged simultaneously.

When the discharge from the bin is controlled by gates, each gate shall be actuated automatically so that the required weight is discharged into the weigh box after which the gate shall automatically close and lock.

The automatic weighing device shall be so designed that the number of proportions required may be set at the same time and that proportions and the sequence of weighing individual sizes may be changed without delay. The locking mechanisms or devices shall be so arranged that they may be locked at the direction of the Engineer.

When specified by the plans or special provisions, automatic scales shall be equipped with a recorder capable of printing the weight of each proportion and the total batch weight.

Automatic proportioning devices shall comply with the general requirements for scales. In order for the State inspection forces to check the accuracy of batch weights, the gross weight and tare weight of batch trucks, truck mixers and truck agitators shall be determined when ordered by the Engineer. The equipment shall be weighed on truck scales conforming to the requirements of Subarticle 500.3.(1). of this specification.

(b) Asphaltic Mixtures. When specifically indicated on the plans, asphaltic mixture mixing plants used in the production of asphaltic base and surface mixtures shall be equipped with approved fully automatic devices for the batching and cycling operations. There shall be interlock cut-off circuits to interrupt and stop all operations at any time there is a malfunctioning of any part of the control system.

The automatic proportioning controls shall include equipment for accurately proportioning batches of the various components of the mixture by weight. Visible dial scales shall be provided to show the weights of each batch ingredient.

Over and under asphalt and aggregate weight check sensors shall be included in the proportioning system to check the accuracy of the asphalt and aggregate bin weights. The over-under tolerance limits for aggregate shall be selected by the Engineer after the amounts of the various ingredients have

been determined for a batch of mixture. The equipment shall be capable of a tolerance range of ± 0.5% to ± 2% as applied to the material being weighed. The tolerance limits for asphalt shall be ±1% of the total asphalt being weighed. The tolerance limits for the no-load condition shall be ± 1 scale graduation for the aggregate scales and ± 3 graduations for the asphalt scales. The tolerances shall be locked in such manner that the settings for the over and under sensors cannot be altered or bypassed without the express permission of the Engineer. The system shall incorporate provisions for a manual check which the operator would perform periodically as requested by the Engineer.

At least one set of scale dials shall be provided, one dial for aggregate and one dial for asphalt. The scale dials shall be divided into increments not to exceed 1/1000 of the total dial capacity. The scale dials may be located either in the dust proof control room or on the plant near the weighing hopper. In either location, the scale dials shall accurately indicate the weight in the weighing hopper from zero load to the maximum batch weights.

If the scale dials are located on the plant outside the control room, there shall be provided either an identical set of scale dials inside the control room or digital weight indicators which for either type shall duplicate within a tolerance of ± one graduation for aggregate scales and ± one graduation for asphalt scales any reading of the scale dial indicators located outside on the plant. Wherever located, the scale dials shall be so positioned that the dial and indicators are in full view of the operator in the electronic control room. The normal weight of a batch of aggregate shall be not less than one-half the aggregate scale dial capacity.

The automatic proportioning system shall be provided with low bin indicators arranged in such manner that under normal working operations the batching operation will be automatically stopped when the level of material in any supply bin is not sufficient to complete the weighing of a complete batch of the asphaltic mixture.

The system shall include a batch counter which can be preset for determining the number of batches which may be desired in one uninterrupted production sequence, and a counter to show the number of batches for the day's run.

The mixer shall have an accurate time-locking device to control the operation of a complete mixing cycle by locking the weigh box gate(s) after charging the mixer. It shall remain locked until the mixing cycle is complete, the mixture has been dumped, and the mixer discharge gate is closed. The timing device shall automatically control the dry and wet mixing period in accordance with the governing specification.

The control of the timing shall be adjustable and capable of being preset at the time intervals directed by the Engineer. Changes in mixing time shall be made only when approved in writing by the Engineer.

The aggregate dryer and asphalt tank heaters shall be equipped with burners that are automatically controlled by thermostats. This automatic equipment shall control the heat of the materials within the specified tolerances. Manual controls shall be used only as directed by the Engineer.

Temperature recording devices shall be supplied to record the temperatures of the aggregate at the discharge end of the dryer and the asphalt near the discharge valve of the mixer unit.

The automatic heat control panel and the temperature recording devices shall be located inside the dust-proof control room.

Automatic controls shall be housed in a dust-proof room located in such manner that the mixer discharge chute is in full view of the operator.

If at any time the automatic control devices become inoperative, the plant operations will be allowed to continue under manual controls for not more than two days of operation, at which time all plant operations shall cease until the necessary repairs are made. Continuous and frequent breakdowns of the automatic control devices shall be cause for suspending operations until the devices are properly repaired.

When specifically provided for in the plans, the proportioning system shall be equipped with an automatic digital record printer and will record batch weights and print out the required information on a continuous tape or ticket through the use of a printing calculator. When requested by the Engineer, the Contractor shall demonstrate the accuracy of the printout device, within a tolerance of ± one scale graduation for aggregate scales and ± one graduation for asphalt scales. The printout accuracy shall also apply to the no-load condition.

In the event of a breakdown of the recording equipment, the pay weights shall be determined by weighing the mix in the trucks on approved platform and recording scales or by calculated batch weights for a maximum period of not more than two working days. Continuous and frequent breakdowns of the recording equipment shall be cause for suspending operations until the recorder is properly repaired.

Each individual ticket or continuous tape shall contain the following readable information printed automatically by the digital record printer:

Date

Project Identification Code Number. (This number will be supplied by THD and will have a maximum of 4 digits.)

Time of day to the nearest minute at intervals not greater than for each truck load, or at intervals not greater than 10 batches when material is being deposited into a storage bin.

Mix Design Number.

Zero scale record for aggregate and asphalt to be printed at intervals not greater than before each truck loading or at intervals not greater than 10 batches when material is being deposited in a storage bin.

Weight of each aggregate for each batch recorded accumulatively or separately.

Total weight of all aggregate in each batch.

Weight of asphalt in batch.

Total of batch weights (combined mixture of asphalt and aggregate) for the day and/or any part of a day as required by the Engineer. This printing will be required on the tape or ticket at the times specified herein during each day of operation.

Total of either the aggregate or the asphalt for the day and/or any part of a day as requested by the Engineer. This printing will be required on the tape or ticket at the times specified herein during each day of operation.

One copy of the tape shall be provided the Texas Highway Department at the end of each day's run. If tickets are used, the Highway Department shall be furnished three tickets with each truck load.

The recording unit shall be in the same room as the automatic batching console unit. The recording unit may be separate from the console.

(7) Asphaltic Material Bucket. The asphaltic material bucket shall be of sufficient size to hold the necessary asphaltic material for one batch. If the material is measured by weight, the bucket shall be properly attached to the scales. If the proportioning is by volume based on weight, the measuring bucket used shall be of the over-flow type and shall meet the requirements of the Engineer. The valves at the asphaltic material bucket shall be of a quick cut-off type that do not leak.

On batch plants equipped with a pressure type flow meter for volumetric measurement of the asphalt required in each batch, the metering device and auxiliary equipment shall meet the following requirements:

The volumetric meter shall be so designed and constructed to automatically measure the asphaltic material into each batch within the tolerance of plus or minus 0.1 percent of the total batch weight. The meter shall be so constructed that any setting may be locked and the meter will automatically reset itself to this setting after the addition of the asphaltic material to each batch. A thermometer shall be installed in the asphalt line to accurately measure the temperature within plus or minus 5 F over a range from 50 F to 400 F. Provisions of a permanent nature shall be made for checking accuracy of meter output, including scales and container of such size that a full batch of asphaltic material may be weighed.

(8) Water. The measuring device for measuring water by volume shall indicate the quantity in gallons and fractions thereof. When a volumetric tank or bucket is used for measuring the water, the supply inlet shall cut off automatically and remain off until the container has emptied completely and the discharge line to the mixer is closed. When water is measured by weight, the weigh bucket shall be properly attached to scales meeting the general requirements of this specification. When a pressure type flow meter for volumetric measurement of the water is used, it shall be so constructed that any setting may be locked and the meter shall be capable of being manually or automatically reset to the locked setting after the addition of water to each batch.

Regardless of the method of water measurement used, the operating mechanism shall regulate the quantity of water required for any given batch to within plus or minus 0.2 percent of the total batch for bituminous mixtures and to within plus or minus 1.0 percent of the specified quantity of water required for concrete mixes. Provisions of a permanent nature shall be made for checking the accuracy herein specified.

500.4. Measurement and Payment. The furnishing, erection, checking, and certifying maintenance and operation of items listed under this specification will not be measured and paid for directly but shall be considered subsidiary to other bid items.

ITEM 501

AUTOMATIC SCREED CONTROLS FOR ASPHALTIC-CONCRETE SPREADING AND FINISHING MACHINE

501.1. Description. This item shall establish the requirements for automatic screed control systems for asphaltic-concrete spreading and finishing machines when this item is included in the List of Governing Specifications in the Proposal. Asphaltic-concrete spreading and finishing machines shall be equipped with an approved automatic dual longitudinal screed control system and a transverse screed control system. The longitudinal controls shall be capable of operating from any longitudinal grade reference including a stringline, ski, mobile stringline, or matching shoe. The Contractor shall furnish all equipment required for grade reference. It shall be maintained in good operating condition by personnel trained in the use of this type of equipment. The equipment shall be such as to construct a finished surface within specified tolerances.

501.2. Surface Requirements. The automatic grade control device shall produce a finished surface meeting the requirements of the surface test on the items of work for which a spreading and finishing machine is required. Skin-patching on wearing surface course will not be permitted, and sections of pavement exceeding the minimum tolerance shall be corrected at the Contractor's expense.

501.3. Construction Procedure. Unless otherwise shown on the plans or directed by the Engineer, the grade reference used by the Contractor may be of any type approved by the Engineer. Control points if required by the plans or Engineer will be established for the finished profile by the Engineer. These points will be set on both sides of the course being laid, when necessary, at intervals not to exceed 50 feet. The Contractor shall set the grade reference for the sensor of the automatic control to follow from the control points established by the Engineer and the grade reference shall have sufficient support so that the maximum deflection shall not exceed 1/16 inch per 25 feet.

501.4. Measurement and Payment. The furnishing, erecting, checking and certifying, maintaining and operating of equipment and work required by this specification will not be measured nor paid for directly, but shall be considered subsidiary to other bid items.

ITEM 502

READY-MIX PLANTS

502.1. Description. This item shall govern for the plant facilities, equipment and operation of Ready-Mix Plants.

502.2. Materials. All materials for concrete placed in structures shall conform to the requirements of the Item, "Concrete for Structures", or the Item, "Lightweight Concrete for Structures".

All material for concrete placed in pavements shall conform to the requirements of the governing items of "Concrete Pavement".

502.3. General. It shall be the Contractor's responsibility to furnish concrete meeting all requirements of the governing specification items and concrete not meeting the slump, workability and consistency requirements of the governing specification item shall not be placed in the structure or pavement.

Ready-Mixed Concrete shall be mixed and delivered by means of one of the following approved methods:

(1) Mixed completely in a stationary mixer and transported to the point of delivery in a truck agitator or a truck mixer operating at agitation speed. (Central-Mix Concrete)

(2) Mixed completely in a truck mixer and transported to the placement site at mixing and/or agitating speed (Transit-Mix Concrete), subject to the following provisions:

a. Truck mixers will be permitted to transport concrete to the job site at mixing speed if equipped with double actuated counters which will separate revolutions at mixing speed from total revolutions.

b. Truck mixers equipped with a single actuated counter counting total revolutions of the drum shall mix the concrete at the plant not less than 50 nor more than 70 revolutions at mixing speed, transport it to the job site at agitating speed and complete the required mixing before placing the concrete.

(3) Mixed completely in a stationary mixer and transported to the job site in approved nonagitating trucks with special bodies. This method of transporting will be permitted for concrete pavement only.

502.4. Class of Plants. The class of plant shall be in accordance with one of those specified herein. Unless the class and type of plant is specifically indicated on the plans, either class of central or transit mix plant may be furnished. A central mix plant may always be used when a transit mix plant is specified.

(1) A Class 1 plant shall be for the exclusive use of the Department for a single project and when required, will be designated on the plans as one of the following:

(a) Class 1A – Central-Mix Plant

(b) Class 1B – Transit-Mix Plant

(2) A Class 2 plant shall be for the exclusive use of the Department for more than one project as specified by the Engineer and when required, will be designated on the plans as one of the following:

(a) Class 2A – Central-Mix Plant

(b) Class 2B – Transit-Mix Plant

(3) A Class 3 plant shall be a commercial plant designated for the exclusive use of the Department during continuous placements only, as specified by the Engineer, but available for commercial work during other periods and when required, will be designated on the plans as one of the following:

(a) Class 3A – Central-Mix Plant

(b) Class 3B – Transit-Mix Plant

(4) A Class 4 plant shall be a commerical plant, either central-mix or transit-mix.

Classes 1 and 2 plants shall be located on or near the project as approved by the Engineer. All classes of plants shall be located to meet time requirements for hauling and placing concrete.

502.5. Certification of Plant. Before mixing and hauling concrete to Department projects, the plant will be thoroughly inspected and must be approved by the Engineer. All scales, water measuring devices, mixers, agitators, hoppers and storage bins shall be in satisfactory operating condition and together with the method of operation, storage facilities, materials and any other necessary item required in the manufacture and delivery of concrete will be inspected for approval by the Engineer.

Weighing and measuring equipment shall be in good working condition, properly calibrated and shall meet all requirements of the Item, "Weighing and Measuring Equipment".

Admixture dispensing equipment shall be as specified in the Item, "Concrete Admixtures".

A metal plate(s) shall be attached in a prominent place on each mixer plainly showing the various uses for which it was designed. The data shall include the drum's speed of rotation for mixing and agitating and the capacity of the unit for complete mixing and/or agitating only. A copy of the manufacturer's design, showing dimensions and arrangement of blades, shall be available at the plant at all times. Accumulations of hardened concrete and worn or damaged blades shall be corrected in accordance with Subarticle 502.6.(2).(a).

If, at any time, the equipment and/or facilities fail to meet specified requirements, approval of the plant will be withdrawn until the defects are corrected and the plant reapproved.

502.6. Equipment.

(1) Batching Plant. The batching plant shall be provided with adequate bins for batching all aggregates and materials required by the specifications.

Bulk cement shall be weighed on a scale separate from those used for other materials and in a hopper entirely free and independent of that used for weighing the aggregates.

Admixtures shall be measured and dispensed as specified in the Item, "Concrete Admixtures".

(2) Mixers and Agitators.

(a) General. Mixers shall be of an approved stationary or truck-type capable of combining the ingredients into a thoroughly mixed and uniform mass.

Facilities shall be provided to permit ready access to the inside of the drum for inspection, cleaning and repair of blades.

Mixers and agitators shall be subject to daily examination for changes in condition due to accumulation of hardened concrete and/or wear of blades and any hardened concrete shall be removed before the mixer will be permitted to be used. Worn blades shall be repaired or replaced with new in accordance with the manufacturer's design and arrangement for that particular unit when any part or section is worn as much as 10 percent below the original height of the manufacturer's design.

(b) Stationary Mixers. These shall conform to the requirements of Article 421.11. Truck mixers mounted on a stationary base will not be considered as a stationary mixer.

(c) Truck Mixers. In addition, truck mixers shall comply with the following requirements:

An engine in satisfactory working condition and capable of accurately governing the desired speed of rotation shall be mounted as an integral part of the mixing unit for the purpose of rotating the drum. Truck mixers equipped with a transmission that will govern the speed of the drum within the specified rpm will not require a separate engine.

All truck mixers shall be equipped with actuated counters by which the proper number of revolutions of the drum as specified in Article 502.3 may be readily verified. The counters shall be read and recorded at the start of mixing at mixing speeds.

Each unit shall have adequate water supply and accurate metering or gauging devices for measuring the amount used.

(d) Agitators. Concrete agitators shall be of the truck type, capable of maintaining a thoroughly mixed and uniform concrete mass and discharging it within the same degree of uniformity specified for mixers. Agitators shall comply with all of the requirements for truck mixers except for the actual mixing requirements.

502.7. Operation of Plant and Equipment.

The production and delivery of ready-mixed concrete shall equal or exceed the rate approved by the Engineer for continuous placements. In all cases, the delivery of concrete to the placement site shall assure complaince with the time limits in the applicable specifications for depositing successive batches in any monolithic unit. The Contractor shall satisfy the Engineer that adequate standby trucks are available.

A standard THD ticket system will be used for recording concrete batching, mixing and delivery data.

Tickets shall be signed by the plant inspector and delivered to the job inspector by the operator of the truck.

Loads arriving without tickets and/or in unsatisfactory condition shall not be used.

When a stationary mixer is used for the entire mixing operation, the mixing time for one cubic yard of concrete shall be one minute plus 15 seconds for each additional cubic yard or portion thereof. This mixing time shall start when all cement, aggregates and initial water have entered the drum. The mixer shall be charged so that some of the mixing water will enter the drum in advance of the cement and aggregate. All of the mixing water shall be in the drum by the end of the first one-fourth of the specified mixing time. Water used to flush down the blades after charging shall be accurately measured and included in the quantity of mixing water. The introduction of the initial mixing water, except blade washdown water and that permitted in this Article shall be prior to or simultaneous with the charging of the aggregates and cement.

The loading of truck mixers shall not exceed 63 percent of the total volume of the drum. When used as an agitator only, the loading shall not exceed 80 percent of the drum volume.

When Ready-Mix Concrete is used, additional mortar (one sack cement, three parts sand and sufficient water) shall be added to the batch to coat the drum of the mixer or agitator truck and this shall be required for every load of Class C, F and H concrete only and for the first batch from central mix plants.

A portion of the mixing water, required by the batch design to produce the desired slump, may be withheld and added at the job site, but only with permission of the Engineer and under his supervision. When water is added under the above conditions, it shall be thoroughly mixed as specified below for water added at the job site.

Mixing speed shall be attained as soon as all ingredients are in the mixer, and each complete batch (containing all the required ingredients) shall be mixed not less than 70 nor more than 100 revolutions of the drum at mixing speed except that when water is added at the job site, 25 revolutions (minimum) at mixing speed, will be required to uniformly disperse the additional water throughout the mix. Mixing speed shall be as designated by the manufacturer. All revolutions after the prescribed mixing time shall be at

agitating speed. The agitating speed shall be not less than one nor more than 5 rpm. The drum shall be kept in continuous motion from the time mixing is started until the discharge is completed.

Adequate storage facilities shall be provided for all Department approved materials and intermixing with nonapproved materials either in stockpiles or bins will not be permitted. Aggregates from different sources shall be stored in separate stockpiles. Where space is limited, stockpiles shall be separated by physical barriers.

Aggregates shall be stockpiled in such a manner to prevent segregation and maintained as nearly as possible in a uniform condition of moisture.

To provide uniformity, each aggregate stockpile shall be reworked with suitable equipment when required by the Engineer.

502.8. Mixer Performance Test. Mixers producing concrete, which in the opinion of the Engineer is acceptably uniform need not be tested. Mixers which do not meet the requirements for acceptable uniformity shall be tested as specified below.

Any mixer failing these tests will not be permitted on further work until corrective measures are taken. Corrective measures may include mixing smaller loads, requiring a more efficient charging sequence, blade repair, drum cleanout or other measures necessary to comply with the performance requirements.

When tests are required, transit mixers shall be capable of satisfactorily mixing a complete design batch (containing all the required ingredients) within 70 to 100 mixing speed revolutions of the drum. Performance tests shall be made under these conditions without additional water added.

In making a performance test, the variation within a batch will be determined for each concrete property listed in Table 1 as the difference between the highest and the lowest value obtained from different portions of the batch. The comparison will be between two representative samples, taken after discharge of approximately 15 percent and 85 percent respectively of the maximum load recommended by the manufacturer. Both samples shall be obtained within a period of 15 minutes or less.

Concrete Property	Requirement, expressed as maximum permissible difference in results of tests of samples taken from two locations in the concrete batch.
Weight per cubic foot calculated to an air-free basis	1.0 lb.
Air content, percent by volume of concrete	1.0
Slump	
If average slump is 4 in. or less	1.0 in.
If average slump is 4 to 6 in.	1.5 in.
Coarse aggregate content, portion by weight of each sample retained on No. 4 sieve, percent	6.0

TABLE 1 – REQUIREMENTS FOR UNIFORMITY OF CONCRETE

502.9. Measurement and Payment. No direct compensation will be made for concrete produced under the requirements of this item. Payment will be made under the various items for which prices are provided in the contract.

ITEM 510

PIPE UNDERDRAINS

510.1. Description. This item shall consist of pipe underdrains embedded in filter material, constructed at such places as shown on the plans or as directed by the Engineer and in accordance with lines and grades established by the Engineer.

510.2. Materials.

(1) Pipe. The pipe shall be of the type shown on the plans and the proposal and the size indicated shall be the inside diameter. The pipe shall meet the following requirements:

Type 1. Vitrified Clay or Concrete Pipe.

The pipe may be either thoroughly and perfectly burned or glazed vitrified clay or non-reinforced concrete. The pipe shall be of first quality hub-and-spigot style, sound, without warps or cracks or other imperfections and shall be sufficiently tough so that it may be cut with a chisel and hammer.

Type 2. Clay Drain Tile.

Standard clay drain tile shall conform to the specifications of AASHO Designation: M 179.

Type 3. Concrete Drain Tile.

Butt-end concrete drain tile shall conform to the specification of ASTM Designation: C 412. Tongue and groove concrete drain tile shall conform to the specifications of ASTM Designation: C 118.

Type 4. Porous Concrete Pipe.

Porous concrete pipe shall conform to the specifications of AASHO Designation: M 176.

Type 5. Perforated Asbestos-Cement Pipe.

Asbestos-cement pipe and fittings shall conform to the specifications for Asbestos-Cement Perforated Underdrain Pipe of ASTM Designation: C 508.

Couplings shall be the sleeve type suitable for holding the pipe in alignment without the use of sealing compounds or gaskets. The coupling need not be of the type that effectively seals the joints. Tapered couplings will be acceptable.

Type 6. Perforated Clay Pipe.

Perforated clay pipe shall conform to the specifications for standard strength perforated clay pipe of AASHO Designation: M 65 except that extra strength clay pipe may be substituted for standard strength clay pipe.

Type 7. Perforated Corrugated Metal Pipe.

Perforated corrugated metal pipe shall be fabricated from corrugated galvanized sheets and shall comply with AASHO Designation: M 36 and with the following modifications: The pipe may conform to any one of the types specified in M 36.

Type 8. Perforated Corrugated Metal Pipe (Bituminous Coated).

The pipe shall conform in all particulars to the requirements specified above for perforated corrugated metal pipe. The pipe shall be uniformly coated inside and out with a bituminous coating to a minimum thickness of 0.05 inch.

The bituminous material used to coat the pipe shall meet the following requirements when tested in accordance with Test Method Tex-522-C:

Solubility, % by wt. in Carbon Tetrachloride	99.5 min.
Brittleness Test	Pass
Flow, inches	0.25 max.

Type 9. Perforated Concrete Pipe.

Perforated concrete pipe shall conform to the specifications for "Standard Strength Perforated Non-reinforced Concrete Underdrain Pipe" of ASTM Designation: C 444, except that "Extra Strength Perforated Non-reinforced Concrete Underdrain Pipe" may be substituted for standard strength pipe.

Type 10. Perforated Bitumenized-Fiber Drainage Pipe.

Perforated Bitumenized-Fiber Drainage Pipe shall conform to the specification requirements of ASTM Designation: D 2818-69.

Type 11. ABS Perforated Pipe.

ABS pipe shall be extruded and the fittings molded from virgin acrylonitrile-butadiene-styrene (ABS) plastic material conforming to ASTM Designation: D 1788-62T, Type 4, except that the minimum heat deflection temperature is 180 F. The Contractor shall furnish certified test reports as evidence that the material used for the project meets ASTM requirements. The dimensions of ABS pipe shall be as shown in Table 1. Fittings shall conform to the manufacturer's standard for the particular size of pipe required.

TABLE I

NOMINAL SIZE, IN.	INSIDE DIA. IN., MIN.	THICKNESS OF BARREL IN., MIN.
4	3.82	0.19
6	5.70	0.28

Perforations shall conform to the requirements for Type 5 pipe underdrains. The crushing strength of ABS pipe shall meet or exceed the minimum values in Table II when tested in accordance with the flat-plate loading method as outlined in ASTM Designation: 2412-65T.

TABLE II

NOMINAL SIZE, IN.	MIN. STRENGTH LB.-IN.
4	179
6	604

The pipe shall withstand at least 35 percent vertical deflection without rupture of the pipe wall, and the stiffness shall equal or exceed the values at 5 percent deflection. Vertical deflection shall be computed as follows:

$$\text{Percent Deflection} = \frac{\text{Reduction Vert. I.D.}}{\text{Nominal I.D.}} \times 100$$

The ends of ABS pipe, couplings and fittings shall be perpendicular or square to the longitudinal axis of the main body within a maximum angle of 3 degrees. The outer and inner surface of the pipe shall be free from blisters, voids and discontinuities.

(2) Filter Material. Filter material for use in backfilling trenches under, around and over underdrains shall consist of hard, durable, clean sand, gravel, crushed stone, crushed shell or other material specified on the plans and shall

be free from organic matter, clay balls or other deleterious matter. Unless otherwise shown on plans crushed limestone will not be permitted.

The percentage composition by weight of the filter material in place shall conform to the following gradings.

Percentage Retained on Sieve

Sieve Size	Type A	Type B	Type C	Type D	Type E	Type F
2"	–				Shall con-	As
1-1/2"	–		0-10		form to the	Shown
3/4"	–	0-10	20-40		Item, "Aggre-	on
3/8"	–	15-35	–	0	gate for Sur-	Plans
No. 4	0-10	35-55	40-60	0-5	face Treat-	
No. 8				0-20	ments" of	
No. 16				15-50	the type and	
No. 30				40-75	grade as	
No. 50				70-90	shown on	
No. 100				90-100	plans	

That portion of the filter material of Type A, B or C that is finer than No. 4 sieve shall be graded as follows:

Sieve Size	Percentage Retained
No. 4	—
No. 20	35-65
No. 50	75-100

The loss by decantation shall not exceed one percent on the material retained on the No. 4 sieve and shall not exceed four percent on the material passing the No. 4 sieve. Type E material shall conform to the Item, "Aggregate for Surface Treatments". Unless otherwise shown on the plans, Type B or Type C filter material, at the option of the Contractor, shall be used around underdrains. If Type A or Type D filter material is specified, it shall not be placed within 6 inches of any perforation. If Type E filter material is specified it shall not be placed within 6 inches of the water bearing strata.

510.3. Construction Methods. The excavation of each trench shall begin at its outlet and proceed toward its upper end. The trench must not be excavated below the proposed grade line and shall be located as indicated on the plans or as directed by the Engineer, and true to line and grade. The trench shall be dressed with a tile-hoe or shovel in such manner that a groove will be made to conform to the shape of the pipe. When perforated metal pipe is used and the trench is founded in pervious material, a thin layer of tamped impervious material shall be placed on the bottom of the trench as shown on the plans or indicated by the Engineer. If the bottom of the trench is founded on impervious material the tamped layer shall be omitted. The sections shall be jointed with band couplers. All perforated pipe shall be laid with the perforations on the sides below the horizontal axis with the imperforated sections centered on the flow line.

When clay or concrete pipe is used and the trench is founded in pervious material, a bottom course of the specified filter material shall be placed and tamped to a uniform depth of 2 inches. The pipe shall then be firmly embedded in the filter material, hub end upgrade, and the spigot firmly centered into the adjacent hub end or in the case of butt-end type drains with an open joint of approximately 3/8 inch.

The open pipe joints shall then be covered with approved two-ply tar paper strips not less than 6 inches in width and of sufficient length to permit the ends being turned outward and laid flat on the bottom course of filter material on each side for a distance of 3 inches. When the trench is founded in impervious material the 2 inch bottom course of filter material shall be omitted, the pipe laid directly in the trench and filter material placed in the trench to a depth of 2 inches on each side of the pipe. The two-ply tar paper strips shall then be placed as specified above.

Asbestos-cement pipe shall be laid as specified above for clay and concrete pipe, and the sections shall be joined by couplers. No tar paper strips shall be used.

After the pipes have been laid and approved, the filter material shall be carefully placed to the depth shown on the plans and in such manner as not to displace the pipe or joint covering around and over the pipe. The depth of filter material shall in no case be less than 12 inches above the bottom of the pipe and such depth shall be placed where no dimension is shown on the plans. The remainder of the trench shall be backfilled with suitable materials which shall be tamped in layers not exceeding 4 inches.

Approved plugs shall be placed in the upper ends of all pipes and all exposed ends of underdrains shall be covered with 1/2-inch galvanized hardware cloth as directed by the Engineer.

When required by the plans, concrete riprap or headwalls of the dimensions shown on the plans shall be constructed at the outlet ends of the pipe underdrains. Concrete materials and proportions shall conform to the requirements specified for Class "B" Concrete as set out in the Item, "Concrete for Structures".

Perforated ABS pipe shall be jointed by couplers or solvent welding according to the manufacturer's recommendation. No tar paper strips shall be used.

510.4. Measurement. Work and accepted materials for "Pipe Underdrains" will be measured by the linear foot of pipe measured along the slope and shall include the length of all elbows, wyes, tees and other branches.

"Underdrain Excavation" shall be measured in cubic yards by the method of average end areas calculated from limits of excavation as shown on the plans or if not indicated on the plans shall be computed within the following limits:

(1) The horizontal limits for computing pay quantities shall be as shown

in the following table:

Depth of Trench (Feet)	Limits of Excavation for Payment, Dist. in Ft. Outside Neat Lines of Pipe Underdrain
0 to 6	1.00
6 to 10	1.50
10 to 15	2.00
Over 15	2.50

(2) The upper limits for computing pay quantities of "Underdrain Excavation" shall be the gound surface as it exists prior to start of construction operations except where the excavation is performed within roadway or ditch excavation areas, "Underdrain Excavation" will include only materials below or outside the limits of the completed road section.

(3) The lower limits for computing pay quantities of "Underdrain Excavation" shall be a plane at the lower limits of the pipe.

"Filter Material" shall be measured by the cubic yard complete in place. Horizontal limits for computing quantities shall be the same as specified for "Underdrain Excavation".

510.5. Payment. Work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pipe Underdrains" of the type and size specified, which price shall be full compensation for furnishing and placing all materials; for all plugs and screens; and for all labor, tools, equipment and incidentals necessary to complete the work except "Underdrain Excavation" and "Filter Material".

All underdrain excavation measured as provided under "Measurement" will be paid for at the unit price bid for "Underdrain Excavation" which price shall be full compensation for all excavating, bracing and removal of same, backfilling of trench, disposal of excess materials and all labor, tools, equipment and incidentals necessary to complete the work.

Filter material measured as provided under "Measurement" will be paid for at the unit price bid for "Filter Material" or "Filter Material" of the type specified, which price shall be full compensation for furnishing and placing all filter material including tamping, all labor, tools, equipment and incidentals necessary to complete the work.

All riprap or headwalls required by the plans will be measured and paid for in accordance with the provisions of the Items of "Riprap" or "Concrete for Structures".

ITEM 520

CONCRETE CURB

520.1. Description. "Concrete Curb" shall consist of Portland cement concrete curb, with or without reinforcing steel as required, constructed on an approved subgrade in accordance with this specification and in conformity with the lines and grades established by the Engineer and details shown on the plans.

520.2. Materials. Materials and proportions for concrete used in construction under this item shall conform to the requirements as specified for Class "A" Concrete under the Item, "Concrete for Structures", or concrete as specified in the Item, "Concrete Pavement". Reinforcing steel, if required, shall conform to the requirements as specified in the Item, "Reinforcing Steel", or the Item, "Concrete Pavement". Expansion joint filler shall be premoulded material meeting the requirements specified in the Item, "Concrete Structures" or material meeting the requirements specified in the Item, "Concrete Pavement".

520.3. Construction Methods. The subgrade shall be excavated and shaped to line, grade and cross section and, if considered necessary in the opinion of the Engineer, hand tamped and sprinkled. If dry, the subgrade shall be sprinkled lightly before concrete is deposited thereon.

Forms shall be of wood or metal, of a section satisfactory to the Engineer, straight, free of warp, and of a depth equal to the depth of the curb. They shall be securely staked to line and grade and maintained in a true position during the depositing of concrete. The inside forms shall be rigidly attached to the outside forms.

The reinforcing steel, if required, shall be placed in position as shown on the typical section. Care shall be exercised to keep all steel in its proper location.

Concrete for the curb shall be mixed in a manner satisfactory to the Engineer. The curb shall be placed in sections of the length indicated on plans, and each section shall be separated by a premoulded or board joint of cross section specified for the curb and of the thickness indicated on the plans.

After the concrete has been struck off and after it has become sufficiently set, the exposed surfaces shall be thoroughly worked with a wooden float. The exposed edges shall be rounded by the use of an edging tool to the radius indicated on plans. Unless specified otherwise on plans, when the concrete in the curb has been sufficiently set, the inside form shall be carefully removed and the surface shall be plastered with a mortar consisting of one part of Portland cement and two parts fine aggregate. The mortar shall be applied with a template or "mule" made to conform to curb dimensions as shown on plans. All exposed surfaces of curb shall be brushed to a smooth and uniform surface.

The completed curb shall be cured in accordance with the requirements of the Item, "Membrane Curing", Type 2, white pigmented, unless otherwise

shown on plans. Other methods of curing as outlined in the Items, "Concrete Pavement" and "Concrete Structures" will be acceptable with a required curing period of 72 hours.

The curb shall be backfilled to the full height of the concrete, tamped and sloped as directed.

520.4. Measurement. Concrete curb will be measured by the linear foot, complete in place.

520.5. Payment. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Curb" of the type indicated on the plans, which price shall be full compensation for preparing the subgrade, furnishing and placing all materials, including reinforcing steel and expansion materials; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 521

MACHINE LAID CURB

521.1. Description. This item shall consist of Portland cement concrete curb with or without reinforcing steel on an approved foundation or on the finished roadway surface in accordance with the lines and grades established by the Engineer and the details shown on the plans.

521.2. Materials. Unless otherwise specified on plans, materials shall conform to the requirements for Class "C" Concrete of the Item, "Concrete for Structures", except that the slump shall be as directed by the Engineer and the coarse aggregates when tested by approved methods shall conform to the following grading requirements:

Retained on 1/2" sieve	0%
Retained on 3/8" sieve	0 to 5%
Retained on No. 4 sieve	35 to 60%
Retained on No. 10 sieve	90 to 100%
Loss by decantation (Test Method Tex-406-A)	1.0% Maximum

Reinforcing Steel shall conform to the requirements for the Item, "Reinforcing Steel".

521.3. Construction Methods. The curbs shall be laid by an extrusion machine approved by the Engineer. Immediately prior to placing of the curb, the previously approved foundation shall be thoroughly cleaned. If required by plan details the cleaned surface shall then be coated with an approved adhesive or such other coating as specified at the rate of application shown.

The line for top of curb shall be maintained from a guideline set by the Contractor from survey marks established by the Engineer. Curb outline shall strictly conform to the details shown on plans. The forming tube of the

extrusion machine shall be readily adjustable vertically during the forward motion of the machine, to provide required variable height of curb necessary to conform to the established gradeline. To provide a continual check on the curb grade, a pointer or gauge shall be attached to the machine in such a manner that a comparison can be made between the curb and the guideline. Other methods may be used if approved by the Engineer in writing.

The approved mix shall be fed into the machine in such a manner and at such consistency that the finished curb will present a well compacted mass with a surface free from voids and honeycomb and true to established shape, line and grade.

Any additional surface finishing specified and/or required shall be performed immediately after extrusion. Joints as specified, shall be constructed at such time as directed and to the details shown on plans.

The completed curb shall be cured for a period of not less than 72 hours by one of the methods specified in the Item, "Concrete Pavement (Water Cement Ratio)" excluding "Asphalt Curing" or with the requirements of the Item, "Membrane Curing", of the type as shown on plans.

521.4. Measurement. Machine laid curbs will be measured by the linear foot of completed and accepted curb, complete in place.

521.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Machine Laid Curb" of the type specified which price shall be full compensation for cleaning and coating the base, furnishing and applying all water, mortar, adhesives or other material, including reinforcing steel, if required; for furnishing, loading and unloading, storing, hauling and handling all ingredients, including all freight and royalty involved; for mixing, placing, finishing, sawing, cleaning and sealing joints and curing all concrete; for furnishing all materials for sealing joints and placing joints, and joint filler material in proper position; and for all manipulations, labor, equipment, appliances, tools, traffic provisions and incidentals necessary to complete the work.

ITEM 522

CONCRETE CURB AND GUTTER

522.1. Description. "Concrete Curb and Gutter" shall consist of Portland cement combined concrete curb and gutter or separate concrete gutter with or without reinforcing steel as required, constructed on an approved subgrade or foundation material in accordance with these specifications, in conformity with the lines and grades established by the Engineer and details shown on the plans.

522.2. Materials. Unless otherwise specified on plans, materials and proportions for concrete used in construction under this item shall conform to the requirements as specified for Class "A" Concrete under the Item, "Concrete for Structures", or concrete as specified in the Item, "Concrete

Pavement". Reinforcing steel, if required, shall conform to the requirements as specified in the Items, "Reinforcing Steel" or "Concrete Pavement". Expansion joint filler shall be premoulded material meeting the requirements specified in the Item, "Concrete Structures" or material meeting the requirements specified in the Item, "Concrete Pavement".

522.3. Construction Methods. The subgrade or foundation shall be excavated and shaped to line, grade and cross section, and, if considered necessary in the opinion of the Engineer, hand tamped and sprinkled. If dry, the subgrade or foundation material shall be sprinkled lightly immediately before concrete is deposited thereon.

Outside forms shall be of wood or metal, of a section satisfactory to the Engineer, straight, free of warp and of a depth equal to the depth of the curb and gutter. They shall be securely staked to line and grade, and maintained in a true position during the depositing of concrete. Inside forms for the curb shall be of approved material, shall be of such design as to provide the curb required and shall be rigidly attached to the outside forms. Where specifically permitted by the Engineer in writing, the Contractor may place concrete curb and gutter with an extrusion machine.

The reinforcing steel, if required, shall be placed in position as shown on the typical sections. Care shall be exercised to keep all steel in its proper location.

Concrete for curb and gutter shall be mixed in a manner satisfactory to the Engineer. The curb and gutter shall be poured in sections of the length indicated on the plans, and each section shall be separated by a premoulded or board joint of cross section specified for the curb and gutter, and of the thickness indicated on the plans.

After the concrete has been struck off and after it has become sufficiently set, the exposed surfaces shall be thoroughly worked with a wooden float. The exposed edges shall be rounded by the use of an edging tool to the radius indicated on plans. Unless specified otherwise on plans, when the concrete in the curb and gutter has become sufficiently set, the inside form shall be carefully removed and the surface shall be plastered with a mortar consisting of one part of Portland cement and two parts fine aggregate. The mortar shall be applied with a template or "mule" made to conform to curb and gutter dimensions as shown on plans. All exposed surfaces of curb and gutter, or gutter, shall be brushed to a smooth and uniform surface.

The completed curb and gutter shall be cured in accordance with the requirements of the Item, "Membrane Curing", Type 2, white pigmented, unless shown otherwise on plans. Other methods of curing as outlined in the Items, "Concrete Pavement" and "Concrete Structures" will be acceptable with a required curing period of 72 hours.

The curb and gutter shall be backfilled to the full height of the concrete, tamped and sloped as directed.

522.4. Measurement. Concrete Curb and Gutter or Concrete Gutter will be measured by the linear foot, complete in place.

522.5. Payment. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Curb and Gutter", or "Concrete Gutter", of the type indicated on the plans, as the case may be, which prices shall each be full compensation for preparing the subgrade; furnishing and placing all materials including reinforcing steel and expansion material; for furnishing, placing, shaping and tamping backfill; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 524

CONCRETE SIDEWALKS AND DRIVEWAYS

524.1. Description. This item shall consist of sidewalks and driveways, with or without reinforcing steel, composed of Portland cement concrete, constructed as herein specified on an approved subgrade, in conformity with the lines and grades established by the Engineer, and the details shown on the plans.

524.2. Materials. Materials and proportions used in construction under this item shall conform to the requirements as specified for Class "A" Concrete under the Item, "Concrete for Structures", or concrete as specified in the Item, "Concrete Pavement". Reinforcing steel, if required, shall conform to the requirements as specified for the Item, "Reinforcing Steel" or in the Item, "Concrete Pavement". Expansion joint filler shall be premoulded material meeting the requirements specified in the Item, "Concrete Structures" or board material meeting the requirements specified in the Item, "Concrete Pavement".

524.3. Construction Methods. The subgrade shall be excavated and shaped to line, grade and cross section and if considered necessary in the opinion of the Engineer, hand tamped and sprinkled. The subgrade shall be moist at the time the concrete is placed.

Forms shall be of wood or metal, of a section satisfactory to the Engineer, straight, free from warp, and of a depth equal to the thickness of the finished work. They shall be securely staked to line and grade and maintained in a true position during the depositing of concrete.

The reinforcing steel, if required, shall be placed in position as shown on the plans. Care shall be exercised to keep all steel in its proper locations.

Sidewalks shall be constructed in sections of the lengths shown on plans. Unless otherwise provided by the plans, no section shall be of a length less than 8 feet and any section less than 8 feet shall be removed by the Contractor at his own expense. The different sections shall be separated by a premoulded or board joint of the thickness shown on the plans, placed vertically and at right angles to the longitudinal axis of the sidewalk. Where the sidewalk or driveways abut a curb or retaining wall, approved expansion material shall be placed along their entire length. Similar expansion material shall be placed around all obstructions protruding through sidewalks or driveways.

Concrete shall be mixed in a manner satisfactory to the Engineer, placed in the forms to the depth specified and spaded and tamped until thoroughly compacted and mortar entirely covers the surface. The top surface shall be floated with a wooden float to a gritty texture. The outer edges and joints shall then be rounded with approved tools to the radii shown on plans.

Sidewalks shall be marked into separate sections, each 4 feet in length, by the use of approved jointing tools.

When completed, the sidewalks and driveways shall be cured in accordance with the requirements of the Item, "Membrane Curing", Type 2, white pigmented. Other methods of curing as outlined in the Items, "Concrete Pavement" and "Concrete Structures" will be acceptable with a required curing period of 72 hours.

524.4. Measurement. Work and accepted material as prescribed for this item will be measured by the square yard of surface area of completed sidewalks, driveways, or sidewalks and driveways or by the cubic yard as indicated on the plans.

524.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Sidewalks", "Driveways" or "Sidewalks and Driveways" as the case may be, which prices shall each be full compensation for preparing the subgrade; for furnishing and placing all materials, including all reinforcing steel and expansion joint materials; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 530

CEMENT STABILIZED RIPRAP

530.1. Description. "Cement Stabilized Riprap" shall consist of the stabilization of suitable materials for the purpose of protecting portions of the roadway against erosion.

530.2. Materials. The materials shall consist of aggregate, Type I Portland cement and water. Cement and water shall conform to the requirements of the Item, "Concrete for Structures". Aggregate shall consist of suitable materials secured from sources designated on the plans or approved by the Engineer. Where indicated on the plans, processed material from the flexible base source may be used for stabilization. When used, this material shall meet the grading requirements established by the base course specifications. All materials shall be approved by the Engineer before being incorporated in the work.

530.3. Construction Methods. The Contractor shall excavate the area where the stabilized riprap is to be constructed, to the depth shown on plans. The outline of the area to be riprapped need not be formed but it shall be the Contractor's responsibility that the required depth of stabilized material is placed over the entire area indicated on the plans.

The maximum size aggregate, exclusive of soil, shall not exceed two-thirds the depth of course to be placed. Soil shall be pulverized to the extent that no particles greater than 1/2-inch shall remain in the aggregate.

The processed aggregate shall then be mixed with Portland cement at the rate of 3 sacks of cement per cubic yard of the aggregate. When thoroughly mixed, water shall be added in such quantity that a plastic mass will result. The mixture after addition of water shall be of such consistency that it will not flow. Hand mixing will be permitted on small quantities; otherwise, mixing shall be done in a batch mixer of approved type and size which w ill insure the uniform distribution of the material throughout the mass so that the mixture will be uniform in color and smooth in appearance.

The mixed material shall be deposited on the prepared subgrade, consolidated and the surface finished by use of trowel, wooden float or other approved methods, to the required grade and section.

The completed riprap shall be cured in accordance with the requirements of the Item, "Membrane Curing", Type 2, white pigmented. Other methods of curing as outlined in the Items, "Concrete Pavement" and "Concrete Structures" will be acceptable with a required curing period of 4 days.

530.4. Measurement. Completed and accepted work as prescribed by this item will be measured by the cubic yard, complete in place.

530.5. Payment. The work performed as prescribed for this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Cement Stabilized Riprap" which price shall be full compensation for excavation necessary in preparation of subgrade, disposal of excavated material, furnishing all materials required in the construction (including any royalty costs), all processing, mixing, placing, curing, and for all equipment, tools and incidentals necessary to complete the work.

ITEM 531

MEMBRANE CURING

531.1. Description. This item shall consist of curing concrete pavement, concrete pavement (base), curbs, gutters, retards, sidewalks, driveways, medians, islands, concrete riprap, cement stabilized riprap, concrete structures and other concrete as indicated on the plans by impervious membrane method.

531.2. Materials. The membrane curing compound shall comply with the "Standard Specification for Liquid Membrane-forming Compounds for Curing Concrete", ASTM Designation: C 309, Type 1 clear or translucent, or Type 2 white pigmented. The material shall have a minimum flash point of 80 F when tested by the "Pensky-Martin Closed Cup Method".

It shall be of such consistency that it can be satisfactorily applied as a fine mist through an atomizing nozzle by means of approved pressure spraying equipment at atmospheric temperatures above 40 F.

It shall be of such nature that it will not produce permanent discoloration of concrete surfaces nor react deleteriously with the concrete or its components. Type 1 compound shall contain a fugitive dye that will be distinctly visible not less than 4 hours nor more than 7 days after application.

The compound shall produce a firm, continuous, uniform moisture impermeable film free from pinholes and shall adhere satisfactorily to the surfaces of damp concrete. It shall, when applied to the damp concrete surface, at the rate of coverage specified herein, dry to touch in not more than 4 hours and shall adhere in a tenacious film without running off or appreciably sagging. It shall not disintegrate, check, peel or crack during the required curing period.

The compound shall not peel or pick up under traffic and shall disappear from the surface of the concrete by gradual disintegration.

The compound shall be delivered to the job only in the manufacturer's original containers, which shall be clearly labeled with the manufacturer's name, the trade name of the material, and a batch number or symbol with which test samples may be correlated.

The water retention test shall be in accordance with Test Method Tex-219-F. Percentage loss shall be defined as the water lost after the application of the curing material was applied. The permissible percentage moisture loss (at the rate of coverage specified herein) shall not exceed the following:

24 hours after application	2 percent
72 hours after application	4 percent

531.3. Construction Methods. The membrane curing compound shall be applied after the surface finishing has been completed, and immediately after the free surface moisture has disappeared. The surface shall be sealed with a single uniform coating of the specified type of curing compound applied at the rate of coverage recommended by the manufacturer and directed by the Engineer, but not less than 1 gallon per 180 square feet of area. The Contractor shall provide satisfactory means and facilities to properly control and check the rate of applications of the compound.

The compound shall be thoroughly agitated during its use and shall be applied by means of approved mechanical power pressure sprayers. The sprayers used to apply the membrane to concrete pavement or concrete pavement (base) shall travel at uniform speed along the forms and be mechanically driven. The equipment shall be of such design that it will insure uniform and even application of the membrane material. The sprayers shall be equipped with satisfactory atomizing nozzles. Only on small miscellaneous items will the Contractor be permitted to use hand-powered spray equipment. For all spraying equipment, the Contractor shall provide facilities to prevent the loss of the compound between the nozzle and the concrete surface during the spraying operations.

The compounds shall not be applied to a dry surface and if the surface of the concrete has become dry, it shall be thoroughly moistened prior to

application of membrane by fogging or mist application. Sprinkling or coarse spraying will not be allowed.

At locations where the coating shows discontinuities, pinholes, or other defects; or if rain falls on the newly-coated surface before the film has dried sufficiently to resist damage, an additional coat of the compound shall be applied immediately at the same rate of coverage specified herein.

To insure proper coverage, the Engineer shall inspect all treated areas after application of the compound for the period of time designated in the governing specification for curing, either for membrane curing or for other methods. Dry areas are identifiable because of the lighter color of dry concrete as compared to damp concrete. All suspected areas shall be tested by placing a few drops of water on the suspected areas. If the water stands in rounded beads or small pools which can be blown along the surface of the concrete without wetting the surface, the water-impervious film is present. If the water wets the surface of the concrete as determined by obvious darkening of the surface, or by visible soaking into the surface, no water-impervious film is present. Should the foregoing test indicate that any area during the curing period is not protected by the required water-impervious film, an additional coat or coats of the compound shall be applied immediately, and the rate of application of the membrane compound shall be increased until all areas are uniformly covered by the required water-impervious film.

When temperatures are such as to warrant protection against freezing, curing by this method shall be supplemented with an approved insulating material capable of protecting the concrete for the specified curing period.

If at any time there is reason to believe that this method of curing is unsatisfactory or is detrimental to the work; the Contractor, when notified, shall immediately cease the use of this method and shall change to curing by one of the other methods specified under this contract.

531.4. Measurement and Payment. Work and materials prescribed herein will not be paid for directly but shall be included in the unit price bid for the items of construction in which these materials are used.

ITEM 540

ROCK RETARDS

540.1. Description. "Rock Retards" shall consist of a course or layer of stones with the spaces between them filled with spalls and selected earth and shall be constructed at such places as shown on the plans or as designated by the Engineer, in accordance with these specifications and in conformity with the lines, grades, depth and other details shown on the pertinent typical sections.

540.2. Material. The stones shall be hard and durable, of uniform quality, free from structural defects, not less than 1/3 cubic foot in volume and shall have a reasonable uniform thickness of not less than 4 inches nor

more than 7 inches. The width of the stones shall not be less than twice their thickness. The spalls shall be of material of similar quality.

Broken concrete pavement or other suitable concrete removed from retards or structures may be used in the construction of retards provided the material so removed meets the requirements specified for stone and provided other provisions are not made in the plans for use of the concrete.

All materials shall be approved by the Engineer prior to use.

540.3. Construction. Prior to placing any material, the excavation for retards shall be made to proper section for the width and depth of the retard. The stones shall be bedded in the trench, one against the other, with the ends in contact. The spaces between the larger pieces shall be filled with spalls of suitable sizes and the smaller interstices then filled with selected earth. All spalls and earth shall be thoroughly rammed into place. The finished surface of the retard shall present an even, tight surface, true to the lines, grades and sections given.

Material excavated from the trench shall be uniformly spread on adjacent areas or otherwise disposed of as directed by the Engineer.

540.4. Measurement. Rock Retards will be measured by the cubic yard, complete in place.

540.5. Payment. The work performed and material furnished as prescribed by this item, and measured as provided under "Measurement", will be paid for at the unit price bid for "Rock Retards", which price will be full compensation for all excavation, furnishing, hauling and placing all material; disposal of excavated material; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 542

GROUTED ROCK RETARDS

542.1. Description. "Grouted Rock Retards" shall consist of approved stones laid in Portland cement mortar, constructed at such places as shown on the plans or as designated by the Engineer, in accordance with these specifications and in conformity with the lines, grades, depth and other details shown on the pertinent typical sections.

542.2. Materials. The stone shall be clean, hard and durable. The individual stones shall not be less than 3 inches in their smallest dimensions and no stones with a volume of less than 0.10 cubic foot shall be used.

Broken concrete pavement or other suitable concrete removed from retards or structures may be used in the construction of retards provided the material so removed meets the requirements specified for stone and provided other provisions are not made in the plans for use of the concrete.

The mortar shall be composed of one part Portland cement and three

parts of clean, hard, durable sand thoroughly mixed with water to a consistency such that it can be easily handled and spread by trowel.

All materials shall be approved by the Engineer prior to use.

542.3. Construction Methods. Prior to placing the stones and mortar, the excavation for retards shall be made to proper section for the width and depth of retard. All stones shall be thoroughly cleaned, wetted, hand placed, and fully embedded in Portland cement mortar so that no two will touch but shall be bound firmly together with mortar. The finished surface shall present a neat, smooth, and workmanlike appearance, with no piece varying more than 1 inch from the grades or lines of the surface of the retard, as shown on the plans.

No mortar work is to be done when the temperature is below 35 F and all work shall be protected from freezing. After completion of the retard, all exposed surfaces shall be covered with burlap or other approved covering and kept wet for a period of 3 days. Membrane curing, in accordance with the requirements of the Item, "Membrane Curing", may be used in lieu of other covering.

Material excavated from the trench shall be uniformly spread on adjacent areas or otherwise disposed of as directed by the Engineer.

542.4. Measurement. Grouted Rock Retards will be measured by the cubic yard, complete in place.

542.5. Payment. The work performed and material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Grouted Rock Retards", which price shall be full compensation for all excavation; furnishing, hauling and placing all materials; disposal of excavated material; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 544

CONCRETE RETARDS

544.1. Description. "Concrete Retards" shall consist of Portland cement concrete retards, constructed at such places as shown on plans or as designated by the Engineer, in accordance with these specifications and in conformity with lines, grades, depth and other details shown on the pertinent typical sections.

544.2. Materials. All concrete materials used in construction under this item shall conform to the requirements of the Item, "Concrete for Structures", except that when indicated on the plans, processed material from the base source, meeting the grading requirements established by the base course specification, may be used. All material shall be approved by the Engineer before being incorporated into the work.

544.3. Construction Methods. Prior to placing the concrete, the excavation for retards shall be made to proper section, and if considered necessary by the Engineer, the bottom of excavation shall be hand tamped and sprinkled. The excavated area for retards shall be moist when the concrete is placed.

Unless otherwise shown on plans, materials and proportions for concrete used in construction under this item shall conform to the requirements as specified for Class "B" concrete under the Item, "Concrete for Structures".

When the plans indicate that the use of base course material as aggregate will be permitted, the proportions of cement and aggregate will be as shown on the plans.

After the concrete has been placed, compacted and shaped to conform to the dimensions of typical sections shown on the plans, and after it has become sufficiently set, it shall be given a moderately rough finish by floating with a wood float.

No mortar or concrete work shall be done when the temperature is below 35 F and all work shall be protected from freezing. After completion of the retard, all exposed surfaces shall be covered with burlap, cotton mats or other approved covering and kept wet for a period of 3 days. White pigmented curing compound conforming to the requirements of the Item, "Membrane Curing", Type 2, will be permitted when applied to all exposed surfaces.

Material excavated from the trench shall be uniformly spread on adjacent areas, or otherwise disposed of as directed by the Engineer.

544.4. Measurement. Concrete Retards will be measured by the cubic yard, complete in place.

544.5. Payment. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Retards", which price shall be full compensation for all excavation; furnishing, hauling and placing all materials required in the construction (including any royalty costs); disposal of excavated material; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 546

CONCRETE FOR STRUCTURE APPROACH SLABS

546.1. Description. This item shall consist of concrete structure approach slabs with reinforcement as shown on the plans, with or without curb as required, with or without slab support as required, constructed as herein specified on an approved subgrade or other base courses in accordance with this specification, in conformity with the thickness, details and typical cross sections shown on the plans and to the lines and grades established by the Engineer.

546.2. Materials. Unless otherwise specified on plans, materials and proportions for concrete used in construction for this item shall conform to the requirements as specified for Class "A" Concrete in the Item, "Concrete for Structures", or concrete as specified in the Item, "Concrete Pavement". Reinforcing steel, if required, shall conform to the requirements as specified in the Item, "Reinforcing Steel" or in the Item, "Concrete Pavement". Expansion-joint filler shall be premoulded material meeting the requirements specified in the Item, "Concrete Structures" or material meeting the requirements specified in the Item, "Concrete Pavement".

546.3. Construction Methods. The subgrade or foundation for the structure approach slab and component parts shall be excavated or shaped to line, grade and cross section and if considered necessary in the opinion of the Engineer, shall be compacted or hand tamped and sprinkled. If dry, the subgrade or foundation material shall be sprinkled lightly immediately before concrete is deposited thereon.

Outside forms shall be wood or metal of a section satisfactory to the Engineer, straight, free of warp, and of a depth equal to or greater than the depth of the specified section. The forms shall be securely staked to line and grade and maintained in a true position during the depositing of concrete. Inside forms for curbs shall be of approved material, shall be of such design to provide the curb required and shall be rigidly attached to the outside forms.

The reinforcing steel shall be placed in positions as shown on typical sections or design details. Care shall be exercised to keep all steel in its proper location.

The concrete shall be mixed, placed, consolidated, cured and finished as specified in the Item, "Concrete for Structures" or as specified in the Item, "Concrete Pavement".

546.4. Measurement. The quantities of concrete which constitute the complete and accepted work will be measured by the cubic yard in place. Only accepted work will be included and the dimensions used for measurement will be those shown on the plans or ordered in writing by the Engineer.

546.5. Payment. Work performed and materials furnished as prescribed by this specification, measured as provided under Measurement, will be paid for at the unit price bid per cubic yard for "Concrete for Structure Approach Slabs" which price shall be full compensation for excavation necessary in preparation of the subgrade, disposal of excavated material, preparation of subgrade; for furnishing, hauling and mixing all concrete materials; for placing, consolidating, curing and finishing all concrete; for all grouting and pointing; for furnishing and placing all drains and expansion joints and for all labor, tools, equipment and incidentals necessary to complete the work including reinforcing steel.

ITEM 550

RIGHT OF WAY MARKERS

550.1. Description. This item shall consist of constructing, installing and/or removing and replacing reinforced concrete right of way markers on right of way lines at points designated on plans or as directed by the Engineer.

550.2. Materials. Right of way markers shall be either precast or cast in place of Class "A" Concrete conforming to the requirements of the Item, "Concrete for Structures".

Reinforcing steel shall conform to the requirements of the Item, "Reinforcing Steel".

The bronze disks where required may be purchased from the Department and charged to the Contractor at a price of $1.52 each unless specified otherwise on plans. Reimbursement to the State will be accomplished by making deductions from the Contractor's estimates for the actual cost of bronze disks purchased. Bronze disks are stored by the Department in warehouses located in Seguin, Athens and Post, Texas.

Every effort will be made to maintain a stock of disks at each location and the disks usually will be shipped from the warehouse nearest to the required destination. However, the right is reserved to ship from either warehouse in case of necessity. Shipments will be made direct to the Contractor at the location designated by the Contractor with transportation charges to be paid by the Consignee. The Contractor shall place his order for disks through the District Engineer. Disks not used which were purchased from the Department may be returned to the District Warehouse upon completion of the contract and credit will be given.

Bronze disks purchased on the open market shall not be used unless they have been inspected and approved by the Engineer. It is the Contractor's responsibility to order bronze disks sufficiently in advance of work to insure delivery of disks meeting the Engineer's inspection requirements.

Markers to be used in "Removing and Replacing Right of Way Markers" shall be obtained in the removal of those existing on the old right of way.

550.3. Construction Methods. Right of way markers shall be cast and finished in accordance with the requirements of the Item, "Concrete Structures", except that a surface finish will not be required for the portion of the markers to be placed below the ground line. The shape and dimensions of the markers and the placement of steel shall be in accordance with details shown on the plans.

Markers shall be installed at designated points to the depth, lines and grades established by the Engineer, and as shown on plans. Backfilling shall be thoroughly tamped in 6-inch layers.

The Contractor will be required to exercise due care in the removal of right of way markers to prevent damage and will be required to replace markers damaged due to his carelessness at his entire expense.

550.4. Measurement. "Right of Way Markers", "Installing Right of Way Markers", or "Removing and Replacing Right of Way Markers", will be measured as each marker, complete in place.

550.5. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Right of Way Markers", of the type specified, which price shall be full compensation for furnishing all materials, all preparation and erection, all hauling, and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

When bids are requested for "Installing Right of Way Markers", satisfactory markers will be furnished the Contractor free of charge at sources indicated on plans for installation at designated points. The work, performed as prescribed by this item, and measured as provided under "Measurement", will be paid for at the unit price bid for "Installing Right of Way Markers", which price shall be full compensation for all hauling and erection, and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

When bids are requested for "Removing and Replacing Right of Way Markers", markers will be removed from the old right of way line and installed at new locations as shown on plans. The work performed as prescribed above, measured as provided under "Measurement" will be paid for at the unit price bid for "Removing and Replacing Right of Way Markers", which price shall be full compensation for the removal of all existing markers as designated on the plans and the installation of such markers at new locations as shown on plans or as directed by the Engineer, which price shall be full compensation for removal, transportation to new locations, installation at new locations, and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 560

METAL BEAM GUARD FENCE

560.1. Description. Metal beam guard fence shall consist of one line of metal beam rail element supported on timber or steel posts. Metal beam guard fence (barrier) shall consist of two or more lines of rail element supported on timber or steel posts. Metal beam guard fence and metal beam guard fence (barrier) shall be constructed of materials and workmanship as prescribed by these specifications, at such places as shown on the plans or as designated by the Engineer, and in conformity with the plans and typical details shown. Where shown on details the rail element shall be blocked-out from the posts with spacers.

560.2. Materials.

(1) Rail Elements. The rail elements shall be of the deep beam type fabricated to develop continuous beam strength and shall consist of metal

plate or sheet formed into a beam not less than 12 inches wide and 3 inches deep as shown in the standard drawing of the plans. The beam shall be free from warp. When tested with a straight edge or string along either edge of a 12-1/2-foot sectional length of beam, the maximum deviation of the beam edges from the straight edge shall not exceed 1/2-inch at any point. The rail elements shall be designed to meet the requirements for the specified class of rail as shown in the following table:

Class	Nominal Thickness (Aluminum) Inches	Minimum Gauge (Steel)	Minimum Tensile Strength of Rail Element and Joint Pounds
A	0.156	10	100,000
B	0.105	12	60,000

Where aluminim rail is used the plate or sheet shall be of the nominal thickness shown above with variations in thickness not exceeding those as outlined in ASTM Designation B 209. Where painted steel rail is used, the plate or sheet shall conform to the requirements of ASTM Designation A 415 for permissible variations in dimensions. The Class A rail shall be of a 10 gauge nominal thickness (0.1345 inches) and the Class B rail shall be 12 gauge (0.1046 inches) with the permissible variations in thickness not exceeding those outlined in Table 3 of ASTM Designation A 415. Where the rail element is galvanized after fabrication in accordance with ASTM Designation A 123 as modified below, the plate or sheet shall conform to the requirements outlined above for painted steel rail. Where the rail element is galvanized before fabrication in accordance with the requirements of ASTM Designation A 525 the plate or sheet shall conform to the requirements of ASTM Designation A 525 and the galvanized sheet for Class A shall have a mean thickness of 0.1382 inches and the galvanized sheet for Class B shall have a mean thickness of 0.1084 inches with the permissible variations in thickness as outlined in Table A 2 of ASTM Designation: A 525.

The rail elements may be either aluminum, painted steel or galvanized steel, unless one is specifically required by the plans, and shall meet one of the following requirements:

Aluminum Rail. The rail element shall be aluminum alloy AA Alloy Alclad 2024 or ASTM Alloy Clad CG42A sheet, temper T3 conforming to ASTM Designation: B 209.

The terminal sections shall be aluminum alloy AA Alloy Alclad 2024 or ASTM Alloy Clad CG42A sheet, temper T42 conforming to ASTM Designation: B 209.

Painted Steel Rail. The rail element and terminal section shall be formed from open-hearth, electric-furnace or basic oxygen steel and painted in accordance with the Item, "Paint and Painting" and pertinent special provisions thereto. A test specimen of the rail material shall elongate not less than 12 percent in a 2-inch gauge length.

Galvanized Steel Rail. The rail element and terminal section shall be formed from open-hearth, electric-furnace or basic oxygen steel and a test specimen of the rail material shall elongate not less than 12 percent in a 2-inch gauge length.

Unless otherwise shown on plans or specified elsewhere the rail element may be galvanized before or after fabrication in accordance with the requirements of ASTM Designation A 123 or ASTM Designation A 525 whichever is applicable, except that the rail element shall have a minimum coating class of 2.50 ounces per square foot of double exposed surface in accordance with the requirements of ASTM Designation A 525.

Steel rail elements shall contain not more than 0.04 percent phosphorous nor more than 0.05 percent sulphur.

(2) Posts. The posts shall be either timber or steel as indicated on the plans and shall meet one of the following requirements:

Timber Posts. Timber posts and spacers where required shall be Southern Yellow Pine. All posts shall be round. Posts shall not be less, in any place, than 7 inches in diameter. The diameter shall be determined by means of a circumference-diameter tape. The average diameter at the base of the dome shall not exceed the specified diameter by more than 1-inch. The diameter at the butt of any post shall not exceed the diameter at the base of the dome of that post by more than 1-inch. The supplier shall stencil in the butt of each post the nominal diameter of the top (7"). The stenciled numeral shall be one (1) inch high. The length of the posts shall not vary more than one inch from the specified length. They shall be of the length shown on the plans; the bottom and the top shall be fabricated as shown on plans.

For domed posts, the dome shall be approximately hemispherical in shape and the radius of the dome of each post shall be one-half the diameter of the posts at the base of the domed portion. The dome shall be smooth and the distance from the top of the dome to the base of the dome shall not vary more than 1-inch at any location. For beveled posts, no posts will be accepted with less than 10° bevel. A tolerance of $+5^{\circ}$ will be permitted. The posts shall be machine peeled and trimmed of all knots and knobs and shall be straight and smooth. The posts, and spacers where required, shall be sound and free from defects such as injurious ring shakes, unsound or loose knots, or other defects which might impair their strength and durability. Sound knots will be permitted provided they are not in clusters and they do not exceed one-third of the small diameter or least dimensions. Any defect or combination of defects which would be more injurious than the maximum allowable knot will not be permitted. A line drawn from the center of each end of the post shall not fall outside the center of the post at any point more than 1-1/4-inches.

All timber posts, and spacers where required, shall be bored and cut to dimensions shown on plans before being treated. They shall be treated with 0.4 lbs./cu. ft. dry pentachlorophenol treatment by assay in accordance with the Item, "Timber Preservative and Treatment". Posts, and spacers where required, shall be painted with two coats of good quality aluminum paint after the guard fence is erected unless specified otherwise on the plans.

When specified on the plans, timber posts for this item will be furnished free of charge to the Contractor by the Texas Highway Department at locations shown on the plans. Such posts shall not be subject to the above requirements, but shall meet requirements as directed by the Engineer. Posts furnished and not bored shall be bored by the Contractor. Unless specified otherwise on plans, posts shall be painted with two coats of good quality aluminum paint after the guard fence is erected.

Steel Posts. Steel posts and spacers where required shall be of the rolled sections as shown on the plans. The posts and spacers where required shall be structural steel conforming to the requirements of ASTM Designation A 36. The top of all posts shall be beveled, or square as required by detail and drilled or punched for bolts for rail attachments.

Steel posts and spacers where required used with painted steel rail shall be painted in accordance with the Item, "Paint and Painting".

Steel posts and spacers where required used with aluminum or galvanized steel rail shall be galvanized and shall conform to the requirements of ASTM Designation A 123.

(3) Fittings. Fittings shall consist of bolts, nuts and washers and shall conform to the details given on the designated standard plan and shall comply with the requirements as specified herein.

All bolts and nuts used with aluminum rail shall be as follows:

Bolts shall be aluminum alloy 2024-T4 with Alumilite finish or equal, and shall be made from rod conforming to ASTM Designation: B 211, Alloy CG42A, and shall be supplied in the T4 temper. Nuts shall be aluminum alloy 6061-T6 made from rod conforming to ASTM Designation: B 211, Alloy GS11A, condition T6.

All bolts and nuts used with painted or galvanized steel rail shall be made by either the open-hearth or electric-furnace process and shall conform to the requirements of ASTM Designation: A 307. They shall be hot-dip galvanized to conform to ASTM Designation: A 153.

Unless specified otherwise on plans, the concrete for terminal anchor posts or for embedment of other posts in concrete, where required, shall meet the requirements for Class "A" Concrete, as specified in the Item, "Concrete for Structures" and subsequent Special Provisions thereto. The rail element for the terminal anchor section shall be of the same materials as the rail element used throughout the project.

560.3. Sampling and Testing. A sample of the rail and terminal section may be taken for each project or for each shipment to a project. Samples of bolts and nuts may also be required. All samples shall be furnished to the Texas Highway Department free of charge. The plate or sheet shall be sampled and tested in accordance with the requirements of ASTM Designation: E 8. For galvanized articles the weight of coating shall be determined by stripping in accordance with ASTM Designation: A 90.

The uniformity of the zinc coating shall be determined by visual inspection. If, in the opinion of the Engineer, visual examination is not

conclusive, the Preece Test as described in ASTM Designation: A 239 shall be made. When so tested, all items designated in ASTM Designation: A 153 as Class B-2, B-3, C and D shall withstand a minimum of 4 one-minute dips; all other items shall withstand a minimum of 6 one-minute dips.

560.4. Construction Methods. The posts shall be set plumb and firm to the line and grade shown on the plans. Unless the plans call for setting in concrete, the posts shall be backfilled by thoroughly tamping the material in 4-inch layers. The rail elements shall be erected to produce a smooth, continuous rail paralleling the line and grade of the roadway surface or as shown on the plans. The rail elements shall be joined end to end by bolts and lapped in the direction of traffic in the lane adjoining the guard fence. When designated on the plans, the rail elements shall be curved before erection. Holes for special details may be field-drilled or punched, when approved by the Engineer.

Driving will be an acceptable method of attaining the established line and grade for posts. A structural steel driving head suitable for the type and size of post being driven shall be used. Wood cushion blocks shall be used as necessary to prevent damage to the post. Rope mat, belting, or other similar cushioning material may be used in addition to wood cushion blocks. Before driving posts, the ground adjacent to the post shall be excavated to a depth of 6 inches below finished shoulder grade, and after placing, each post shall be painted, where required by the plans, from 6 inches below the ground surface to 2 inches above, with one brush-coat application of hot asphalt, finished to a neat line at the top. Pilot holes may be required or permitted. The size and depth shall be determined by the Contractor with the approval of the Engineer based on results of trial operations of the first few posts driven. Loosened soil around the post shall be thoroughly tamped and any void between the soil and the post resulting from the driving shall be filled with suitable material and thoroughly compacted as directed by the Engineer.

Where posts are driven the driving may be performed with power hammers (steam, compressed air or diesel) or gravity hammers approved by the Engineer.

After erection, all parts of painted steel posts, and spacers where required, and rail elements on which the primer coat has becomed scratched or chipped shall be thoroughly cleaned and spot painted in accordance with the Item, "Paint and Painting."

After erection, all parts of galvanized steel posts, spacers where required, washers, bolts, and rail elements on which the galvanizing has become scratched, chipped or otherwise damaged shall be thoroughly cleaned by wire brushing the damaged area to remove all loose, cracked or bruised spelter coating. The cleaned area shall be painted with two coats of zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641b or shall be repaired by application of galvanizing repair compounds meeting Federal Specification 0-G-93 (Stick only) in accordance with the manufacturer's recommendations.

Where fabrication is done after galvanizing and **where required by plans** the cut edges and bolt holes shall be cleaned by brushing and the cleaned area

shall be painted with two coats of zinc dust-zinc oxide paint conforming to the requirements of the Federal Specification TT-P-641b or shall be repaired by application of galvanizing repair compounds meeting Federal Specification 0-G-93 (Stick only) in accordance with the manufacturer's recommendations.

No painting of aluminum or galvanized steel rail members will be required.

560.5. Measurement. This item will be measured by the linear foot of fence, complete in place, measurement being made upon the face of the rail in place, from center to center of end posts, from terminal-anchor sections, or, in the case of structure-railing connection, from the points shown on the plans except as follows: Where bids are requested for "Terminal-Anchor Sections", measurement will be made as each section, complete in place, each section consisting of a terminal-anchor post and one 25-foot rail element, as shown on the plans.

560.6. Payment. The work performed and material furnished as prescribed by this Item, measured as provided under "Measurement", will be paid for at the unit price bid for "Metal Beam Guard Fence", "Metal Beam Guard Fence (Barrier)", "Metal Beam Guard Fence (Barrier) (Blockout)", "Metal Beam Guard Fence (Blockout)", of the class specified or for "Aluminum Beam Guard Fence", "Aluminum Beam Guard Fence (Barrier)", "Aluminum Beam Guard Fence (Barrier) (Blockout)", "Aluminum Beam Guard Fence (Blockout)", "Painted Steel Beam Guard Fence", "Painted Steel Beam Guard Fence (Barrier)", "Painted Steel Beam Guard Fence (Barrier) (Blockout)", "Painted Steel Beam Guard Fence (Blockout)", "Galvanized Steel Beam Guard Fence", or "Galvanized Steel Beam Guard Fence (Barrier)", "Galvanized Steel Beam Guard Fence (Barrier) (Blockout)", or "Galvanized Steel Beam Guard Fence (Blockout)", of the class specified which price shall each be full compensation for furnishing all materials, except timber for all posts furnished by the Texas Highway Department, including necessary boring for preparation, hauling and erection and painting of same; for setting posts in concrete when specified, and spacers where required and for all labor, tools, equipment and incidentals necessary to complete the work, including driving posts, excavating, backfilling and disposing of surplus material.

When bids are requested for "Terminal Anchor Section", measured as provided under "Measurement", payment will be made at the unit price bid for "Terminal Anchor Section" which shall be full compensation for furnishing the turn down rail element, anchor assembly, terminal anchor post, foundations and for all labor, tools, equipment and incidentals necessary to complete the work including excavation, backfilling and disposal of surplus materials.

ITEM 561

REMOVING METAL BEAM GUARD FENCE

561.1. Description. "Removing Metal Beam Guard Fence" shall consist of the removal of existing metal beam guard fence and its storage at locations shown on plans or as directed by the Engineer.

561.2. Construction Methods. All rail elements shall be carefully removed in original lengths and neatly stacked. All fittings shall be removed from the posts and the metal rail. The posts shall then be loosened and pulled. Removal of all materials shall be performed in such manner that they will not be marred or damaged.

Posts which are set in concrete may be cut off 1 foot below new subgrade elevation and the concrete and bottom of post left in place. Any concrete less than 1 foot below subgrade shall be removed.

Eyebolts anchored to deadmen need not be removed but may be cut off or bent down at an elevation at least 1 foot below subgrade elevation and left in place along with the deadman.

All materials thus removed and salvaged shall be neatly stored at designated sites or disposed of as directed by the Engineer.

The Contractor will not be required to haul the salvaged material beyond the limits of the project.

561.3. Measurement. Removing Metal Beam Guard Fence will be measured by the linear foot. Measurement will be made upon the face of the fence in its original position from center to center of end posts.

561.4. Payment. The work performed as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Removing Metal Beam Guard Fence", which price shall be full compensation for removing all materials, loading, hauling, unloading, and satisfactorily storing; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 562

REMOVING AND REPLACING METAL BEAM GUARD FENCE

562.1. Description. "Removing and Replacing Metal Beam Guard Fence" shall consist of the removal of existing metal beam guard fence and replacing same on finished roadway at locations indicated on the plans in accordance with these specifications and the details shown on the plans, or as directed by the Engineer.

562.2. Construction Methods. All rail elements shall be carefully removed in original lengths and neatly stacked. All fittings shall be removed from the posts and the metal rail. The posts shall then be loosened and pulled. Removal of all materials shall be performed in such manner that they will not be marred or damaged. Any materials scarred, battered or broken by the Contractor or not suitable for reuse shall be replaced at his own expense to result in the same length of installed fence as that removed or specified in plans.

Posts that are set in concrete may be cut off 1 foot below new subgrade elevation and the concrete and bottom of post left in place. Any concrete less than 1 foot below subgrade shall be removed.

Eyebolts anchored to deadmen need not be removed but may be cut off or bent down at an elevation at least 1 foot below subgrade elevation and left in place along with the deadman.

All materials thus removed and salvaged shall be neatly stored at sites within the right of way as designated by the Engineer, until such time as it is replaced in its new location. Replacing metal beam guard fence shall be done in accordance with the construction methods of the Item, "Metal Beam Guard Fence".

562.3. Measurement. "Removing and Replacing Metal Beam Guard Fence" will be measured upon the face of the rail from center to center of end posts by the linear foot of replaced fence in its new location, complete in place unless shown otherwise on plans.

562.4. Payment. The work performed as provided under "Measurement", will be paid for at the unit price bid for "Removing and Replacing Metal Beam Guard Fence" of the type specified on the plans, which price shall be full compensation for furnishing all materials, including replacing damaged material and additional material as may be required to complete the work, labor, tools, equipment and incidentals necessary to complete the work and for furnishing and applying all paint, all preparation, hauling and installation of same, and for all excavation, backfilling and disposal of surplus material.

ITEM 565

REMOVING TIMBER POST GUARD FENCE

565.1. Description. "Removing Timber Post Guard Fence" shall consist of the removing of existing guard fence posts that have been placed on the road and the stockpiling of these posts at a designated location within the limits of the project.

565.2. Construction Methods. Guard fence posts shall be loosened and pulled. The removal of these posts shall be performed in such manner that they will not be marred or damaged. All posts shall be cleaned and neatly stored at designated sites as directed by the Engineer. The storage sites will be within the limits of the project.

565.3. Measurement. "Removing Timber Post Guard Fence" will be measured as each individual post to be removed.

565.4. Payment. The work performed as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Removing Timber Post Guard Fence", which price shall be full compensation for removing and cleaning the existing posts, hauling and stockpiling, and for all labor, tools, equipment and incidentals necessary to complete the work.

ITEM 566

REMOVING AND REPLACING TIMBER POST GUARD FENCE

566.1. Description. "Removing and Replacing Timber Post Guard Fence" shall consist of the removal of existing timber guard fence posts and replacing same on finished roadway at locations indicated on the plans in accordance with these specifications and the details shown on the plans, or as directed by the Engineer.

566.2. Constuction Methods. Existing posts shall be removed in such a manner that they will not be damaged and shall be carefully placed in neat piles along the right of way so as not to interfere with traffic or construction until ready for replacement. Any posts scarred, battered or broken by the Contractor shall be replaced at his own expense.

Posts shall be placed at locations shown on the plans or as directed by the Engineer. Posts shall be placed in the manner indicated on Guard Fence Standard in the plans. The posts shall be set plumb and firm to the line and grade shown on the plans. Backfilling shall be thoroughly tamped in 4-inch layers.

All timber posts shall be thoroughly cleaned of all dirt and other foreign matter and after erection that portion of the post above the ground line shall be painted with one coat of aluminum paint following which a 6-inch band of black paint shall be painted 8 inches below the top of the post. The material for painting shall be a good quality paint that will produce a neat and workmanlike job satisfactory to the Engineer.

566.3. Measurement. "Removing and Replacing Timber Post Guard Fence" will be measured as each post, complete in place.

566.4. Payment. The work performed as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Removing and Replacing Timber Post Guard Fence", which price shall be full compensation for furnishing all labor, tools, equipment and incidentals necessary to complete the work, and for furnishing and applying all paint, all preparation, hauling and installation of same, and for all excavation, backfilling and disposal of surplus material.

ITEM 567

WIRE FENCE

567.1. Description. "Wire Fence" shall consist of constructing one line of fence supported on metal or wood posts in accordance with the details and at the locations shown on the plans. The fence shall consist of barbed wire or a combination of woven fence fabric and barbed wire as specified on the plans.

567.2. Materials.

(1) Metal Posts and Braces. Steel pipe used for posts and braces shall conform to the specifications of ASTM Designation: A 120. Steel sections used for posts and braces shall be a good commercial quality weldable steel. All material shall be new and no used, rerolled or open seam material will be acceptable. All posts and braces shall meet the weight and length requirements shown on the plans. Galvanized steel sections shall conform to ASTM Designation: A 123. All posts and braces, except galvanized products, shall be painted with an approved anti-corrosive paint and after installation all areas where the paint coat has been damaged shall be spot-coated with paint of the same color as the shop coat. No other painting will be required. All fittings required for posts and braces shall be pressed or rolled steel, forged steel, malleable iron or wrought iron of good commercial quality and shall conform to the details shown on the plans.

(a) Metal Line Posts, Pull Posts and Braces for Pull Posts. Metal posts and braces shall be "H" column, tubular or any other approved shape and shall be properly adapted to provide means for attaching the fencing to the posts in a manner that will not damage the posts nor fencing material. Metal line posts, pull posts and braces for pull posts shall each be of the weight and dimensions shown on the plans. Line posts shall be provided with tapered anchor plates securely attached thereto. The anchor plates shall be of the area, size and weight shown on the plans. The anchor plate may be omitted provided the post is set in a concrete footing as shown on the plans.

(b) Metal Corner, End and Gate Posts. Metal corner, end and gate posts and braces shall be any one of the shapes specified for line posts. Metal posts shall each be of the weight and dimensions shown on the plans.

(2) Untreated Wood Posts and Braces. Untreated wood posts and braces shall be pine, cedar or mesquite of the length and size shown on the plans and shall be cut from sound timber. Posts shall have a minimum diameter as indicated on the plans and shall be approximately round, shall be trimmed of all knots and knobs and shall be straight and relatively smooth. The posts shall be free from defects such as injurious ring shakes, unsound or loose knots, splits or other defects that might impair their strength and durability. Sound knots will be permitted provided they are not in clusters and do not exceed one-third of the small diameter or least dimension of the posts. A line drawn from the center of each end of the post shall not fall outside the center of the post at any point more than 2 inches.

Braces shall be similar to the regular posts and shall be notched in place. Other types of braces, equal in strength and durability, may be used when approved by the Engineer.

(3) Treated Wood Posts and Braces. Treated wood posts and braces shall be pine or fir timber of the size and dimensions shown on the plans. The timber shall be sound and free from all decay, shakes, splits or any other defects which would weaken the posts or braces or otherwise make them structurally unsuitable for the purposes intended.

The posts and braces shall be round, square or sawed rectangular shape. The slope of grain in sawed, square or rectangular posts for the full length shall not exceed one in ten and knots shall be sound, tight, well spaced and shall not exceed one-third of the small diameter or least dimension of the post. A line drawn from the center of each end of the post shall not fall outside the center of the post at any point more than 2 inches. All posts shall have a creosote oil or pentachlorophenol treatment of not less than 8 pounds per cubic foot as specified in the Item, "Timber Preservative and Treatment". Posts shall be inspected at time of treatment. Round posts and braces shall be peeled to remove all outer bark and all inner cambium bark, except that occasional strips of bark may remain if not over 1/2-inch wide or over 3 inches long. All knots shall be trimmed flush with the sides, spurs and splinters removed and the ends cut square. The allowable taper from end to end of round posts and braces shall not exceed 1-1/2-inches.

(4) Gates and Gate Posts. Gates and gate posts shall be of the materials and to the dimensions detailed on the plans.

(5) Barbed Wire. Barbed wire shall conform to ASTM Designation: A 121, Class 1. The barbed wire shall consist of two strands of 12-1/2-gauge wire, twisted with two-point 14-gauge barbs spaced not more than 5 inches apart, or may be as specified on the plans for high tensile wire.

(6) Wire Mesh. Wire mesh fabric shall conform to ASTM Designation: A 116, Class 1. The wire mesh shall be of the height and design shown on the plans. The top and bottom wires shall be 10-gauge minimum and the intermediate wires and vertical stays shall be 12-1/2-gauge minimum.

567.3. Miscellaneous. Galvanized bolts and nuts for attaching braces and straps to metal posts and suitable galvanized devices for holding barbed wire and wire mesh firmly in position shall be of good commercial quality and design.

Staples used to secure barbed wire and wire mesh fabric to wood posts shall be not less than 1-1/2-inches long and the wire from which they are made shall be galvanized as specified in Subarticle 567.2.(5), "Barbed Wire".

567.4. Construction Methods. Fence posts shall be spaced at the intervals and set to the depth shown on the plans. Posts shall be set in a vertical position. Corner and pull posts shall be braced in two directions. End and gate posts shall be braced in one direction. Where alignment changes 30-degrees or more, a corner post shall be installed. At alignment angles varying from 15 to less than 30-degrees, the angle post shall be braced to adjacent line posts by diagonal tension wires. Where steel posts are specified, a pull post assembly shall be installed at approximately 500-foot intervals and where wood posts are specified the spacing of pull post assemblies shall be approximately 1000-feet, unless otherwise shown on the plans. Metal line posts may be driven in place providing such driving does not damage the posts. Metal corner, end, pull posts and braces shall be set in Portland cement concrete footings crowned at the top to shed water. All posts shall be placed the minimum depth below ground as shown on the plans or as directed by the Engineer. Posts shall be set plumb and firm to the line and grade shown on

the plans. Backfilling shall be thoroughly tamped in 4-inch layers. The timber post braces shall be notched as shown on plans.

The corner, end or angle post assembly shall be installed before stretching the wire between line posts. At all grade depressions where stresses tend to pull the posts out of the ground, the fencing shall be snubbed or guyed at the critical point by means of a double 9-gauge galvanized wire connected to each horizontal line of barbed wire or to the top and bottom wire or wire mesh fabric, and to a deadman weighing not less than 100 pounds, buried in the ground as shown on plans. The fencing shall be stretched before being snubbed and guyed. Existing cross-fences shall be connected to the new fences and corner posts with braces which shall be placed at junctions with existing fences. The barbed wire and wire fabric shall be drawn taut and fastened to posts with galvanized ties or staples as specified on the plans.

567.5. Measurement. Fencing shall be measured by the linear foot of wire fence, measured at the bottom of the fabric along the centerline of the fence from center to center of end posts, excluding gates. Gates will be measured as each gate, complete in place.

567.6. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Wire Fence" of the type shown on the plans, which price shall each be full compensation for furnishing and installing all fencing materials (except gates); for all preparation, hauling and installing of same; and for all labor, tools, equipment and incidentals necessary to complete the work, including excavation, backfilling and disposal of surplus material.

Gates measured as provided under "Measurement" will be paid for at the unit price bid for "Gate" of the type, height and opening shown on the plans, which price shall be full compensation for furnishing all materials; for fabricating; for all preparation, hauling and erection; for all labor, tools, equipment and incidentals necessary for a complete in-place gate installation.

ITEM 568

CHAIN LINK BARRIER FENCE

568.1. Description. This item shall consist of one line of chain link fabric supported on posts and constructed of material and workmanship as prescribed by this specification at such places as shown on the plans or as designated by the Engineer and in accordance with the plans and typical details shown.

568.2. Materials. All materials shall meet the requirements as indicated below:

(1) Fabric. Fabric and appurtenances shall meet the following requirements.

(a) The fabric width shall be as shown on the plans. The overall height of the fence when erected, shall be the height above grade as shown on the plans or typical details. The fabric shall be woven into an approximately 2-inch mesh such that in a vertical dimension of 23-inches along the diagonals of the openings there shall be at least seven meshes. The fabric shall have a twisted and barbed finish for the top and bottom selvages. The barbing shall be done by cutting the wire on a bias thus creating sharp points. The wire in the fabric shall withstand a minimum tensile strength test of 75,000 pounds per square inch after galvanizing. Except as provided herein the chain link fence fabric shall conform to the specifications of ASTM Designation: A 392, Class II. The wire in the fabric shall be of the gauge specified on the plans.

(b) Between posts, the fabric shall be fastened to a top and bottom tension wire by steel wire ties of the gauge and spacing shown on the plans. The tension wire shall be at least 7-gauge galvanized coil spring steel of good commercial quality.

(2) Posts, Braces and Gates. Steel pipe used for posts, braces and gate frames shall conform to the specifications of ASTM Designation: A 120. Steel sections used for posts, frames and braces shall be a good commercial quality weldable steel. All material shall be new and no used, rerolled or open seam material will be acceptable. All posts shall meet the weight and length requirements shown on the plans. The fabric bands and steel wire ties shall conform to the gauge and spacing as shown on the plans and shall be of suitable design to fasten fabric to the posts. Steel wire ties of the gauge shown may be used in lieu of fabric bands. All fittings required for posts shall be pressed or rolled steel, forged steel, malleable iron or wrought iron of good commercial quality and spaced as shown on the plans.

(a) Line Posts. Line posts may be either H-column, T-section or tubular. Tubular line posts shall be fitted with watertight malleable iron caps.

(b) Terminal Posts. All end, corner and pull posts shall be known as terminal posts and shall be of either round or square sections. All terminal posts shall be furnished with watertight malleable iron caps. Fabric shall be fastened to terminal posts by steel stretcher bars and stretcher bar bands fitted with carriage bolts and nuts of the size and spacing shown on the plans.

(c) Gate Posts. Gate posts shall be either round or square. All gate posts shall be furnished with watertight malleable iron caps. The fabric shall be attached to the gate posts by means of steel stretcher bars and stretcher bar bands fitted with carriage bolts and nuts of the size and spacing shown on the plans.

(d) Gates. The gate frames shall be fabricated from sections either round or square of the size and weight specified on the plans and shall be filled out with the same type fabric specified for the chain link fence. All gates shall be equipped with approved malleable iron or steel latches, stops and center rest. A satisfactory locking device suitable for padlocking shall be provided. The gates shall be hung by at least two steel or malleable iron hinges securely fastened to the posts. Hinges shall not twist or turn under the action of the gate, shall be capable of allowing a full 180-degree opening turn,

shall be so arranged that a closed gate cannot be lifted off the hinges to obtain entry, and shall be easily operated by one person. All gates shall be equipped with a positive stop which will not permit any portion of the gate to swing over an adjacent traffic lane and shall provide a positive means of maintaining the gate in a closed position.

(e) Braces. All braces shall be of the size, weight and length specified on the plans. Single braces shall be used on fences 4-feet or less in height and double braces on fences over 4-feet high. All braces shall be trussed with rods and turnbuckles of the dimensions shown on the plans. Braces shall be installed on all terminal posts and shall extend to the adjacent line posts. All corner and pull posts shall have braces on each side of terminal.

568.3. Galvanizing. All materials used in "Chain Link Barrier Fence" shall be hot dip galvanized to meet the following requirements. The zinc used for the coating shall conform to ASTM Designation: B 6 and shall be at least equal to the grade designated as "Prime Western". Unless otherwise specified, all materials shall have a zinc coating of not less than 2-ounces per square foot of the actual surface. The weight of coating shall be determined in conformance with ASTM Designation: A 90.

(1) Fabric. The fabric shall be hot dip galvanized after weaving to conform to ASTM Designation: A 392, Class II.

(2) Posts, Braces and Gates. All posts, braces, frames and gates shall be hot dip galvanized inside and outside in conformance with ASTM Designation: A 123.

(3) Fittings, Bolts and Other Miscellaneous Hardware. All fittings, bolts and miscellaneous hardware shall be hot dip galvanized in conformance with ASTM Designation: A 153.

(4) Tension Wire. Tension wire shall have a minimum coating of 0.8-ounces per square foot of uncoated surface when tested in conformance with ASTM Designation: A 116.

The uniformity of the zinc coating shall be determined by visual inspection. If, in the opinion of the Engineer, visual examination is not conclusive, he may use the Preece Test as described in ASTM Designation: A 239. When so tested, all items shall withstand a minimum of 6 one-minute dips except for those items designated in ASTM Designation: A 153 as Class B-2, B-3, C and D which shall withstand a minimum of 4 one-minute dips.

Careful visual inspection shall be made to determine the quality of the zinc coating. Excessive roughness, blisters, salammoniac spots, bruises and flaking if present to any considerable extent, shall provide a basis for rejection. Where practicable, all inspection and tests shall be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the progress of the work.

Damaged spelter coating shall be repaired by thoroughly wire brushing the damaged area and removing all loose, cracked or weld-burned spelter coating. The cleaned area shall be painted with two coats of zinc oxide-zinc

dust paint conforming to the requirements of Federal Specification TT-P-641B or approved equal. The paint shall be furnished by the Contractor at his expense.

568.4. Inspection and Sampling. The Contractor shall furnish, upon request of the Engineer, samples of each component part of the fence including fittings. These samples shall be subjected to the galvanizing, weight, and where required, strength tests. A sample may be taken for each project or for each shipment to a project, when requested by the Engineer. All samples shall be furnished to the Department free of charge.

If any specimen tested fails to meet the requirements of this specification, two additional specimens shall be cut from the remainder of the sample and tested, both of which shall meet the requirements in every respect or the lot represented by the sample may be rejected.

568.5. Construction Methods. The Chain Link Barrier Fence shall be erected to lines and grades established by the Engineer in accordance with the details shown on the plans. The fence shall be true to line, taut and shall comply with the best practice for fence construction of this type.

(1) Erection of Posts. Posts shall be set plumb and permanently positioned and anchorages firmly set before fabric is placed. Posts shall be set in Class "B" Concrete, unless otherwise specified on the plans. Concrete and equipment therefor shall conform to the requirements of the Item, "Concrete for Structures." Hand mixing of concrete will be permitted on batches under 1/2 cubic yard. All batches exceeding this volume shall be machine mixed.

Concrete footings shall be carried down to at least the depth, and shall be not less than the dimensions shown on the plans. Where rock is encountered within the required depth to which the post is to be erected, a hole of a diameter slightly larger than the largest dimension of the post may be drilled into the rock and the post grouted in. The regular dimensioned concrete footing as shown on plans shall then be placed between the top of the rock and required grade shown on the plans. Posts shall be approximately centered in their footings. All concrete shall be placed promptly and compacted by tamping or other approved methods.

If the ground is firm enough to permit excavation of the post hole to neat lines, the concrete may be placed without forms by completely filling the hole. Under these conditions the earth coming in contact with the concrete shall be moistened to a depth of at least 2 inches prior to placing concrete. No curing will be required other than covering concrete with not less than 4 inches of loose moist material, free of clods and gravel, immediately after placing concrete.

Where the ground cannot be satisfactorily excavated to neat lines, forms must be used for footings. Under these conditions, when the soil is not moist, not less than 1 gallon of water shall be poured into each hole and as soon as this water has been absorbed, the concrete shall be placed. Not later than 24 hours after the concrete has been placed, the forms shall be removed. As soon as each form is removed, the footing shall be backfilled, with moistened material, and thoroughly tamped. The top of the concrete shall then be

covered with not less than 4 inches of loose moistened material. All excess material from footings, including loose material used for curing, shall be disposed of in a manner satisfactory to the Engineer.

Pull posts shall be placed not over 500 feet apart in straight runs and at each vertical angle point, all as directed by the Engineer. Corner posts shall be placed at each horizontal angle point. Corner and pull posts shall have horizontal braces and tie rods as specified above and as indicated on the plans.

(2) Erection of Fabric. After all posts have been permanently positioned and anchorages firmly set, the fabric shall be placed by securing one end and applying sufficient tension to the other to remove all slack before making attachments. Fabric shall be fastened as shown on the plans and the bottom of the fabric shall be placed a normal distance of 2 inches above the ground line; however, over irregular ground this distance may vary between 1 inch and 6 inches for a distance not to exceed 8 feet. Any necessary backfilling required, in order to comply with these provisions, will be considered as incidental work.

(3) Electrical Grounds. The fence shall be grounded where a power line passes over the fence. The ground shall consist of a copperweld rod 8 feet long and a minimum of 5/8-inch in diameter driven, or drilled in, vertically until the top of the rod is approximately 6 inches below the top of the ground. A No. 6 solid copper conductor shall be brazed to the rod and to the fence in such a manner that each element of the fence is grounded.

A ground shall be placed at not to exceed 1000 feet apart in straight runs. Each section of fence shall have at least one ground.

568.6. Measurement. Chain Link Barrier Fence, of each height specified will be measured by the linear foot of fence measured at the bottom of the fabric along the centerline of fence from center to center of terminal posts, excluding gates. Gates will be measured as each gate, complete in place.

568.7. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Chain Link Barrier Fence" of the height specified which price shall each be full compensation for furnishing and installing all fencing materials (except gates) including all miscellaneous fittings, braces, post caps, line wires, connection clips or wires; digging post holes and grouting in rock where required; furnishing and placing concrete for setting posts; furnishing and installing all electrical grounds; all hauling and handling charges; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work, including excavation, backfilling and disposal of surplus material.

Gates measured as provided under "Measurement" will be paid for at the unit price bid for "Pedestrian Gate" or Vehicular Gate", of the type, height and opening specified which price shall each be full compensation for furnishing all materials; fabricating, preparation, hauling, handling charges and erecting, including all miscellaneous fittings, braces, latches, gate hinges, stops and center anchorage; and for all manipulations, labor, tools, equipment and incidentals necessary for complete installation.

ITEM 570

METAL SERIES RAILROAD CROSSING SIGNS

570.1. Description. This item shall consist of furnishing and installing two series of reflectorized railroad signs which together shall comprise the standard "Metal Series Railroad Crossing Signs".

570.2. Materials.

(1) Metal for Sign Blanks. The metal, in addition to being of the type required by the plans, shall meet all requirements of the latest revision of the American Railroad Signal Specifications covering composition, quality, treatment, coatings and painting of metals for signs.

(a) Sheet steel sign blanks shall be 12-gauge.

(b) Sheet aluminum sign blanks shall be a minimum of 0.080-inches in thickness.

(c) Extruded aluminum sign blanks shall be a minimum of 0.109-inches in thickness.

(2) Reflex-Reflecting Material. Reflex-reflecting material used shall be such that the completed sign shall comply with the requirements of the latest revision of the Association of American Railroad Signal Specifications.

(3) Masts, Adapters, Clamps, Pinnacles and Break-away Bases. Material, construction, treatment and coating of all masts, adapter clamps and pinnacles shall comply with all requirements of the latest revision of the American Railroad Signal Specification. Break-away base assembly connections shall be constructed, galvanized and placed in accordance with the plan details.

(4) Concrete Bases for Crossbuck Signs. All concrete shall be Class "A". Materials, methods of construction and workmanship shall be in accordance with the Item, "Concrete for Structures". The exposed surface of the concrete shall be steel trowel finished.

570.3. Construction Methods. Crossbuck signs shall be assembled and installed complete in place at the location shown on the plans, or as altered by the Engineer. Installed signs shall comply with all applicable requirements of the American Railroad Signal Specifications. Concrete for bases shall be poured in holes excavated to neat lines. Following sign installation, any existing railroad or highway crossing signs in place near the crossing prior to installation of the new signs shall be removed and stored for the Texas Highway Department on highway right of way.

570.4. Measurement. Measurement will be made of each complete unit of "Metal Series Railroad Crossing Signs". Each series of signs shall be complete with pinnacle, adapter clamp, concrete base and all bolts, nuts, paint and painting and incidentals necessary for the complete sign series, installed as specified herein and shown on the plans.

570.5. Payment. Work performed and materials furnished as prescribed by this item, measured as prescribed under "Measurement" will be paid for at the unit price bid for "Metal Series Railroad Crossing Signs" which price shall be full compensation for furnishing all materials, equipment, labor, tools, transportation and incidentals necessary to complete the work.

ITEM 575

EPOXY ADHESIVE

575.1. General. This item consists of furnishing and applying four basic types of epoxy adhesive designed to bond ceramic, glass or plastic traffic markers to roadway and bridge surfaces. Those adhesives designated as Types I through IV are intended for hand mixing and application. On projects where the adhesive is to be handled by automatic metering, mixing and application equipment, Types I-M through IV-M, which are designed specifically for machine application, shall be used. Each adhesive shall be furnished in two components, herein referred to as the epoxy-resin component and the hardener component, the two components to be mixed immediately prior to use.

The type of adhesive to be used on a specific project shall be designated by the Engineer based upon the setting time required under the prevailing weather and traffic conditions. The various types of adhesives are as follows:

Type I and I-M:	Rapid Setting Marker Adhesive (For use when a very fast set is required or if markers must be placed when pavement temperature is below 60 F. Type I is not recommended for general use as it is more toxic and currently more expensive than the other types.
Type II and II-M:	Medium Setting Marker Adhesive
Type III and III-M:	Standard Setting Marker Adhesive
Type IV and IV-M:	Slow Setting Marker Adhesive (For use where rapid setting is not a consideration)

Approximate set times at different temperatures for adhesive meeting the maximum set time allowed for each type are shown below.

Approximate Set Time, Hours

Pavement Temp., F	Type I & I-M	Type II & II-M	Type III & III-M	Type IV & IV-M
115	0.4	0.5	1	3
95	0.5	1	2	6
77	0.7	2	4	12
60	0.9	4	8	24
50	1.5	–	–	–

575.2. Materials.

(1) **Component Properties.** For Types I through IV, the ratio of the resin and hardener components to be mixed together to form the finished adhesive shall be specified by the manufacturer and the components packaged in the proper proportions.

For Types I-M through IV-M, the ratio of the epoxy-resin and hardener components to be mixed together to form the finished adhesive shall be 1 to 1 by volume.

Packaging of the two components shall be specified for the individual job or requisition.

The resin component shall be pigmented white and the hardener component black.

All pigments, fillers and/or thixotropic agents in either the epoxy-resin or hardener component must be of sufficiently fine particle size and dispersed so that no appreciable separation or settling will occur during storage.

The fillers present in the "M" adhesives must be of such a nature that they will not abrade or damage the application equipment. No alumina, silica flour or other hard abrasive materials shall be used.

Each component of the "M" adhesives shall be 100-percent solids. Adhesive for machine use shall contain no solvents.

(2) **Adhesive Properties.** The adhesive mixture must be of such a consistency that it can be applied to the surfaces which are to be bonded without difficulty. The adhesive must be capable of wetting the surfaces to be bonded so that good adhesion will be obtained. Type "M" adhesives must comply with the following specific consistency requirements.

	Minimum	Maximum
Viscosity of the individual components at 77 F ±1, Poises	100	1500
Average viscosity of the resin and hardener components, Poises	500	1500

Average Viscosity =

$$\frac{\text{(Viscosity of epoxy-resin comp. + Viscosity of hardener comp.)}}{2}$$

Ratio of viscosity of most viscous component to the viscosity of other component 7

Pot Life at 77 F.

The minimum pot life at 77 F for the various adhesives is shown below:

Types I, II and III	10 minutes
Type IV	30 minutes
Types I-M, II-M and III-M	7 minutes
Type IV-M	20 minutes

Set Time.

Set requirements for these adhesives are shown below:

	Type I & I-M	Type II & II-M	Type III & III-M	Type IV & IV-M
Set time at 77 F, Maximum	40 min.	2 hr.	4 hr.	12 hr.
Set time at 40 F, Maximum	3 hr.	–	–	–

(3) Physical Properties. The mixed marker adhesive shall comply with the following physical requirements.

Property	Requirements
Thixotropy (Avg. Thickness of cured material remaining on test panel, mils,) (Minimum)	80
Adhesive Shear Strength, psi. Minimum	1800
Cleavage Strength, psi. Minimum	800
Water Gain, percent by wt., Maximum	0.4
Impact Strength at 70-80 F Ft. – Lbs., Minimum	6-1/2
Wet Strength, psi., Minimum	300

575.3. Test Methods. The procedures to be followed in determining the various properties called for in this specification are given below.

(1) Consistency. This determination shall be made with a Brookfield Synchro-Lectric Viscometer of suitable range. The samples shall be placed in a container of such size that at least one inch of clearance is provided between the bottom and sides of the spindle and the container when the spindle is immersed to the proper depth in the liquid. The temperature of the samples for all viscosity determinations shall be 77 F ± 1.

When making a viscosity determination, the proper spindle shall be attached to the lower end of the motor shaft. With disc type spindles, the spindle is first immersed in the liquid at an angle to eliminate air bubbles, then screwed onto the shaft. Adjust the height to bring the liquid level to the indentation in the spindle. Level the instrument, set the speed control at 20 rpm and start the motor. Allow the spindle to rotate for approximately two minutes before taking a reading. The scale reading obtained shall be converted to viscosity in poises by multiplying by the factor supplied by Brookfield for the combination of spindle and speed used.

The spindle used shall be either a No. 5, 6 or 7 as required to result in a scale reading between 20 and 80.

(2) Set Time at 77 F. The ambient temperature and the initial temperature of the materials used in this test shall be 77 F ± 2.

Mortar briquettes shall be prepared according to ASTM C 190-63

(Tensile Strength of Hydraulic Cement Mortars) using Type III cement and sand meeting the requirements for No. 1 Fine Aggregate, of the Item, "Concrete for Structures".

The briquettes shall be cured for a minimum of seven days and then sawed at the center line perpendicular to the long axis. A diamond tooth saw or other cutting tool capable of producing clean smooth faces on the briquette halves shall be used. The halves shall be allowed to dry before use. Approximately 50 grams of the adhesive shall be mixed with a metal spatula in a 6-ounce ointment can for three minutes. The cut faces of the briquettes shall then be coated with the adhesive and put together with light pressure. The excess adhesive shall be removed from the edges of the bonded area and the briquettes allowed to remain undisturbed until time for testing. No more than 10 minutes shall elapse during preparation of the specimens. A minimum of three briquettes shall be prepared. The amount of time allowed to elapse between initiation of mixing and testing shall be as follows:

Type I & I-M	40 minutes
Type II & II-M	2 hours
Type III & III-M	4 hours
Type IV & IV-M	12 hours

The briquettes shall be subjected to tensile loading with the Riehle briquette tester and the load at failure recorded.

Requirements.

The briquettes shall evidence an average strength of 180 psi minimum. If any of the briquettes tested fail in the mortar at strengths below 180 psi, an additional set of specimens shall be prepared and tested.

(3) Set Time at 40 F. The procedure and requirements are the same as specified under **Set Time at 77 F** except that the initial temperature of the adhesive components and the briquette halves and the curing temperature shall be 40 F ± 2. The amount of time allowed to elapse between initiation of mixing and testing shall be as follows:

Type I & I-M	3 hours

(4) Pot Life at 77 F. The initial temperature of the adhesive components and the ambient temperature shall be 77 F ± 2 for this test. A total of 100 grams of the adhesive shall be weighed into a 6-ounce metal ointment can, the time recorded and the two components mixed for three minutes with a metal spatula. The sides and bottom of the can should be scraped periodically during the mixing. For Types I, I-M, II, II-M, III and III-M adhesives, the following procedure shall then be followed:

The can shall be set on a wooden block and probed every minute with a glass stirring rod, starting five minutes from the initiation of mixing.

For Type IV and IV-M, the can shall be set on a wooden block and probed every two minutes with a glass stirring rod, starting 16 minutes from the initiation of mixing.

In all cases, the time at which the material becomes unworkable or begins to solidify is recorded as the pot life.

(5) Thixotropy. The initial temperature of the adhesive and the materials used in this test shall be 120 F ± 3.

The two components of the epoxy adhesive shall be stirred together for the least one, but not more than two minutes and then applied to a smooth clean steel plate to form a panel of epoxy material 2 inches wide, 4 inches in length and 0.10 inch (100 mils) in thickness. A removable form of the proper dimensions may be used in placing the epoxy on the steel plate. The epoxy may be poured into the form and the excess struck off level with the top edge and then the form removed. Immediately after forming the epoxy adhesive, the steel panel shall be placed in a forced draft oven maintained at a temperature of 120 F ± 3. The 4-inch dimension of the epoxy panel shall be perpendicular to the horizontal. Not more than 4 minutes shall elapse between the initiation of the mixing and the placing of the panel in the vertical position. After the adhesive has hardened, the average thickness of material remaining within the original 2 x 4-inch area of the panel shall be determined.

(6) *Adhesive Shear Strength. The procedure used shall be as outlined in ASTM D 1002-64 (Strength Properties of Adhesives in Shear by Tension Loading – Metal to Metal). Steel specimens shall be used. The surfaces of the test specimens used in the adhesive shear strength test shall be prepared by blasting to white metal. The blasted surfaces shall be washed with methyl ethyl ketone and allowed to dry before applying the adhesive. The test specimens shall have a prepared surface of equivalent "anchor pattern" to that which would be obtained by abrasive blasting the surfaces to be bonded with a gun pressure of 50 to 75 psi using a 1/4-inch diameter nozzle and employing Garnet Blasting Abrasive "Gem Blast", 60 mesh (No. 45 to No. 74 U.S. Standard Screens), as marketed by Clemtex, Inc., of P.O. Box 15214, Houston, Texas 77020.

(7) *Cleavage Strength. The procedure used shall be as outlined in ASTM D 1062-51 (Cleavage Strength of Metal to Metal Adhesives). Steel specimens shall be used. Surface preparation shall be as outlined in **Adhesive Shear Strength.**

(8) *Water Gain (24 Hour Immersion at 23 C). The procedure used shall be as outlined in ASTM D 570-63 (Water Absorption of Plastics) with the indicated modification.

The given ASTM procedure shall be modified in that the specimens shall be prepared by casting disks of the epoxy adhesive 2-3/4-inches in diameter and approximately 3/8-inch thick. Prior to testing, the plane surfaces of the disks shall be ground or machined flat and parallel. The machining or grinding must be done in such a way as to not heat the disks above 120 F. The thickness of the disks after preparing the surfaces shall be 0.30 ± 0.02 inch.

(9) *Impact Strength at 70-80 F. For this test the specimens shall be prepared as outlined in Article 575.3, Subarticle (8), **Water Gain.** The finished specimens shall be placed on a concrete slab and a one pound steel ball dropped onto the center of the disks from an initial height of 5 feet. The height shall be increased by 1/2-foot for each successive drop until the specimen fails by cracking or shattering. The height of drop at which failure

occurs shall be recorded as the impact strength in foot-pounds. A minimum of three specimens shall be tested and the average reported to the nearest 1/2-foot-pound.

(10) Wet Strength. A minimum of four specimens shall be prepared as outlined under **Set Time at 77 F.** The bonded briquettes shall be allowed to cure for one day at 70 to 80 F, followed by two days in an oven maintained at 120 F ± 3. The cured specimens shall be immersed in distilled water maintained at 100 F ± 3 for a total of seven days. The specimens shall then be removed from the bath, placed in water maintained at 73 F ± 3 for one hour, then subjected to tensile loading with the Riehle briquette tester and the load at failure recorded. If any of the briquettes tested fail in the mortar at strengths below 300 psi., an additional set of specimens shall be prepared and tested.

575.4. Handling Instructions. Each component container shall be clearly labeled concerning toxicity and handling precautions. The manufacturer shall furnish instructions regarding mixing of the adhesive. In the case of Types I, II and III adhesives no more than one-quart of finished adhesive should be mixed in a given batch due to the short working life of these materials.

*These tests are to be performed on specimens that have been cured for seven days at 70-80 F.

575.5. Measurement and Payment. No direct measurement or payment will be made for the work to be done or for the materials to be furnished under this Item, but they shall be considered subsidiary to the particular items required by the plans and specifications.

ITEM 580

STRUCTURE FOR FIELD OFFICE AND LABORATORY

580.1. Description. This specification shall govern for the erection or furnishing of a building to be used by the Engineer during the construction of the project as a Field Office, Field Laboratory or Field Office and Laboratory.

580.2. General Requirements. The structure to be furnished by the Contractor shall be of the type or Types A, B, C, D, E as described in this Item or Type "F" as described on the plans.

The building shall be provided immediately after work on the project is begun and shall remain in place until the project is accepted by the State as complete, unless its earlier removal is authorized by the Engineer. It shall be floored and roofed, weather-tight and constructed in a workmanlike manner. All windows shall be screened and a screen door provided in addition to the regular door.

It is contemplated that the building will be constructed of the same kind of material as that used by the Contractor for his office and job buildings. It

shall be constructed or furnished near the site of the work, at a location acceptable to the Engineer and shall be an independent unit, detached from any office, storage or warehouse building occupied by the Contractor, and shall be at a minimum clear distance of 50 feet away from any such building. The building shall be for the sole use of the Engineer and the inspecting force.

Should the building be destroyed or damaged in any manner, except through causes due to negligence of the occupying Engineering force, the Contractor shall immediately restore it to its original state. Upon the completion of the project the building will become the property of the Contractor and shall be removed from the project site.

Unless specified otherwise on plans, the structures for field office and laboratory shall be electrically wired for lights, outlets and plugs and piped for water and fuel as directed by the Engineer. The Contractor shall furnish equipment, electricity, water and fuel, but will not be required to furnish a heater. Fuel may be either natural gas or liquified petroleum gas.

A rental building meeting specified minimum requirements at a suitable location and acceptable to the Engineer may be furnished by the Contractor instead of the individual buildings prescribed in this item.

580.3. Type of Structure.

(1) Type A Structure, Field Office. This building shall not be less than 10 feet by 16 feet and 8 feet high or an approved equivalent and shall have not less than three glass windows and one door. A table not less than 3 feet wide and 8 feet long shall be provided.

(2) Type B Structure, Field Laboratory. This building shall be not less than 6 feet by 16 feet and 8 feet high or an approved equivalent, and shall have not less than two glass windows and one door. A workbench not less than 3 feet wide and 6 feet long shall be provided.

(3) Type C Structure, Field Office and Laboratory. This building shall be not less than 16 feet by 16 feet and 8 feet high or an approved equivalent and shall have not less than four glass windows and one door. A workbench and a table, each not less than 3 feet wide and 6 feet long, shall be provided.

(4) Type D Structure, Field Office and Laboratory. This building shall be not less than 8 feet by 16 feet and 8 feet high or an approved equivalent and shall have not less than four glass windows and one door. A workbench and a table, each 3 feet wide and 6 feet long, shall be provided.

(5) Type E Structure, Field Laboratory. This building shall be not less than 8 feet by 20 feet and 8 feet high, containing not less than 2 windows and 2 doors and a workbench 3 feet wide and 8 feet long. In addition, the building shall contain a substantial workbench 3 feet by 4 feet with supports extending through the floor and firmly fixed in the ground, clear of the building floor, and a small platform not less than 12 inches square substantially mounted on a post of not less than 6-inch by 6-inch lumber extending through the floor and firmly fixed in the ground.

(6) Type F Structure. This building shall be as described on plans or an approved equivalent.

580.4. Measurement. Structure for Field Office and Laboratory will be measured as each unit, of the various types, complete in place.

580.5. Payment. Work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Field Office" of the type specified, "Field Laboratory" of the type specified or "Field Office and Laboratory" of the type specified, which price shall be full compensation for furnishing and removing structures; and for labor, tools, materials, furnishing equipment and incidentals necessary to complete the work.

ITEM 590

CONCRETE MEDIANS AND DIRECTIONAL ISLANDS

590.1. Description. This item shall consist of cast in place concrete medians and/or concrete directional islands, with or without reinforcement, constructed on designated or prepared foundations in conformity with the lines and grades established by the Engineer, and to the details shown on the plans.

590.2. Materials. All concrete and concrete ingredients shall conform to the requirements for the class of concrete indicated on the plans as specified in the Item, "Concrete for Structures". (Concrete used in an extrusion machine shall conform to the requirements of the Item, "Machine Laid Curb". Joint materials shall conform to the requirements of the Item, "Concrete Structures". If reinforcing steel is required by the plans, it shall conform to the requirements of the Item, "Reinforcing Steel".

590.3. Construction Methods. The concrete shall be placed on the prepared foundation to the grade and dimensions specified. Forms, where required, shall be of wood or metal, straight, free of warp and of a depth equal to the depth of required section. They shall be securely held in place, true to line and grade, during the concrete placing operations. Reinforcing steel and/or dowels if specified shall be securely held in position.

Concrete shall be mixed and placed in a manner satisfactory to the Engineer. Each section shall be placed to the dimensions indicated on the plans. When required by the plans, the section shall be separated from adjacent curbs or adjoining sections by expansion or contraction joints of the type and size specified. When indicated on the plans or permitted by the Engineer, an extrusion machine may be used to form curbs or sections of the median or island.

After the concrete has been struck off and has set sufficiently, the exposed surfaces shall be thoroughly worked with a wooden float. Exposed edges shall be rounded to the required radius by the use of edging tools.

When the concrete has set sufficiently, the forms shall be carefully removed and the surface thus exposed shall be pointed up where necessary, then wetted and rubbed with a wood block to remove all form marks and other irregularities, producing a smooth, uniform finish. When directed by the Engineer, mortar consisting of one part Portland cement and two parts fine aggregate shall be used to plaster exposed surfaces. The mortar shall be applied with a template or "mule" made to conform to the desired cross section shown on the plans. Cold weather placing of concrete shall be governed by conditions specified under the Item, "Concrete for Structures".

Immediately after finishing operations are completed, the surface shall be cured for a period of 3 days in accordance with the requirements of the Item, "Membrane Curing", Type 2, white pigmented. Other methods of curing as outlined in the Items, "Concrete Pavement" and "Concrete Structures" will be acceptable.

590.4. Measurement. Concrete Medians and/or Concrete Directional Islands will be measured by the linear foot or by the square yard complete in place.

590.5. Payment. The work performed and materials furnished as prescribed above and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Median" or "Concrete Directional Island" which price shall be full compensation for cleaning and moistening median surfaces, furnishing, hauling, and placing all materials; for furnishing and placing reinforcing steel; for furnishing and placing joint materials; for curing and for all manipulations, labor, equipment, tools and incidentals necessary to complete the work.

ITEM 591

VEHICULAR IMPACT ATTENUATOR ASSEMBLY
(Steel Barrel)

591.1. Description. This specification shall govern for the furnishing and installation of an assembly of collapsible steel barrels. The barrel assembly will in general be located in the gores of diverging roadways in front of fixed objects. The Steel Barrel Vehicular Impact Attenuator Assembly shall be constructed in accordance with the plans and these specifications at the locations shown in the plans.

591.2. Materials. All materials shall be new.

The barrels called for in the plans shall be commercially available 55-gallon tight head drums of 20-gauge steel for the top, bottom and sides. The drums shall weigh approximately 35 pounds each prior to the removal of a 7-inch diameter hole which shall be punched or cut in the center of the top and bottom of each drum. Filling and dispensing fittings that are normally furnished in drum tops will not be required. The outside of the drums shall be white in color unless otherwise specified on plans. Oval spacers and barrel spacers shall be painted with an approved white paint.

Where required, concrete for foundations, back up walls and anchors shall be Class A Concrete in accordance with the Item, "Concrete for Structures". Steel reinforcement, anchor fittings and cables shall meet the requirements of the Item, "Reinforcing Steel" or "Metal for Structures" whichever is applicable.

Upon application to the Engineer and with his approval, steel drums of heavier gauge material will be permitted provided that alternate cut out patterns in the top and bottom of the heavier gauge drums are used. The Engineer will furnish the alternate cut out patterns upon application. The cut out patterns will vary depending upon the weight of drums furnished.

The Contractor shall furnish for approval manufacturer's certificates or literature for all items of the barrel assembly that are stock items prior to fabrication and installation of the barrel assembly.

All fabricated steel parts other than barrels and spacers used in the Vehicular Impact Attenuator Assembly shall be galvanized. Commercial galvanizing will be acceptable.

591.3. Construction. The steel barrel assembly shall be fabricated and installed in accordance with the details shown in the plans.

591.4. Measurement. Completed and accepted work as described by this item and in accordance with details in plans shall be measured as each Vehicular Impact Attenuator Assembly installation complete in place.

591.5. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement" shall be paid for at the unit price bid for "Vehicular Impact Attenuator Assembly" which price shall be full compenstion for all labor, equipment, tools, incidentals, and services, and for furnishing all materials necessary to complete the work described by this item, including barrels, spacers where required, banding material, cable, fittings and attachment of same as shown on plans, and foundations, back up walls, anchors, anchor fittings and reinforcing steel where required.

ITEM 592

CONSTRUCTING DETOURS

592.1. Description. This item shall consist of the construction, maintenance and removal, if required, of detours of the type and length, and to the lines, grades and typical cross section shown on the plans. The work shall be done in accordance with the provisions of this specification.

592.2. Materials. The material for the required embankment shall be procured from the roadway excavation or borrow sources specified or as directed by the Engineer and sprinkled, compacted and shaped to conform to the typical section as specified or determined satisfactory and acceptable by the Engineer.

Any pipe required for temporary drainage across the detour, will be furnished by the Contractor, and will become the property of the Contractor upon removal.

Permanent pipe proposed on this project may be used temporarily for the detour, if the sequence of work will permit. When, in the opinion of the Engineer, pipe so used is damaged such that it will not be acceptable in the completed project, it will remain the property of the Contractor and shall not be incorporated in the final project.

592.3. Construction. The detours shall be constructed at the locations and to the lines and grades as shown on the plans and it shall be the entire responsibility of the Contractor to provide for the passage of traffic in comfort and safety as required or as directed by the Engineer.

Flexible Base material shall be deposited on the subgrade, sprinkled, bladed, compacted and shaped to conform to the typical sections shown on the plans and as specified in the pertinent flexible base item.

The finished base shall receive surfacing where specified on the plans in accordance with the pertinent surfacing items.

After the detours are no longer needed for traffic, where required, the embankment material, including base, shall be removed and utilized as shown on the plans or as directed by the Engineer.

592.4. Measurement. Constructing Detour as prescribed for this item will be measured by the method described as either Class 1, 2, 3 or 4 as follows and as specified on the plans.

When Class 1 measurement is specified, constructing detour will be measured by the 100-foot station of detour constructed complete in place.

When Class 2 measurement is specified, constructing detour will be measured as each detour constructed complete in place.

When Class 3 measurement is specified, constructing detour will be measured by the 100-foot station of completed detour. Embankment, flexible base and surfacing, where required, will be measured in accordance with the pertinent bid items.

When Class 4 measurement is specified, constructing detour will be measured as each completed detour. Embankment, flexible base and surfacing, where required, will be measured in accordance with pertinent bid items.

592.5. Payment. The work performed as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Constructing Detour" of the class indicated on the plans. The prices bid for Class 1 and/or Class 2 detours shall be full compensation for furnishing all material required including flexible base and surfacing; all work, labor, tools, equipment; all excavation and hauling of excavated material; all royalty, sprinkling and compacting; furnishing, installing and removing pipe; maintenance of detour; removal of detour where required; and incidentals necessary to complete the work. The price bid for Class 3 and/or Class 4 detours shall be full compensation for furnishing all work, labor, tools, and

equipment; furnishing, installing and removing pipe; maintenance of detour, removal of detour where required and incidentals necessary to complete the work except that embankment, flexible base and surfacing will be measured and paid for in accordance with other pertinent bid items.

Regardless of the number of manipulations, payment for embankment and flexible base will be made only once.

PART II, CONSTRUCTION DETAILS

DIVISION VI, LIGHTING

ITEM 610

ROADWAY ILLUMINATION ASSEMBLIES

610.1. Description. This item shall govern for the materials and equipment used and for the installation of the various types of roadway illumination assemblies as shown on the plans.

The term "Assembly", as used herein, shall constitute the complete assemblage of parts, equipment and miscellaneous items, except foundations, erected as provided in the plans and in accordance with these specifications, forming a complete and independent lighting unit.

610.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be new, unless otherwise indicated, and in strict accordance with the details shown on the plans.

The Contractor shall furnish six sets of shop drawings of the complete assembly in accordance with the Item, "Steel Structures", to the Texas Highway Department, along with certification that all materials used in the fabrication are in accordance with the plans and specifications.

610.3. Construction Methods. Roadway Illumination Assemblies shall be fabricated and placed in accordance with the details and dimensions shown on the plans, or as directed by the Engineer.

The careful erection and aligning of the poles furnished under this item shall be considered a most essential feature of the installation of the assembly and shall be as near to true alignment as practicable.

All circuits shall test clear of faults, grounds and open circuits to the satisfaction of the Engineer.

After satisfactory completion of the above tests, the illumination system shall be placed in operation. Final acceptance will not be made until the system has operated satisfactorily for a period of not less than 14 days.

Operation of the system shall not in any way be construed as an acceptance of the system or any part of it or as a waiver of any of the provisions of the contract.

The Contractor shall be fully responsible for the system during this period of operation and he shall make any adjustment or repairs which may be required, and remedy any defects or damages which may occur, at his own expense.

The Contractor will not be required to pay for electrical energy consumed by the system during the period of trial operation.

610.4. Measurement. Roadway Illumination Assemblies will be measured as each of the several types of assemblies, complete in place.

610.5. Payment. Work performed and material furnished as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Roadway Illumination Assemblies" of the types specified, which price shall be full compensation for furnishing, installing and testing all luminaires, ballast, poles, lamps, conductor and internal connecting of equipment and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 613

HIGH MAST ILLUMINATION POLES

613.1. Description. This item shall govern for furnishing materials, fabricating and erecting steel illumination poles, in accordance with the details and dimensions shown on the plans or as directed by the Engineer.

613.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be new, unless otherwise indicated, and in strict accordance with the details shown on the plans.

613.3. Construction Methods. The Contractor shall furnish six sets of shop drawings of the complete pole in accordance with the Item, "Steel Structures", to the Texas Highway Department, along with certification that all materials used in the fabrication are in accordance with the plans and this specification.

Fabrication and welding shall be in accordance with the Item, "Steel Structures" and with Texas Highway Department Bulletin C-5, except that the longitudinal seam weld in the pole shall be a minimum of 85 percent penetration as established by radiography or ultrasonic testing by the fabricator.

The careful erection and aligning of the poles furnished under this item shall be considered a most essential feature of the installation of the assembly and shall be as near to true alignment as practicable.

613.4. Measurement. High Mast Illumination Poles will be measured as each of the several types complete in place.

613.5. Payment. Work performed and materials furnished as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "High Mast Illumination Poles" of the types specified, which price shall be full compensation for furnishing, fabricating, galvanizing, assembling and erecting the pole upon a foundation and any other materials or equipment required for a complete installation, and for all labor, tools, equipment and incidentals necessary to complete the work.

ITEM 614

HIGH MAST ILLUMINATION ASSEMBLIES

614.1. Description. This item shall govern for the furnishing and assembling of all materials on a "High Mast Illumination Pole" for a complete illumination assembly.

The term "Assembly" as used herein, shall constitute the complete assemblage of parts, equipment and miscellaneous items, except foundations and pole shafts, erected as provided in the plans and in accordance with these specifications, forming a complete and independent lighting unit.

614.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be new, unless otherwise indicated, and in strict accordance with the details shown on the plans.

The Contractor shall furnish six sets of shop drawings of the complete assembly in accordance with the Item, "Steel Structures", to the Texas Highway Department, along with certification that all materials used in the fabrication are in accordance with the plans and this specification.

The Contractor shall also make brochure submittals on the following: lighting units and ballasts, wire rope and terminals, electrical cable, electrical fittings (receptacles, caps, connector bodies), cable grips, drill motor, winch and transformers.

614.3. Construction Methods. High Mast Illumination Assemblies shall be fabricated and placed in accordance with the details and dimensions shown on the plans, or as directed by the Engineer.

All circuits shall test clear of faults, grounds and open circuits to the satisfaction of the Engineer.

After satisfactory completion of the above tests, the illumination system shall be placed in operation. Final acceptance will not be made until the system has operated satisfactorily for a period of not less than 14 days.

Operation of the system shall not in any way be construed as an acceptance of the system or any part of it or as a waiver of any of the provisions of the contract.

The Contractor shall be fully responsible for the system during this period of operation and he shall make any adjustment or repairs which may be required, and remedy any defects or damages which may occur, at his own expense.

The Contractor will not be required to pay for electrical energy consumed by the system during the period of trial operation.

614.4. Measurement. High Mast Illumination Assemblies will be measured as each of the several types of assemblies, complete in place.

614.5. Payment. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "High Mast Illumination Assemblies" of

the types specified, which price shall be full compensation for furnishing, installing and testing all lighting units, ballasts, lamps, obstruction lights, hoisting assembly, power drive assembly and any other materials and equipment required for a complete installation and for all labor, tools, equipment and incidentals necessary to complete the work.

The furnishing and erection of the pole shaft will be paid for under the Item, "High Mast Illumination Poles".

ITEM 630

ROADWAY ILLUMINATION ASSEMBLY FOUNDATIONS

630.1. Description. This item shall govern for the materials and equipment used and for the construction of the various types of foundations as shown on the plans.

630.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be new and in strict accordance with pertinent specifications and the details shown on the plans.

630.3. Construction Methods. Concrete foundations for roadway illumination assemblies shall be constructed to the dimensions shown on the plans or as directed by the Engineer.

After the foundation has been poured, finished and cured and before final payment is made, the area around the foundation shall be backfilled, compacted and all paving or surface treatment which may have been disturbed by the construction operations shall be replaced in a manner satisfactory to the Engineer. The site shall be left in a neat and sightly condition.

630.4. Measurement. Roadway illumination assembly foundations will be measured as each assembly foundation of the various types, complete in place.

630.5. Payment. Concrete foundations constructed as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Roadway Illumination Assembly Foundations", of the type or types specified, which prices shall each be full compensation for furnishing and installing all materials, including ground rods, anchor bolts, reinforcing steel, conduit, washers and nuts; excavating and backfilling, replacing flexible base, concrete, sod, seal or other surface treatment; and for all labor, tools, equipment and incidentals necessary to complete the work.

ITEM 640

CONDUIT

640.1. Description. This item shall govern for the furnishing and placing of conduit of the types and sizes indicated on the plans, including junction boxes, fittings, attachments and incidentals.

640.2. Materials. Ferrous conduit shall be galvanized and shall have an interior coating of a character and appearance, and non-ferrous conduit of corrosion-resistant material shall have suitable markings, so as to readily distinguish them from ordinary pipe commonly used for other than electrical purposes. Each section of conduit shall bear evidence of approval by Underwriters' Laboratories **for the intended use.**

Junction boxes, pull boxes, expansion devices and conduit fittings shall be fabricated from a material similar to the connecting conduit unless indicated otherwise on the plans and shall be approved by Underwriters' Laboratories.

Fibre conduit shall consist either of wood fibre and coal tar, or asbestos fibre and cement, bonded together into a uniformly impregnated homogeneous state. The bore shall be straight and circular in cross section with a uniform wall thickness. The wall strength shall be sufficient to render the conduit adaptable to direct ground burial without concrete encasement. Joints shall be of the tapered coupling type.

640.3. Construction Methods. The conduit, junction boxes, fittings and incidentals shall be placed in accordance with the lines, grades, details and dimensions shown on the plans, or as directed by the Engineer.

Conduit placed for concrete encasement shall be secured and supported in such a manner that the alignment will not be disturbed during placement of the concrete. No concrete shall be placed until all of the conduit ends have been capped and all box openings closed.

Immediately prior to final acceptance, a spherical template having a diameter of not less than 75% of the inside diameter of the conduit shall be drawn through the conduit to insure that the conduit is free of obstruction; then all conduit ends shall be closed using permanent type caps.

640.4. Measurement. Conduit of the types and sizes specified on the plans will be measured by the linear foot along the main line of the conduit. No measurement will be allowed under this item for conduit used in circuit protector assemblies, service poles, transformer stations or roadway illumination assembly foundations.

640.5. Payment. Conduit measured as provided under "Measurement" will be paid for at the unit price bid for "Conduit", of the types and sizes specified, which prices shall each be full compensation for furnishing and installing all conduit material, jacking, boring, excavating, backfilling, replacing pavement or surface treatment and marking location of conduit; for furnishing and installing all fittings, outlet boxes, bends, expansion devices, junction boxes, attachment devices, etc., and for all labor, tools, equipment and incidentals necessary to complete the work.

ITEM 650

ELECTRIC CONDUCTOR

650.1. Description. This item shall govern for the furnishing and placing of all electric conductors required on the plans, except conductors specifically covered by other items of the contract.

650.2. Materials. Electric conductor shall be annealed copper wire of the size, type, voltage class and in accordance with the latest revisions of the ASTM Specifications indicated in the plans.

650.3. Acceptance. Before installation on this project, the Contractor shall furnish the Engineer conclusive evidence that all conductor complies with pertinent ASTM requirements indicated in the plans. Each reel or coil of insulated conductor shall bear evidence of Underwriters' Laboratories approval.

650.4. Laying Conductors. The conductors shall be installed in accordance with the details on the plans or as directed by the Engineer. Conductors shall be continuous, without splices, from terminal to terminal, and placed as close together as practicable with slack to allow for expansion and contraction of the soil.

650.5. Pulling Conductors. Immediately before any conductor is pulled through any conduit or duct, the conduit or duct shall be thoroughly cleaned. When leaving conduit for direct burial, all conductors shall be centered at the conduit or duct ends and sealed to a depth of 3 inches in the conduit or duct with a nonhardening mastic compound commonly used in the electrical industry for such application.

650.6. Measurement. Electric conductor will be measured by the linear foot of single conductor, complete in place; the measurement being made along the trench or conduit in which the conductor is placed. No measurement will be allowed under this item for conductors used in connecting the components of transformer stations, service poles, circuit protector assemblies or conductor used in roadway illumination assemblies.

650.7. Payment. Electric conductor, measured as provided under "Measurement", will be paid for at the unit price bid for "Electric Conductor", of the specified size and type, which price shall be full compensation for furnishing and installing all conductors, for pulling through conduit or duct, excavating and backfilling the trenches, replacing base, seal, riprap, pavement, sod, or other surface treatment; and for all labor, tools, equipment and incidentals necessary to complete the work.

ITEM 651

DUCT CABLE

651.1. Description. This item shall govern for the fabrication, furnishing and placing of all duct cable required on the plans.

Duct cable as used herein shall consist of a complete assembly of conductors of the types and sizes specified, enclosed in a medium density polyethylene duct which meets the requirements set forth in the specification.

651.2. Materials. Bare conductors shall be copper, annealed, uncoated and conforming to ASTM B-3. Conductors larger than No. 8 AWG shall be stranded in conformance with ASTM B-8 Class B stranding.

Insulated conductors shall be copper, annealed, coated or uncoated. If coated conductors are furnished, the coating shall be in accordance with ASTM B-189 or B-33. Insulation shall be 600 volt THW meeting the requirements of UL No. 83.

651.3. Duct. The duct shall be compounded from polyethylene and shall meet the following requirements when tested by the methods indicated.

PROPERTY	REQUIREMENT	TEST METHOD
Tensile Strength	2,500 PSI Min.	ASTM D 638
Elongation	300% Min.	ASTM D 638
Melt Index	1.5 Max.	ASTM D 1238
Carbon Black Content	3% Max.	ASTM D 1603
Density of Base Resin	0.926-0.940	ASTM D 1505
Brittle Temperature 80% Non-Failure	-80° C	ASTM D 746
Environmental Stress Crack Resistance, Max. Failures Per Ten Specimens After 48 Hours	2 Max.	ASTM D 1693
Incremental Internal Pressure	75% Values Listed for Series 2	ASTM D 1598
Impact Resistance*	0.9 Ft. lb/in of Notch	ASTM D 256 Method A

*The manufacturer may supply duct-cable meeting the following requirements for impact strength in lieu of this specification.

Impact Strength: Falling weight 100 Ft. Lbs. @ -10° C. No Fracture.

The duct shall withstand the impact and bending stresses incidental to transportation, handling and installation at temperatures down to -10° C. It shall not fracture, split nor be damaged in any way by normal handling, including impact at this temperature.

The duct shall have the following dimensions and minimum bending radii:

NOMINAL SIZE. IN.	WALL THICKNESS MINIMUM, IN.	NOMINAL O.D.	BEND RADIUS MINIMUM, IN.
1/2"	.060"	.840"	9"
3/4"	.060"	1.050"	11"
1"	.075"	1.315"	13"
1-1/4"	.100"	1.660"	18"
1-1/2"	.115"	1.900"	21"
2"	.150"	2.375"	26"

651.4. Assembly. The complete assembly shall be packaged on reels having sufficient diameter to prevent injecting permanent set or injury. The duct shall be the size indicated on the plans, but in no case shall the sum of the cross-sectional area of the individual conductors exceed 40 percent of the interior cross-sectional area of the duct. Each reel shall be adequately identified and reflect the voltage, insulation, number of conductors, conductor size, length, duct size and the trade name under which it is produced.

651.5. Acceptance. Before installation on this project, the Contractor shall furnish conclusive evidence to the Engineer that all duct cable complies with the requirements set forth in this specification or indicated in the plans. Individual conductors shall be marked in accordance with industry standards.

651.6. Placement. The duct cable shall be installed in accordance with these specifications and the details on the plans or as directed by the Engineer. The duct cable will be placed by open trench methods at the depth indicated on the plans, except at locations where the duct cable is to be enclosed in conduit. The trench will be backfilled and compacted in accordance with the Item, "Excavation and Backfill for Sewers". Where it becomes necessary to disturb paved surfaces or riprap, the Contractor will be required to saw the edges of the trench prior to excavation or operations. The Contractor, unless otherwise specifically relieved of the responsibility, shall replace all sod, pavement structure, pavement, riprap or other materials disturbed by his operations. Materials and methods used shall be approved by the Engineer. The duct cable shall be continuous, without splices, from terminal to terminal, and bends will be formed with large radii to provide free movement of conductors. The entire installation shall be accomplished in a neat and workmanlike manner.

651.7. Measurement. Duct cable of the types and sizes specified on the plans will be measured by the linear foot complete in place; the measurement being made along the trench or conduit in which the duct cable is placed and shall extend to the end of the conductor group from which the duct has been removed. No measurement will be allowed under this item for duct cable or conductor used in connecting the components of transformer stations, service poles, circuit protector assemblies or used in roadway illumination assemblies.

651.8. Payment. Duct cable measured as provided under "Measurement", will be paid for at the unit price bid for "Duct Cable", of the specified size and type, which price shall be full compensation for furnishing and installing all duct cable, for pulling through conduit, excavating and backfilling the trenches, replacing base material, seal, riprap, pavement, top soil, sod or other surface treatment; and for all labor, tools, equipment and incidentals necessary to complete the work.

ITEM 660

CIRCUIT PROTECTOR ASSEMBLY

660.1. Description. This item shall govern for the furnishing and placing of circuit protector assemblies as shown on the plans.

The term "Assembly", as used herein, shall constitute the complete assemblage of parts, equipment and miscellaneous items as provided for in the plans, forming a complete and independent circuit protection unit.

660.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be new and in strict accordance with the details shown on the plans.

660.3. Construction Methods. Circuit protector assemblies shall be assembled and placed in accordance with the details and dimensions shown on the plans or as directed by the Engineer.

660.4. Measurement. Circuit Protector Assemblies will be measured as each assembly, complete in place.

660.5. Payment. Work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Circuit Protector Assembly", which price shall be full compensation for furnishing all materials, installing and connecting all parts including enclosures, breakers, conduit, fittings, conductor, brackets, bolts, hangers, hardware and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 670

SERVICE POLES

670.1. Description. This item shall govern for the furnishing and placing of service poles as shown on the plans.

The term "Service Poles", as used herein, shall constitute the complete assemblage of parts, equipment and miscellaneous items as provided for in the plans, forming a complete and independent point of service for the various circuits.

670.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be in strict accordance with the details shown on the plans.

670.3. Construction Methods. Service poles shall be assembled and placed in accordance with the details and dimensions shown on the plans or as directed by the Engineer.

670.4. Measurement. Service poles will be measured as each service pole, of the various types, complete in place.

670.5. Payment. Work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Service Pole", of the type or types specified, which price shall be full compensation for furnishing all material, placing and connecting all components including enclosures, breakers, conduit, fittings, conductor, brackets, bolts, hangers, hardware and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 680

TRANSFORMER STATIONS

680.1. Description. This item shall govern for the furnishing and placing of transformer stations as shown on the plans.

The term "Transformer Station", as used herein, shall constitute the complete assemblage of parts, equipment and miscellaneous items as provided for in the plans, forming a complete and independent point of transformation and service.

680.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be in strict accordance with the details shown on the plans.

680.3. Construction Methods. Transformer Stations shall be assembled and placed in accordance with the details and dimensions shown on the plans or as directed by the Engineer.

680.4. Measurement. Transformer Stations will be measured as each transformer station, of the various types, complete in place.

680.5. Payment. Work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Transformer Station", of the type or types specified, which price shall be full compensation for furnishing all material, placing and connecting all components including poles, cross arms, braces, cut-outs, arrestors, transformers, controller, light-sensitive control device, breakers, conduit, fittings, conductor, hangers, hardware and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

PART II, CONSTRUCTION DETAILS

DIVISION VII, SIGNING

ITEM 700

PLYWOOD SIGNS
(TYPE A AND TYPE B)

700.1. Description. Plywood Signs (Type A) are those having sign blanks made from High Density Plastic Faced Plywood and having sign faces reflectorized with Flat Surface or Exposed Lens Flexible Reflective Sheeting. Plywood Signs (Type B) are those having sign blanks made from Medium Density Plastic Faced Plywood and having sign faces reflectorized with Paint and Beads.

700.2. Materials.

(1) Sign Blanks. Sign blanks for Plywood Signs (Type A) and Plywood Signs (Type B) shall conform with the provisions of the Item, "Plastic Faced Plywood for Traffic Signs".

Sign blanks shall be cut to the proper size and shape shown on the plans for the various signs. Thickness of the sign blanks shall be as shown on the plans.

All sign blanks to which Flat Surface or Exposed Lens Flexible Reflective Sheeting is applied shall be High Density Plastic Faced Plywood. All sign blanks to which Paint and Bead Reflectorization is applied shall be Medium Density Plastic Faced Plywood. Blanks or panels shall be free of warping in excess of that permitted in these specifications, contain no open checks, splits, joints, cracks, loose knots or other defects resulting from fabrication which interrupt the smooth continuity of the panel surface. Unless otherwise shown on the plans, no panel shall have a face dimension less than 1'-6".

Sign faces are not acceptable if the variation of the surface in any direction exceeds an amount equal to 1/8-inch per foot of defect of width or height as the case may be. Any vertical or horizontal misalignment between panels greater than 1/8-inch is not acceptable. Misalignment between panel faces shall not be greater than 1/16-inch.

(2) Sign Face Reflectorization.

(a) The face of all Plywood Signs (Type A and Type B) shall be reflectorized and shall be of the color shown on the plans.

(b) Flat Surface Flexible Reflective Sheeting shall be used in conformance with the plans for sign faces which require preparation by the reverse screen process, using colored transparent ink and sign faces having an Interstate Blue background which do not require preparation by the reverse screen process, using colored transparent ink.

(c) Flat Surface Flexible Reflective Sheeting, Exposed Lens Flexible Reflective Sheeting, or Paint and Beads may be used, at the Contractor's option, for reflectorization of sign faces which do not require preparation by the reverse screen process, using colored transparent ink and sign faces which do not have an Interstate Blue background, provided, that the reflective material selected by the Contractor shall be of the same type and manufacture for all signs of the same classification throughout the project.

(d) Flat Surface Flexible Reflective Sheeting shall conform with the Item, "Flat Surface Flexible Reflective Sheeting".

(e) Exposed Lens Flexible Reflective Sheeting shall conform with the Item, "Exposed Lens Flexible Reflective Sheeting".

(f) Paint and Beads for signs having a white or yellow background shall conform with the Item, "Bead Reflectorization for Signs Having a White or Yellow Background".

(g) Paint and Beads for signs having a green background shall conform with the Item, "Bead Reflectorization for Signs Having a Green Background".

(3) Connections. All bolts, nuts, washers, lock washers, and other hardware used in making the signs which are not specifically covered on the plans shall be galvanized steel, stainless steel or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Stainless steel sign post or support connections, bolts, nuts, washers, lock washers and other hardware used in making the signs shall conform with ASTM Specification A 320, Grade B8F, Annealed.

Galvanized steel sign post or support connections, bolts, nuts, washers, lock washers and other hardware used in making the signs shall conform with ASTM Specification A 307. Galvanizing shall be in accordance with the Item, "Metal for Structures" of the Standard Specifications.

Aluminum sign post or support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Application.

700.3. Fabrication.

(1) Application of Reflective Sheeting to the Faces of Plywood Signs (Type A). Reflective sheeting shall be applied to sign faces by an approved vacuum applicator in conformance with the recommended procedures of the manufacturer of the reflective sheeting. Whenever a sign face is comprised of two or more panels to which reflective sheeting is to be applied, the reflective sheeting must be matched carefully for color at the time of sign fabrication to provide uniform appearance and brilliance both day and night. Alternate, successive width sections of panels must be reversed and consecutive to insure that corresponding edges of reflective sheeting lie adjacent on the finished

sign. Each panel shall be matchmarked to insure its proper location in the completed sign upon final erection. Nonconformance may result in non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting which will not be acceptable. When splicing of reflective sheeting is necessary, the number of splices shall be held to a minimum consistent with the reflective sheeting widths furnished by the manufacturer, and the minimum dimension for any one piece of reflective sheeting material shall be 1'-0".

After aging 48 hours at 75 F from the time of application, adhesion of reflective sheeting to the sign blank shall be strong enough to resist stripping when tested with a stiff putty knife.

All sign faces having flat surface reflective sheeting shall be sprayed with one coat of finishing clear or edge sealed in accordance with the sheeting manufacturer's recommendations and instructions. Finishing clear or edge sealer shall not be applied to screen processed signs until after completion of the screen process and shall be applied to sign faces having removable copy prior to the application of the removable copy.

(2) Application of Bead Reflectorization to the Faces of Plywood Signs (Type B) Having a White or Yellow Background.

(a) Reflector Coat. The reflector coat is the unbeaded layer of paint immediately under the beads. It shall consist of a film of bead binder, without beads, having a minimum dry film thickness of 2 mils. Binder specifications are listed in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background". At least 16 hours air-drying time, under satisfactory drying conditions, shall be allowed before the actual bead binder coats and beads are applied.

(b) Bead Binder Coat. This is the coat which holds or binds the reflective beads to the face of the sign. If the binder requires thinning, only the approved thinner shall be used. The viscosity of the binder applied shall not be less than 30 seconds as measured on a #4 Ford Cup at 77 F. There are three different grades or sizes of beads described in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background". Each grade will require a different wet film thickness in order to embed each particular size to a depth of 40 to 60%. The following are the wet film thicknesses usually required to embed the beads 40 to 60%:

Grade 1 Beads	1.50 Mils
Grade 2 Beads	1.25 Mils
Grade 3 Beads	1.00 Mil

These are only suggested film thicknesses; the factor controlling the correct wet film thickness is the amount of embedment obtained when the beads are applied. The correct embedment will be determined by examining a sign immediately after beading. A 10 power magnifier is suitable for this examination.

During sign construction the film thickness over the face of the signs being manufactured shall not vary more than ± 10% from the determined correct film thickness.

(c) Application of the Beads. The bead applicator shall be adjusted so that it will apply a single layer of beads containing a minimum of 80% of the amount of beads theoretically possible uniformly distributed over the face of the sign. Examination of the completed signs with a magnifier, immediately after beading, shall show a unilayer of beads embedded 40 to 60% of their average diameter in the binder with no stacking and piling of the beads. All beads applied to any one sign shall be of one grade or size as defined in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background".

(3) Application of Bead Reflectorization to the Faces of Plywood Signs (Type B) Having a Green Background. Application of Bead Reflectorization to the Faces of Plywood Signs (Type B) having a green background shall be in accordance with the Item, "Bead Reflectorization for Signs Having a Green Background".

(4) Sign Backs. The back side and edges of Plywood Signs (Type A and Type B) shall be coated uniformly with enamel to a minimum dry film thickness of two (2) mils. The dried film shall be smooth, glossy except for edges, uniform, tight adhering, and free of runs, sags, streaks, or pinholes.

White, yellow, red, green and blue enamel used to coat the back side and edges of sign blanks shall match closely the color of the face of the sign and shall meet the requirements of Article 446.4., "Paint Requirements" and 446.5., "Source of Supply", of the Item, "Paint and Painting", of the Standard Specifications for the formulation of the enamel and source of supply.

(5) Sign Messages and Borders. The sign messages and borders shall be of the size, type, and color shown on the plans.

Silk screen processing ink approved by the Texas Highway Department's Materials and Test Division shall be used for sign messages and borders applied to sign faces by the screen process. All messages and borders prepared by a screen process shall have clean, sharp edges with no runs or sags and shall be of sufficient thickness to completely cover the background material.

Reflectorized Removable Copy sign messages and borders specified on the plans for various signs shall conform with the Item, "Removable Reflectorized Cutout Letters, Numerals, Arrows, Symbols, Corner Radii for Sign Borders, Borders, and Reflectorized Outlines for U.S. and State Route Markers".

When Interstate Route Markers are required as a part of the sign message, they shall be reflectorized and shall conform with the plans and with the Item, "Aluminum Signs (Type A)".

When U.S. and State Route Markers are required as a part of the sign message, they shall conform with the plans and with the Item, "Aluminum Signs (Type F)".

(6) Sign Post Connections and Hardware. Sign post connections for Plywood Signs (Type A and Type B) that are erected on Roadside Traffic Sign Mounts Types A, B, C, D, F, G, and H and series of these types of

mounts shall conform with the details on standard plan sheet, "Interstate Standard Roadside Sign Mounting Clamp Details, Route Markers, Warning and Regulatory Signs".

Sign post connections for Plywood Signs (Type A and Type B) that are erected on Roadside Traffic Sign Mounts shall conform with the details shown on the plans.

Where the plans require Plywood Signs (Type A) and/or (Type B) to be mounted on an overhead sign support, the connections for attaching the signs to the support shall be as shown on the plans, or on working drawings furnished by the Contractor, subject to approval by the Engineer.

All sign post or support connections shall be capable of developing the full strength of the sign and they shall be stainless steel, galvanized steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

(7) Working Drawings. The Contractor shall submit for approval of the Engineer five prints of the working drawing for each sign using Removable Reflectorized Cutout Letters, Numerals, Arrows, Symbols, Corner Radii for Sign Borders and Borders, except that when there are two or more signs of identical design, a working drawing for only one of the signs need be submitted. The working drawings shall show the details of the panels, frames, wind beams, stiffeners, joint backing plates, splices, if any, fasteners, brackets, sign post or support connections, and methods of attaching removable cutout copy messages to the sign face. In addition, the working drawing shall show letter and interline spacing of the message in sufficient detail to check against the plans.

(8) Cutting, Handling and Storing Sign Blanks and Panels. High density and medium density exterior type plywood panels may be fabricated with standard woodworking equipment. Precaution shall be taken to prevent overlay surfaces from coming in contact with any substance which would inhibit adhesion of paint or reflective sheeting. Fabrication of all plywood shall be accomplished in uniform and workmanlike manner.

All possible fabrication, including cutting, drilling, and edge routing should be completed prior to painting or application of reflective materials.

Completed sign blanks and panels shall be handled and stored in such manner that corners, edges and faces are not damaged. Any mars, scratches or other damage to the sign faces which are not visible when viewed as outlined in the Manual of Testing Procedures at a distance of fifty feet, shall be acceptable. Finished sign faces shall be stored off the ground in a vertical position and protected from the weather until properly erected.

(9) Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

700.4. Erection. Prior to erection, all bolt heads and hardware showing on sign face shall be covered with reflective sheeting or painted similar in color to the sign face. Other hardware should be painted. All erection hardware on the sign face should either be painted or left untouched. After

the signs have been erected, they shall be washed with a clean solution approved by the sign manufacturer to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles.

700.5. Measurement. Plywood Signs (Type A and Type B) shall be measured by the square foot. Measurement shall be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and the specifications with no deductions for rounding off corners, and no measurement will be made for area in excess of this minimum area.

700.6. Payment. Payment for Plywood Signs (Type A and Type B) will be made at the unit price bid per square foot for "Plywood Signs (Type A) and/or (Type B)" as specified, which price shall be full compensation for furnishing the high density or medium density sign blanks and/or panels; fabrication of the blanks and/or panels; furnishing and application of reflective sheeting or paint and bead reflectorization to the faces of blanks and/or panels; furnishing and applying paint to the back side and edges of blanks and/or panels; application of sign messages and borders to sign blanks by direct or reverse screening where required by the plans; furnishing and attaching to the sign faces all removable reflectorized cutout letters, numerals, arrows, symbols, borders, and corner radii for sign borders where required by the plans; furnishing and fabrication of frames, wind beams, stiffeners, and/or joint backing strips that are required; furnishing all bolts, rivets, screws, fasteners, clamps, brackets, and sign post or support connections; assembling and erecting the signs; washing and cleaning the signs after erection; and all other labor, materials, and incidentals necessary to provide signs complete and attached to the sign posts or supports.

ITEM 702

STEEL SIGNS (TYPE A)

702.1. Definition. Steel Signs (Type A) are signs of one piece construction which are made from sheet steel, and which have the face side reflectorized.

702.2. Sign Blanks. Sheet steel sign blanks shall conform with the requirements of the latest revision of ASTM Specification A-415 and shall be of 12 gauge sheet steel.

Sign blanks shall be cut to the proper size and shape as shown on the plans and shall have a smooth, uniform finish free of cracks, seams, laps, blisters, detrimental rust or other injurious imperfections. Edges of sign blanks shall be sheared and free from burrs or wires. Punched holes in the sign blanks shall be clean and true to size and dimension. Excessive warps, dents or buckles will not be acceptable and the blank shall be essentially a plane surface. Steel sign blanks after shearing and punching, shall have a treatment

of Electro-deposited zinc applied in accordance with the latest revision of ASTM Specification A-164, Type GS. The zinc treated sign blanks shall be treated with an approved chromate type conversion coating which shall precede the application of paint and beads or reflective sheeting.

The sign blanks shall not be handled except by device or clean canvas gloves between cleaning operations and the application of the reflective material. There shall be no opportunity for the blanks to come in contact with grease, oils, or other contaminants prior to the application of the reflective material.

702.3. Sign Face Reflectorization. Sign face reflectorization shall be of the color shown on the plans.

Flat Surface Flexible Reflective Sheeting shall be used for sign faces requiring preparation by the reverse screen process, using colored transparent ink, in conformance with the plans.

Flat Surface Flexible Reflective Sheeting, Exposed Lens Flexible Reflective Sheeting, or Paint and Beads may be used, at the Contractor's option, for reflectorization of sign faces not requiring preparation by the reverse screen process, using colored transparent ink, provided, however, that the reflective material selected by the Contractor shall be of the same type and manufacture for all signs of the same classification throughout the project.

Flat Surface Flexible Reflective Sheeting shall conform with the Item, "Flat Surface Flexible Reflective Sheeting".

Exposed Lens Flexible Reflective Sheeting shall conform with the Item, "Exposed Lens Flexible Reflective Sheeting".

Paint and Beads shall conform with the Item, "Bead Reflectorization for Signs Having a White or Yellow Background".

702.4. Application of Reflective Sheeting to Sign Faces. Reflective Sheeting shall be applied to sign faces by an approved vacuum applicator, using a combination of heat and vacuum in conformance with the recommended procedures of the manufacturer of the reflective sheeting. When splicing of reflective sheeting is necessary, the number of splices shall be held to a minimum consistent with the reflective sheeting widths furnished by the manufacturer, and the minimum dimension for any one piece of reflective sheeting shall be 1'-0".

After aging 48 hours at 75 F from the time of application, adhesion of reflective sheeting to the sign blank shall be strong enough to resist stripping when tested with a stiff putty knife.

All sign faces having flat surface reflective sheeting shall be sprayed with one coat of finishing clear or edge sealed in accordance with the sheeting manufacturer's recommendations and instructions. Finishing clear or edge sealer shall not be applied to screen processed signs until after completion of the screen process and shall be applied to sign faces having removable copy prior to the application of the removable copy.

702.5. Bead Reflectorization for Signs Having a White or Yellow Background.

(1) Reflector Coat. The reflector coat is the unbeaded layer of paint immediately under the beads. It shall consist of a film of bead binder, without beads, having a minimum dry film thickness of 2 mils. Binder specifications are listed in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background". At least 16 hours air-drying time, under satisfactory drying conditions, shall be allowed before the actual bead binder coats and beads are applied.

(2) Bead Binder Coat. This is the coat which holds or binds the reflective beads to the face of the sign. If the binder requires thinning, only the approved thinner shall be used. The viscosity of the binder being applied shall not be less than 30 seconds as measured on a #4 Ford Cup at 77 F. There are three different grades or sizes of beads described in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background". Each grade will require a different wet film thickness in order to embed each particular size to a depth of 40 to 60%. The following are the wet film thicknesses usually required to embed the beads 40 to 60%:

Grade 1 Beads	1.50 Mils
Grade 2 Beads	1.25 Mils
Grade 3 Beads	1.00 Mil

These are only suggested film thicknesses; the factor controlling the correct wet film thickness is the amount of embedment obtained when the beads are applied. The correct embedment will be determined by examining a sign immediately after beading. A 10 power magnifier is suitable for this examination.

During sign construction the film thickness over the face of the signs being manufactured shall not vary more than ± 10% from the determined correct film thickness.

(3) Application of the Beads. The bead applicator shall be adjusted so that it will apply a single layer of beads containing a minimum of 80% of the amount of beads theoretically possible uniformly distributed over the face of the sign. Examination of the completed signs with a magnifier, immediately after beading, shall show a unilayer of beads embedded 40 to 60% of their average diameter in the binder with no stacking and piling of the beads. All beads applied to any one sign shall be of one grade or size as defined in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background".

702.6. Sign Messages and Borders. Sign messages and borders shall be the size and color shown on the plans. Silk screen processing ink approved by the Texas Highway Department's Materials and Test Division shall be used for sign messages and borders applied to sign faces by the screen process. All messages and borders prepared by a screen process shall have clean, sharp edges with no runs or sags and shall be of sufficient thickness to completely cover the background material.

702.7. Sign Post Connections. Sign Post Connections shall conform with the designs shown on the standard sheet "Interstate Standard Roadside Sign Mounting Clamp Details, SMD(3)" of the plans.

702.8. Cleaning. After the signs have been erected, they shall be washed with cleaning solution approved by the sign manufacturer to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles.

702.9. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

702.10. Measurement. Steel Signs (Type A) shall be measured by the square foot. Measurement shall be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and specifications, with no deductions for rounding off corners, and no measurement will be made for area in excess of this minimum area.

702.11. Payment. Payment for Steel Signs (Type A) will be made at the unit price bid per square foot for "Steel Signs (Type A)" which price shall be full compensation for furnishing sheet steel sign blanks; fabrication of the sign blanks; treatment of the sign blanks required by this specification; furnishing and applying reflective sheeting or paint and bead reflectorization to the sign faces; direct or reverse screening of messages and borders as required by the plans; furnishing the sign post connections; washing and cleaning the signs after erection; and furnishing all other materials, labor and incidentals necessary to provide signs completed and attached to the sign posts or supports.

ITEM 704

ALUMINUM SIGNS (TYPE A)

704.1. Definition. Aluminum Signs (Type A) are signs of one piece construction made from sheet aluminum, and which have the face side reflectorized.

704.2. Sign Blanks. Sheet aluminum sign blanks shall conform with the requirements of ASTM Specification B209 alloy 6061-T6 and shall be 0.125-inch thick.

Sign blanks shall be cut to the proper size and shape as shown on the plans, shall be free of buckles, warps, dents, cockles, burrs and other defects resulting from fabrication, and shall be essentially a plane surface.

When reflective sheeting is to be applied to sheet aluminum sign blanks, the face of the sign blanks shall be treated in the manner prescribed by the manufacturer supplying the reflective sheeting. The back of the sign blanks shall be treated with a proprietary chemical process such as Alodine 1200, Iridite 14, Bonderite 710 or Lyfanite according to the manufacturer's instructions and his recommendations regarding suitability for use with

aluminum alloys when such process does not preclude the proper preparation of the sign face for the application of the reflective sheeting. This chemical conversion coating shall be light colored, tight, and free from powdery residues.

When paint and bead reflectorization is to be applied to sheet aluminum sign blanks, the face and back of the blanks shall be treated with a proprietary chemical process such as Alodine 1200, Iridite 14, Bonderite 710, or Lyfanite, according to the manufacturer's instructions and his recommendations. The chemical conversion coating shall be of light color, tight and free from all powdery residue.

The sign blanks shall not be handled except by device or clean canvas gloves between all cleaning operations and the application of the reflective material. There shall be no opportunity for the blanks to come in contact with grease, oils, or contaminants prior to the application of the reflective material.

704.3. Sign Face Reflectorization. Sign face reflectorization shall be of the color shown on the plans.

Flat Surface Flexible Reflective Sheeting shall be used for sign faces requiring preparation by the reverse screen process, using colored transparent ink, in conformance with the plans.

Flat Surface Flexible Reflective Sheeting, Exposed Lens Flexible Reflective Sheeting, or Paint and Beads may be used, at the Contractor's option, for reflectorization of sign faces not requiring preparation by the reverse screen process, using colored transparent ink, provided however, that the reflective material selected by the Contractor shall be of the same type and manufacture for all signs of the same classification throughout the project.

Flat Surface Flexible Reflective Sheeting shall conform with the Item, "Flat Surface Flexible Reflective Sheeting".

Exposed Lens Flexible Sheeting shall conform with the Item, "Exposed Lens Flexible Reflective Sheeting".

Paint and Beads shall conform with the Item, "Bead Reflectorization for Signs Having a White or Yellow Background".

704.4. Application of Reflective Sheeting to Sign Faces. Reflective sheeting shall be applied to sign faces by an approved vacuum applicator, using a combination of heat and vacuum in conformance with the recommended procedures of the manufacturer of the reflective sheeting. When splicing of reflective sheeting is necessary, the number of splices shall be held to a minimum consistent with the reflective sheeting widths furnished by the manufacturer, and the minimum dimension for any one piece of reflective sheeting shall be 1'-0".

After aging 48 hours at 75 F from the time of application, adhesion of reflective sheeting to the sign blank shall be strong enough to resist stripping when tested with a stiff putty knife.

All sign faces having flat surface reflective sheeting shall be sprayed with one coat of finishing clear or edge sealed in accordance with the sheeting manufacturer's recommendations and instructions. Finishing clear or edge sealer shall not be applied to screen processed signs until after completion of the screen process and shall be applied to sign faces having removable copy prior to the application of the removable copy.

704.5. Bead Reflectorization for Signs Having White or Yellow Backgrounds.

(1) Reflector Coat. The reflector coat is the unbeaded layer of paint immediately under the beads. It shall consist of a film of bead binder, without beads, having a minimum dry film thickness of 2 mils. Binder specifications are listed in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background". At least 16 hours air-drying time, under satisfactory drying conditions, shall be allowed before the actual bead binder coats and beads are applied.

(2) Bead Binder Coat. This is the coat which holds or binds the reflective beads to the face of the sign. If the binder requires thinning, only the approved thinner shall be used. The viscosity of the binder being applied shall not be less than 30 seconds as measured on a #4 Ford Cup at 77 F. There are three different grades or sizes of beads described in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background". Each grade will require a different wet film thickness in order to embed each particular size to a depth of 40 to 60%. The following are the wet film thicknesses usually required to embed the beads 40 to 60%:

Grade 1 Beads	1.50 Mils
Grade 2 Beads	1.25 Mils
Grade 3 Beads	1.00 Mil

These are only suggested film thicknesses; the factor controlling the correct wet film thickness is the amount of embedment obtained when the beads are applied. The correct embedment will be determined by examining a sign immediately after beading. A 10 power magnifier is suitable for this examination.

During sign construction the film thickness over the face of the signs being manufactured shall not vary more than ± 10% from the determined correct film thickness.

(3) Application of the Beads. The bead applicator shall be adjusted so that it will apply a single layer of beads containing a minimum of 80% of the amount of beads theoretically possible uniformly distributed over the face of the sign. Examination of the completed signs with a magnifier, immediately after beading, shall show a unilayer of beads embedded 40 to 60% of their average diameter in the binder with no stacking and piling of the beads. All beads applied to any one sign shall be of one grade or size as defined in the Item, "Bead Reflectorization for Signs Having a White or Yellow Background".

704.6. Sign Messages and Borders. Sign messages and borders shall be the size and color shown on the plans. Silk screen processing ink approved by the Texas Highway Department's Materials and Tests Division shall be used for sign messages and borders applied to sign faces by the screen process. All messages and borders prepared by a screen process shall have clean, sharp edges with no runs or sags and shall be of sufficient thickness to completely cover the background material.

704.7. Hardware for Attaching Type A Signs to Guide Signs. When a Type A sign is to be attached to a Guide sign as a part of the sign message, the attachment shall be made by screws of stainless steel, galvanized steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Stainless steel screws, washers, lock washers, and other hardware shall conform with ASTM Specification A320, Grade B8F, Annealed.

Galvanized steel screws, washers, lock washers, and other hardware shall conform with ASTM Specification A307. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standard Specifications.

Aluminum screws, washers, lock washers, and other hardware shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

When required by the plans, aluminum hardware used for signs located in coastal and heavy industrial atmospheres shall be given a dichromate sealed finish conforming with the requirements of Specification MIL-A-8625A, Type II.

704.8. Sign Post Connections. Sign Post Connections shall conform with the designs shown on the standard sheet, "Interstate Standard Roadside Sign Mounting Clamp Details, SMD(3)" of the plans.

704.9. Cleaning. After the signs have been erected, they shall be washed with an approved cleaning solution to remove all grease, oil, dirt smears, streaks, finger marks, and other foreign particles.

704.10. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

704.11. Measurement. Aluminum Signs (Type A) shall be measured by the square foot. Measurement shall be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and specifications, with no deductions for rounding off corners, and no measurement will be made for area in excess of this minimum area.

704.12. Payment. Payment for Aluminum Signs (Type A) will be made at the unit price bid per square foot for "Aluminum Signs (Type A)" which price shall be full compensation for furnishing sheet aluminum sign blanks; fabrication of the sign blanks; treatment of the sign blanks required by this specification; furnishing and applying reflective sheeting or paint and bead reflectorization to the sign faces; direct or reverse screening of messages and

borders as required by the plans; furnishing the sign post connections; washing and cleaning the signs after erection; and furnishing all other materials, labor and incidentals necessary to provide signs completed and attached to the sign posts or supports.

ITEM 706

ALUMINUM SIGNS (TYPE B)

706.1. Definition. Aluminum Signs (Type B) are signs made from extruded aluminum panels.

706.2. Extruded Aluminum Sign Panels. Extruded aluminum sign panels shall have a minimum thickness of 0.109 inch and shall conform to the requirements of ASTM Specification B221 alloy 6061 or a similar alloy approved by the Engineer which is suitable for porcelain enameling to meet the specifications contained herein. The porcelainized panels, after enameling, shall have a minimum yeild strength of 16,000 psi and all other Tensile Requirements are voided. If the porcelain enameling process materially alters the temper of the aluminum panels such that the minimum yield point of the material is below 16,000 psi, the panels shall be artifically aged or processed to raise the yield point to the required 16,000 psi.

Panels shall be of a 12-inch width except that one 6-inch width panel may be used in any one sign where necessary to obtain a specified overall sign height. Adjacent panels shall be attached to each other by means of bolts.

Extruded aluminum sign panels that require splicing shall be spliced by rivets, bolts or other fasteners as shown on working drawings furnished by the Contractor, subject to approval by the Engineer. All splices shall be capable of developing the full strength of the section. Rivets or other fasteners shall be flush with the face side to provide an even surface for the application of porcelain enamel. The aluminum panels shall be fastened to frames, stiffeners, wind beams or joint backing strips as shown on the plans or on working drawings furnished by the Contractor, subject to approval by the Engineer. All fabrication of sign panels including cutting and drilling or punching of holes, except mounting holes for removable cutout letters, numerals, arrows, symbols and borders shall be completed prior to metal degreasing and application of porcelain enamel.

Frames, stiffeners, wind beams, joint backing strips and fasteners shall be stainless steel, galvanized steel, or aluminum subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Unless required otherwise by the plans, stainless steel frames, stiffeners, wind beams, and fasteners shall conform with ASTM Specification A276, Type 302, Annealed, and stainless steel joint backing strips shall conform with ASTM Specification A240, Type 302, Annealed.

Galvanized steel frames, stiffeners, wind beams, joint backing strips, and fasteners shall conform with ASTM Specification A 36. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standarard Specifications.

Aluminum frames, stiffeners, wind beams, and joint backing strips shall conform with the requirements of ASTM Specification B308 alloy 6061-T6, ASTM Specification B235 alloy 6061-T6, or ASTM Specification B209 alloy 6061-T6. Aluminum fasteners shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

706.3. Porcelain Enamel. Porcelain enamel shall conform with Specifications for Porcelain Enamel on Aluminum as used for Signs and Architectural Applications, Porcelain Enamel Institute Designation ALS-105(57), except that paragraph (e) of Part 2, "Requirements" of ALS-105(57) is deleted and replaced by the following requirement: "The porcelain enamel shall have a weight loss of no more than 20 mg./sq. in. in the boiling acid test, when tested according to ASTM C283."

The color of porcelain enamel shall be uniform and shall conform with the Standard Interstate Green color card as shown in the U.S. Department of Transportation, Federal Highway Administration's "Manual on Uniform Traffic Control Devices for Streets and Highways", latest edition, and any subsequent applicable Interpretation Memorandum or approved change which pertains to this Manual. Any noticeable difference in shades of color or gloss on any one sign panel or between adjacent panels shall be cause for rejection.

The chromaticity coordinates x and y, and the luminous directional reflection Y, shall meet the following requirements: $x = 0.25 \pm 0.02$, $y = 0.38 \pm 0.03$, and $Y = 0.07 \pm 0.02$. Test for color shall be run according to Federal Methods of Tests TT-T-141, Method 4252, using a standard green panel, SGR-30, supplied by the National Bureau of Standards.

Porcelain enamel application shall have a gloss reading of a maximum of 40 units at an angle of 45 degrees according to the procedure described in Bulletin T-18 (May 1953) of the Porcelain Enamel Institute, Inc.

706.4. Surface Preparation. Before the porcelain enameling process, panels shall be given a suitable surface preparation as described in the Porcelain Enamel Institute Bulletin AL-2a, 4th Edition, Section II, "Surface Preparation".

706.5. Application of Porcelain Enamel to Face and Edges of Extruded Aluminum Sign Panels. Porcelain enamel shall be so applied to the face side and to the edges of the panels that no aluminum is visible. The thickness of the porcelain enamel application shall be between 0.0015 and 0.007-inch. There shall be no tooling marks on the face side of the panels.

Adherence will be checked on samples selected as outlined in the Texas Highway Department's *Manual of Testing Procedures.*

Porcelain enamel aluminum sign faces shall be uniformly finished and free from surface defects. Blemishes which are not visible from a distance of

fifty feet when viewed at eye level with the sign surface shall be acceptable.

After porcelain enameling is completed, the extruded aluminum sign panel faces shall be flat and true within a tolerance of one-fourth-inch per eight (8) feet of panel length. Flatness along the narrow axis of the panel on the sign face side shall be limited to 0.005 inch per inch of width.

706.6. Application of Porcelain Enamel to Back Side of Extruded Aluminum Sign Panels. Porcelain enamel shall be applied to the back side of extruded aluminum sign panels and shall be the same color and thickness as the face side. Legs of the extruded aluminum sign panels may have only a "dust coat" of porcelain enamel. Tooling marks on the back and legs of extruded aluminum sign panels shall not be cause for rejection.

706.7. Sign Support Connections and Hardware. Sign support connections for signs made from extruded aluminum panels shall be as shown on the plans or of the supplier's choice subject to approval by the Engineer. The connections shall have no fasteners which project through the front face of the panel; they shall be capable of developing the full strength of the panel; and they shall be stainless steel, galvanized steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

All bolts, nuts, washers, lock washers, and other hardware used in making the signs which are not specifically covered on the plans shall be galvanized steel, stainless steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Stainless steel sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with ASTM Specification A320, Grade B8F, Annealed.

Galvanized steel sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with ASTM Specification A307. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standard Specifications.

Aluminum sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

When required by the plans, aluminum sign support connections and other aluminum hardware used for signs located in coastal and heavy industrial atmospheres shall be given a dichromate sealed finish conforming with the requirements of Specification MIL-A8625A, Type II.

706.8. Sign Messages and Borders. The sign messages and borders shall be of the size, type and color shown on the plans for the various signs and shall conform with the applicable specification(s).

When Interstate Route Markers are required as a part of the sign message, they shall be reflectorized and shall conform with the plans and with the Item, "Aluminum Signs (Type A)".

When U.S. and State Route Markers are required as a part of the sign message, they shall conform with the plans and with the applicable specification(s).

706.9. Working drawings. The Contractor shall submit for approval of the Engineer five prints of the working drawings for each sign, except that when there are two or more signs of identical design, a working drawing for only one of the signs need be submitted. The working drawings shall show the details of the panels, frames, wind beams, stiffeners, joint backing plates, splices, if any, fasteners, brackets, sign support connections, and methods of attaching removable cutout copy messages to the sign face. In addition, the working drawings shall show letter and interline spacing of the message in sufficient detail to check against the plans.

Accompanying the working drawings, the Contractor shall submit the following: The Manufacturer's name, the extrusion number, a dimensional cross section of the panel, and the Manufacturer's calculated moment of inertia and section moduli for each type of extruded panel the Contractor proposes to use.

706.10. Cleaning. After the signs have been erected, they shall be washed with a cleaning solution approved by the sign panel manufacturer to remove all grease, oil, dirt, smears, streaks, finger marks and other foreign particles.

706.11. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures*, unless otherwise specified herein.

706.12. Measurement. Aluminum Signs (Type B) shall be measured by the square foot. Measurement shall be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and specifications, with no deductions for rounding off corners, and no measurement will be made for area in excess of this minimum area.

706.13. Payment. Payment for Aluminum Signs (Type B) will be made at the unit price bid per square foot for "Aluminum Signs (Type B)", which price shall be full compensation for furnishing extruded aluminum sign panels; fabrication of the panels; any treatment of sign panels that might be required prior to the application of porcelain enamel; application of porcelain enamel to the sign panels; furnishing and attaching to the sign faces all removable reflectorized cutout letters, numerals, arrows, symbols, borders, and corner radii for sign borders as shown on the plans; furnishing and fabrication of frames, wind beams, stiffeners, and/or joint backing strips that are required; furnishing all bolts, rivets, screws, fasteners, clamps, brackets and sign support connections; assembling and erecting the signs; washing and cleaning the signs after erection; and all other labor, materials and incidentals necessary to provide signs complete and attached to the sign supports.

ITEM 708

ALUMINUM SIGNS
(TYPE C)

708.1. Definition. Aluminum Signs (Type C) are signs made from sheet aluminum honeycomb sign panels and which have the face side porcelainized.

708.2. Sheet Aluminum Honeycomb Sign Panels. The front aluminum sheet of honeycomb sign panels shall be of the thickness shown on the plans, shall conform with the requirements of ASTM Specification B209 alloy 6061, Alclad 6061 or similar alloy approved by the Engineer which is suitable for porcelain enameling to meet the specifications contained herein. The porcelainized panels, after enameling, shall have a minimum yield strength of 16,000 psi and all other Tensile Requirements are voided. If the porcelain enameling process materially alters the temper of the aluminum panels such that a minimum yield point of the material is below 16,000 psi, the panels shall be artifically aged or processed to raise the yield point to the required 16,000 psi.

The back aluminum sheet of honeycomb sign panels shall be of the thickness shown on the plans, shall conform with the requirements of ASTM Specification B209 alloy 6061, 3003, Alclad 6061, or Alclad 3003, and shall have a minimum yield strength of 16,000 psi and all other Tensile Requirements are voided.

The face and back surface sheets of aluminum shall be laminated to a honeycomb core and an extruded aluminum perimeter frame to produce flat rigid panels approxiamtely one(1) inch thick. The core material shall be one(1) inch thick phenolic impregnated paper honeycomb and shall conform to AMS-3720 standards. Thickness of the core material shall be held to within a tolerance of plus or minus 0.01 inch. The core shall conform to the requirements of Specification MIL-E-5272 for resistance to fungus. The extruded aluminum perimeter frame around all panels and the internal extruded aluminum tubing shall conform to the requirements of ASTM Specification B221 alloy 6063-T6. The extruded aluminum perimeter frame shall be butt jointed or mitered and heliarc welded at the corners to seal against moisture. If butt joints are used, the joints shall be horizontal when the sign is in the erected position. The internal extruded aluminum tubing shall be heliarc welded to the perimeter frame in all locations where attachment of panels to support is required.

Sign panels shall have a maximum width of five (5) feet, and not more than two (2) panels for any one sign may be fabricated to a dimension of less than five (5) feet in width to obtain a specific over-all sign dimension. Only vertical joints will be permitted where more than one panel is required to fabricate any one complete sign. The number of panels used in making any one sign shall be kept to a practical minimum.

All units shall be flat within a measured plus or minus 0.040 inch per foot across the plane of each panel from opposite corners. All perimeter edges shall be routed flush and smooth after the panel has been laminated. All edges shall be straight within a tolerance of plus or minus one-sixteenth (1/16) inch.

Sheet aluminum honeycomb sign panels shall be provided with backing strips or other sections approved by the Engineer at the joints to keep abutting panels in proper alignment and shall be such as not to restrict the thermal expansion or contraction of adjacent panels. Each panel shall be provided with flathead elevator type bolts which are so designed as to permit easy attachment to and removal from supporting frames and which will develop the full strength of the panel. All fastenings used in the fabrication of sign panels which project on the sign face shall be anodized a color similar to the color required for the porcelain enameled face. All fasteners used for attaching the sign face to the supporting frames which project on the sign face shall have a porcelain enameled coating similar to the porcelain enameled face or shall be anodized a color similar to the porcelain enameled face.

The face and back surface sheets of aluminum honeycomb panels shall not be spliced. The aluminum panels shall be fastened to frames, stiffeners, wind beams, joint backing strips or other approved sections as shown on the plans or on working drawings furnished by the Contractor, subject to approval by the Engineer. Fasteners for attaching the sign panels to the supporting frame shall pass into or through the internal tubing only and shall not pass into or through any panel perimeter frame.

Frames, stiffeners, wind beams, joint backing strips, or other approved sections and fasteners shall be stainless steel, galvanized steel or aluminum subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Unless required otherwise by the plans, stainless steel frames, stiffeners, wind beams, and fasteners shall conform with ASTM Specification A276, Type 302, Annealed, and stainless steel joint backing strips or other approved sections shall conform with ASTM Specification A240, Type 302, Annealed.

Galvanized steel frames, stiffeners, wind beams, joint backing strips, or other approved sections, and fasteners shall conform with ASTM Specification A 36. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standard Specifications.

Aluminum frames, stiffeners, wind beams, and joint backing strips or other approved sections shall conform with the requirements of ASTM Specification B308 alloy 6061-T6, ASTM Specification B235 alloy 6061-T6, or ASTM Specification B209 alloy 6061-T6. Aluminum fasteners shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

708.3. Porcelain Enamel. Porcelain enamel shall conform with Specifications for Porcelain Enamel on Aluminum as used for Signs and Architectural Applications, Porcelain Enamel Institute Designation ALS-105(57), except that paragraph (e) of Part 2, "Requirements" of ALS-105(57) is deleted and replaced by the following requirement: "The porcelain enamel shall have a weight loss of no more than 20 mg./sq. in. in the boiling acid test, when tested according to ASTM C283".

The color of porcelain enamel shall be uniform and shall conform with the Standard Interstate Green color card as shown in the U.S. Department of Transportation, Federal Highway Administration's "Manual on Uniform

Traffic Control Devices for Streets and Highways", latest edition, and any subsequent applicable Interpretation Memorandum or approved change which pertains to this Manual. Any noticeable difference in shades of color or gloss on any one sign panel or between adjacent panels shall be cause for rejection.

The chromaticity coordinates x and y, and the luminous directional reflection Y, shall meet the following requirements: $x = 0.25 \pm 0.02$, $y = 0.38 \pm 0.03$, and $Y = 0.07 \pm 0.02$. Tests for color shall be run according to Federal Methods of Test TT-T-141, Method 4252 using a standard green panel, SGR-30, supplied by the National Bureau of Standards.

Porcelain enamel application shall have a gloss reading of a maximum of 40 units at an angle of 45 degrees according to the procedure described in Bulletin T-18 (May 1953) of the Porcelain Enamel Institute, Inc.

708.4. Application of Porcelain Enamel. The front aluminum sheet of honeycomb sign panels shall be given a suitable surface preparation as described in the Porcelain Enamel Institute Bulletin AL-2a, 4th Edition, Section II, "Surface Preparation" before the porcelain enameling process.

Porcelain enamel shall be so applied to the face of the front aluminum sheet of honeycomb sign panels that no aluminum is visible when viewed normal to the face. The thickness of the porcelain enamel application shall be between 0.0015 and 0.007 inch. Adherance will be checked on samples selected as outlined in the Texas Highway Department's *Manual of Testing Procedures.*

Porcelain enamel shall not be applied to the back sheet of sheet aluminum honeycomb sign panels or to perimeter frames.

Porcelain enamel aluminum sign faces shall be uniformly finished and free from surface defects. Blemishes which are not visible from a distance of fifty feet when viewed at eye level with the sign surface shall be acceptable.

708.5. Treatment for Sign Backs. If the back aluminum sheet is of ASTM Specification B209 alloy 6061 or 3003, it shall be treated with a proprietary chemical process such as Alodine 1200, Iridite 14, Bonderite 710 or Lyfanite according to the manufacturer's instructions and his recommendations regarding suitability for use with aluminum alloys when such process does not preclude proper preparation for the application of the laminating adhesive. This chemical conversion coating shall be light colored, tight, and free from all powdery residue. If the back aluminum sheet is of Alclad 6061 or Alclad 3003, it need not be treated with a proprietary chemical process.

708.6. Sign Support Connections and Hardware. Sign support connections for signs made from sheet aluminum honeycomb sign panels shall be as shown on the plans or of the supplier's choice subject to approval by the Engineer. The connections shall be capable of developing the full strength of the panel, and they shall be stainless steel, galvanized steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

All bolts, nuts, washers, lock washers, and other hardware used in making the signs which are not specifically covered on the plans shall be galvanized steel, stainless steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Stainless steel sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with ASTM Specification A320, Grade B8F, Annealed.

Galvanized steel sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with ASTM Specification A307. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standard Specifications.

Aluminum sign post connections, bolts, nuts, washers, lock washers and other hardware used in making the signs shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

When required by the plans, aluminum sign support connections and other aluminum hardware used for signs located in coastal and heavy industrial atmospheres shall be given a dichromate sealed finish conforming with the requirements of Specification MIL-A-8625A, Type II.

708.7. Sign Messages and Borders. The sign messages and borders shall be of the size, type, and color shown on the plans for the various signs and shall conform with the applicable specification(s).

When Interstate Route Markers are required as a part of the sign message, they shall be reflectorized and shall conform with the plans and with the applicable specification(s).

When U.S. and State Route Markers are required as a part of the sign message, they shall conform with the plans and with the applicable specification(s).

708.8. Working Drawings. The Contractor shall submit for approval of the Engineer five (5) prints of the working drawing for each sign, except that when there are two or more signs of identical design, a working drawing for only one of the signs need be submitted. The working drawings shall show the details of the panels, frames, wind beams, stiffeners, joint backing strips or other approved sections, splices if any, fasteners, brackets, sign support connections, and methods of attaching removable cutout copy messages to the sign face. In addition, the working drawings shall show letter and interline spacing of the message in sufficient detail to check against the plans.

708.9. Cleaning. The signs shall be washed prior to shop inspection. After erection and before final inspection of the signs, the signs shall be washed with a cleaning solution approved by the sign panel manufacturer to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles.

708.10. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures*, unless otherwise specified herein.

708.11. Measurement. Aluminum Signs (Type C) shall be measured by the square foot. Measurement shall be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and specifications, with no deductions for rounding off corners, and no measurement will be made for area in excess of this minimum area.

708.12. Payment. Payment for Aluminum Signs (Type C) will be made at the unit price bid per square foot for "Aluminum Signs (Type C)", which price shall be full compensation for furnishing sheet aluminum honeycomb sign panels; fabrication of the panels; any treatment of sign panels that might be required prior to the application of porcelain enamel; application of porcelain enamel to the sign panels; treatment for sign backs; furnishing and attaching to the sign faces all removable reflectorized cutout letters, numerals, arrows, symbols, borders, and corner radii for sign borders as shown on the plans; furnishing and fabrication of frames, wind beams, stiffeners, and/or joint backing strips or other approved sections that are required; furnishing all bolts, rivets, screws, fasteners, clamps, brackets, and sign support connections; assembling and erecting the signs; washing and cleaning the signs after erection; and all other labor, materials, and incidentals necessary to provide signs complete and attached to the sign supports.

ITEM 710

ALUMINUM SIGNS (TYPE D)

710.1. Definition. Aluminum Signs (Type D) are signs which are usually, but not restricted to, multi-piece construction, which are made from sheet aluminum, and which have green porcelain enamel on the face side.

710.2. Sheet Aluminum. Sheet aluminum shall be of the thickness shown on the plans, shall conform with the requirements of ASTM Specification B209 alloy 6061, Alclad 6061, or similar alloy approved by the Engineer which is suitable for porcelain enameling to meet the specifications contained herein. The porcelainized pieces of sheet aluminum, after enameling, shall have a minimum yield strength of 16,000 psi and all other Tensile Requirements are voided. If the porcelain enameling process materially alters the temper of the pieces of sheet aluminum such that the minimum yield point of the material is below 16,000 psi, the pieces of sheet aluminum shall be artificially aged or processed to raise the yield point to the required 16,000 psi.

Any one piece of sheet aluminum used in making a sign shall have a maximum width of five (5) feet, and the number of pieces used in making any one sign shall be kept to a practical minimum. Not more than two (2) pieces for any one complete sign may be fabricated to less than five (5) feet in width to obtain a specific overall sign dimension.

Each piece of sheet aluminum shall be flat within measured plus or minus 0.040 inch per foot across the plane of the piece from opposite corners. All edges shall be straight within a tolerance of plus or minus one-sixteenth (1/16) inch.

When more than one piece of sheet aluminum is used in making a sign, backing strips shall be used at the joints to keep abutting pieces in proper alignment. Each piece shall be provided with suitable fastenings which are so designed as to permit easy attachment to and removal from supporting members and which will develop the full strength of the sign. All fastenings and backing strips used in the assembly of individual pieces to form a complete sign, except fastenings for attaching letters, symbols, arrows, corner radii for borders, and borders to the sign face, shall be so designed that there will be no projection on the sign face.

Where splicing of sheet aluminum is required, the splicing shall be done by rivets, bolts, or other fasteners as shown on working drawings furnished by the Contractor, subject to approval by the Engineer. Rivets or other fasteners shall be flush with the face side to provide a smooth even surface for the application of porcelain enamel.

The pieces of sheet aluminum used in making the sign shall be fastened to stiffeners, wind beams, or joint backing strips as shown on the plans or on working drawings furnished by the Contractor, subject to approval by the Engineer. Stiffeners, wind beams, joint backing strips, and fasteners shall be stainless steel, galvanized steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Unless required otherwise by the plans, stainless steel stiffeners, wind beams, and fasteners shall conform with ASTM Specification A276, Type 302, Annealed, and stainless steel backing strips shall conform with ASTM Specification A240, Type 302, Annealed.

Galvanized steel stiffeners, wind beams, backing strips, and fasteners shall conform with ASTM Specification A 36. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standard Specifications.

Aluminum stiffeners, wind beams, and joint backing strips shall conform with the requirements of ASTM Specification B308 alloy 6061-T6, ASTM Specification B235 alloy 6061-T6, or ASTM Specification B209 alloy 6061-T6. Aluminum fasteners shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

All fabrication of sheet aluminum used in making the signs, including cutting and drilling or punching of holes, except holes for attaching removable cutout letters, numerals, arrows, symbols, borders, and corner radii for sign borders, shall be completed prior to degreasing and application of porcelain enamel.

710.3. Porcelain Enamel. Porcelain enamel shall conform with Specifications for Porcelain Enamel on Aluminum as used for Signs and Architectural Applications, Porcelain Enamel Institute Designation ALS-105(57), except that paragraph (e) of Part 2, "Requirements" of ALS-105(57) is deleted and

replaced by the following requirement: "The porcelain enamel shall have a weight loss of no more than 20 mg./sq. in. in the boiling acid test, when tested according to ASTM C283".

The color of porcelain enamel shall be uniform and shall conform with the Standard Interstate Green color card as shown in the U. S. Department of Transportation, Federal Highway Administration's "Manual on Uniform Traffic Control Devices for Streets and Highways", latest edition, and any subsequent applicable Interpretation Memorandum or approved change which pertains to this Manual. Any noticeable difference in shade of color or gloss on any one piece of sheet aluminum or between adjacent pieces of sheet aluminum shall be cause for rejection.

The chromaticity coordinates x and y, and the luminous directional reflection Y, shall meet the following requirements: $x = 0.25 \pm 0.02$, $y = 0.38 \pm 0.03$, and $Y = 0.07 \pm 0.02$. Test for color shall be run according to Federal Methods of Tests TT-T-141, Method 4252 using a standard green panel, SGR-30, supplied by the National Bureau of Standards.

Porcelain enamel application shall have a gloss reading of a maximum of 40 units at an angle of 45 degrees according to the procedure described in Bulletin T-18 (May 1953) of the Porcelain Enamel Institute, Inc.

710.4. Surface Preparation. Before the porcelain enameling process, panels shall be given a suitable surface preparation as described in the Porcelain Enamel Institute Bulletin AL-2a, 4th Edition, Section II, "Surface Preparation".

710.5. Application of Porcelain Enamel. Porcelain enamel shall be so applied to the face side of each piece of sheet aluminum used in a sign that no aluminum surface is visible when viewed normal to the face. The thickness of the porcelain enamel application shall be between 0.0015 and 0.007 inch. There shall be no tooling marks on the face side of the sign.

Porcelain enamel may be applied to the back side of the sheet aluminum used in making the sign. If the sheet aluminum is of ASTM Specification B209 alloy 6061 and porcelain enamel is not applied to the back side, the back side shall be treated with a proprietary chemical process such as Alodine 1200, Iridite 14, Bonderite 710 or Lyfanite according to the manufacturer's instructions and his recommendations regarding suitability for use with aluminum alloys. This chemical conversion coating shall be light colored, tight, and free from all powdery residue. If the sheet aluminum is of Alclad 6061 and porcelain enamel is not applied to the back side, the back side shall not be treated with a proprietary chemical process. Adherence will be checked on samples selected as outlined in the Texas Highway Department's *Manual of Testing Procedures.*

Porcelain enamel aluminum sign faces shall be finished uniformly and free from surface defects. Blemishes which are not visible from a distance of fifty feet when viewed at eye level with the sign surface shall be acceptable.

710.6. Sign Support Connections and Hardware. Sign support connections shall be as shown on the plans or of the supplier's choice, subject to

approval by the Engineer. The connections shall be capable of developing the full strength of the sign; and they shall be stainless steel, galvanized steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

All bolts, nuts, washers, lock washers, and other hardware used in making the signs which are not specifically covered on the plans shall be galvanized steel, stainless steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Stainless steel sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with ASTM Specification A320, Grade B8F, Annealed.

Galvanized steel sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with ASTM Specification A307. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standard Specifications.

Aluminum sign support connections, bolts, nuts, washers, lock washers, and other hardware used in making the signs shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

When required by the plans, aluminum sign support connections and other aluminum hardware used for signs located in coastal and heavy industrial atmospheres shall be given a dichromate sealed finished conforming with the requirements of Specification MIL-A-8625A, Type II.

710.7. Sign Messages and Borders. The sign messages and borders shall be of the size, type, and color shown on the plans for the various signs and shall conform with the applicable specification(s).

When Interstate Route Markers are required as a part of a sign message, they shall be reflectorized and shall conform with the plans and with the Item, "Aluminum Signs (Type A)".

When U.S. and State Highway Route Markers are required as a part of a sign message, they shall conform with the plans and with the applicable specification(s).

710.8. Working Drawings. The Contractor shall submit for approval of the Engineer five prints of the working drawing for each sign, except that when there are two or more signs of identical design, a working drawing for only one of the signs need be submitted. The working drawings shall show the details of the sign, wind beams, stiffeners, joint backing plates, splices, if any, fasteners, brackets, sign support connections, and methods of attaching removable cutout copy messages to the sign face. In addition, the working drawings shall show letter and interline spacing of the message in sufficient detail to check against the plans.

710.9. Cleaning. After the signs have been erected, they shall be washed with a cleaning solution approved by the sign panel manufacturer to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles.

710.10. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures*, unless otherwise specified herein.

710.11. Measurement. Aluminum Signs (Type D) shall be measured by the square foot. Measurement shall be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and specifications with no deductions for rounding off corners, and no measurement will be made for area in excess of this minimum area.

710.12. Payment. Payment for Aluminum Signs (Type D) will be made at the unit price bid per square foot for "Aluminum Signs (Type D)", which price shall be full compensation for furnishing sheet aluminum; fabrication of the signs; any treatment of sheet aluminum that might be required prior to the application of porcelain enamel; application of porcelain enamel to the sheet aluminum; furnishing and attaching to the sign faces all removable reflectorized cutout letters, numerals, arrows, symbols, borders, and corner radii for sign borders as shown on the plans; furnishing and fabrication of wind beams, stiffeners, and/or joint backing strips that are required; furnishing all bolts, rivets, screws, fasteners, clamps, brackets, and sign support connections; assembling and erecting the signs; washing and cleaning the signs after erection; and all other labor, materials, and incidentals necessary to provide signs complete and attached to the sign supports.

ITEM 712

ALUMINUM SIGNS (TYPE F)

712.1. Definition. Aluminum Signs (Type F) are signs of one piece construction which are made from sheet aluminum and which have white porcelain enamel on the face side.

712.2. Sign Blanks. Sheet aluminum for Aluminum Signs (Type F) shall be 0.063 inch thick, shall conform to the requirements of ASTM Specification B209 alloy 6061, Alclad 6061 or similar alloy approved by the Engineer which is suitable for porcelain enameling to meet the specifications contained herein.

Sign blanks shall be cut to the proper size and shape as shown on the plans, shall be free from buckles, warps, dents, cockles, burrs, and other defects resulting from fabrication, and shall be essentially a plane surface. All fabrication of the sign blanks including cutting and punching or drilling of holes, except sign mounting holes and mounting holes for removable cutout letters, numerals, border, corner radii, and outlines for U.S. Route Markers shall be completed prior to metal degreasing and application of porcelain enamel.

712.3. Porcelain Enamel. Porcelain enamel shall conform with Specifications for Porcelain Enamel on Aluminum as used for Signs and Architectural

Applications, Porcelain Enamel Institute Desgination ALS-105(57), except that paragraph (e) of Part 2, "Requirements" of ALS-105(57) is deleted and replaced by the following requirement: "The porcelain enamel shall have a weight loss of no more than 20 mg./sq. in. in the boiling acid test, when tested according to ASTM C283".

The color of the porcelain enamel shall be uniformly white and its C.I.E. Chormaticity coordinate limits when determined in accordance with Federal Methods of Tests TT-T-141, Method 4252, shall fall within a rectangle having the following corner points:

1		2		3		4		
x	y	x	y	x	y	x	y	Reflectance Limit
.315	.330	.322	.325	.312	.310	.305	.315	70 Minimum

Porcelain enamel application shall have a gloss reading of between 50 and 70 units at an angle of 45 degrees according to the procedure described in Bulletin T-18 (May 1953) of the Porcelain Enamel Institute, Inc.

712.4. Surface Preparation. Before the porcelain enameling process, panels shall be given a suitable surface preparation as described in the Porcelain Enamel Institute Bulletin AL-2a, 4th Edition, Section II, "Surface Preparation".

712.5. Application of Porcelain Enamel. Porcelain enamel shall be so applied to the face side of sheet aluminum sign blanks that no aluminum surface is visible when viewed normal to the face. The thickness of the porcelain enamel application shall be between 0.0025 and 0.007 inch. There shall be no tooling marks on the face side of sheet aluminum sign blanks. Porcelain enamel may be applied to the back side of sheet aluminum sign blanks. Adherence will be checked on samples selected as outlined in the Texas Highway Department's *Manual of Testing Procedures.*

Porcelain enamel aluminum sign faces shall be uniformly finished and free from surface defects. Blemishes which are not visible from a distance of fifty feet when viewed at eye level with the sign surface shall be acceptable.

After porcelain enameling is completed, the sheet aluminum sign blanks shall be flat within measured plus or minus 0.040 inch per foot across the plane of each blank from opposite corners.

712.6. Sign Messages and Borders. The sign messages and borders shall be of the size, type, and color shown on the plans for the various signs and shall conform with the applicable specification(s).

712.7. Hardware for Attaching Type F Signs to Guide Signs. Type F signs shall be attached to Guide signs as shown on the plans by screws or bolts of stainless steel, galvanized steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Stainless steel screws, washers, lock washers, and other hardware shall conform with ASTM Specification A320, Grade B8F, Annealed.

Galvanized steel screws, washers, lock washers, and other hardware shall

conform with ASTM Specification A307. Galvanizing shall be in accordance with the Item, "Metal for Structures", of the Standard Specifications.

Aluminum screws, washers, lock washers, and other hardware shall conform with the latest current recommendations of the Aluminum Association's Committee on Highway Applications.

When required by the plans, aluminum hardware used for signs located in coastal and heavy industrial atmospheres shall be given a dichromate sealed finish conforming with the requirements of Specification MIL-A-8625A, Type II.

712.8. Working Drawings. The Contractor shall submit for approval of the Engineer five prints of the working drawing for each sign, except that when there are two or more signs of identical design, a working drawing for only one of the signs need be submitted. The working drawings shall show the method of attaching removable cutout copy messages to the Type F signs and the method of attaching the Type F signs to the face of the Guide signs. In addition, the working drawings shall show letter and interline spacing of the message on the Type F signs in sufficient detail to check against the plans.

712.9. Cleaning. After the Type F signs have been attached to the Guide signs, they shall be washed with cleaning solution approved by the sign manufacturer to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles.

712.10. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures*, unless otherwise specified herein.

712.11. Measurement. Aluminum Signs (Type F) shall be measured by the square foot. Measurement shall be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and specifications with no deductions for rounding off the corners, and no measurement will be made for area in excess of this minimum area.

712.12. Payment. Payment for Aluminum Signs (Type F) will be made at the unit price bid per square foot for "Aluminum Signs (Type F)", which price shall be full compensation for furnishing the sheet aluminum sign blanks; fabrication of the sign blanks; any treatment of the sign blanks that might be required prior to the application of the porcelain enamel; application of porcelain enamel to the sign blanks; furnishing and attaching to the sign faces all removable reflectorized cutout letters, numerals, symbols, borders for State route markers, corner radii for State route markers, and reflectorized outlines for U.S. route markers; furnishing all screws or bolts used for attaching the Type F signs to the Guide signs; attaching the Type F signs to the Guide signs; washing and cleaning the signs after attachment to the Guide signs; and all labor, materials, and incidentals necessary to provide Type F signs complete and attached to the Guide signs.

ITEM 716

FLAT SURFACE FLEXIBLE REFLECTIVE SHEETING

716.1. General Requirements. Reflective sheeting shall consist of glass spheres embedded beneath a flexible transparent plastic which forms a smooth, flat outer surface as exposed in use. The backing to which the glass spheres are adhered shall consist of synthetic sheet resins or other suitable material.

Screened signs or 20 sq. ft. sections of sheeting shall appear uniform in color and/or retroreflectivity when viewed under normal day or night lighting conditions from a distance of 50 ft.

716.2. Film Characteristics.

(1) Tensile strength and elongation. Conditioned for 48 hours, the tensile strength of sheeting or sign faces shall have a minimum of 5 lbs./inch width when tested in accordance with ASTM D 828; when tested in accordance with ASTM D 987-48T, the elongation shall be a minimum of 10%.

(2) Flexibility. Sheeting or sign faces when applied, according to manufacturer's recommendations, to clean and etched .015"x2"x8" aluminum, conditioned (48 hours) and tested at 72 F – 50% R.H., shall be sufficiently flexible to show no cracking when bent around a 3/4" mandrel.

(3) Temperature Stability. The sheeting shall permit cutting, application and color processing at any combination of the following temperatures and relative humidity: Temperature 60 to 100 F, relative humidity 20 to 90%. Sheeting will permit heat curing of unapplied sheeting at temperatures up to 150 F and up to 200 F for applied sheeting.

(4) Chemical Resistance. Sheeting or sign faces after 48 hours of conditioning at 80 to 100 F shall show no effect when exposed for 15 minutes to the following chemicals according to Federal Test Method 6081: mineral spirits, turpentine, methanol, or 10% aqueous solution of NaCl.

(5) Film Thickness. Thickness of sheeting without adhesive and screen ink shall be 4.5 to 7 mils.

716.3. Adhesive.

(1) Type. The reflective sheeting or sign faces shall include a pre-coated tack-free adhesive which will adhere to prescribed surfaces only when activated by heat (175 F to 200 F). The pre-coated adhesive shall not require additional adhesive coats on the reflective material or the application surface.

(2) Quality. Sheeting or sign faces applied (according to the manufacturer's instructions) to clean, smooth, paintable surfaces, shall adhere so securely at temperatures of –20 to 175 F that peeling, pulling, or scraping of the material from the adhering surfaces in pieces containing areas greater than 2 square inches will be impossible. Adhesion tests to be run not less than 48 hours after application.

(3) **Stain Resistance.** The adhesive shall have no staining effect on the reflective sheeting and must be mildew resistant.

716.4. Durability.

(1) **Weatherometer test** shall consist of exposure for 1,200 hours in an Atlas Weather-O-Meter. In addition to requirements specifically listed in this specification, sheeting or sign faces shall show no cracking, crazing, blistering, or dimensional change after a weatherometer test.

(2) **Process Inks.** A minimum of 96 hours after processing, as well as after the weatherometer exposure, no process ink will be removed when tested according to Federal Test Method 6301.

716.5. Color and Gloss.

(1) **Color.** The diffuse day color, before and after weatherometer exposure, shall comply with the specified color requirements. Color requirements are defined by an enclosed area formed by using the following CIE Chromaticity Coordinates as corner points and the listed Y reflectance limits.

CHROMATICITY COORDINATES

Color	x	y	Y Reflectance Limits	Munsell Ref. Standards
White	0.359	0.372		
	0.344	0.387	40 min.	5.1GY – 6.9/12
	0.312	0.319		
Red	0.587	0.325		
	0.580	0.312		
	0.699	0.251	6.5 to 12.0	7.0 R – 3.5/13
	0.735	0.265		
	0.690	0.307		
Orange	0.535	0.375		
	0.604	0.391	19.8 to 30.1	2.5YR – 5.5/14
	0.578	0.415		
	0.535	0.399		

CHROMATICITY COORDINATES
CONT.

Color	x	y	Y Reflectance Limits	Munsell Ref. Standards
Brown	0.445	0.353		
	0.603	0.396	3.8 to 7.7	5.0YR – 2.75/5
	0.552	0.441		
	0.445	0.386		
Yellow	0.476	0.457		
	0.489	0.433	36.2 to 59.1	
	0.536	0.462		10YR – 7.5/14
	0.510	0.486		
Green	0.245	0.407		
	0.010	0.730	3.8 to 10.4	7.5G – 3.0/8
	0.015	0.473		
	0.220	0.364		
Blue	0.196	0.217		
	0.210	0.202	3.1 to 9.0	2.5PB – 3.0/8
	0.109	0.088		
	0.093	0.127		

(2) **Tests.** Color will be determined according to Test Method Tex-839-B.

(3) **Gloss.** The sheeting's face and screened areas shall have an 85° gloss meter rating of not less than 35 before and after weatherometer exposure.

716.6. Reflective Characteristics.

(1) **Intensity.** Reflective sheeting for background, when specified, and reversed screened signs using transparent ink shall have the following minimum brightness values (before and after weatherometer test) at the divergence angle shown, expressed in units of candlepower per foot-candle per square foot.

Color	Divergence Angle	Angle of Incidence 2°	10°	20°
White	.2°	30	20	10
	1/3°	25	15	5
Blue	.2°	2	1.0	–
	1/3°	1	0.6	–
Green	.2°	2.5	1	–
	1/3°	2.0	1.5	–
Yellow	.2°	8	6	3
	1/3°	6	4	2
Red	.2°	3	2	1
	1/3°	2	1.0	0.5
Orange	.2°	8	6	3
	1/3°	6	4	2
Brown	.2°	2	1	–
	1/3°	1	0.6	–

(2) Test. Specific intensity will be determined according to Test Method Tex-842-B.

(3) Contrast. For stop signs, the quotient of legend specific intensity/background specific intensity shall not be less than 6 nor more than 15. For other signs the quotient of legend specific intensity/specific intensity of any other color shall not be less than 6. These contrast requirements are to apply to material both before and after weatherometer test.

716.7. Sampling and Testing.

(1) Methods. Sampling and testing will be in accordance with the Highway Department's *Manual of Testing Procedures* and specific tests are usually indicated in conjunction with the specification requirements, but the Texas Highway Department reserves the right to conduct whatever other tests are deemed necessary to identify and to determine the quality, characteristics, and uniformity of any material. Tests will be made on washed and air dried samples.

(2) Prequalification. Some of the tests required by this specification extend over a prolonged period of time and some tests cannot be made after the reflective material is applied to sign blanks. These tests may be waived by the Materials and Tests Engineer if, in his opinion, the material has been adequately identified and if the identified material has an adequate performance history.

716.8. Measurement and Payment. Flat Surface Flexible Reflective Sheeting shall not be paid for directly but shall be considered subsidiary to the signs on which it is used.

ITEM 718

EXPOSED LENS FLEXIBLE REFLECTIVE SHEETING

718.1. Description. This Item shall consist of glass spheres embedded in a waterproof binder and adhered to a waterproof flexible backing. The backing to which the glass spheres are adhered shall consist of synthetic sheet resin or other suitable noncellulosic material.

718.2. Materials.

(1) General. Reflective sheeting shall be uniform in color and reflectivity. Variations in color or reflectivity noticeable at a distance of 50 feet or more, under day or night lighting conditions, in a single sign shall be cause for rejection of the sign.

Reflective sheeting shall be free from ragged edges, cracks, scale and blisters. Reflective sheeting shall be moisture-resistant and readily cut with scissors, knife, blade or shears without cracking, crazing, checking or flaking.

(2) Adhesive Requirements. Reflective sheeting shall include a precoated adhesive on the back which shall be activated with heat or solvent, without the necessity of additional adhesive coats on the reflective sheeting or application surface.

The pre-coated adhesive shall form a durable bond to clean, well painted surfaces, unpainted high-density overlaid plywood or unpainted corrosion-proof metals such as galvanized steel, aluminum and porcelain enameled metals. The pre-coated adhesive, after 48 hours of aging at 75 F from the time of application, shall be strong enough to resist peeling the reflective sheeting from the application surface; tough enough to resist scuffing and marring during normal handling; elastic enough at low temperatures to resist shocking off when struck at 20 F and moisture-resistant enough to withstand eight hours of soaking in water at 75 F without appreciable decrease in adhesion. The pre-coated adhesive shall have no staining effect on the reflective sheeting and must be mildew-resistant.

Protective liner for preventing contamination and premature adhesion shall be removable by peeling without the necessity of soaking in water or other solvents.

(3) Reflective Characteristics. Reflective sheeting for backgrounds and screened (not reverse screened) signs, when specified, shall have the following minimum brightness values at one-third degree divergence expressed in units

of candlepower per square foot per foot-candle.

Angle of Incidence Degrees	Divergence Angle Degrees	Specific Brightness Cp./Sq. Foot/Foot-Candle		
		White	Yellow	Green
0	1/3	7.1	5.7	6
10	1/3	6.7	5.4	3
20	1/3	–	–	0.3
30	1/3	5	4	–

Measurements shall be conducted in accordance with the Texas Highway Department standard photometric-testing procedures for measuring the amount of light reflected by sign material.

(4) Lens Elements. The reflective sheeting shall possess stable and durable spherical lens elements which, following extraction, shall show no deterioration following submersion in a 5N solution of sulphuric acid (H_2SO_4) for 30 minutes at 72 F.

(5) Color. Color of reflective sheeting shall be as noted on the plans and shall conform to the Standard Interstate Color Card as shown in the U.S. Department of Transportation, Federal Highway Administration's "Manual on Uniform Traffic Control Devices for Streets and Highways", latest edition, and any subsequent applicable Interpretation Memorandum or approved change which pertains to this Manual.

(6) Durability. Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and following cleaning, shall show no appreciable discoloration, cracking, crazing, blistering or dimensional change and not less than 80% of the specified minimum brightness values when exposed to accelerated weathering of either 1 year, south facing, unprotected at 45 degrees in Austin, Texas, or 1,200 hours in an Atlas Weather-O-Meter in accordance with ASTM D822-46T.

(7) Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

718.3. Measurement and Payment. Exposed Lens Flexible Reflective Sheeting will not be measured nor paid for directly but will be considered subsidiary to the signs on which it is used.

ITEM 720

BEAD REFLECTORIZATION FOR SIGNS HAVING A WHITE OR YELLOW BACKGROUND

720.1. Description. This item shall consist of glass beads embedded in a white or yellow binder which has been applied to a sign blank surface.

720.2. Materials.

(1) Bead Binders.

(a) Pigments.

White Binder. The pigmentation shall consist of pure titanium dioxide or a mixture of pure titanium dioxide and zinc oxide (small amounts of tinting pigment permitted).

Yellow Binder. The pigmentation shall consist of a chrome-yellow pigment with or without additional hiding and tinting pigments which will yield a binder conforming to the color requirements of this specification.

(b) Vehicle. The exact type of vehicle is not specified. Other requirements of this specification will determine the suitability of the vehicle. A suggested vehicle is one made using a long oil alkyd resin meeting Federal Specification TT-R-266a, Type I, Class A.

(c) Quantative Requirements.

Pigment, percent based on total solids of binders

	Min.	Max.
White	65	73
Yellow	50	65
Pigment Composition, percent		
White – Pure TiO_2	75	–
Zinc Oxide	–	25
Pure TiO_2 – ZnO	99.5	–
Yellow – Yellow-Chrome	90	–
Other Pigments	–	10
Vehicle Solids, percent based on total solids of binders		
White	27	35
Yellow	35	50

Percent Solids at a consistency of 65 K.U.'s (Using the same thinner to be used during sign manufacturing)

White and Yellow	69	–

Drying time, air-drying (Two-mil wet film with binders thinned to 65 K.U. with thinner used during sign manufacturing) set-to-touch, hours

White	1	4
Yellow	1	7
Dry hard, hours		
White	–	16
Yellow	–	16

60° Specular Gloss (Without correction for diffuse reflectance) After 48 hours, air-dry

White and Yellow	80	–
Fineness of Grind, N.S.		
White and Yellow	7	–
Daylight 45°, 0° directional reflectance		
White only	79	–

(d) Qualitative Requirements.

Color of Yellow Binder. Color shall be such that the finished sign will conform to the Standard Interstate Color Card as shown in the U.S. Department of Transportation, Federal Highway Administration's "Manual on Uniform Traffic Control Devices for Streets and Highways", latest edition and any subsequent applicable Interpretation Memorandum or approved change which pertains to this Manual.

Flexibility. Binder shall not crack when bent over a 1/8" rod after air-drying 24 hours and baking 8 hours at 100 C. A 2-mil wet film drawdown shall be made with the binders thinned to 65 K.U. with the thinner to be used during sign production.

(2) Beads. The beads shall be of glass, and shall show no change after 24 hours immersion in a solution composed of 40% methylene chloride, 20% methyl alcohol, 20% butyl acetate and 20% MEK. The beads shall show no discoloration after 100 hours in an Atlas Weather-O-Meter (Model XWR with a 102-18 cam for alternate light).

At least 90% of the beads shall be perfect spheres without bubble inclusions, milkiness, surface scoring or scratches. A minimum of 90% of the beads shall be free of sharp or angular particles.

The color of the beads, as determined by Test Method Tex-823-B, shall meet the following requirements:

The x and y chromaticity coordinates shall satisfy the following requirements:

y + x shall not be greater than 0.722 nor less than 0.620.

y – x shall not be greater than 0.018 nor less than –0.004.

The Y Tristimulus Value otherwise called the luminance factor, or brightness shall be not less than 0.560.

The beads, when tested by Test Method Tex-822-B, shall have an index of refraction of 1.91 to 1.95.

Crushed beads shall show no darkening when immersed for twenty-four (24) hours with frequent shaking in a solution made up of 50% sodium sulphide (A.C.S.), 49-1/2% distilled water and 1/2% Triton X-100, or a similar wetting agent.

The beads shall meet the following gradation requirements when tested on standard brass sieves:

Bead Size	99-100% by weight shall pass screen with the following aperture	98-100% by weight shall be retained on screen with following aperture
1	0.0069" Sieve	0.0041" Sieve
2	0.0058" Sieve	0.0035" Sieve
3	0.0049" Sieve	0.0029" Sieve

The beads shall be clean and free of dirt, trash, moisture, other foreign materials and static electricity, and shall remain free-flowing in the bead dispenser during the entire beading operation.

(3) Qualitative Requirements of the Completed Sign.

(a) Reflective Requirements. The beaded signs shall have the following minimum brightness values at one-third degree divergency, expressed in units of candlepower per square foot per foot-candle.

Angle of Incidence Degrees	Divergency Angle Degrees	Specific Brightness Cp/Sq. Ft./Ft.-Candle	
		White	Yellow
0	1/3	8.0	6.0
20	1/3	7.5	5.5

(b) Bead Embedment and Bead Retention. All finished signs shall have a uniform layer of beads which are firmly embedded and which, after 24 hours of air-drying, adhere tightly to the faces of the signs.

(4) Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

720.3. Measurement and Payment. Bead Reflectorization for Signs Having a White or Yellow Background will not be measured nor paid for directly but will be considered subsidiary to the signs on which it is used.

ITEM 722

BEAD REFLECTORIZATION FOR SIGNS HAVING A GREEN BACKGROUND

722.1. Description. This item shall consist of the reflectorization of green colored sign panels for subsequent fabrication into highway signs.

The reflectorization is to be carried out by a process involving three separate paint coats or films with a single layer of glass beads embedded in

the top coat. These coats are a metallic reflector coat, a transparent green colored spacer coat and a transparent green colored bead binder coat.

722.2. **Materials.**

(1) **General.** Since there may be considerable variation between production methods used by the manufacturers, the exact equipment, raw materials and production methods used in the manufacturing of green sign panels are not specified but must be approved by the Texas Highway Department before panel production begins.

(2) **Sign Blanks.** The sign panel blanks which are to be reflectorized must meet requirements of the specifications covering the material being used.

(3) **Reflectorization.**

(a) **Transparent Coatings.** Transparent coatings shall be phthalocyanine green pigments completely dispersed in suitable binders and thinners to produce coatings that will produce panels meeting all the requirements of this specification.

(b) **Beads.** Beads of only one grade or size, and with a refractive-index variation of no greater than 0.01 shall be used in the production of sign panels destined for use on any single contract. The beads, when tested by Test Method Tex-822-B shall have an index of refraction of 1.66 to 1.72.

The beads shall be of glass, and shall show no change after 24-hours immersion in a solution composed of 40% methylene chloride, 20% methyl alcohol, 20% butyl acetate, and 20% MEK; or discoloration after 100 exposure hours in an Atlas Weather-O-Meter (Model XWR with a 102-18 cam for alternate light).

A minimum of 95% of the beads shall be perfect spheres without bubble inclusions, milkiness, surface scoring or scratches. A minimum of 99% of the beads shall be free of sharp, angular particles.

The color of the beads as determined by Test Method Tex-823-B shall meet the following requirements:

The x and y chromaticity coordinates shall satisfy the following requirements:

$y + x$ shall not be greater than 0.722 nor less than 0.620

$y - x$ shall not be greater than 0.018 nor less than -0.004

The Y Tristimulus Value, otherwise called the luminance factor or brightness, shall be not less than 0.560.

Crushed beads shall show no darkening when immersed for twenty-four hours with a frequent shaking in a solution made up of 50% sodium sulfide (A.C.S.), 49-1/2% distilled water, and 1/2% Triton X-100, or a similar wetting agent.

The beads shall meet the following gradation requirements when tested on standard brass sieves:

Bead Size	99-100% by weight shall pass screen with following aperture	98-100% by weight shall be retained on screen with following aperture
1	0.0069" Sieve	0.0041" Sieve
2	0.0058" Sieve	0.0035" Sieve
3	0.0049" Sieve	0.0029" Sieve

The beads shall be clean and free of dirt, trash, moisture, other foreign materials and static electricity and shall remain free-flowing in the bead dispenser during the beading operation.

(4) Suggested Production Method. Standard panels and instructions describing each step of a suggested method of production will be made available, upon request, to qualified sign contractors.

(5) Finished Panel Requirements.

(a) Appearance. The color of the panels must closely match the color of the Texas Highway Department Standard Panel when lighted with either daylight or tungsten light.

The finished panels shall have a uniform appearance when subjected to both day and night viewing. Panels with streaks or other nonuniform areas in any single panel or variation between panels visible when viewed from a minimum distance of 50 feet will not be acceptable.

(b) Reflectance. Completed panels shall have the following minimum brightness values expressed in units of candlepower per square foot per foot-candle:

Angle of Incidence Degrees	Divergence Angle Degrees	Specific Brightness Cp./Sq. Foot/Foot-Candle
0	1/3	6
10	1/3	3

(c) Bead Adhesion. The bead adhesion of the completed panel shall be such that the beads cannot be removed from the binder without tearing out some of the binder along with the beads. This is determined by scraping a spot on the signs with a metal blade and observing the spot under a 35 power microscope. No smooth, even bead pockets should be left where the beads have been knocked out.

(d) Paint Adhesion. The adhesion of paint to the sign blank and each coat of paint to the other coats shall be equal to that of the Texas Highway Department Standard Panel.

(e) Smoothness. Sign surfaces shall be equal in smoothness to that of the Texas Highway Department Standard Panel.

(f) Durability. A 3" x 9" panel prepared simultaneously with production panels destined for Texas Highway Department use shall be exposed in an Atlas Weather-O-Meter, Model XWR, for 100 hours with a 102-18 cam for alternate light without water spray and light with water spray. Noticeable change in color or loss of beads will be cause for rejection of all sign panels similarly manufactured.

(g) Coding. Each panel shall be coded on the back surface so that date of production and production batch number may be readily determined for each panel. This code shall not be visible on the completed sign at a distance greater than ten (10) feet.

(h) Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

722.3. Measurement and Payment. Bead Reflectorization for Signs Having a Green Background will not be measured nor paid for directly but will be considered subsidiary to the signs on which it is used.

ITEM 724

REMOVABLE REFLECTORIZED CUTOUT LETTERS, NUMERALS, ARROWS, SYMBOLS, CORNER RADII FOR SIGN BORDERS, BORDERS AND REFLECTORIZED OUTLINES FOR U.S. AND STATE ROUTE MARKERS

724.1. Description. This item shall consist of acrylic-plastic reflectors supported by embossed-aluminum frames.

Letter design shall be the Federal Highway Administration's lower-case alphabet and modified initial capital letters and numerals, modified to accommodate the required reflectors.

724.2. Materials.

(1) General. All items shall be fabricated from 0.040-inch sheet aluminum. Sheet aluminum shall conform to the requirements of ASTM Specification B209 alloy 3003.

The size and spacing of holes for reflector units shall be such as to afford maximum night legibility and visibility to the finished cutout figure.

Holes shall be provided within the frames for attaching Letters, Numerals, Arrows, Symbols, Corner Radii for Sign Borders, Borders and Reflectorized Outlines for U.S. and State Route Markers to the sign face.

(2) Finishing. After metal fabrication has been completed, the aluminum frames shall be finished in white or black porcelain enamel as required by the plans. The porcelain enamel shall have a gloss reading of between 50 and 70 units at an angle of 45 degrees according to the procedure described in Bulletin T-18 (May 1953) of the Porcelain Enamel Institute, Inc. Porcelain finish shall be Class "A", or better, in acid resistance and applied in conformance with current specifications of the Porcelain Enamel Institute.

(3) Acrylic-Plastic Reflectors.

(a) General. The reflectors shall be acrylic plastic and shall consist of a clear and transparent plastic face, herein referred to as the lens, and a back material attached to the lens around the entire perimeter to form a homogeneous unit permanently sealed against dust, water and air. The reflectors shall be colorless. The lens shall consist of a smooth front surface free from projection or indentations other than for identification and a rear surface bearing a prismatic configuration such that it will effect internal reflection of light. The manufacturer's name or trade mark shall be moulded legibly into the face or back of the lens.

Reflectors shall be designed for installation as an integral part of the frame or otherwise securely affixed to the frame to prevent their displacement in handling or service. Frames in which reflectors are assembled by means of tape are unacceptable.

(b) Optical Performance. The specific intensity of the reflectors shall equal or exceed the following minimum values:

Entrance Angle Degrees	Divergence Angle Degrees	Specific Intensity Cp./Sq. Foot/Foot-Candle
0	1/10	2000
20	1/10	800
0	1/3	1000
20	1/3	400

(c) Durability. The reflectors shall withstand without visible damage the following tests:

Seal Test. The reflectors shall comply with the requirements listed in Test Methods Tex-724-I and Tex-845-B.

Heat-Resistance Test. The reflectors shall comply with the requirements listed in Test Methods Tex-724-I and Tex-846-B.

Corrosion Test. Where applicable the reflectors shall withstand the combined corrosion test set forth in ASTM Specification B117.

(4) Fasteners. Aluminum or stainless-steel screws shall be used to fasten the Letters, Numerals, Arrows, Symbols, Corner Radii for Sign Borders, Borders and Reflectorized Outlines for U.S. and State Route Markers to the sign face subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

(5) Material Source. All Removable Reflectorized Cutout Letters, Numerals, Arrows, Symbols, Corner Radii for Sign Borders, Borders and Reflectorized Outlines for U.S. and State Route Markers used on signs for this contract shall be of the same manufacture.

(6) Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

724.3. **Measurement and Payment.** Removable Reflectorized Cutout Letters, Numerals, Arrows, Symbols, Corner Radii for Sign Borders, Borders and Reflectorized Outlines for U.S. and State Route Markers will not be paid for directly but will be considered subsidiary to the signs to which the items are attached.

ITEM 726

PLASTIC FACED PLYWOOD FOR TRAFFIC SIGNS

726.1. **Description.** This item shall consist of the following.

(1) **Type A Panels (High Density Overlay).** The panels shall be of a smooth, weather-resistant material suitable for highway signs produced by permanently bonding high density plastic overlay sheets to both sides of Marine Exterior Grade douglas fir or western larch plywood panels.

(2) **Type B Panels (Medium Density Overlay).** The panels shall be of a smooth, paintable, weather-resistant material suitable for highway signs produced by permanently bonding medium-density plastic overlay sheets to both sides of Marine Exterior Grade douglas fir or western larch plywood panels.

726.2. **Materials.**

(1) **Color.** Natural.

(2) **Plywood.**

(a) **Grade.** Marine Exterior.

(b) **Veneer.** B-B or Better.

(c) **Veneer Defects, Permits and Bonding.** Defects in Veneer, Permits and Bond of Veneers shall be in accordance with the latest revision of U.S. Products Standard PS 1-66, Marine Grade.

(d) **Core Gaps and Edge Splits.** Neither edge of a panel shall have any core gap or edge split in excess of 1/8" wide. Core gaps and edge splits per 8 feet of crossband layer shall not exceed four in number. End splits and gaps on either end of a panel shall not exceed 1/8" in aggregate width. Filling of core gaps and edge splits with materials that serve to conceal the gaps or splits is prohibited.

(3) **Overlay Sheet.**

(a) **Density.**

Type A (High Density Overlay). The sheets shall be high density and shall meet the requirements of the latest revision of U.S. Product Standard PS 1-66 "High Density Type".

Type B (Medium Density Overlay). The sheets shall be medium density

and shall meet the requirements of the latest revision of U.S. Product Standard PS 1-66 "Medium Density Type".

(b) **Finish.**

Type A (High Density Overlay). The sheets shall present a finished surface that is hard, smooth, unbroken and of such character that further finishing by paint or varnish is not required.

Type B (Medium Density Overlay). The sheet faces shall present a smooth, uniform, one piece surface suitable for high quality paint finishes without further preparation. Surfaces shall not show grain raising, blistering, pinholing and similar defects when painted.

(4) **Complete Panel.**

(a) **Flatness.** To be acceptable for sign use a panel, when placed on a level, plane surface, shall not deviate from the surface more than two inches at any point.

(b) **Defects.** All panels shall be free of dents, bruises, scratches, veneer or overlay delaminations, paint, stains or other damage which would interfere with its use in sign construction.

(c) **Size.** Panels shall be four feet by eight feet or smaller and shall be of one-piece construction free of either scarf or butt joints.

(d) **Grademarking.** All panels shall bear legible American Plywood Association (DFPA) grademarkings which shall reflect the following:

Plywood Grade (Marine – Ext.)
Overlay (HDO for High Density Overlay; MDO for Medium Density Overlay)
The Inspection Agency (DFPA)
The Specification (PS 1-66)
The Producing-Mill Identification

(5) **Sampling and Testing.** Sampling and Testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

726.3. Measurement and Payment. Plastic Faced Plywood for Traffic Signs will not be measured nor paid for directly but will be considered subsidiary to Plywood Traffic Signs (Type A or Type B) for which it is used.

ITEM 728

ROADSIDE TRAFFIC SIGN SUPPORTS (STEEL PIPE)

728.1. Description. This item shall consist of ground mounted supports of steel pipe which are used for traffic signs normally erected at a minimum

height of seven (7) feet from the top of the pavement edge to the bottom of the sign or to the bottom of the lowest sign when more than one sign is erected on the same mount.

728.2. Materials. The sign supports shall be made from new galvanized steel pipe. The size and specifications for the pipe shall be as shown on the plans. Galvanizing shall be in accordance with the Item, "Metal for Structures", and shall be done after fabrication and punching or drilling of any holes that may be permitted by the plans or by the Engineer.

728.3. Construction Methods. The length of each post for each traffic sign shown on the plans shall be verified by the Contractor before ordering in order to meet the existing field conditions and to conform with sign-mounting heights shown on the plans. Should it be necessary to field cut a steel post to shorten it, the cut end shall be placed in the concrete foundation.

Pipe sign supports shall be built up as required by the plans. Any part of the pipe from which the galvanizing has been knocked or chipped off down to bare metal in fabrication, transit, or erection or when bare metal is exposed shall be repaired by application of galvanizing repair compounds meeting Federal Specification O-G-93 (*Stick only*) in accordance with the manufacturer's recommendations.

The sign supports shall be located as shown on the plans, except that the Engineer may shift a sign support where necessary to secure a more desirable location. The Engineer will stake all sign support locations.

Sign supports shall be so erected that: (1) the sign faces will normally be vertical when attached to the supports, and (2) the sign faces shall be 87 degrees, measured from the forward tangent, away from the center line of the lane(s) of traffic which the signs serve.

The pipe posts shall be set carefully in the foundation holes and held in place by an approved form or template before the concrete for the foundation is placed. The forms and templates supporting the sign posts shall not be removed until the concrete has aged at least twenty-four (24) hours. No sign shall be attached to the posts until the concrete has aged at least seven (7) curing days. A curing day shall be as defined in the Item, "Concrete Structures".

Springing or raking of posts to secure proper alignment will not be permitted.

728.4. Foundations. Foundations shall conform with the Item, "Foundations for Traffic Signs".

728.5. Submittals for Approval. Prior to the fabrication of supports, approval of shop drawings showing the fabrication details of each support shall be required.

(1) Shop drawings shall be submitted in five prints to the Engineer.

(2) Shop drawings shall be prepared on sheets 22x36 inches in size, with a 1-1/2-inch left margin and other margins of 1/2-inch; and each sheet shall

have a title in the lower right-hand corner which includes the sheet index data shown in the Project Plans, names of the Fabricator and Contractor and sheet numbering.

(3) Drawings for only one support need to be submitted for two or more supports in the submittal which are of identical design and dimensions.

(4) The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fit and field connections, although the drawings have been approved by the Department.

728.6. **Measurement.** The supports shall be measured by the linear foot for the various sizes of pipe as erected. Measurement of lengths shall be made along the center line from end of pipe to end of pipe, from end of pipe to center line of cross pipe of junction and from center of junction to center of junction.

728.7. **Payment.** Payment for the supports will be made at the unit price bid per linear foot for the various sizes of "Galvanized Pipe Posts", which payment shall be full compensation for furnishing, fabricating and erecting the posts, including galvanizing and all other details and incidentals except foundations, necessary to provide the sign mounts complete and erected in place ready for the attachment of the sign(s).

ITEM 730

ROADSIDE TRAFFIC SIGN SUPPORTS (STRUCTURAL STEEL)

730.1. **Description.** This item shall consist of ground mounted supports of structural steel which are used for traffic signs normally erected at a minimum height of seven (7) feet from the top of the pavement edge to the bottom of the sign or the bottom of the sign lighting fixtures, when such fixtures are used unless shown otherwise on the plans.

730.2. **Materials.** The sign supports shall be structural steel I-Beam and Wide Flange Beam posts as shown on the plans and shall conform to the requirements of the Item, "Metal for Structures".

All steel posts, bolts, nuts, washers (except shims) and plates (including cast-iron plates) shall be galvanized after fabrication in accordance with the Item, "Metal for Structures", except where specifically permitted otherwise on the plans. The metal shall be thoroughly cleaned and pickled before galvanizing. All holes in steel posts that may be permitted by the plans or by the Engineer shall be punched or drilled before the posts are galvanized.

The length of each post for each traffic sign shown on the plans shall be verified by the Contractor before ordering in order to meet the existing field conditions and to conform with sign mounting heights shown on the plans. Should it be necessary to field cut a steel post to shorten it, except those having base connections, the cut end shall be placed in the concrete foundation.

Any parts of steel posts from which galvanizing has been knocked or chipped off down to bare metal in fabrication, transit, erection or field alteration or when bare metal is exposed shall be repaired by application of galvanizing repair compounds meeting Federal Specification O-G-93 (*Stick Only*) in accordance with the manufacturer's recommendations.

730.3. Fabrication. Fabrication shall be in accordance with the Item, "Steel Structures".

730.4. Construction Methods. The sign supports shall be located as shown on the plans, except that the Engineer may shift a sign support where necessary to secure a more desirable location. The Engineer will stake all sign support locations.

Sign supports shall be so erected that: (1) the sign faces will normally be vertical when attached to the supports and (2) the sign faces shall be 87 degrees, measured from the forward tangent, away from the center line of the lane(s) of traffic which the signs serve.

The structural steel posts for roadside traffic sign mounts of one-piece construction shall be set carefully in the foundation holes and held in place by an approved form or template before the concrete for the foundation is placed. The forms and templates supporting the sign posts shall not be removed until the concrete has aged at least twenty-four (24) hours. No sign shall be attached to the posts until the concrete has aged at least seven (7) curing days. A curing day shall be as defined in the Item, "Concrete Structures".

The structural steel posts for roadside traffic sign mounts consisting of two or more sections may, at the Contractor's option, be cast in the concrete foundation with or without the upper post section attached. The stub post sections or assembled posts shall be set carefully in the foundation holes and held in place by an approved form or template before the concrete for the foundation is placed. The stub post sections shall be so positioned that the projection above finished grade is as shown on the plans with the ear plates so positioned that when the upper post section is attached, using shims as required, the upper post section is vertical and plumb and properly oriented with the roadway. The forms and templates supporting the stub post section or the assembled post shall not be removed until the concrete has aged at least twenty-four (24) hours. No sign shall be attached to the post until the concrete has aged at least seven (7) days. A curing day shall be defined as in the Item, "Concrete Structures".

The posts shall be attached to the stub post sections by bolts as shown on the plans. Care shall be exercised to insure one flat washer on each bolt separates the matching ear plates of the upper and lower sections and a flat washer is positioned under the head and the nut of each bolt. With all supporting form work removed from the posts, the bolts shall be tightened following exactly the procedure and tightening to the torque values set forth in the plans.

Springing or raking of posts to secure proper alignment will not be permitted.

730.5. Foundations. Foundations shall conform with the Item, "Foundations for Traffic Signs".

730.6. Design Submittals for Approval. Prior to the fabrication of supports, approval of shop drawings showing the fabrication details of each support shall be required.

(1) The shop drawings shall be submitted in five prints to the Engineer.

(2) Shop drawings shall be prepared on sheets 22 x 36 inches in size, with 1-1/2 inch left margin and other margins of 1/2 inch; and each sheet shall have a title in the lower right-hand corner which includes the sheet index data shown in the Project Plans, names of the Fabricator and Contractor, and sheet numbering.

(3) Drawings for only one support need be submitted for two or more supports in the submittal which are of identical design and dimensions.

(4) The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fit and field connections, although the drawings have been approved by the Department.

730.7. Measurement. The supports shall be measured by the pound for the various sizes of structural steel beams as fabricated and erected and shall include ear plates, bolts, nuts, washers, shims and cast-iron plates as required by the plans. No weight will be allowed for zinc applied to the steel in the process of galvanizing.

730.8. Payment. Payment for the supports will be made at the unit price bid per pound for "Galvanized Structural Steel Posts", which payment shall be full compensation for furnishing, fabricating, and erecting the posts, including ear plates, bolts, nuts, washers, shims and cast-iron plates as required by the plans, and including galvanizing and all other details and incidentals, except foundations, necessary to provide the sign mounts complete and erected in place ready for the attachment of the sign(s).

ITEM 732

OVERHEAD TRAFFIC SIGN SUPPORTS (COMMERCIAL ALUMINUM)

732.1. Description.

(1) General. This item covers Commercial Designs of Aluminum for Overhead Traffic Sign Supports which are designed to provide a normal minimum clearance of seventeen feet, six inches (17'-6") between the highest point on the pavement and the bottom of the lowest sign or the bottom of the lowest sign lighting fixture when such fixtures are used.

(2) Types of Overhead Sign Supports. Overhead Sign Supports shall include the following types complete with foundations:

(a) Braced Tee Mount Overhead Sign Support

(b) Balanced Tee Mount Overhead Sign Support

(c) Overhead Bridge Sign Support

(d) Combined Bridge and Cantilever Overhead Sign Support

(e) Cantilever Overhead Sign Support

For further identification of the Types of Overhead Sign Supports see standard designs incorporated in the plans.

(3) Design. The structural design and construction specifications of sign supports shall conform with the latest Edition of the "Specifications for the Design and Construction of Structural Supports for Highway Signs", published by the American Association of State Highway Officials.

Designs and engineering plans for sign supports shall be prepared by or under the responsible supervision of a Professional Engineer currently registered in the State of Texas and certification of compliance with this requirement shall be the imprint of the seal of the Professional Engineer.

All sign supports shall be designed for the total area of signs to be attached thereto or as otherwise noted in the Project Plans, except that Cantilever Overhead Sign Supports of Types A-1 and A-2 shall be designed for the total area of the signs to be attached thereto or 312 square feet if the greater.

Tower lacing of sign supports shall lie within the minimum horizontal cross sectional area through the vertical tower leg members.

The Contractor shall be responsible for designing foundations for overhead sign supports covered herein. If adequate, the foundation designs shown in the Project Plans may be used with the approval of the Engineer. Review and approval will be as outlined in Section 732.2(1).

732.2. Design Submittals for Approval. Prior to fabrication of sign supports, approval by the Department shall be required based on evidence stipulated and described below.

(1) Design Data. Prior to submittal of shop drawings, the Contractor shall submit three copies of pertinent design data, criteria, loadings and design calculations and three copies of line drawings which show pertinent information required for verifying structural adequacy, including dimensions, member sizes, span and panel lengths, heights, widths, joint connections, etc., to the State Highway Engineer, Austin, Texas 78701, Attention File D-18M.

The line drawings shall include all components of a support, including the span member, towers, base plate/anchor bolt assembly and foundations.

For those sign support types whose adequacies are checked by the Department utilizing the electronic computer, one completed copy of

computer data sheets, furnished by the Department, shall be included with this submittal instead of design calculations.

The data, drawings and design calculations shall be prepared on sheets 8-1/2 x 11 inches or larger, with adequate blank space provided for affixing stamps of approval.

Each sheet of drawings and design calculations shall show the identification and/or location of the support or supports included; and shall have a title in the lower right hand corner which includes the sheet index data shown on the lower right hand corner of the Project Plans, names of the Designer and Contractor and sheet numbering; and shall bear the imprint of the seal of the supervising Professional Engineer referred to in Section 732.1(3).

Where two or more supports of a submittal are of the same design, the data, drawings and design calculations or computer data sheets for the support with the controlling load conditions need be submitted with the identification and/or location of such supports shown thereon.

(2) Shop Drawings. Subsequent to approval of structural design, the Contractor shall submit seven prints of shop drawings showing the fabrication and erection details for each support, including foundations which shall be shown on sheets separate from those showing other components of a support, to the State Highway Engineer, Austin, Texas 78701, Attention File D-5.

The drawings shall be prepared on sheets 22 x 36 inches in size, with 1-1/2 inch left margin and other margins of 1/2 inch.

Each sheet shall have a title in the lower right hand corner which includes the sheet index data shown in the lower right hand corner of the Project Plans, names of the Fabricator and Contractor, and sheet numbering; and shall bear the imprint of the seal of the supervising Professional Engineer referred to in Section 732.1(3).

Drawings for only one support need be submitted for two or more supports in the submittal which are of identical design and dimensions.

The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fit and field connections, although the drawings have been approved by the Department.

732.3. Materials.

(1) Brackets, Clamps, Bolts and Other Hardware. Any brackets, clamps, bolts and other hardware used in commercial designs of aluminum for overhead traffic sign supports shall be galvanized steel, stainless steel or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

Aluminum castings will not be permitted for structural members of aluminum sign structures, but they may be used for strictly ornamental parts if desired.

(2) Foundation Anchor Bolts. Each foundation anchor bolt shall include a standard nut, head or 90 degree bend on the embedded end; or an

equivalent or better device as may be approved by the Department.

(3) Foundations. For specifications governing foundations, other than *Measurement* and *Payment*, see the Item, "Foundations for Traffic Signs".

732.4. Construction Methods.

(1) Welds. Procedure and welder qualifications shall be in accordance with the Texas Highway Department Bulletin C-5. The Department reserves the right to make radiographic inspections of any welds, at its own expense, at any time until final acceptance of the structure. Any structural members having welds deemed to be unsatisfactory shall be removed by mechanical means, re-annealed, rewelded and re-heat treated, or they shall be replaced by new structural members having satisfactory welds. Flame cutting will not be permitted. Welding shall be in accordance with the manufacturer's recommendations.

(2) Fabrication. Fabrication of overhead sign supports shall conform with the Item, "Steel Structures", and pertinent Special Provisions thereto, and in accordance with Texas Highway Department Bulletin C-5.

(3) Location and Positioning. The sign supports shall be located as shown on the plans, except that the Engineer may shift a support where necessary to secure a more desirable location. The Engineer will stake all sign support locations.

The sign supports shall be so erected that the sign faces will normally be vertical when attached to the supports.

(4) Erection of Posts and Towers. When the posts or towers are placed on the concrete foundation, the nuts supporting the post or tower base plates shall be adjusted to bring the bottom of the base plate level with the top of the cap foundation and to bring the post or tower to a true vertical plane. The nuts on top of the base plate shall then be tightened securely. Springing or raking of posts or towers will not be permitted to make sign bridges or trusses fit between the posts or towers.

After the base plates of the post or tower are at their proper elevation and the post or tower is in a true vertical plane, a layer of lean Portland cement grout of the thickness shown on the plans shall be worked thoroughly in the area between the top of the concrete foundation and the bottom of the post or tower base plates and around the anchor bolts. The grout shall not cover any portion of the top of the concrete foundation beyond the edges of the base plates except for a bevel of approximately 12 to 12 extending from the bottom of the base plate to the top of the foundation. Grout shall be made from one part Portland cement and four parts of clean field or mortar sand, all of which passes a Number 10 sieve.

732.5. Measurement. Overhead Traffic Sign Supports shall be measured as follows:

(1) Braced Tee Mount Overhead Sign Supports shall be measured as each unit complete in place, including concrete footing(s), for the various crossarm lengths.

(2) Balanced Tee Mount Overhead Sign Supports shall be measured as each unit complete in place, including the concrete footing(s), for the sign size specified to be attached thereto.

(3) Overhead Bridge Sign Supports shall be measured as each unit complete in place, including concrete footing(s), for the various span lengths.

(4) Combined Bridge and Cantilever Overhead Sign Supports shall be measured as each unit complete in place, including concrete footing(s), for the various bridge and cantilever lengths.

(5) Cantilever Overhead Sign Supports shall be measured as each unit complete in place, including concrete footing(s), for the various types and cantilever lengths.

732.6. Payment. Payment for Overhead Traffic Sign Supports will be made as follows:

(1) Payment for Braced Tee Mount Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Braced Tee" for the various crossarm lengths, which payment shall be full compensation for furnishing, fabricating and erecting the Braced Tee Mount Overhead Sign Support; for the concrete footing(s), which shall include digging or drilling and/or underreaming the hole(s) where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Braced Tee Mount Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(2) Payment for Balanced Tee Mount Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bal. Tee" for the sign size specified to be attached thereto, which payment shall be full compensation for furnishing, fabricating and erecting the Balanced Tee Mount Overhead Sign Support; for the concrete footing(s), which shall include digging or drilling and/or underreaming the hole(s) where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Balanced Tee Mount Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(3) Payment for Overhead Bridge Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bridge" for the various span lengths, which payment shall be full compensation for furnishing, fabricating and

erecting the Overhead Bridge Sign Supports; for the concrete footing(s), which shall include digging or drilling and/or underreaming the holes where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing the electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide an Overhead Bridge Sign Support in accordance with the specifications, plans, or approved working drawings, complete in place and ready for the attachment of the sign(s).

(4) Payment for Combined Bridge and Cantilever Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bridge-Cant." for the various bridge and cantilever lengths, which payment shall be full compensation for furnishing, fabricating and erecting the Combined Bridge and Cantilever Overhead Sign Support; for the concrete footing(s) which shall include digging or drilling and/or underreaming the hole(s) where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Combined Bridge and Cantilever Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(5) Payment for Cantilever Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Cant." for the various types and cantilever lengths, which payment shall be full compensation for furnishing, fabricating and erecting the Cantilever Overhead Sign Support; for the concrete footing(s) which shall include digging or drilling and/or underreaming the holes where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing the electrical conduit in the footing where required; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Cantilever Overhead Sign Support in accordance with the specifications, plans, or approved working drawings, complete in place and ready for the attachment of the sign(s).

Where any change or alteration, authorized by the Engineer, in concrete footing(s) for any Overhead Sign Support is (1) made from that shown on the approved working drawings submitted by the Contractor, or is (2) made from the concrete footing(s) shown in the project plans when the Contractor, with the approval of the Engineer, elects to construct the concrete footing(s) as shown in the project plans, the work made necessary by such changes or alteration shall be defined as "Extra Work" in accordance with Article 4.4, "Extra Work", Item 4, "Scope of Work", of the Standard Specifications. Payment for "Extra Work" shall be made in accordance with Article 9.4,

"Payment for Extra Work", Item, 9, "Measurement and Payment", of the Standard Specifications.

ITEM 734

OVERHEAD TRAFFIC SIGN SUPPORTS (COMMERCIAL STEEL)

734.1. Description.

(1) General. This item covers Commercial Designs of Steel for Overhead Traffic Sign Supports which are designed to provide a normal minimum clearance of seventeen feet, six inches (17'-6") between the highest point on the pavement and the bottom of the lowest sign or the bottom of the lowest sign lighting fixture when such fixtures are used.

(2) Types of Overhead Sign Supports. Overhead Sign Supports shall include the following types complete with foundations:

(a) Braced Tee Mount Overhead Sign Support

(b) Balanced Tee Mount Overhead Sign Support

(c) Overhead Bridge Sign Support

(d) Combined Bridge and Cantilever Overhead Sign Support

(e) Cantilever Overhead Sign Support

For further identification of the Types of Overhead Sign Supports, see standard designs incorporated in the plans.

(3) Design. The structural design and construction specifications of sign supports shall conform with the latest Edition of the "Specifications for the Design and Construction of Structural Supports for Highway Signs", published by the American Association of State Highway Officials.

Designs and engineering plans for sign supports shall be prepared by or under the responsible supervision of a Professional Engineer currently registered in the State of Texas and certification of compliance with this requirement shall be the imprint of the seal of the Professional Engineer.

All sign supports shall be designed for the total area of signs to be attached thereto or as otherwise noted in the Project Plans, except that Cantilever Overhead Sign Supports of Types A-1 and A-2 shall be designed for the total area of the signs to be attached thereto or 312 square feet if the greater.

Tower lacing of sign supports shall lie within the minimum horizontal cross sectional area through the vertical tower leg members.

All tubular steel components of sign supports shall be open ended.

The Contractor shall be responsible for designing foundations for overhead sign supports covered herein. If adequate, the foundation designs

shown in the Project Plans may be used with the approval of the Engineer. Review and approval will be as outlined in Section 734.2(1).

734.2. Design Submittals for Approval. Prior to fabrication of sign supports, approval by the Department shall be required based on evidence stipulated and described below.

(1) Design Data. Prior to submittal of shop drawings the Contractor shall submit three copies of: pertinent design data, criteria, loadings, and design calculations; and three copies of line drawings which show pertinent information required for verifying structural adequacy, including dimensions, member sizes, span and panel lengths, heights, widths, joint connections, etc., to the State Highway Engineer, Austin, Texas 78701, Attention File D-18M.

The line drawings shall include all components of a support, including the span member, towers, base plate/anchor-bolt assembly, and foundations.

For those sign support types whose adequacies are checked by the Department utilizing the electronic computer, one completed copy of computer data sheets, furnished by the Department, shall be included with this submittal instead of design calculations.

The data, drawings and design calculations shall be prepared on sheets 8-1/2 x 11 inches or larger, with adequate blank space provided for affixing stamps of approval.

Each sheet of drawings and design calculations shall show the identification and/or location of the support or supports included; and shall have a title in the lower right hand corner which includes the sheet-index data shown on the lower right hand corner of the Project Plans, names of the Designer and Contractor, and sheet numbering; and shall bear the imprint of the seal of the supervising Professional Engineer referred to in Section 734.1(3).

Where two or more supports of a submittal are of the same design, the data, drawings, and design calculations or computer data sheets for the support with the controlling load conditions need be submitted with the identification and/or location of such supports shown thereon.

(2) Shop Drawings. Subsequent to approval of structural design, the Contractor shall submit seven prints of shop drawings showing the fabrication and erection details for each support, including foundations which shall be shown on sheets separate from those showing other components of a support, to the State Highway Engineer, Austin, Texas 78701, Attention File D-5.

The drawings shall be prepared on sheets 22 x 36 inches in size, with 1-1/2 inch left margin and other margins of 1/2 inch.

Each sheet shall have a title in the lower right hand corner which includes the sheet index data shown in the lower right hand corner of the Project Plans, names of the Fabricator and Contractor, and sheet numbering; and shall bear the imprint of the seal of the supervising Professional Engineer referred to in Section 734.1(3).

Drawings for only one support need be submitted for two or more supports in the submittal which are of identical design and dimensions.

The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fit and field connections, although the drawings have been approved by the Department.

734.3. Materials.

(1) Brackets, Clamps, Bolts and Other Hardware. Any brackets, clamps, bolts and other hardware used in commercial designs of steel for overhead traffic sign supports shall be galvanized steel, stainless steel or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

(2) Foundation Anchor Bolts. Each foundation anchor bolt shall include a standard nut, head or 90-degree bend on the embedded end; or an equivalent or better device as may be approved by the Department.

(3) Foundations. For specifications governing foundations other than Measurement and Payment, see the Item, "Foundations for Traffic Signs".

(4) Galvanization. All parts and members of steel overhead sign supports shall be galvanized in conformance with the Item, "Metal for Structures", of the Standard Specifications. Any holes in parts or members that may be permitted by the plans and/or by the Engineer shall be punched or drilled before the parts or members are galvanized. Any steel part or member from which galvanizing has been knocked off down to bare metal in fabrication, in transit or in erection and any steel part or member welded after galvanizing shall be repaired by application of galvanizing repair compounds meeting Federal Specification O-G-93 (*Stick Only*) in accordance with the manufacturer's recommendations.

734.4. Construction Methods.

(1) Fabrication. Fabrication of overhead sign supports shall conform with the Item, "Steel Structures", and pertinent Special Provisions thereto, and be in accordance with Texas Highway Department Bulletin C-5.

(2) Location and Positioning. The sign supports shall be located as shown on the plans, except that the Engineer may shift a support where necessary to secure a more desirable location. The Engineer will stake all sign support locations.

The sign supports shall be so erected that the sign faces will normally be vertical when attached to the supports.

(3) Erection of Posts or Towers. When the posts or towers are placed on the concrete foundations, the nuts supporting the post or tower base plates shall be adjusted to bring the bottom of the base plate level with the top of the cap foundation and to bring the post or tower to a true vertical plane. The nuts on top of the base plate shall then be tightened securely. Springing or raking of posts or towers will not be permitted to make sign bridges or trusses fit between the posts or towers.

After the base plates of the post or tower are at their proper elevation and the post or tower is in a true vertical plane, a layer of lean Portland

cement grout of the thickness shown on the plans shall be worked thoroughly in the area between the top of the concrete foundation and the bottom of the post or tower base plates and around the anchor bolts. The grout shall not cover any portion of the top of the concrete foundation beyond the edges of the base plates except for a bevel of approximately 12 to 12 extending from the bottom of the base plate to the top of the foundation. Grout shall be made from one part Portland cement and four parts of clean field or mortar sand, all of which passes a Number 10 sieve.

734.5. Measurement. Overhead Traffic Sign Supports shall be measured as follows:

(1) Braced Tee Mount Overhead Sign supports shall be measured as each unit complete in place, including concrete footing(s), for the various crossarm lengths.

(2) Balanced Tee Mount Overhead Sign Supports shall be measured as each unit complete in place, including the concrete footing(s), for the sign size specified to be attached thereto.

(3) Overhead Bridge Sign Supports shall be measured as each unit complete in place, including concrete footing(s), for the various span lengths.

(4) Combined Bridge and Cantilever Overhead Sign Supports shall be measured as each unit complete in place, including concrete footing(s), for the various bridge and cantilever lengths.

(5) Cantilever Overhead Sign Supports shall be measured as each unit complete in place, including concrete footing(s), for the various types and cantilever lengths.

734.6. Payment. Payment for Overhead Traffic Sign Supports will be made as follows:

(1) Payment for Braced Tee Mount Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Braced Tee" for the various crossarm lengths, which payment shall be full compensation for furnishing, fabricating and erecting the Braced Tee Mount Overhead Sign Support; for the concrete footing(s), which shall include digging or drilling and/or underreaming the hole(s) where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts, and washers; for furnishing and placing electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Braced Tee Mount Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(2) Payment for Balanced Tee Mount Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bal. Tee" for the sign size specified to be attached thereto, which payment shall be full

compensation for furnishing, fabricating and erecting the Balanced Tee Mount Overhead Sign Support; for the concrete footing(s), which shall include digging or drilling and/or underreaming the hole(s) where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Balanced Tee Mount Overhead Sign Support in accordance with the specifications, plans, or approved working drawings, complete in place and ready for the attachment of the sign(s).

(3) Payment for Overhead Bridge Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bridge" for the various span lengths, which payment shall be full compensation for furnishing, fabricating, and erecting the Overhead Bridge Sign Supports; for the concrete footing(s), which shall include digging or drilling and/or underreaming the holes where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts, and washers; for furnishing and placing the electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide an Overhead Bridge Sign Support in accordance with the specifications, plans, or approved working drawings, complete in place and ready for the attachment of the sign(s).

(4) Payment for Combined Bridge and Cantilever Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bridge Cant." for the various bridge and cantilever lengths, which payment shall be full compensation for furnishing, fabricating and erecting the Combined Bridge and Cantilever Overhead Sign Support; for the concrete footing(s) which shall include digging or drilling and/or underreaming the hole(s) where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing the electrical conduit in the footing; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Combined Bridge and Cantilever Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(5) Payment for Cantilever Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Cant." for the various types and cantilever lengths, which payment shall be full compensation for furnishing, fabricating and erecting the cantilever Overhead Sign Support; for the concrete footing(s) which shall include digging or drilling and/or underreaming the holes where required regardless of the type of material encountered; for furnishing and placing the concrete; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing the

electrical conduit in the footing where required; for furnishing and placing reinforcing steel where required; for finishing the top of the footing(s); for grouting; for disposal of excavation material; and for all other details and incidentals necessary to provide a Cantilever Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

Where any change or alteration, authorized by the Engineer, in concrete footing(s) for any Overhead Sign Support is (1) made from that shown on the approved working drawings submitted by the Contractor, or is (2) made from the concrete footing(s) shown in the project plans when the Contractor, with the approval of the Engineer, elects to construct the concrete footing(s) as shown in the project plans, the work made necessary by such changes or alteration shall be defined as "Extra Work" in accordance with Article 4.4, "Extra Work", Item 4, "Scope of Work", of the Standard Specifications. Payment for "Extra Work" shall be made in accordance with Article 9.4, "Payment for Extra Work", Item 9, "Measurement and Payment", of the Standard Specifications.

ITEM 736

OVERHEAD TRAFFIC SIGN SUPPORTS

736.1. Description.

(1) General. This Item covers Highway Department Designs for Overhead Traffic Sign Supports which are designed to provide a normal minimum clearance of seventeen feet, six inches (17'-6") between the highest point on the pavement and the bottom of the lowest sign or the bottom of the lowest sign lighting fixture when such fixtures are used.

(2) Types of Overhead Sign Supports. Overhead Sign Supports shall include the following types:

(a) Braced Tee Mount Overhead Sign Support

(b) Balanced Tee Mount Overhead Sign Support

(c) Overhead Bridge Sign Support

(d) Combined Bridge and Cantilever Overhead Sign Support

(e) Cantilever Overhead Sign Support

For further identification of the types of Overhead Sign Supports, see standard designs incorporated in the plans.

(3) Design. Overhead sign supports shall be of steel as shown on the plan sheets. Unless specified otherwise on the plan sheets, all steel shall conform with the Item, "Metal for Structures".

736.2. Design Submittal for Approval. Prior to fabrication of sign supports, approval by the Department of shop drawings shall be required.

The shop drawings shall show the fabrication and erection details of each support, and shall be submitted in six prints to the State Highway Engineer, Austin, Texas 78701, Attention File D-5.

The drawings shall be prepared on sheets 22 x 36 inches in size, with 1-1/2 inch left margin and other margins of 1/2 inch.

Each sheet shall have a title in the lower right hand corner which includes the sheet index data shown in the lower right hand corner of the Project Plans, names of the Fabricator and Contractor, and sheet numbering.

Drawings for only one support need be submitted for two or more supports in the submittal which are of identical design and dimensions.

The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fit and field connections, although the drawings have been approved by the Department.

736.3. Materials.

(1) Brackets, Clamps, Bolts and Other Hardware. Any brackets, clamps, bolts and other hardware used in fastening signs to the overhead sign supports shall be galvanized steel, stainless steel or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

(2) Foundations. For specifications governing foundations, see the Item, "Foundations for Traffic Signs".

(3) Galvanization. All parts and members of overhead sign supports that are fabricated from steel shall be galvanized in conformance with the Item, "Metal for Structures". Any holes in steel parts or members that may be permitted by the plans or by the Engineer shall be punched or drilled before the parts or members are galvanized. Any steel part or member from which galvanizing has been knocked off down to bare metal in fabrication, in transit or in erection, and any steel part or member welded after galvanizing shall be repaired by application of galvanizing repair compounds meeting Federal Specification O-G-93 (*Stick Only*) in accordance with the manufacturer's recommendations.

736.4. Construction Methods.

(1) Fabrication. Fabrication of overhead sign supports shall conform with the Item, "Steel Structures", and pertinent Special Provisions thereto, and in accordance with Texas Highway Department Bulletin C-5.

(2) Location and Positioning. The sign supports shall be located as shown on the plans, except that the Engineer may shift a support where necessary to secure a more desirable location. The Engineer will stake all sign support locations.

The sign supports shall be so erected that the sign faces will normally be vertical when attached to the supports.

(3) Erection of Posts or Towers. When the posts or towers are placed on the concrete foundation, the nuts supporting the post or tower base plates

shall be adjusted to bring the bottom of the base plate level with the top of the cap foundation and to bring the post or tower to a true vertical plane. The nuts on top of the base plate shall then be tightened securely. Springing or raking of posts or towers will not be permitted to make sign bridges or trusses fit between the posts or towers.

After the base plates of the post or tower are at their proper elevation and the post or tower is in a true vertical plane, a layer of lean Portland cement grout of the thickness shown on the plans shall be worked thoroughly in the area between the top of the concrete foundation and the bottom of the post or tower base plates and around the anchor bolts. The grout shall not cover any portion of the top of the concrete foundation beyond the edges of the base plates except for a bevel of approximately 12 to 12 extending from the bottom of the base plate to the top of the foundation. Grout shall be made from one part Portland cement and four parts of clean field or mortar sand, all of which passes a number 10 sieve.

736.5. Measurement. Overhead Traffic Sign Supports shall be measured as follows:

(1) Braced Tee Mount Overhead Sign Supports shall be measured as each unit complete in place, *excluding foundations,* for the various crossarm lengths.

(2) Balanced Tee Mount Overhead Sign Supports shall be measured as each unit complete in place, *excluding foundations,* for the sign size specified to be attached thereto.

(3) Overhead Bridge Sign Supports shall be measured as each unit complete in place, *excluding foundations,* for the various span lengths.

(4) Combined Bridge and Cantilever Overhead Sign Supports shall be measured as each unit complete in place, *excluding foundations,* for the various bridge and cantilever lengths.

(5) Cantilever Overhead Sign Supports shall be measured as each unit complete in place, *excluding foundations,* for the various types and cantilever lengths.

736.6. Payment. Payment for Overhead Traffic Sign Supports will be made as follows:

(1) Payment for Braced Tee Mount Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Braced Tee" for the various crossarm lengths, which payment shall be full compensation for furnishing, fabricating, and erecting the Braced Tee Mount Overhead Sign Support; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing electrical conduit in the footing; for grouting; and for all other details and incidentals necessary to provide a Braced Tee Mount Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(2) Payment for Balanced Tee Mount Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bal. Tee" for the sign size specified to be attached thereto, which payment shall be full compensation for furnishing, fabricating and erecting the Balanced Tee Mount Overhead Sign Support; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing electrical conduit in the footing; for grouting, and for all other details and incidentals necessary to provide a Balanced Tee Mount Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(3) Payment for Overhead Bridge Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bridge" for the various span lengths, which payment shall be full compensation for furnishing, fabricating and erecting the Overhead Bridge Sign Supports; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing the electrical conduit in the footing; for grouting; and for all other details and incidentals necessary to provide an Overhead Bridge Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(4) Payment for Combined Bridge and Cantilever Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Bridge-Cant." for the various bridge and cantilever lengths, which payment shall be full compensation for furnishing, fabricating, and erecting the Combined Bridge and Cantilever Overhead Sign Support; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing the electrical conduit in the footing; for grouting; and for all other details and incidentals necessary to provide a Combined Bridge and Cantilever Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

(5) Payment for Cantilever Overhead Sign Supports will be made at the unit price bid per each for "Sign Suppt., Cant." for the various types and cantilever lengths, which payment shall be full compensation for furnishing, fabricating and erecting the Cantilever Overhead Sign Support; for furnishing and placing anchor bolts, nuts and washers; for furnishing and placing the electrical conduit in the footing where required; for grouting; and for all other details and incidentals necessary to provide a Cantilever Overhead Sign Support in accordance with the specifications, plans or approved working drawings, complete in place and ready for the attachment of the sign(s).

ITEM 738

FOUNDATIONS FOR TRAFFIC SIGNS

738.1. Description. This Item shall govern for the construction of concrete foundations for traffic signs.

Reinforced drilled shaft foundations shall have concrete wings, tie beams,

slabs and/or bell-type footings when required by the plans. Non-reinforced and reinforced drilled shaft foundations shall be placed in drilled excavation.

738.2. **Materials.** All concrete materials and their preparations shall be in accordance with the requirements of the Item, "Concrete for Structures", of the Standard Specifications and the additional requirements herein. All concrete shall be "Class A". Materials for drilled shaft foundations and bell footings shall be in accordance with the Item, "Drilled Shaft Foundations".

Reinforcing steel shall conform to the requirements of the Item, "Reinforcing Steel". The sizes and dimensions shall be as shown on the plans.

738.3. **Construction Methods.**

(1) **Drilled Shaft Foundations and Bell Footing.** Drilled shaft foundation and bell footing construction shall be in accordance with the Item, "Drilled Shaft Foundations".

(2) **Excavation.** All excavation required for wings, tie beams and slabs, shall be done through whatever substances encountered, and to the dimensions and elevation shown on the plans or required by the site conditions and/or as established by the Engineer. This excavation shall be done in accordance with the Item, "Structural Excavation", except that it will not be measured for payment and it will be considered as subsidiary to the respective sign supports.

(3) **Reinforcing Steel.** Reinforcing steel for the wings, tie beams and slabs shall be positioned as shown on the plans and in conformance with the Item, "Reinforcing Steel", except that it will not be measured for payment and it will be considered as subsidiary to the respective sign supports.

(4) **Concrete.** The work shall be performed in conformance with the provisions of the Item, "Concrete Structures", and with the requirements herein.

Any posts to be imbedded in drilled shaft foundations shall be set carefully in the foundation holes and held in place by an approved template before the concrete for the foundation is placed. The forms and templates supporting the sign posts shall not be removed until the concrete has aged a minimum of 24 hours. Springing or raking of posts to secure proper alignment will not be permitted.

Electrical conduit where required, and anchor bolts of the size, length and number as shown on the plans shall be positioned before the concrete is placed. Anchor bolt groups shall be set and maintained in position with a template during the placement of that portion of concrete into which anchor bolts are embedded. Care shall be taken to obtain the orientation of the anchor bolts and spacing of the anchor bolt groups as shown on the plans.

All parts of the concrete foundations extending above the natural or finished ground line shall be given an ordinary surface finish in accordance with the Item, "Concrete Structures". If a higher type finish is specified in the plans it shall be in accordance with Special Specification "Surface Finishes for Concrete".

No structure or post shall be erected on a concrete foundation nor shall any traffic sign be attached to a signpost embedded in concrete until it has aged at least seven curing days.

(5) Backfilling. Backfilling shall be in accordance with the requirements of the Item, "Structural Excavation", and the additional requirements herein.

All backfilling shall be completed prior to the erection of any sign on the structure.

Where riprap, embankment protection or surfacing is removed for placing foundations for traffic signs, it shall be replaced with like material as directed by the Engineer.

738.4. Measurement. Acceptable drilled shaft foundations in place, will be measured as specified in the Item, "Drilled Shaft Foundations". Acceptable wings, tie beams and slabs constructed to the specified dimensions or to altered dimensions as authorized by the Engineer will be measured by the cubic yard. Measurement will be made of all concrete above the bottom of the wings, tie beams and slabs included in the specified dimensions or altered dimensions as authorized by the Engineer.

Foundations required by Commercial Designs will not be measured as a separate pay item but shall be considered as subsidiary to their respective sign supports.

738.5. Payment. "Non-reinforced drilled shaft foundations" and "Reinforced drilled shaft foundations" and bell footings, when measured as specified above, will be paid for in accordance with the Item, "Drilled Shaft Foundations".

Wings, tie beams and slabs constructed to the specified dimensions or to the altered dimensions as authorized by the Engineer will be paid for at the unit price bid per cubic yard for "Cl. A Conc.".

The foregoing unit prices shall be full compensation for making all excavations; doing any necessary pumping; furnishing and placing all concrete and reinforcing steel; furnishing, placing and removing all forms; finishing and curing concrete; placing and compacting all backfill; replacing riprap, embankment protection and/or surfacing which has been removed; and furnishing all tools, labor, equipment and incidentals, including cleanup, necessary to complete the work.

Payment for foundations required by Commercial Designs will be included in the unit price bid per each for the respective types of supports.

ITEM 740

DELINEATORS

740.1. Description. This item shall consist of furnishing and mounting delineators of the types specified on the plans.

740.2. Materials.

(1) General. Delineators shall consist of one, two, three or nine reflectors of the color specified for the various types of delineators as shown on the plans. Delineators shall be either the acrylic plastic prismatic type reflector or the encapsulated reflective sheeting type reflector which conforms to the requirements specified herein; however, all delineators furnished shall be of the same type and manufacture.

(2) Independently Housed Acrylic Plastic Prismatic Reflector Unit Delineators.

(a) General Description. Delineators shall consist of one, two three or nine acrylic plastic prismatic reflectors of the color specified for the various types of delineators as shown on the plans, complete with aluminum housing, backplate and assembly hardware. The reflector unit shall be a circular shape conforming with the dimensions shown on the plans.

(b) Design and Fabrication. Delineator housings and backplates shall be 0.063 inch 3003-H-14 or similar aluminum, conforming with the dimensions shown on the plans, including all assembly hardware and post mounting hardware. The post mounting hardware shall consist of all bolts, nuts, plain washers, lock washers, fastening plates and brackets as required by the plans.

(c) Reflector Unit Requirements. The reflector unit shall consist of a clear and transparent plastic face, herein referred to as the lens, and a back material attached to the lens to form a unit hermetically sealed against water, dust and air. The lens shall consist of a smooth front surface free from projections or indentations other than for identification. The manufacturer's name or trade mark shall be molded legibly on the reflector unit.

Specific Intensity. Ninety-six percent (96%) or more of the reflector units shall equal or exceed the following minimum values of specific intensity, when run in accordance with T.H.D. Test Method Tex-840-B:

Entrance Angle Degrees	Divergence Angle Degrees	Specific Intensity Cp./Foot-Candle/Reflector Unit	
		White	Yellow
0	1/10	60	30
20	1/10	30	15
0	1/3	30	15
20	1/3	15	8

Seal Test. Ninety-six percent (96%) or more of the reflector units shall pass the seal test when run in accordance with T.H.D. Test Method Tex-845-B.

Heat Test. The reflector units shall pass the heat test when run in accordance with T.H.D. Test Method Tex-846-B.

(3) Encapsulated Reflective Sheeting Delineators.

(a) General Description. Delineators shall consist of one, two, three or nine units of reflective sheeting of the color specified for the various types of delineators as shown on the plans, encapsulated within a clear weather-proof rigid plastic, comprising a sealed optical system, complete with aluminum housing and assembly hardware. The reflector unit shall be a circular shape of approximately three inches diameter or it may be another geometric shape so long as the surface area of the unit will contain an inscribed circle having a diameter of approximately three inches.

(b) Design and Fabrication. Delineator housing shall be 0.063 inch 5052-H-14 or similar aluminum, conforming with the dimensions shown on the plans, including all assembly hardware and post mounting hardware. The post mounting hardware shall consist of all bolts, nuts, plain washers, lock washers, fastening plates and brackets as required by the plans.

(c) Reflector Requirements. The reflector sheeting shall consist of glass spheres adhered to a synthetic sheet resin or other suitable non-cellulosic material. The completed encapsulated reflectors shall have the following minimum brightness values:

Entrance Angle Degrees	Divergence Angle Degrees	Specific Intensity Cp./Foot-Candle/Sq.Foot	
		White	Yellow
0	1/3	130	78
10	1/3	120	72
20	1/3	35	21

(4) Center Mount Acrylic Plastic Prismatic Reflector Unit Delineators.

(a) General Description. Delineators shall consist of one, two, three or nine acrylic plastic prismatic reflectors of the color specified for the various types of delineators as shown on the plans, complete with aluminum housing and mounting hardware. The reflector unit shall be a circular shape conforming with the dimensions shown on the plans.

(b) Design and Fabrication. Reflector units shall be securely fastened in a 0.020 inch aluminum housing that completely covers the back, sides and sealing edge of the reflector unit. The delineator shall have a mounting hole in its center with an aluminum grommet with a 3/16 inch inside diameter expanded within its mounting hole. A suitable mounting fastener conforming with the plans or other fastening means approved by the Engineer shall be furnished with each reflector.

(c) Reflector Unit Requirements. The reflector unit shall comply with Section 740.2 (2) (c) of this Specification with an exception to permit mounting hole.

740.3. Construction Methods. Delineators shall be mounted on the delineator posts in accordance with the plans or as directed by the Engineer.

740.4. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

740.5. Measurement. Delineators shall be measured as each of the several types of delineators completely assembled and mounted in place.

740.6. Payment. The work performed and materials furnished as prescribed by this specification, measured as provided under "Measurement", will be paid for at the unit price bid for "Delineators (Independently Housed)" of the type specified or "Delineators (Center Mount)" of the type specified, which price shall be full compensation for furnishing, fabricating and erecting the delineators as shown on the plans and as specified herein, including housings, backplates, frames, reflector units, fastening plates or brackets where required, and all bolts, nuts and washers.

ITEM 742

DELINEATOR AND MILEPOST MARKER POSTS

742.1. Description. This item shall consist of furnishing and erecting galvanized posts for delineators and milepost markers in accordance with the lines, grades, details and dimensions shown on the plans or as directed by the Engineer.

742.2. Materials. Delineator and Milepost Marker Posts shall be made from steel conforming to the requirements of ASTM Specifications A-1, A-16, A-415, A-245 Grade C or A-499. The posts shall be fabricated to the general shape and dimensional limitations as shown on the plans; shall be of uniform cross section throughout their length; shall be of the lengths shown on the plans and shall have a nominal weight of two pounds per linear foot based on gross section prior to the punching or drilling of holes, clipping or galvanizing. Permissible variations in weight from the two pounds per lineal foot specified shall be the established standard mill tolerances for the material from which the post is fabricated. The posts shall have holes drilled or punched as shown on the plans and any projecting metal around the holes shall be removed.

The flanges of the posts shall lie in the same plane and the posts shall be straight within 1/4" per 5 ft. of length after galvanizing. All fabrication including forming, punching or drilling, deburring and clipping shall be complete prior to galvanizing. Posts shall be galvanized in accordance with ASTM Designation A-123.

742.3. Construction Methods. Delineator and Milepost Marker Posts shall be so erected that the delineators and milepost markers will be at elevations called for on the plans and shall be true to line and grade and truly vertical.

In material other than rock, Delineator and Milepost Marker Posts shall be driven to the depth shown on the plans. A suitable cap shall be provided and after driving, the top of the posts shall have substantially the same cross sectional dimensions as the body of the posts. Battered heads will not be permitted, and any posts bent or otherwise damaged to the extent that they are, in the opinion of the Engineer, unfit on the finished work, shall be removed from the site and replaced by the Contractor at his own expense.

If rock is encountered at a depth less than the minimum depth shown on the plans, the holes for the Delineator and Milepost Marker Posts shall be drilled not less than six (6) inches in diameter and to the depth shown on the plans, and the posts shall be set in Class "A" Concrete conforming to the Item, "Concrete for Structures".

742.4. Measurement. "Delineator and Milepost Marker Posts" will be measured as each post of the various specified lengths complete in place.

742.5. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Delineator and Milepost Marker Posts", of the stated length, which price shall be full compensation for furnishing, galvanizing, driving the posts or drilling holes and setting the posts in Class "A" Concrete and for all other details and incidentals necessary to provide the Delineator and Milepost Marker Posts complete and erected in place ready for the attachment of the Delineator or Milepost Markers.

ITEM 744

TIMBER DELINEATOR POSTS

744.1. Description. This specification shall govern for furnishing and erecting timber delineator posts in accordance with the lines, grades, details and dimensions shown on the plans or as directed by the Engineer.

744.2. Material. Timber delineator posts shall be treated Southern Yellow Pine conforming to the dimensions shown on the plans. The bottom shall be sawed off square and the top shall be dome-shaped. The posts shall be round, peeled and free of all outer and inner bark. The posts shall be uniform, straight and smooth. Posts shall be free from any defects which may impair their strength and durability, such as bark inclusions, cross breaks, decay, shakes, splits, unsound or loose knots, numerous knots or holes and double or reverse sweeps. Sound knots will be permitted provided they are not in clusters and they do not exceed one-inch in diameter. Any defect or combination of defects which would be more injurious than the maximum allowable knot will not be permitted. The heartwood of the post shall have a minimum cover of one-inch sapwood. A straight line drawn from the center of each end of the post shall not fall outside the center of the post at any point more than one inch. Posts shall be cut to dimensions shown on the plans before treatment.

Unless shown on the plans, all posts shall be pressure treated with a pentachlorophenol treatment of not less than eight pounds per cubic foot, as required in the Item, "Timber Preservative and Treatment".

744.3. Construction Methods. The timber delineator posts shall be so erected that the delineators will be at elevations called for on the plans and shall be true to line and grade and plumb. Unless the plans call for setting in concrete, the post holes shall be backfilled by thoroughly tamping the material in four inch layers. Drilled holes for posts shall have a minimum diameter of eight inches.

After erection, the timber posts shall be painted with two coats of aluminum paint. The paint shall be of good quality that will produce a neat and workmanlike appearance and shall conform to the requiremets of the Item, "Paint and Painting".

After the posts have been erected and painted, the delineators shall be mounted on the posts at the elevation indicated on the plans. The delineators shall be oriented to provide maximum visibility to approaching traffic or as directed by the Engineer.

744.4. Measurement. Timber Delineator Posts shall be measured as each post of the various specified lengths complete in place.

744.5. Payment. Payment for Timber Delineator Posts will be made at the unit price bid per each for "Timber Delineator Posts" of the stated length, which payment shall be full compensation for furnishing and setting the posts, drilling holes, painting, all concrete if required, and for all other details and incidentals necessary to provide the Timber Delineator Posts complete and erected in place ready for the attachment of the Delineators.

ITEM 746

HIGHWAY SIGN LIGHTING FIXTURES

746.1. Description. This item shall govern the furnishing and erection of Highway Sign Lighting Fixtures of the types specified in accordance with locations, spacings and dimensions shown on the plans.

746.2. Materials. All materials furnished, assembled, fabricated or installed under this item shall be new, unless otherwise indicated, and in strict accordance with the details shown on the plans and in compliance with the National Electric Code Specifications.

746.3. Construction Methods. The installation of the Highway Sign Lighting Fixtures shall be carried out in conformance with the details shown on the plans. Upon completion of the work, each assembly shall present a neat and workmanlike finished appearance.

746.4. Measurement. The Highway Sign Lighting Fixtures will be measured as each unit of each type erected, complete in place.

746.5. Payment. Work performed and materials furnished as prescribed in this item, measured as provided under "Measurement", will be paid for at the unit price bid for each "Hwy. Sign Ltg. Fixture", of the type specified, which payment shall be full compensation for furnishing, installing and testing all fixtures complete with lamps, ballasts, ballast boxes, all conduit required for installing the fixtures, conductors between the fixtures and the base of the tower or post supporting the sign structure, brackets for mounting the fixtures on the sign structure, hardware, internal connections and for furnishing all labor, tools, equipment and incidentals necessary to provide the Highway Sign Lighting Fixture complete in place and ready for operation.

ITEM 748

SIGN WALKWAYS

748.1. Description.

(1) General. Sign walkways shall consist of grating attached to supporting members and shall be provided with a fold-down type handrail. Walkways shall be attached to and supported by the sign lighting brackets.

(2) Design. The design shall be in accordance with the requirements of "Specifications for the Design and Construction of Structural Supports for Highway Signs", published by the American Association of State Highway Officials, and adopted by Letter Ballot, June 12, 1961.

The grating shall have such minimum safe live load capacity as to support a single live load of 500 pounds distributed over the 24 inch span.

The handrail shall have such minimum safe live load capacity as to support a concentrated load of 150 pounds applied horizontally in any direction at the top of the top rail when the handrail is in a raised position.

748.2. Materials. Materials in sign walkways shall be as shown on the plans.

Dissimilar metals in contact shall be so treated or insulated as to prevent interaction between the metals.

The grating shall be open-type and shall have a skid resistant surface. The width shall be 24 inches with minor variations permitted to accommodate the manufacturer's pattern.

748.3. Construction Methods. Fabrication shall be in accordance with the Item, "Steel Structures". Steel parts shall be galvanized after fabrication in accordance with the Item, "Metal for Structures".

Assemblies and pieces shall be plainly marked to show their location in the finished structure. The parts shall be bundled for shipment to minimize risk of damage in transit.

Care shall be exercised in transportation, storage and erection to prevent damage. Any damage to galvanizing down to bare metal or when bare metal is exposed shall be repaired by application of galvanizing repair compounds

meeting Federal Specification O-G-93 (*Stick Only*) in accordance with the manufacturer's recommendations.

748.4. Measurement. Sign walkways shall be measured by the linear foot of walkway in place.

748.5. Payment. Payment for walkways will be made at the unit price bid per linear foot for "Sign Walkways", which payment shall be full compensation for furnishing, fabricating and erecting the walkway, including the railing, railing connections, latches, plates, bolts, nuts, washers and all incidentals necessary, including galvanizing, to provide a completed walkway in place as shown on the project plans and in compliance with the specifications.

ITEM 750

JIGGLE BARS

750.1. Description. This specification shall govern for furnishing all labor, materials and services necessary to install jiggle bars complete in place in conformity with details shown in the plans and as described herein.

750.2. Materials. Unless otherwise shown on the plans jiggle bars shall be made of ceramic tile or plastic resin. Jiggle bars made of plastic resin may contain inert fillers and coloring pigments.

(1) Jiggle Bars. Jiggle bars shall be shaped to conform with the details in the plans and shall meet either of the following requirements:

(a) Ceramic-Tile Jiggle Bars. The glazed surface shall not craze, spall, or peel when subjected to one cycle of the Autoclave test at 250 psi (ASTM: C 424). The jiggle bars shall comply with the adhesion requirements of Test Method Tex-611-J.

The glazed surface shall meet the color requirements given in the table below. The jiggle bar tiles shall have a compressive strength as follows:

Minimum average of five units 6000 psi

Individual minimum, one unit 5000 psi

(b) Plastic Resin Jiggle Bars.

Impact Resistance, New (Feet)	10 min.
Impact Resistance, heat aged (feet)	10 min.
Tensile Strength (psi)	3000 min.
Shore Durometer Hardness (Type D)	85 min.

All tests shall be performed at room temperature, 70 F-80 F. Heat aging shall be 24 hours in a 158 F oven. Impact resistance shall be performed by placing the bar, base down, on a concrete slab. A 1-pound steel ball shall be dropped from a height of 10 feet. If the bar does not crack or shatter it shall be considered satisfactory. Tensile strength shall be determined in accordance

with ASTM D 638-64T using Type 1 specimens 1/4 inch thick. The base of jiggle bar units shall not deviate from a true plane more than 0.07 inch.

The bottom surface of the jiggle bars shall be of a roughness comparable to at least that of a fine grade of sandpaper. The bottom surface of the jiggle bars shall not be grooved such that air will be trapped in the grooves when it is pressed into the epoxy adhesive.

Jiggle bars shall be either white or yellow in color as called for in the plans. The color of the jiggle bars shall be uniform and its C.I.E. Chromaticity coordinate limits when determined in accordance with Federal Methods of Tests TT-T-141, Method 4252, shall fall within a rectangle having the following corner points:

	1		2		3		4		Brightness
	x	y	x	y	x	y	x	y	(Percent MgO)
White	.290	.316	.310	.296	.330	.321	.310	.342	80 min.
Yellow	.470	.460	.515	.485	.545	.455	.490	.425	40 min.

(2) Adhesive. Adhesive shall conform to the requirements of the Item, "Epoxy Adhesive".

750.3. Sampling and Testing. Samples of jiggle bar tiles and adhesives shall be submitted to the Engineer for approval prior to installation. The installation of the jiggle bars may begin after approval of the samples.

750.4. Construction Methods. The jiggle bars shall be installed where indicated in the plans or as directed by the Engineer. The Contractor shall use a template or a straightedge to align individual jiggle bar tiles to produce a neat true jiggle bar.

The surface on which the jiggle bars are to be installed shall be dry and free form grease, oil, dirt, etc. The Contractor shall demonstrate to the Engineer a satisfactory method of cleaning the bonding surface. The wet adhesive shall be spread on the surface such that 100 percent of the bonding area is covered.

The wet adhesive applications shall be of sufficient thickness so that when the tiles are shoved into the adhesive, excess adhesive shall be forced out under all sides of the tiles.

750.5. Measurement. Jiggle bars will be measured by the linear foot. The length for payment will be the nominal width of the jiggle bar tiles as detailed in the plans multiplied by the number of tiles installed.

750.6. Payment. The work performed under this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Jiggle Bars", which price shall include all labor, materials, incidentals and services necessary to complete the work.

ITEM 752

PAVEMENT MARKERS (REFLECTORIZED)

752.1. Description. This item shall consist of furnishing and installing reflectorized pavement markers at locations designated on plans or as directed by the Engineer.

752.2. Materials.

(1) Marker

(a) Design and Shape. The outer surface of the marker shall be smooth and all corners and edges exposed to traffic must be rounded. The base of the marker shall have a width of 4.0 inches ± 1/2 inch and shall have a minimum area exposed to traffic of 12.5 square inches. The maximum height shall be 3/4-inch. The maximum slope of the reflective face or faces shall be not more than 30 degrees from the horizontal.

The bottom surface of the marker shall be of a roughness comparable to at least that of a fine grade of sandpaper. The bottom surface of the marker shall not be grooved such that air will be trapped in the grooves when it is pressed into the epoxy adhesive.

Pavement Markers shall be of the following types:

Type I-A shall contain one face that reflects amber light and the body other than the reflective face shall be yellow.

Type I-C shall contain one face that reflects white light and the body other than the reflective face shall be white, silver white or light gray.

Type I-R shall contain one face that reflects red light and the body other than the reflective face shall be white, silver white or light gray or may be and one-half red on the side which reflects red light, or may be all white, silver white or light gray.

Type II-A-A shall contain two reflective faces each of which shall reflect amber light and the body other than the reflective faces shall be yellow.

Type II-C-C shall contain two reflective faces, each of which shall reflect white light and the body other than the reflective faces shall be white, silver white or light gray.

Type II-A-C shall contain two reflective faces one of which shall reflect amber light and one of which shall reflect white light; the body other than the reflective faces shall be white, silver white or light gray or may be one-half yellow on the side that reflects amber light and one-half white, silver white or light gray on the side that reflects white light.

Type II-A-R shall contain two reflective faces, one of which reflects amber light and one of which reflects red light; the body other than the reflective faces shall be one-half yellow on the side which reflects amber light and one-half red on the side which reflects red light or may be all white, silver white or light gray.

Type II-C-R shall contain two reflective faces, one of which reflects white light and one of which reflects red light; the body other than the reflective faces shall be white, silver white or light gray or may be one-half white, silver white or light gray on the side that reflects white light and one-half red on the side that reflects red light.

The reflective faces of the Type II markers shall be located so that the direction of reflection from one face shall be directly opposite to the direction of reflection of the other face.

(b) Physical Requirements. The markers shall comply with the adhesion requirements of Test Method Tex-611-J.

The marker shall withstand a falling-ball impact of 5 (five) feet without breaking, cracking or being significantly deformed when tested according to Test Method Tex-430-A.

The marker shall show no change in shape or color when subjected to the requirements of Test Method Tex-846-B. The temperature shall be 140 F with the marker in a vertical position.

(c) Optical Requirements.

1. Definitions. Horizontal entrance angle shall mean the angle, in a plane parallel to the base of the marker, between a line in the direction of the incident light and a line perpendicular to the leading edge of the reflective surface.

Divergence angle shall mean the angle at the reflector between observer's line of sight and the direction of the light incident on the marker.

Specific intensity shall mean candlepower of the returned light at the chosen divergence and entrance angles for each footcandle of incident light per reflective face. Test Method Tex-842-B will be used to determine specific intensity.

2. Optical Performance. For the pavement markers the specific intensity of the reflecting surface at 1/5 degree divergence angle shall be not less than the following when the incident light is parallel to the base of the marker.

	Specific Intensity		
Horizontal Entrance Angle, Degrees	Crystal	Amber	Red
0	3.0	2.0	0.4
20	1.5	1.0	0.2

The specific intensity of the marker shall be not less than 80 percent of the above minimum values after being subjected to the heat test required in Section 752.2(1)(b).

(2) Epoxy Adhesive. Epoxy Adhesive shall conform to the requirements of the Item, "Epoxy Adhesive". The particular type adhesive shall be chosen from this item.

752.3. Construction Methods. The pavement markers shall be placed at locations in such a way that the color of the reflected light is in accordance with the plans or as directed by the Engineer.

The portion of the highway surface to which the marker is attached by the adhesive shall be buffed, ground, sandblasted or other method approved by the Engineer in order to be free of dirt, curing compound, grease, oil, moisture, loose or unsound pavement and any other material which would adversely affect the bond of the adhesive.

The wet epoxy adhesive shall be spread on the bonding surface so that 100 percent of the bonding area of the marker will be covered. The wet adhesive applications shall be of sufficient thickness so that when the markers are pressed into adhesive, excess adhesive shall be forced out around the entire perimeter of the pavement markers. All excess adhesive shall be removed from in front of the reflective faces. If any adhesive or foreign matter cannot be removed from the reflective faces, the marker will be replaced.

When the project is complete, the markers shall be firmly bonded to the pavement, lines formed by the markers shall be true and the entire installation shall present a neat appearance.

752.4. Sampling and Testing. Sampling and testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures.*

752.5. Measurement. Pavement markers will be measured as each pavement marker complete in place.

752.6. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Pavement Markers (Single Reflector) and/or (Double Reflector)", which price shall be full compensation for furnishing all materials, all preparation and installation and for all labor, equipment, tools and incidentals necessary to complete the work.

ITEM 754

TRAFFIC BUTTONS (NON-REFLECTORIZED)

754.1. Description. Traffic Buttons shall be round and dome-shaped with a uniform curvature. The top and sides of the buttons shall be smooth and free from surface irregularities, pits, cracks, checks, chipping, discoloration and any other defects which adversely affect appearance and application. The bottom of the buttons shall be rough-textured, free from gloss, glaze or any other substance that may reduce its bond to the adhesive.

The buttons shall, at the Contractor's option, be made from ceramic, glass or plastic material conforming with Article 754.2 of this specification; provided, however, that all buttons used on any one project shall be of the same material and same manufacture.

Each traffic button shall be 4 inches ± 1/8 inch in diameter at the base. Height of the button shall be 11/16 inch ± 1/16 inch. The base of the button shall not deviate from a flat plane by more than 1/16 inch.

754.2. Materials.

(1) Ceramic Traffic Buttons.

(2) Glass Traffic Buttons.

(3) Plastic Traffic Buttons.

754.3. Physical Requirements.

(1) Water Absorption. The water absorption of the button shall not exceed 1.0 percent of the original dry weight when tested in accordance with ASTM Designation: C 373.

(2) Autoclave Test (Does not apply to Plastic Traffic Buttons). The glazed surface of the button shall not craze, spall or peel when subjected to one cycle of the Autoclave test at 250 psi. (ASTM Designation: C-424).

(3) Strength Requirements. A random sample of 5 buttons shall be subjected to the compressive load test. The average compressive strength of the 5 buttons shall not be less than 1500 pounds and no individual button shall have a compressive strength less than 1200 pounds when tested in accordance with Test Method Tex-434-A.

(4) Impact Test (Applies to Plastic Traffic Buttons only). The button shall not break or crack when subjected to the impact test in accordance with Test Method Tex-435-A.

(5) Color. The color of the buttons shall be as designated on the plans, shall be uniform and shall be determined by visual comparison with calibrated standards having C.I.E. Chromaticity Coordinate limits determined in accordance with Federal Methods of Tests TT-T-141, Method 4252 falling within an area having the following corner points:

	1		2		3		4		Brightness
	x	y	x	y	x	y	x	y	(%MgO)
White	.290	.316	.310	.296	.330	.321	.310	.342	80 min.
Yellow	.470	.460	.515	.485	.545	.455	.490	.425	40 min.

(6) Glaze Thickness (Applies to Ceramic Traffic Buttons only). The glazed surface shall have a mean thickness not less than 0.005 inch when measured not closer than 1/4 inch from the edge of the button. The glaze thickness shall be measured on a fractured edge of the button to the nearest 0.001 inch by a calibrated scale microscope.

(7) Hardness (Applies to Plastic Traffic Buttons only). The Shore Durometer Hardness (Type D) when determined in accordance with ASTM Designation: D 2240, shall be a minimum of 86 when measured at room temperature and a minimum of 83 when measured at 150 F.

(8) Adhesion Requirements. The buttons shall comply with the adhesion requirements of Test Method Tex-611-J.

754.4. Sampling and Testing. A minimum of twenty-five (25) traffic buttons selected at random by the Engineer will constitute a sample. No buttons will be returned. Testing will be in accordance with the Texas Highway Department's *Manual of Testing Procedures* except as otherwise indicated in this specification.

754.5. Epoxy Adhesive. The adhesive used to bond the traffic buttons to the roadway surface shall conform to the Item, "Epoxy Adhesive".

754.6. Construction Methods. The traffic buttons shall be placed in accordance with the plans or as directed by the Engineer. The portion of the highway surface to which the button is attached by the adhesive shall be buffed, ground, sandblasted or other method approved by the Engineer in order to be free of dirt, curing compound, grease, oil, moisture, loose or unsound pavement and any other material which would adversely affect the bond of the adhesive. The wet epoxy shall be applied so that 100 percent of the bonding area of the button will be in contact and shall be of sufficient thickness so that the excess adhesive shall be forced out around the perimeter of the button. When the project is complete, the button shall be firmly bonded to the pavement; lines formed by the buttons shall be true; and the entire installation shall present a neat appearance.

754.7. Measurement. Traffic Buttons (Non-Reflectorized) will be measured as each traffic button complete in place.

754.8. Payment. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Traffic Buttons (Non-Reflectorized)", which price shall include all labor, epoxy adhesive and all other materials and services necessary to complete the work.

PART III, FORMS

DIVISION I, DOCUMENTARY FORMS

NOTICE TO CONTRACTORS OF PROPOSED TEXAS HIGHWAY CONSTRUCTION

Sealed proposals addressed to the State Highway Engineer of Texas, for the improvement of certain highways in the counties listed in the respective notices attached hereto, will be received at the office of the State Highway Engineer, Austin, Texas, **until the time specified in each respective notice, then publicly opened and read.**

Detailed plans and specifications of the work may be examined and information may be obtained at the Engineer's Office listed in each respective notice and at the Office of the State Highway Department, State Highway Building, Austin, Texas.

Those desiring individual plans may secure same from a commercial blue print company of Austin, Texas. Minimum wage rates have been, or will be, predetermined as required by Law, and will be set forth in the Bid Proposals. All proposals must be secured from the **Construction Engineer (File D-6),** Austin, Texas.

Certified check, cashier's check, bank money order or bank draft on a State or National Bank of the specified amount, made payable without recourse to the order of the State Highway Commission of Texas, must accompany each proposal as a guarantee that the bidder, if successful, will enter into contract and make bond in accordance with requirements of the specifications. The right is reserved by the State Highway Commission to reject any or all proposals and to waive all technicalities.

All Bids received will be retained by the State Highway Department. Conditional bids will not be considered.

Proposals shall be submitted in sealed envelopes as furnished with the proposals. All data in lower left-hand corner of envelope shall be properly filled in showing county, project number, time, date of letting, signature and address of bidder.

* * * * *

NOTE: THE ITEMS, DESCRIPTIONS AND QUANTITIES FOR ALL PROJECTS SHOWN IN DETAIL NOTICE TO CONTRACTORS ARE TENTATIVE ONLY AND ARE NOT NECESSARILY LISTED IN THE SAME ORDER AND AMOUNTS AS MAY BE SHOWN IN THE OFFICIAL PROPOSAL FOR THE SCHEDULED LETTINGS.

CONTRACTORS' NOTICE OF TEXAS HIGHWAY CONSTRUCTION

Sealed proposals for constructing_____miles of_____

From_____

To_____

on Highway No._____, covered by_____ in_____

_____County, will be received at the Highway Department, Austin, until 9:00 A.M.,_____, 19____, and then publicly opened and read.

Plans and specifications including minimum wage rates as provided by Law are available at the office of_____, _____ Engineer, _____Texas, and Texas Highway Department, Austin. Usual rights reserved.

CONTRACTORS' NOTICE OF TEXAS HIGHWAY CONSTRUCTION

Sealed proposals for constructing _____miles of_____

From_____

To_____

on Highway No._____, covered by_____ in_____

_____ County, will be received at the Highway Department, Austin,

until 9:00 A.M., _____, 19____, and then publicly opened and read.

THIS CONTRACT IS SUBJECT TO THE WORK HOURS ACT OF 1962, PL-87-581 AND IMPLEMENTING REGULATIONS.

The State Highway Department, in accordance with the provisions of Title VI of the Civil Rights Act of 1964 (78 Stat. 252) and the Regulations of the U.S. Department of Transportation (15 C.F.R., Part 8), issued pursuant to such Act, hereby notifies all bidders that it will affirmatively insure that the contract entered into pursuant to this advertisement will be awarded to the lowest responsible bidder without discrimination on the ground of race, color, or national origin.

Plans and specifications including minimum wage rates as provided by Law are available at the office of_____,

_____Engineer, _____, Texas, and Texas Highway Department, Austin. Usual rights reserved.

(Urban, Primary and
Secondary Projects)

CONTRACTORS' NOTICE OF TEXAS HIGHWAY CONSTRUCTION

Sealed proposals for constructing_____, miles of_____

From_____

To_____

on Highway No._____, covered by_____ in

_____County, will be received at the Highway

Department, Austin, until 9:00 A.M., _____ 19____, and then publicly opened and read.

The State Highway Department, in accordance with the provisions of Title VI of the Civil Rights Act of 1964 (78 Stat. 252) and the Regulations of the U.S. Department of Transportation (15 C.F.R., Part 8), issued pursuant to such Act, hereby notifies all bidders that it will affirmatively insure that the contract entered into pursuant to this advertisement will be awarded to the lowest responsible bidder without discrimination on the ground of race, color, or national origin.

Plans and specifications including minimum wage rates as provided by

Law are available at the office of_____,

_____Engineer, _____, Texas, and Texas High-

way Department, Austin. Usual rights reserved.

Control_____

Project_____

Highway_____

County_____

TEXAS HIGHWAY DEPARTMENT
GOVERNING SPECIFICATIONS AND
SPECIAL PROVISIONS

All specifications and special provisions applicable to this project are identified as follows:

Standard Specifications: Adopted by the State Highway Department of Texas, January 3, 1972.

Item_____ _____

Item_____ _____

Special Provisions: Special Provisions shall govern and take precedence over the specifications enumerated hereon wherever in conflict therewith.

Required Provisions: Required Provisions– Federal-Aid Contracts_____.

Special Provision_____

Special Provision_____

Special Specifications:

_____

_____

General: The above listed specification items are those under which payment is to be made. These, together with such other pertinent items, if any, as may be referred to in the above listed specification items, and including the special provisions listed above, constitute the complete specifications for this project.

THIS PROPOSAL ISSUED TO:

Control_____
Project_____
Highway_____
County_____

PROPOSAL TO THE STATE HIGHWAY COMMISSION

FOR THE CONSTRUCTION OF_____
IN _____ COUNTY, TEXAS

The undersigned, as bidder, declares that the only person or parties interested in this proposal as principals are those named herein; that this proposal is made without collusion with any other person, firm, corporation; that he has carefully examined the form of contract, instructions to bidders, profiles, grades, specifications, and the plans therein referred to, and has carefully examined the locations, conditions and classes of materials of the proposed work; and agrees that he will provide all the necessary machinery, tools, apparatus, and other means of construction, and will do all the work and furnish all the materials called for in the contract and specifications in the manner prescribed therein and according to the requirements of the Engineer as therein set forth.

It is understood that the following quantities of work to be done are approximate only, and are intended principally to serve as a guide in figuring out the bids.

It is further understood that the quantities of work to be done and materials to be furnished may be increased or diminished as may be considered necessary, in the opinion of the Engineer, to complete the work fully as planned and contemplated, and that all quantities of work, whether increased or decreased, are to be performed at the unit prices set forth below except as provided for in the specifications.

It is further understood that the work is to be completed in full in _____ working days.

Accompanying this proposal is a certified check, cashier's check, bank money order or bank draft on a State or National Bank payable to the order of the Texas State Highway Commission for_____ Dollars ($_____).

Texas Highway Department
Form 419A Revised 9-69

NOTICE TO CONTRACTORS

ANY CONTRACTORS INTENDING TO BID ON ANY WORK TO BE AWARDED BY THIS DEPARTMENT MUST SUBMIT A SATISFACTORY "FINANCIAL STATEMENT" AND "EXPERIENCE QUESTIONNAIRE" AT LEAST TEN DAYS PRIOR TO THE LETTING DATE.

UNIT PRICES MUST BE SHOWN IN WORDS FOR EACH ITEM LISTED IN THIS PROPOSAL.

PROPOSAL SHEET
Texas Highway Department
Form 234-B 1-61-5M

PROJECT_____

COUNTY_____

Alt.	Item-Code			Item Description and Unit Bid Price Written in Words	Unit	Approximate Quantities
	Item No.	Desc. Code	S. P. No.			
				..... Dlrs. and ..... Cents		
				..... Dlrs. and ..... Cents		
				..... Dlrs. and ..... Cents		
				..... Dlrs. and ..... Cents		
				..... Dlrs. and ..... Cents		
				..... Dlrs. and ..... Cents		
				..... Dlrs. and ..... Cents		
				..... Dlrs. and ..... Cents		

The check accompanying this proposal shall be returned to the bidder, unless in case of the acceptance of the proposal the bidder shall fail to execute and file a contract within fifteen days after its acceptance, in which case the check shall become the property of said Commission, and shall be considered as payment for damages due to delay and other inconveniences suffered by said Commission on account of failure of the bidder to execute contract. It is understood that the party of the first part reserves the right to reject any and all bids.

In the event of the award of a contract to the undersigned, the undersigned will make bonds for the full amount of the contract, to secure proper compliance with the terms and provisions of the contract, and to insure and guarantee the work until final completion and acceptance, and to guarantee payment of all lawful claims for labor performed and materials furnished in the fulfillment of the contract.

The work proposed to be done shall be accepted when fully completed and finished to the entire satisfaction of the State Highway Engineer.

The undersigned certifies that the bid prices contained in this proposal have been carefully checked and are submitted as correct and final.

_____
(Print Firm Name)

*Signed_____
(Title)

_____

_____

_____
Address Zip Code

_____
Address Zip Code

IMPORTANT

CHECK RETURN INFORMATION ON
PAGE I MUST BE COMPLETED.

***NOTE**: Signatures to comply with Article 2.5. of the standard specifications.

Texas Highway Department
Form 419A Revised 9-69

PROJECT_____

COUNTY_____

BIDDER DATE DIV. JOB

Texas Highway Department
Form 234-A 5-64-5M

Item-Code			ITEM DESCRIPTION	Unit	Approximate Quantities	Unit Bid Price	Extension
Item No.	Desc. Code	S. P. No.					

Texas Highway Department
Form 389-A

Control_____
Project_____
Highway_____
County_____

CONTRACT

This agreement made this _____day of_____ , 19____, by and between the State of Texas, represented by the State Highway Engineer, party of the first part, and _____

_____

_____

his/their executors, administrators, heirs, successors or assigns, the Contractor, party of the second part.

WHEREAS, the State desires to enter into a contract for the highway improvement as shown and described in the plans, specifications and special provisions included herein or as far as the money available will construct in accordance with the provisions of the State Statutes, and

WHEREAS, the Contractor has been engaged in and now does such work and represents that he is fully equipped, competent and capable of performing the desired and herein outlined work and is ready and willing to perform such work in accordance with the unit prices listed herein and the provisions of the herein included specifications, special provisions and plans, now

WITNESSETH: That for and in consideration of the Unit prices listed herein, a part of this contract, the Contractor agrees to do, at his own proper cost and expense, all the work necessary for the highway improvement as shown and described in the plans and in accordance with the provisions of the specifications and special provisions which are a part of this contract.

Time for completion of this contract shall be computed beginning _____, 19____.

The work to be constructed under this contract shall be completed in _____ working days.

And the State in consideration of the full and true performance of said work by the Contractor hereby agrees and binds itself to pay to the Contractor for the quantities of work performed in compliance with this contract at the respective unit prices set forth herein, subject to adjustment as herein provided. The following items of work and respective unit prices are those contained in the original proposal and are a part of this contract. The State limits its obligation hereunder to the funds available.

The Contractor expressly warrants that he has employed no third person to solicit or obtain this contract in his behalf, or to cause or procure the same to be obtained upon compensation in any way contingent, in whole or in part, upon such procurement, or in compensation for services in connection therewith, any brokerage commission or percentage upon the amount receivable by him hereunder; and that he has not in estimating the contract price demanded by him, included any sum by reason of any such brokerage, commission or percentage; and that all moneys payable to him hereunder are free from all obligations of any other person for services rendered, or supposed to have been rendered, in the procurement of this contract. He further agrees that any breach of this warranty shall constitute adequate cause for the annulment of this contract by the State or for the deduction from any sums due or to become due thereunder an amount equal to any brokerage, commission or percentage so paid or agreed to be paid or both.

In the employment of labor in the performance of this contract, preference shall be given, other conditions being equal, to honorably discharged service personnel, but no other preference or discrimination among citizens of the United States shall be made.

It is acknowledged and agreed by the parties hereto that this contract is the full and complete contract for the construction of the work called for and described herein.

IN WITNESS WHEREOF, the parties hereto have set their hands the date herein named.

STATE OF TEXAS

Party of the First Part

Certified as being executed for the purpose and effect of activating and/or carrying out the orders, established policies, or work programs heretofore approved and authorized by the State Highway Commission:

By:_____

Executed and approved for State Highway Commission under authority of Commission Minute 60394.

RECOMMENDED FOR EXECUTION:

_____

Director, Finance

_____

Construction Engineer

CONTRACTOR

Party of the Second Part

_____

(Print Firm Name)

By:_____

(Title)

By:_____

(Title)

By:_____

(Title)

Texas Highway Department
Form 390-A

PERFORMANCE BOND

KNOW ALL MEN BY THESE PRESENTS: That we_____

_____

_____

as principal, and the other undersigned as surety, are held and firmly bound unto the State of Texas, in the penal sum of _____

_____Dollars ($_____),

lawful money of the United States, well and truly to be paid to the State of Texas, and we bind ourselves, our heirs, successors, executors, and administrators, jointly and severally, firmly by these presents.

Whereas, the above bounden principal has entered into the foregoing contract with the State of Texas attached hereto, and whereas, under the law said principal is required before commencing the work provided for in said contract to execute a bond in the amount of said contract.

The condition of this obligation is such that if the above bounden principal, his or its heirs, successors, executors, and administrators shall well and faithfully do and perform each and every, all and singular, the work in accordance with the plans, specifications, and contract documents as provided in said contract aforesaid, then this obligation shall be null and void; otherwise to be and remain in full force and effect.

WITNESS our hands this the _____ day of _____, 19_____.

_____

PRINCIPAL (Print Firm Name)

By:_____

(Title)

By:_____

(Title)

By:_____

(Title)

_____

SURETY (Print Firm Name)

*By:_____

(Title)

_____

SURETY (Print Firm Name)

*By:_____

(Title)

Approved as to form:
ATTORNEY GENERAL OF TEXAS

By:_____

Assistant Attorney General

*Note: If signed by an officer of the Surety Company there must be on file a certified extract from the by-laws showing that this person has authority to sign such obligation. If signed by an Attorney in Fact, we must have copy of power of attorney for our files.

Texas Highway Department
Form 390-B

PAYMENT BOND

KNOW ALL MEN BY THESE PRESENTS: That we _____

_____

_____

as principal, and the other undersigned as surety, are held and firmly bound unto the State of Texas, in the penal sum of _____

_____ Dollars ($_____), lawful money

of the United States, well and truly to be paid to the State of Texas, and we bind ourselves, our heirs, successors, executors, and administrators jointly and severally, firmly by these presents.

Whereas, the above bounden principal has entered into the foregoing contract with the State of Texas attached hereto, and whereas, under the law said principal is required before commencing the work provided for in said contract to execute a bond in the amount of said contract solely for the protection of all claimants supplying labor and materials as defined by law, in the prosecution of the work provided for in said contract, for the use of each such claimant.

The condition of this obligation is such that if the above bounden principal, his or its heirs, successors, executors, and administrators shall well and faithfully make payments to each and every claimant as defined by law, supplying labor and materials as defined by law, in the prosecution of the work provided for in said contract aforesaid, then this obligation shall be null and void; otherwise to be and remain in full force and effect.

WITNESS our hands this the _____ day of _____, 19____.

_____

PRINCIPAL (Print Firm Name)

By:_____

(Title)

By:_____

(Title)

By:_____

(Title)

_____

SURETY (Print Firm Name)

*By:_____

(Title)

_____

SURETY (Print Firm Name)

*By:_____

(Title)

Approved as to form:
ATTORNEY GENERAL OF TEXAS

By:_____

Assistant Attorney General

*Note: If signed by an officer of the Surety Company there must be on file a certified extract from the by-laws showing that this person has authority to sign such obligation. If signed by an Attorney in Fact, we must have copy of power of attorney for our files.

Texas Highway Department
Form 177

CONSTRUCTION ESTIMATE

Highway No. ..... District No. .....
Residency No. .....
County .....No. .....
Project ..... P.D. .....
Control No. ..... Sec. ...Job. .....
ESTIMATE NO. .....
Contract Amount .....

Estimate Period
From ..... , 19.... to..... , 19 ...
On first estimate and final estimate use actual work dates

For .....
Contractor

Item	Unit of Measure	Project Estimate Quantities	Total Work Done on Contract	Contract Price	Amount

APPROVED:

..... Date
Resident Engineer

..... Date
District Engineer or Engineer-Manager

..... Date
Construction Engineer

..... Date
Bridge Engineer

For Res. Engr's Office
Calculations Verified By:
Supporting Papers O.K.
Proof Read By:
For Dist. Engr's Office
Calculations Verified By:
Supporting Papers O.K.
Proof Read By:

Total Amount of Work Done ..... $.....
Less Retainage ..... $.....
Difference ..... $.....
Less Special Deductions ..... $.....
Less Liquidated Damage ..... $.....
Less Previous Payments ..... $.....
Amount Due This Estimate ..... $.....

DIVISION I
INDEX TO PAY QUANTITIES

Item	Description	Unit of Measurement
100	**PREPARING RIGHT OF WAY**	
	Prep R O W	Ac
	Prep R O W	Sta
	Refers to Items 102 and 132	
102	**CLEARING AND GRUBBING**	
	Clear and Grub	Ac
	Clear and Grub	Sta
	Clear and Grub (Palm)	Ea
	Clear and Grub (Tree) (of the size specified)	Ea
104	**REMOVING OLD CONCRETE**	
	Remov Old Conc (of type specified)	SY
	Remove Old Conc (of type specified)	CY
	Remove Old Conc (of type specified)	LF
110	**ROADWAY EXCAVATION**	
	Uncl Rd Excav (Ord. Comp.)	CY
	Rock Rd Excav (Ord Comp)	CY
	Com Rd Excav (Ord Comp)	CY
	Uncl Rd Excav (Dens Cont)	CY
	Rock Rd Excav (Dens Cont)	CY
	Com Rd Excav (Dens Cont)	CY
	Refers to Items 132 and 140	
120	**CHANNEL EXCAVATION**	
	Uncl Chan Excav (Ord Comp)	CY
	Rock Chan Excav (Ord Comp)	CY
	Com Chan Excav (Ord Comp)	CY
	Uncl Chan Excav (Dens Cont)	CY
	Rock Chan Excav (Dens Cont)	CY
	Com Chan Excav (Dens Cont)	CY
	Refers to Items 132 and 140	
130	**BORROW**	
	Uncl Borrow (Ord Comp)	CY
	Rock Borrow (Ord Comp)	CY
	Com Borrow (Ord Comp)	CY

Item	Description	Unit of Measurement
	Uncl Borrow (Dens Cont)	CY
	Rock Borrow (Dens Cont)	CY
	Com Borrow (Dens Cont)	CY
	Refers to Items 132 and 140	
131	**BORROW (DELIVERED)**	
	Borr (Del) (Ord Comp) (of the type and class specified)	CY
	Borr (Del) (Dens Cont) (of the type and class specified)	CY
	Refers to Item 132	
140	**OVERHAUL**	
	Overhaul	YQ
150	**BLADING**	
	Blading	Hr
152	**ROAD GRADER WORK**	
	Rd Grader Work (Ord Comp)	Sta
	Rd Grader Work (Dens Cont)	Sta
	Refers to Items 132, 154, 156, 204, 210, 211, 212, 213, 214, 215 and 216	
154	**SCRAPER WORK**	
	Scraper Work (Ord Comp)	Hr
	Scraper Work (Dens Cont)	Hr
	Scraper Work (Ord Comp)	YH
	Scraper Work (Dens Cont)	YH
	Refers to Items 132, 150, 152, 204, 210, 211, 212, 213, 214, 215 and 216	
156	**BULLDOZER WORK**	
	Bulldozer Work (Ord Comp)	Hr
	Bulldozer Work (Dens Cont)	Hr
	Refers to Items 132, 150, 152, 204, 210, 211, 212, 213, 214, 215 and 216	
160	**SALVAGING AND PLACING TOPSOIL**	
	Salv Topsoil	Sta
	Salv Topsoil	CY
	Placing Topsoil	Sta
	Placing Topsoil	SY
	Placing Topsoil	CY
	Salv and Placing Topsoil	Sta

Item	Description	Unit of Measurement
	Salv and Placing Topsoil	SY
	Salv and Placing Topsoil	CY
	Refers to Items 100, 102, 204, 210, 211, 212, 213, 214, 215, 216	
162	**SODDING FOR EROSION CONTROL**	
	Spot Sodding	SY
	Block Sodding	SY
	Grass Retards	SY
	Broadcast Sprigging	SY or CY
	Mulch Sodding	SY or CY
	Refers to Items 166 and 204	
164	**SEEDING FOR EROSION CONTROL**	
	Broadcast Seeding (of type specified)	SY or Ac
	Straw Mulch Seeding (of type specified)	SY or Ac
	Asphalt Mulch Seeding (of type specified)	SY or Ac
	Accent Seeding (of type specified)	SY or Ac
	Refers to Items 166, 204, and 300	
166	**FERTILIZER**	
	Fertilizer (of the analysis specified)	Ton
170	**OBLITERATING ABANDONED ROAD**	
	Oblit Aband Rd	Sta
	Refers to Items 110, 130, 140 and 496	
180	**FINISHING ROADWAY**	
	Finishing Roadway	Sta
190	**ROADSIDE PLANTING**	
	Plant Establishment	LS
	(various plants specified)	Ea
200	**STRIPPIN G**	
	Stripping	CY
204	**SPRINKLING**	
	Sprinkling	MG
210	**ROLLING (FLAT WHEEL)**	
	Rolling (Flat Wheel)	Hr
	Refers to Item 204	
211	**ROLLING (TAMPING)**	
	Rolling (Tamping)	Hr
	Refers to Items 204 and 212	

Item	Description	Unit of Measurement
212	**ROLLING (HEAVY TAMPING)**	
	Rolling (Hvy Tamping)	Hr
	Refers to Item 204	
213	**ROLLING (PNEUMATIC TIRE)**	
	Rolling (Light Pneum Tire)	Hr
	Rolling (Medium Pneum Tire) (of the type specified)	Hr
	Refers to Item 204	
214	**ROLLING (HEAVY PNEUMATIC)**	
	Rolling (Hvy Pneum)	Hr
	Refers to Item 204	
215	**ROLLING (GRID)**	
	Rolling (Grid)	Hr
	Refers to Item 204	
216	**ROLLING (PROOF)**	
	Rolling (Proof)	Hr
	Refers to Item 204	
230	**ROADBED TREATMENT**	
	Rdbed Treat (Ord Comp) (of the type specified)	CY
	Rdbed Treat (Ord Comp) (of the type specified)	Ton
	Rdbed Treat (Dens Cont) (of the type specified)	CY
	Rdbed Treat (Dens Cont) (of the type specified)	Ton
	Rdbed Treat (Stockpiled) (of the type specified)	CY
	Rdbed Treat (Stockpiled) (of the type specified)	Ton
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 204, 210, 211, 212, 213, 214, 215, 216, and 500	
232	**FLEXIBLE BASE (CALICHE)**	
	Flex Base (Ord Comp) (of the type and grade specified)	CY
	Flex Base (Ord Comp) (of the type and grade specified)	Ton
	Flex Base (Dens Comp) (of the type and grade specified)	CY
	Flex Base (Dens Cont) (of the type and grade specified)	Ton
	Flex Base (Stockpiled) (of the type and grade specified)	CY or Ton

Item	Description	Unit of Measurement
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 110, 130, 150, 152, 154, 200, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
234	**FLEXIBLE BASE (SHELL WITH SAND ADMIXTURE)**	
	Flex Base (Ord Comp) (of the grade specified)	CY
	Flex Base (Ord Comp) (of the grade specified)	Ton
	Flex Base (Dens Cont) (of the grade specified)	CY
	Flex Base (Dens Cont) (of the grade specified)	Ton
	Sand Admix	CY
	Addl Qtr Mi Haul (Sand Admix)	CY
	Refers to Items 110, 130, 150, 152, 154, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
236	**FLEXIBLE BASE (BANK RUN GRAVEL)**	
	Flex Base (Ord Comp) (of the grade specified)	CY
	Flex Base (Ord Comp) (of the grade specified)	Ton
	Flex Base (Dens Cont) (of the grade specified)	CY
	Flex Base (Dens Cont) (of the grade specified)	Ton
	Flex Base (Stockpiled) (of the grade specified)	CY
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 110, 130, 150, 152, 154, 200, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
238	**FLEXIBLE BASE (PROCESSED GRAVEL)**	
	Flex Base (Ord Comp) (of the grade specified)	CY
	Flex Base (Ord Comp) (of the grade specified)	Ton
	Flex Base (Dens Cont) (of the grade specified)	CY
	Flex Base (Dens Cont) (of the grade specified)	Ton
	Flex Base (Stockpiled) (of the grade specified)	CY
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 110, 130, 150, 152, 154, 200, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
240	**FLEXIBLE BASE (IRON ORE)**	
	Flex Base (Ord Comp) (of the grade specified)	CY
	Flex Base (Ord Comp) (of the grade specified)	Ton
	Flex Base (Dens Cont) (of the grade specified)	CY
	Flex Base (Dens Cont) (of the grade specified)	Ton
	Flex Base (Stockpiled) (of the grade specified)	CY or Ton

Item	Description	Unit of Measurement
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 110, 130, 150, 152, 154, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
242	**FLEXIBLE BASE (CRUSHED STONE)**	
	Flex Base (Ord Comp) (of the type and grade specified)	CY
	Flex Base (Ord Comp) (of the type and grade specified)	Ton
	Flex Base (Dens Cont) (of the type and grade specified)	CY
	Flex Base (Dens Cont) (of the type and grade specified)	Ton
	Flex Base (Stockpiled) (of the type and grade specified)	CY or Ton
	Addl Qtr Mi Haul	CY
	Addl Qtr M i Haul	Ton
	Refers to Items 110, 130, 150, 152, 154, 200, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
244	**FLEXIBLE BASE (CLASS 1)**	
	Flex Base (of the type and grade specified)	CY
	Flex Base (of the type and grade specified)	Ton
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 110, 130, 150, 152, 154, 200 and 500	
246	**FOUNDATION COURSE**	
	Fnd Crse (Ord Comp)	CY
	Fnd Crse (Ord Comp)	Ton
	Fnd Crse (Dens Cont)	CY
	Fnd Crse (Dens Cont)	Ton
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 110, 120, 200, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
248	**FLEXIBLE BASE**	
	Flex Base (of the compaction method, type and grade specified) (Class 1)	CY
	Flex Base (of the compaction method, type and grade specified) (Class 2)	Ton

Item	Description	Unit of Measurement
	Flex Base (of the compaction method, type and grade specified) (Class 3)	CY
	Flex Base (Type D) (of the compaction method and grade specified) (Class 1)	CY
	Flex Base (Type D) (of the compaction method and grade specified) (Class 2)	Ton
	Flex Base (Type D) (of the compaction method and grade specified) (Class 3)	CY
	Flex Base (Type E) (of the compaction method and grade specified) (Class 1)	CY
	Flex Base (Type E) (of the compaction method and grade specified) (Class 3)	CY
	Flex Base (Stkpl) (of the type and grade specified (Class 1)	CY
	Flex Base (Stkpl) (of the type and grade specified (Class 2)	Ton
	Flex Base (Stkpl) (of the type and grade specified) (Class 3)	CY
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Sand Admix	CY
	Caliche Admix	CY
	Addl Qtr Mi Haul (Sand Admix)	CY
	Addl Qtr Mi Haul (Caliche Admix)	CY
	Refers to Items 110, 130, 150, 152, 154, 200, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
249	**FLEXIBLE BASE (DELIVERED)**	
	Flex Base (Del) (of the compaction method, type and grade specified) (Class 1)	CY
	Flex Base (Del) (of the compaction method, type and grade specified) (Class 2)	Ton
	Flex Base (Del) (of the compaction method, type and grade specified) (Class 3)	CY
	Flex Base (Del) (Type E) (of the compaction method and grade specified) (Class 1)	CY
	Flex Base (Del) (Type E) (of the compaction method and grade specified) (Class 2)	Ton
	Flex Base (Del) (Type E) (of the compaction method and grade specified) (Class 3)	CY
	Flex Base (Del) (Stkpl) (of the compaction method, type and grade specified) (Class 1)	CY
	Flex Base (Del) (Stkpl) (of the compaction method, type and grade specified) (Class 2)	Ton

Item	Description	Unit of Measurement
	Flex Base (Del) (Stkpl) (of the compaction method, type and grade specified) (Class 3)	CY
	Sand Admix	CY
	Caliche Admix	CY
	Sand Admix	Ton
	Caliche Admix	Ton
	Refers to Items 110, 130, 150, 152, 154, 204, 210, 211, 212, 213, 214, 215, 216 and 500	
250	**SCARIFYING AND RESHAPING BASE COURSE**	
	Scar and Reshap Base Crse (Ord Comp)	Sta
	Scar and Reshap Base Crse (Dens Cont)	Sta
	Refers to Items 204, 210, 211, 213, 214, 215 and 216	
252	**SALVAGING AND REPLACING BASE**	
	Salv and Replac Base (Ord Comp)	Sta
	Salv and Replac Base (Dens Cont)	Sta
	Salv and Replac Base (Ord Comp)	CY
	Salv and Replac Base (Dens Cont)	CY
	Refers to Items 110, 130, 150, 152, 154, 204, 210, 211, 212, 213, 214, 215 and 216	
254	**SCARIFYING EXISTING PAVEMENT**	
	Scar Exist Pvt	Sta
	Scar Exist Pvt	SY
	Refers to Items 110 and 140	
260	**LIME TREATMENT FOR MATERIALS IN PLACE**	
	Lime (of the type specified)	Ton
	Lime Treat Subgr (Ord Comp)	SY
	Lime Treat Subgr (Dens Cont)	SY
	Lime Treat Exist Subbs (Ord Comp)	SY
	Lime Treat Exist Subbs (Dens Cont)	SY
	Lime Treat Exist Base (Ord Comp)	SY
	Lime Treat Exist Base (Dens Cont)	SY
	Refers to Items 204, 210, 211, 212, 213, 214, 215, 216, 264 and 500	
262	**LIME TREATMENT FOR BASE COURSES**	
	Lime (of the type specified)	Ton
	Refers to Items 264 and 500	

Item	Description	Unit of Measurement
270	**PORTLAND CEMENT TREATMENT FOR MATERIALS IN PLACE**	
	Portland Cement	Bbl
	Cement Treat (Exist Matl)	SY
	Refers to Item 500	
272	**PORTLAND CEMENT TREATMENT FOR BASE COURSES**	
	Portland Cement	Bbl
	Refers to Item 500	
274	**CEMENT STABILIZED BASE**	
	Cement Stab Base (of the type, grade, depth and compaction method specified)	SY
	Cement Stab Base (of the type, grade, depth and compaction method specified)	Ton
	Cement Stab Base (of the type, grade, depth and compaction method specified)	CY
	Cement Stab Base (of the depth and compaction method specified)	SY
	Cement Stab Base (of the depth and compaction method specified)	CY
	Refers to Items 110, 130, 150, 152, 154, 204, 210, 211, 212, 213, 214, 215, 216, 249, 300, 360 and 500	
280	**SOIL ASPHALT BASE (ROAD MIX)**	
	Soil Asph Base	SY
	Addl Soil	CY
	Addl Soil	Ton
	Asph Matl	Gal
	Asph Matl	Ton
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	Refers to Items 200, 210, 211, 212, 213, 214, 215,.216, 300 and 500	
290	**SHELL CONCRETE BASE (WATER CEMENT RATIO)**	
	Shell Conc Base	SY
	Shell Conc Base	CY
	Mono Curb	LF
	Refers to Items 110, 130, 150 and 360	

Item	Description	Unit of Measurement
292	**ASPHALT STABILIZED BASE (PLANT MIX)**	
	Aggr (of the grade specified)	Ton
	Asph (of the type and grade specified)	Ton
	Refers to Items 213, 300, 310 and 500	
310	**PRIME COAT (ASPHALTIC MATERIAL ONLY)**	
	Asph Matl (of the type and grade specified)	Gal
	Refers to Item 300	
312	**PRIME COAT (ASPHALTIC MATERIAL AND SAND)**	
	Asph Matl (of the type and grade specified)	Gal
	Native Sand	CY
	Refers to Item 300	
314	**EMULSIFIED ASPHALT TREATMENT**	
	Emul Asph (of the type and grade specified)	Gal
	Refers to Items 204 and 300	
316	**SEAL COAT**	
	Aggr (of the class, type and grade specified)	CY
	Aggr (Stkpl) (of the class, type and grade specified)	CY
	Load Haul and Dist Aggr	CY
	Asph (of the type and grade specified)	Gal
	Refers to Items 210, 213, 300, 301, 302, 303, 304 and 305	
320	**ONE COURSE SURFACE TREATMENT**	
	Aggr (of the class, type and grade specified)	CY
	Aggr (Stkpl) (of the class, type and grade specified)	CY
	Asph (of the type and grade specified)	Gal
	Refers to Items 210, 213, 300, 301, 302, 303, 304 and 305	
322	**TWO COURSE SURFACE TREATMENT**	
	Aggr (of the class, type and grade specified)	CY
	Aggr (Stkpl) (of the type and grade specified)	CY
	Asph Matl (of the type and grade specified)	Gal
	Refers to Items 210, 213, 300, 301, 302, 303, 304 and 305	
324	**THREE COURSE SURFACE TREATMENT**	
	Aggr (of the class, type and grade specified)	CY
	Aggr (Stkpl) (of the type and grade specified)	CY

Item	Description	Unit of Measurement
	Asph Matl (of the type and grade specified)	Gal
	Refers to Items 210, 213, 300, 301, 302, 303, 304 and 305	
330	**COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT (CLASS A)**	
	Cold Mix LRA Pvt (of the types specified)	Ton
	Refers to Items 213, 300, 310, 500 and 501	
340	**HOT MIX ASPHALTIC CONCRETE PAVEMENT (CLASS A)**	
	Asph	Ton
	Aggr (of the types specified)	Ton
	Refers to Items 213, 300, 310, 500 and 501	
350	**HOT MIX-COLD LAID ASPHALTIC CONCRETE PAVEMENT (CLASS A)**	
	Hot Mix-Cold Laid ACP (of the types specified)	Ton
	Refers to Items 213, 300, 310, 500 and 501	
360	**CONCRETE PAVEMENT (WATER CEMENT RATIO)**	
	Conc Pvt	SY
	Conc Pvt	CY
	Conc Pvt (HS)	SY
	Conc Pvt (HS)	CY
	Conc Pvt (HY Stl)	SY
	Conc Pvt (HY Stl)	CY
	Conc Pvt (DWM)	SY
	Conc Pvt (DWM)	CY
	Mono Curb	LF
	Refers to Items 110, 130, 150, 204, 210, 211, 212, 213, 214, 215, 216, 300, 421, 437, 500, 502 and 531	
364	**CONCRETE PAVEMENT (CLASS A CONCRETE)**	
	Conc Pvt (Cl A Conc)	SY
	Conc Pvt (Cl A Conc)	CY
	Mono Curb	LF
	Refers to Items 110, 130, 360 and 421	
366	**CONCRETE PAVEMENT (CONTINUOUSLY REINFORCED)**	
	Conc Pvt (Contin Reinf HY Stl)	SY
	Conc Pvt (Contin Reinf HY Stl)	CY
	Conc Pvt (Contin Reinf DWM)	SY

Item	Description	Unit of Measurement
	Conc Pvt (Contin Reinf DWM)	CY
	Mono Curb	LF
	Refers to Items 110, 130, 150, 204, 210, 211, 212, 213, 214, 215, 216 and 360	
370	**ASPHALT UNDERSEAL FOR CONCRETE PAVEMENT**	
	Asph (of the type and grade specified)	Gal
	Holes	Ea
	Refers to Item 300	
372	**ASPHALT SUBGRADE MEMBRANE**	
	Asph (of the type and grade specified)	Gal
	Sand	CY
	Refers to Item 300	
400	**STRUCTURAL EXCAVATION**	
	Uncl Str Excav	CY
	Rock Str Excav (of the type specified)	CY
	Com Str Excav (of the type specified)	CY
	Uncl Str Excav (of the type specified)	CY
	Cem Stab Bkfl	CY
401	**EXCAVATION AND BACKFILL FOR SEWERS**	
	Sewer Excav	CY
	Cem Stab Bkfl	CY
	Refers to Items 421 and 464	
405	**FOUNDATION TEST LOAD**	
	Test Load	Ea
	Refers to Items 404 and 416	
406	**TIMBER PILING**	
	Treat Tim Pil	LF
	Treat Tim Test Pil	Ea
	Untr Tim Pil	LF
	Untr Tim Test Pil	Ea
	Refers to Items 404, 405 and 492	
407	**STEEL PILING**	
	Stl H Pil (of the specified size and weight)	LF
	Stl H Test Pil (of the specified size and weight)	LF
	Sheet Pil (of the type shown)	SF
	Refers to Items 404, 405, 420, 421, 441, 442, 446 and 448	

Item	Description	Unit of Measurement
408	**METAL SHEEL PILING**	
	Metal Shell Pil (of the size specified)	LF
	Metal Shell Test Pil (of the size specified)	LF
	Refers to Items 404, 405, 420, 421, 440, 442, 446 and 448	
409	**CONCRETE PILING**	
	Conc Pil (of the size specified)	LF
	Conc Test Pil (of the size specified)	LF
	Refers to Items 404, 405, 420, 421, 425, 426, 440 and 448	
416	**DRILLED SHAFT FOUNDATIONS**	
	Drill Shaft (of the specified diameter)	LF
	Drill Shaft (Non-Reinf) (of the specified diameter)	LF
	Bell Ftg	CY
	Test Hole (of the specified diameter)	LF
	Test Bell (of the specified diameter)	Ea
	Refers to Items 405, 420, 421, 440 and 448	
421	**CONCRETE FOR STRUCTURES**	
	Cl (Various Classes) Conc (Various Classifications)	CY
	Cl (Various Classes) Conc (Various Type Units)	Ea
	Cl (Various Classes) Conc (Various Type Units)	SF
	Cl (Various Classes) Conc (Various Type Units)	SY
	Cl (Various Classes) Conc (Various Type Units)	LF
	Refers to Items 420, 437, 500 and 502	
423	**LIGHTWEIGHT CONCRETE FOR STRUCTURES**	
	Cl (Various Classes) Conc (Various Classifications)	CY
	Cl (Various Classes) Conc (Various Type Units)	Ea
	Cl (Various Classes) Conc (Various Type Units)	SF
	Cl (Various Classes) Conc (Various Type Units)	SY
	Cl (Various Classes) Conc (Various Type Units)	LF
	Refers to Items 420, 421, 437, 500 and 502	
425	**PRESTRESSED CONCRETE STRUCTURES**	
	Prestr Conc (specify name and/or type)	LF
	Prestr Conc (specify name and/or type)	Ea
	Prestr Conc (specify name and/or type)	SF
	Refers to Items 409, 421, 423, 426, 435, 440, 441, 442 and 498	

Item	Description	Unit of Measurement
426	**PRESTRESSING**	
	Prestr (Grout)	MKF
	Prestr (Coat)	MKF
	Refers to Items 409, 420, 421, 423, 425, 434, 435, 436, 440, 441, 442 and 498	
428	**CONCRETE SURFACE TREATMENT**	
	Conc Surf Treat	SY
430	**EXTENDING CONCRETE STRUCTURES**	
	Cl (Various Classes) Conc for Ext Str (Various Classifications)	CY
	Refers to Items 400, 420, 421, 423, 436, 440 and 448	
431	**PNEUMATICALLY PLA CED CONCRETE**	
	Pneum Plac Conc (of type specified)	SF
	Refers to Items 120, 400, 420, 421, 437 and 440	
432	**RIPRAP**	
	Riprap (of various classifications shown)	CY
	R efers to Items 400, 420, 421, 431 and 440	
434	**SLIDING ELASTOMERIC BEARINGS**	
	Sliding Elastomeric Bear (of the type specified)	Ea
	Refers to Item 442	
435	**ELASTOMERIC MATERIALS**	
	Elastomeric Bear (of the type specified)	Ea
436	**PREFORMED JOINT SEAL**	
	Preformed Joint Seal (of the size specified)	LF
440	**REINFORCING STEEL**	
	Reinf Stl	Lb
	Refers to Item 448	
442	**METAL FOR STRUCTURES**	
	Str Stl (HYC)	Lb
	Str Stl (HS)	Lb
	Str Stl (of other classifications of metal shown)	Lb
	Refers to Items 441, 446, 447 and 448	
446	**PAINT AND PAINTING**	
	Clean and Paint Exist Str	LS

Item	Description	Unit of Measurement
450	**RAILING**	
	Rail (of classification and type shown)	LF
	Refers to Items 420, 421, 423, 440, 441, 442, 446 and 448	
451	**REMOVING AND REPLACING RAILING**	
	Remov and Repl Rail (of the type specified)	LF
	Refers to Item 446	
452	**REMOVING RAILING**	
	Remov Rail (of the type specified)	LF
	Refers to Item 430	
453	**TEMPORARY RAILING**	
	Temp Rail	LF
	Refers to Item 446	
458	**WATERPROOFING**	
	Watrpf (of the type specified)	SY
460	**CORRUGATED GALVANIZED METAL PIPE**	
	CGM Pipe (of various sizes)	LF
	CGM Pipe (of various sizes) (gauges)	LF
	CGM Pipe (protective coating) (of various sizes)	LF
	CGM Pipe (protective coating) (of various sizes) (gauges)	LF
	CGM Pipe Arch (of various design sizes)	LF
	CGM Pipe Arch (of various design sizes) (gauges)	LF
	CGM Pipe Arch (protective coating) (of various design sizes)	LF
	CGM Pipe Arch (protective coating) (of various design sizes (gauges)	LF
	Refers to Item 400	
461	**STRUCTURAL PLATE PIPES, PIPE ARCHES, ARCHES AND UNDERPASSES**	
	Str Pl Pipe (of various sizes) (gauges)	LF
	Str Pl Pipe Arch (of various sizes) (gauges)	LF
	Str Pl Arch (of various sizes) (gauges)	LF
	Str Pl U/P (of various sizes) (gauges)	LF
	Refers to Items 400, 420, 421, 432 and 440	
464	**REINFORCED CONCRETE PIPE CULVERTS**	
	R C Pipe (of class specified) (of various sizes)	LF
	RC Pipe (of class specified) (of various design sizes)	LF

Item	Description	Unit of Measurement
	RC Pipe Ellip (of class specified) (of various design sizes)	LF
	Refers to Items 400 and 421	
465	**PIPE SEWERS**	
	Pipe Sewer (of class specified) (of various sizes)	LF
	Refers to Items 401, 420, 421, 440 and 464	
470	**MANHOLES AND INLETS**	
	Manh (Compl) (of type specified)	Ea
	Manh (Stage I) (of type specified)	Ea
	Manh (Stage II) (of type specified)	Ea
	Inlet (Compl) (of type specified)	Ea
	Inlet (Stage I) (of type specified)	Ea
	Inlet (Stage II) (of type specified)	Ea
	Inlet Ext	Ea
	Refers to Items 400, 401, 420, 421, 440, 441, 442 and 471	
471	**FRAMES, GRATES, RINGS AND COVERS**	
	Grate	Ea
	Frame	Ea
	Grate and Frame	Ea
	Frame and Cover	Ea
	Ring and Cover	Ea
	Refers to Item 448	
472	**RELAYING CULVERT PIPE**	
	Relay Culv Pipe (18 in Dia and Under)	LF
	Relay Culv Pipe (Over 18 In Dia)	LF
	Refers to Items 400, 401, 460, 461 and 464	
473	**LAYING CULVERT PIPE**	
	Laying Culv Pipe	LF
	Refers to Items 400, 460 and 464	
476	**JACKING, BORING OR TUNNELING PIPE**	
	Jack or Bor Pipe (of type, size and class or gauge specified)	LF
	Jack, Bor or Tun Pipe (of type, size and class or gauge specified)	LF
	Refers to Items 460 and 464	
479	**ADJUSTING MANHOLES AND INLETS**	
	Adj Manh	Ea

Item	Description	Unit of Measurement
	Adj Inlet	Ea
	Adj Manh and Inlet	Ea
	Refers to Items 401 and 470	
491	**TIMBER FOR STRUCTURES**	
	Treat Tim	MFBM
	Untr Tim	MFBM
	Refers to Items 490 and 492	
496	**REMOVING OLD STRUCTURES**	
	Remov Old Str (Large)	Ea
	Remov Old Str (Small)	Ea
	Remov Old Str (Pipe)	LF
	Refers to Item 430	
510	**PIPE UNDERDRAINS**	
	Pipe Underdrains (of the type and size specified)	LF
	Filter Matl	CY
	Filter Matl (of the type specified)	CY
	Underdrain Excav	CY
	Refers to Items 302, 421 and 432	
520	**CONCRETE CURB**	
	Conc Curb (of the type indicated on the plans)	LF
	Refers to Items 360, 420, 421, 440 and 531	
521	**MACHINE LAID CURB**	
	Machine Laid Curb (of the type specified)	LF
	Refers to Items 360, 421 and 440	
522	**CONCRETE CURB AND GUTTER**	
	Conc C and G (of the type indicated on the plans)	LF
	Conc Gutter (of the type indicated on the plans)	LF
	Refers to Items 360, 420, 421, 440 and 531	
524	**CONCRETE SIDEWALKS AND DRIVEWAYS**	
	Sidewalks	SY
	Sidewalks	CY
	Driveways	SY
	Driveways	CY
	Sidewalks and Driveways	SY
	Sidewalks and Driveways	CY
	Refers to Items 360, 420, 421, 440 and 531	

Item	Description	Unit of Measurement
530	**CEMENT STABILIZED RIPRAP**	
	Cement Stab Riprap	CY
	Refers to Items 360, 420, 421 and 531	
540	**ROCK RETARDS**	
	Rock Retards	CY
542	**GROUTED ROCK RETARDS**	
	Grouted Rock Retards	CY
	Refers to the Item 531	
544	**CONCRETE RETARDS**	
	Conc Retards	CY
	Refers to Items 421 and 531	
546	**CONCRETE FOR STRUCTURE APPROACH SLABS**	
	Conc for Structure Appr Slabs	CY
	Refers to Items 360, 421 and 440	
550	**RIGHT OF WAY MARKERS**	
	Right of Way Markers (of the type specified)	Ea
	Instal Right of Way Markers	Ea
	Remov and Repl Right of Way Markers	Ea
	Refers to Items 420, 421 and 440	
560	**METAL BEAM GUARD FENCE**	
	Metal Beam Gd Fence (of the class specified)	LF
	Metal Beam Gd Fence (Bar) (of the class specified)	LF
	Metal Beam Gd Fence (Bar) (Blockout) (of the class specified)	LF
	Metal Beam Gd fence (Blockout) (of the class specified)	LF
	Al Beam Gd Fence (of the class specified)	LH
	Al Beam Gd Fence (Bar) (of the class specified)	LF
	Al Beam Gd Fence (Bar) (Blockout) (of the class specified)	LF
	Al Beam Gd Fence (Blockout) (of the class specified)	LF
	Painted Stl Beam Gd Fence (of the class specified)	LF
	Painted Stl Beam Gd Fence (Bar) (of the class specified)	LF
	Painted Stl Beam Gd Fence (Bar) (Blockout) (of the class specified)	LF
	Painted Stl Beam Gd Fence (Blockout) (of the class specified)	LF
	Galv Stl Beam Gd Fence (of the class specified)	LF

Item	Description	Unit of Measurement
	Galv Stl Beam Gd Fence (Bar) (of the class specified)	LF
	Galv Stl Beam Gd Fence (Bar) (Blockout) (of the class specified)	LF
	Galv Stl Beam Gd Fence (Blockout) (of the class specified)	LF
	Terminal Anchor Section	Ea
	Refers to Items 421, 446 and 492	
561	**REMOVING METAL BEAM GUARD FENCE**	
	Remov Metal Beam Gd Fence	LF
562	**REMOVING AND REPLACING METAL BEAM GUARD FENCE**	
	Remov and Repl Metal Beam Gd Fence	LF
	Refers to Item 560	
565	**REMOVING TIMBER POST GUARD FENCE**	
	Remov Timber Post Gd Fence	Ea
566	**REMOVING AND REPLACING TIMBER POST GUARD FENCE**	
	Remov and Repl Timber Post Gd Fence	Ea
567	**WIRE FENCE**	
	Wire Fence (of the type shown on the plans)	LF
	Gate (of the type, height and opening shown on the plans)	Ea
	Refers to Item 492	
568	**CHAIN LINK BARRIER FENCE**	
	Chain Link Barrier Fence (of the height specified)	LF
	Pedestrian Gate (of the type, height and opening specified)	Ea
	Vehicular Gate (of the type, height and opening specified)	Ea
	Refers to Item 421	
570	**METAL SERIES RAILROAD CROSSING SIGNS**	
	Met Ser RR Xing Signs	Ea
	Refers to Item 421	
580	**STRUCTURE FOR FIELD OFFICE AND LABORATORY**	
	Field Office (of the type specified)	Ea
	Field Laboratory (of the type specified)	Ea
	Field Office and Laboratory (of the type specified)	Ea

Item	Description	Unit of Measurement
590	**CONCRETE MEDIANS AND DIRECTIONAL ISLANDS**	
	Conc Med	LF
	Conc Med	SY
	Conc Directional Isl	LF
	Conc Directional Isl	SY
	Refers to Items 360, 420, 421, 440, 521 and 531	
591	**VEHICULAR IMPACT ATTENUATOR ASSEMBLY (STEEL BARREL)**	
	Vehicular Impact Attenuator Assembly	Ea
	Refers to Items 421, 440 and 442	
592	**CONSTRUCTING DETOURS**	
	Constructing Detour (Class 1)	Sta
	Constructing Detour (Class 2)	Ea
	Constructing Detour (Class 3)	Sta
	Constructing Detour (Class 4)	Ea
610	**ROADWAY ILLUMINATION ASSEMBLIES**	
	Rdwy Illum Assem (of the types specified)	Ea
613	**HIGH MAST ILLUMINATION POLES**	
	High Mast Illum Pole (of the type specified)	Ea
	Refers to Item 441	
614	**HIGH MAST ILLUMINATION ASSEMBLIES**	
	High Mast Illum Assem (of the type specified)	Ea
	Refers to Items 441 and 613	
630	**ROADWAY ILLUMINATION ASSEMBLY FOUNDATIONS**	
	Rdwy Illum Assem Fnd (of the types specified)	Ea
640	**CONDUIT**	
	Conduit (of the types and sizes specified)	LF
650	**ELECTRIC CONDUCTOR**	
	Elec Condr (of the types and sizes specified)	LF
651	**DUCT CABLE**	
	Duct Cable (of the types and sizes specified)	LF
	Refers to Item 401	
660	**CIRCUIT PROTECTOR ASSEMBLY**	
	Circuit Protector Assembly	Ea

Item	Description	Unit of Measurement
670	**SERVICE POLES**	
	Service Pole (of the types specified)	Ea
680	**TRANSFORMER STATIONS**	
	Transformer Sta (of the types specified)	Ea
700	**PLYWOOD SIGNS (TYPE A AND TYPE B)**	
	Plywood Signs (of the type specified)	SF
	Refers to Items 442, 446, 704, 712, 716, 718, 720, 722, 724 and 726	
702	**STEEL SIGNS (TYPE A)**	
	Steel Signs (Type A)	SF
	Refers to Items 716, 718 and 720	
704	**ALUMINUM SIGNS (TYPE A)**	
	Aluminum Signs (Type A)	SF
	Refers to Items 442, 716, 718 and 720	
706	**ALUMINUM SIGNS (TYPE B)**	
	Aluminum Signs (Type B)	SF
	Refers to Items 442, 704, 712 and 724	
708	**ALUMINUM SIGNS (TYPE C)**	
	Aluminum Signs (Type C)	SF
	Refers to Items 442, 704, 712 and 724	
710	**ALUMINUM SIGNS (TYPE D)**	
	Aluminum Signs (Type D)	SF
	Refers to Items 442, 704, 712 and 724	
712	**ALUMINUM SIGNS (TYPE F)**	
	Aluminum Signs (Type F)	SF
	Refers to Items 442 and 724	
728	**ROADSIDE TRAFFIC SIGN SUPPORTS (STEEL PIPE)**	
	Galvanized Pipe Posts (of various sizes of pipe)	LF
	Refers to Items 420, 442, 448 and 738	
730	**ROADSIDE TRAFFIC SIGN SUPPORTS (STRUCTURAL STELL)**	
	Galvanized Structural Steel Posts	Lb
	Refers to Items 420, 441, 442, 448 and 738	

Item	Description	Unit of Measurement
732	**OVERHEAD TRAFFIC SIGN SUPPORTS (COMMERCIAL ALUMINUM)**	
	Sign Support (of type and length specified)	Ea
	Refers to Items 4, 9, 441 and 738	
734	**OVERHEAD TRAFFIC SIGN SUPPORTS (COMMERCIAL STEEL)**	
	Sign Support (of type and length specified)	Ea
	Refers to Items 4, 9, 441, 442, 448 and 738	
736	**OVERHEAD TRAFFIC SIGN SUPPORTS**	
	Sign Support (of type and length specified)	Ea
	Refers to Items 441, 442, 448 and 738	
740	**DELINEATORS**	
	Delineators (Independently Housed) (of type specified)	Ea
	Delineators (Center Mount) (of type specified)	Ea
742	**DELINEATOR AND MILEPOST MARKER POSTS**	
	Delineator and Milepost Marker Posts (of length specified)	Ea
	Refers to Item 421	
744	**TIMBER DELINEATOR POSTS**	
	Timber Delineator Posts (of length specified)	Ea
	Refers to Items 446 and 492	
746	**HIGHWAY SIGN LIGHTING FIXTURE**	
	Highway Sign Lighting Fixture (of type specified)	Ea
748	**SIGN WALKWAYS**	
	Sign Walkways	LF
	Refers to Items 441, 442 and 448	
750	**JIGGLE BARS**	
	Jiggle Bars	LF
	Refers to Item 575	
752	**PAVEMENT MARKERS (REFLECTORIZED)**	
	Pavement Markers–Single Reflector	Ea
	Pavement Markers–Double Reflector	Ea
	Refers to Item 575	
754	**TRAFFIC BUTTONS (NON-REFLECTORIZED)**	
	Traffic Buttons (Non-Reflectorized)	Ea
	Refers to Item 575	