

TEXAS HIGHWAY DEPARTMENT



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**STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE
CONSTRUCTION**

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STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION

Adopted by the State Highway Department of Texas,
January 2, 1962



Von Boeckmann-Jones Co.

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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 to .22

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, AASHTO 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 to .41

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. ASA. American Standards Association.

- 1.42. **API.** American Petroleum Institute.
- 1.43. **AWS.** American Welding Society.
- 1.44. **NEMA.** National Electrical Manufacturers Association.
- 1.45. **EEL.** 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. **BPR.** The United States Bureau of Public Roads.
- 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. **Screens and Sieves.** As defined by the ASTM.
- 1.56. **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.
- 1.57. **Arterial Highway.** A general term denoting a highway primarily for through traffic, usually on a continuous route.
- 1.58. **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.
- 1.59. **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

1.60 to 2.2

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.

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

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

1.62. 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.

1.63. 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.

1.64. 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 ap-

proximate 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

2.6 to .10

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 on 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 to 4.2

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 to .7

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 to .6

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. Finished surfaces in all cases shall conform with lines, grades, cross-sections and dimensions shown on the plans. Such 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

5.9 to .12

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

6.2 to .3

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.

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.

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 trade-

7.4 to .7

mark 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.

7.9 to .10

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 travelling 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.

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 to 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)

7.13 to 8.1

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 contract within 30 days after the date of the authorization to begin work and shall continuously prosecute same with such diligence 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

8.6 to .7

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 Day
\$ 25,000 or less	\$ 30
25,001 to 50,000	50
50,001 to 100,000	75
100,001 to 500,000	100
500,001 to 1,000,000	150
1,000,001 to 2,000,000	200
Over 2,000,00	300

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 the contract will be measured by the Engineer according to United States Standard Measures unless otherwise specified. All longitudinal measurements for surface area

9.2

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 Quantity", the measurement of such quantities shall represent an accurate calculation, made by the methods described in the governing specification, and may or may not represent the exact quantity of material moved or handled during the execution of the contract.

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 re-

sponsible 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.

9.6 to .7

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 certified copies of invoices and freight bills, an estimate shall be made and included for 75 percent of the 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 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. 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 pro-

vided 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, stumps, bushes, shrubs, curb and gutter, driveways, paved parking areas, miscellaneous stone, brick, concrete, sidewalks, drainage structures, manholes, inlets, abandoned railroad tracks, scrap iron, all rubbish 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 entire right of way for this project and such additional areas, including public or corporate areas, including public or corporate lands, as made available for construction of this project shall be cleared of all structures, obstructions and vegetation, as defined above, except trees or shrubs specifically designated by the Engineer for preservation. Trees and shrubs designated for preservation shall be carefully trimmed as directed and shall be protected from scarring, barking, or other injuries during construction operations. Exposed ends of pruned limbs shall be treated with an approved asphaltic material.

100.3

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 specifications 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 entire right of way shall be cleared of all trees, stumps, brush, logs and rubbish, except such trees and brush as may be designated by the Engineer for preservation. Trees and brush designated to be left in place shall be carefully trimmed as directed and shall be protected from scarring, barking or other injuries during construction operations. Pruned limbs shall be treated by painting the exposed ends 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

102.3 to .4

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 back-filled. 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 brush) 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.

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.

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", which price shall be full compensation for furnishing all labor, equipment, tools, supplies 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,

104.4 to 110.2

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 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 $\frac{1}{2}$ 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 by him outside the limits of the right of way.

“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

110.4 to .6

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.

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 to 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:

120.3 to .4

(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 $\frac{1}{2}$ 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.

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".

130.2 to .3

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 $\frac{1}{2}$ 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 ma-

terial 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 slightly 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.

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.

132.1 to .2

All hauling of materials will be measured and paid for in accordance with the provisions governing the Item, "Overhaul".

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 $\frac{1}{4}$ 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 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 recompact 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 2½ 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 dimension 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 composed 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

132.3 to .4

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.

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-

150.3 to 152.1

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 sur-

face 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

154.1 to .3

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 capacity 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 yards (as rated loaded flush by the manufacturer) 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 an 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 to the depth shown on plans, stockpiling the salvaged topsoil along the right of way line or at locations designated on plans, and then spreading on areas indicated on the plans to the lines and grades as established by the Engineer.

160.2. Construction Methods. After the "Preparing Right of Way" and "Clearing and Grubbing" have been completed, and before any grading work has begun, the existing topsoil shall be moved from the area to be occupied by the roadway, as indicated on plans, to a windrow along the right of way, or to locations designated on the plans.

Trash, wood, brush, stumps and other objectionable 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 align-

160.3 to 162.2

ment, grades and cross sections, and prior to the spreading of the salvaged topsoil, the surfaces shall be scarified by plowing furrows 6 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 or mulch of topsoil of uniform thickness across the section and of a minimum thickness of 4 inches after compaction. 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 placing topsoil will be measured by the 100-foot station or by the cubic yard in vehicles as delivered on the road. 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", 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 Bermuda grass 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

Bermuda grass 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 obnoxious 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 raked 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.

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

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 ap-

162.5 to .6

proximately 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. Augustine grass 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 $\frac{1}{2}$ 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 compact, 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 wooden 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

162.9 to .10

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 "Culti-packer" type. All rolling of slope areas shall be on the contour.

162.9. Measurement. Work and acceptable material for "Spot Sodding", "Block Sodding", and "Grass Retards" 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 cubic yard in vehicles as delivered to the place of planting.

162.10. 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", "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 and planting seed, or a mixture of seeds, of the kind specified along and across such areas as are designated on the plans and in accordance with these specifications.

164.2 Materials. All seed used must carry a Texas Testing Seed Label showing purity and germination, name and type of seed that the seed meets all requirements of the Texas Seed Law. Seed furnished shall be of the previous season's crop and the date of analysis shown on each tag shall be within 9 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 specified seed shall equal or exceed the following percentages for purity and germination:

Common Name	Scientific Name	Purity	Germination
Bermuda Grass	<i>Cynodon dactylon</i>	95%	90%
Rye Grass	<i>Lolium multiflorum</i>	95%	85%
Buffalo Grass	<i>Buchloe dactyloides</i>	40%	40%
Blue Grama Grass	<i>Bouteloua gracilis</i>	30%	75%
Side-oats Grama Grass	<i>Bouteloua curtipendula</i>	20%	50%
Little Bluestem Grass	<i>Andropogon scoparius</i>	20%	50%
Big Bluestem Grass	<i>Andropogon furcatus</i>	20%	50%
K-R Bluestem Grass	<i>Andropogon species</i>	20%	50%
Buffel Grass	<i>Pennisetum ciliare</i>	90%	75%
Sudan Grass	<i>Sorghum vulgare</i> var. <i>Sudanense</i>	80%	80%
Dropseed Grass	<i>Sporobolus Texanus</i>	90%	60%
Western Wheat Grass	<i>Agropyron Smithii</i>	65%	65%
Yellow Clover	<i>Melilotus officinalis</i>	90%	90%
Oats	<i>Avena sativa</i>	85%	85%

Planting Season. All planting shall be done between the dates specified for each type 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:

Type 1.

Bermuda Grass—hulled 8 lb. April through Sept.

Type 2.

Buffel Grass 10 lb. March through May

164.3 to .4

Type 3.

Rye Grass	35 lb.	Sept. through Jan. 15
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Type 4.

Bermuda Grass—unhulled	12 lb.	
Rye Grass	30 lb.	Sept. through Jan. 15

Type 5.

Bermuda Grass—hulled	8 lb.	
Sudan Grass	10 lb.	Feb. through May

Type 6.

Blue Grama	15 lb.	
Side-oats Grama	4 lb.	
Western Wheat	5 lb.	
Yellow Clover	4 lb.	
Dropseed Grass	4 lb.	
Sudan Grass	8 lb.	March through May

Type 7.

Mixture, rate, and planting dates as shown on plans.

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

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 of the type specified shall be performed in accordance with the requirements hereinafter described.

(1) **Watering.** The seeded areas shall be watered as directed by the Engineer so as to prevent washing of slopes or dislodgement of the seed.

(2) **Finishing.** Where applicable, the shoulders, slopes and ditches shall be smoothed after seed bed preparation has been completed and shaped to conform to the cross sections previously provided and existing at the time planting operations were begun.

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. Seed and fertilizer may be distributed at the same time provided the specified uniform rate of application for both is obtained.

"Finishing" as specified under Article 3, is not applicable since no seed bed preparation is required.

164.5. Disked Seeding. The soil over the area shown on the plans, or as directed to be seeded, shall be loosened to a minimum depth of 3 inches, and all particles in the seed bed shall be reduced to less than 1 inch in diameter or they shall be removed. The area shall then be finished to line and grade as specified under "Finishing" in Article 3.

The seed or seed mixture specified shall then be planted at the rate required and the application shall be made uniformly. 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. Seed and fertilizer may be distributed at the same time provided the specified uniform rate of application for both is obtained. After planting, the seed shall be raked or harrowed into the soil to a depth of approximately $\frac{1}{8}$ inch. The planted area shall be rolled with a corrugated roller of the "Cultipacker" type. All rolling of slope areas shall be on the contour.

164.6. Straw Mulch Seeding. The soil over the area shown on the plans, or as directed to be seeded, shall be loosened to a minimum depth of 3 inches, and all particles in the seed bed shall be reduced to less than 1 inch in diameter or they shall be removed. The area shall then be finished to line and grade as specified under "Finishing" in Article 3.

The seed or seed mixture specified shall then be planted at the rate required and the application shall be made uniformly. 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. Seed and fertilizer may be distributed at the same time provided the specified uniform rate of application for both is obtained. After planting, the seed shall be raked or harrowed into the soil to a depth of approximately $\frac{1}{8}$ inch. The planted area shall be rolled with a corrugated roller of the "Cultipacker" type. All rolling of slope areas shall be on the contour.

Upon completion of planting operations, straw mulch shall be spread uniformly over the area at the rate of 2 tons per acre. This straw mulch is to be anchored by spraying cutback asphalt over the area at a rate of 0.10 gallon per square yard, unless shown otherwise on plans. Asphaltic material shall be a cutback asphalt of the type and grade shown on the plans and shall conform to the requirements of the Item, "Asphalts, Oils and Emulsions".

164.7. Asphalt Mulch Seeding. The soil over the area

164.8 to .9

shown on the plans, or as directed to be seeded, shall be loosened to a minimum depth of 3 inches, and all particles in the seed bed shall be reduced to less than 1 inch in diameter or they shall be removed. The area shall then be finished to line and grade as specified under "Finishing" in Article 3.

Water shall then be applied to the cultivated area or seed bed until a minimum depth of 6 inches is thoroughly moistened.

After the watering, when the ground has become sufficiently dry to be loose and friable, the seed or seed mixture specified shall then be planted at the rate required and the application shall be made uniformly. 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. Seed and fertilizer may be distributed at the same time provided the specified uniform rate of application for both is obtained. After planting, the seed shall be raked or harrowed into the soil to a depth of approximately $\frac{1}{4}$ inch. The planted area shall then be rolled with a smooth roller developing 15 to 25 pounds per square inch contact pressure upon the planted surface area and giving a smooth surface without ruts or tracks. In between the time compacting is completed and the asphalt is applied, the planted area shall be watered sufficiently to assure uniform moisture from the surface to a minimum of 6 inches in depth.

The application of the asphalt shall follow the last watering as rapidly as possible. 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". Application of the asphalt shall be at the rate of 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.

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

164.9. 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", "Disked Seeding", "Straw Mulch Seeding" or "Asphalt Mulch Seeding" of the type specified, as the case may be, which prices shall each be full compensation for furnishing all

materials 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".

All water 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 acid, 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 to 170.4

166.4. Measurement. Work and acceptable material for "Fertilizer" will be measured by the ton of 2000 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 to 190.2

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 planting vines, shrubs and trees at points indicated on plans or as directed by the Engineer.

Planting Season. All planting shall be done between December 1 and March 1, except as otherwise noted on plans or as specifically permitted by written order of the Engineer. Planting of Live Oaks will be permitted only between February 1 and March 1.

190.2. Materials. Plant materials shall be of first class grade of the size and height shown on the plans and shall meet all requirements of the "American Standard for Nursery Stock" as issued by the American Association of Nurserymen. All plants shall be nursery-grown unless otherwise noted on plans. When the Engineer is furnished sufficient evidence that suitable nursery-grown plants are not available, collected native material may be used. Plant materials having any of the following unnatural or objectionable features will be rejected.

1. Abrasions of the bark
2. Dried root system
3. Dried top wood or dried foliage of evergreens
4. Plants not true to type or specified size
5. Prematurely opened buds, or with buds stripped off
6. Diseased or insect-infested plants
7. Dry, loose, broken and/or underweight ball of earth of balled and burlapped plants
8. Showing evidence of heating, molding or freezing
9. Failure to have a permit tag of the State Department of Agriculture attached to the shipment of nursery-grown plants.

(1) **Collected Materials.** Collected native materials shall have none of the above listed objectionable features and shall

be taken from the soils in regions similar to those to which the plants are to be transplanted. At least 3 days before beginning to dig any collected native plant material the Contractor shall notify the Engineer of the time and place of the proposed digging, and the Engineer shall within such 3 days, either approve or disapprove the location as a source; however, the inspection of material will be made upon delivery to the project as hereinafter described. No plants shall be collected within view of any State or Federal Highway.

(2) Standard Nomenclature. "Standardized Plant Names", adopted by the American Joint Committee on Horticultural Nomenclature, shall govern.

When sufficient evidence is submitted showing that a specified tree or plant cannot practicably be obtained, substitutions in kind may be made upon written approval by the Engineer.

(3) Delivery. Material shall not be delivered upon the project until ordered in writing by the Engineer, and when so ordered, the Engineer shall be notified of a proposed delivery of plant materials at least 24 hours prior to its arrival on the project. Each shipment shall be accompanied by an invoice showing the number, sizes and varieties of the materials included. Balled and burlapped plants and bare-rooted plants shall be delivered with roots and balls in a moist condition, properly protected from sun and air 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.

(4) Receipt of Plants. On delivery of stock to the selected destination point or to the job, the Contractor shall assist the Engineer in the inspection of material. No shipment of plant material shall be accepted or planted by the Contractor until such material shall have been inspected and accepted by the Engineer. In the measurement of trees, the caliper measurement for diameter shall be taken 6 inches above the original ground line. In the measurement of shrubs, a plant well grown with single stem, well shaped and bushy, and having sufficiently well spaced side branches to give it weight equal to one grown with numerous canes, shall be an acceptable plant.

(5) Size of Balls for Balled and Burlapped Plants. All balled and burlapped stock shall have solid, firm balls which conform to the weights or sizes shown on plans.

190.3

Certain small shrubs commercially grown in cans or pots of usual size will be accepted in lieu of balled plants when permitted by the Engineer. Such plants shall be well established in containers before the planting season. At the time of planting potted or container-grown plants, the root ball and plant shall be removed from the receptacle 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.

(6) **Mulching.** Mulching shall consist of loose, partially decomposed vegetable humus, and shall be free of dry leaves, sticks, excess soil or other foreign matter. Mulching material shall be moistened to proper consistency before being placed around plants.

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

The means employed to protect plants with exposed roots from drying out during the time the plants are removed from the "heeling-in" bed until actually planted shall be satisfactory to the Engineer. Certain bare-rooted plants such as yuccas, agave and ocotillo shall have the roots exposed to the air for a period of 24 hours prior to planting.

(1) **Preparation of Soil.** Planting holes shall be excavated to the depths and sizes as listed below:

Plants	Min. Depth of Holes	Size of Holes		Approx. Quan.
		Square	Round	
1. Large Trees (1½" Caliper and up to 3")	2.5'	4.0'x4.0'	4.5' Dia.	1.48 C.Y.
2. Small Trees (less than 1½" caliper) Semi - Tree and Large Shrubs (where mature heights exceed 10')	2.0'	3.0'x3.0'	3.4' Dia.	.67 C.Y.

3. Medium and Small Shrubs (where mature height is less than 10')	2.0'	2.5'x2.5'	2.9' Dia.	.46 C.Y.
4. Dwarf Shrubs and Vines (ground cover and herbaceous perennials) .	1.5'	1.5'x1.5'	1.7' Dia.	.13 C.Y.

(Note: 1, 2, 3 and 4 in the first column refer to Key Numbers shown on plans.)

For holes on slopes the above minimum depths apply to the lower side. Size of pits for trees larger than 3 inches will be noted on plans.

Topsoil from the excavated holes shall be kept separate from the subsoil and before backfilling shall be rendered loose and friable. When soil conditions require the introduction of additional topsoil to improve the soil excavated from the plant holes, it shall be furnished in the amounts directed.

Shape of planting holes will be adjusted to permit use of mechanical hole diggers.

(2) **Pruning Roots.** Any necessary pruning of the roots of bare-rooted plants shall meet the approval of the Engineer.

(3) **Pruning of Tops.** Plants shall not be pruned before delivery to the job, except by written permission of the Engineer. The topping of live oaks will not be permitted.

The final pruning of plants, unless otherwise required by the Engineer, 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 of approved manufacture.

(4) **Planting and Backfilling.**

(a) **Depth of Transplanting.** The depth to which plants shall be set shall be appropriate to the various types of material and the special requirements of each. In general, plants shall stand, after settlement of the backfill, slightly deeper than they stood in the nursery or collecting field.

Roses, budded or grafted plants shall be set at least 3 inches below previous earth line.

(b) All plants shall be planted plumb.

(c) Plants with Exposed Roots. 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. 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, except that small pieces of sod may be used near the bottom of the pit in limited amounts.

(d) Balled and Burlapped Plants. Plants of this type shall be handled in such manner that the soil of the ball will not be loosened. 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. The planting of a hard, dry ball will not be permitted.

(e) Finishing Surface after Backfilling. The ground in planted areas shall be smoothed over as the work progresses and left in a neat and sightly condition. A shallow basin with a diameter equal to the hole or pit and a depth approximately one-sixth of this diameter shall be constructed around each plant. On steep slopes, the soil on the lower side of the plant shall be graded in such manner that it will provide a basin as above specified.

Material excavated from the plant holes which is unsuitable for backfilling shall be utilized to form a basin around the plant or be thinly scattered and leveled off with all lumps broken fine so as to leave a neat, smooth appearance. In case the subsoil is of such consistency and lumpy character that it cannot be readily scattered over the surface of the planting areas in an acceptable manner, or in case the scattering of material will interfere with drainage, or otherwise be detrimental, all such material shall be removed and disposed of as directed.

(5) Staking and Bracing Trees and Shrubs. All trees shall be adequately braced diagonally with wires firmly attached to three equally spaced 2½-foot stakes. Number 16 galvanized wire shall be used and shall be fastened to the

tree using a section of rubber hose or three thicknesses of burlap. All stakes shall be driven 2 feet into the ground. Stakes may be of durable native wood and 1½ inches to 3 inches in diameter with bark removed or of sawed pine 2 inches by 2 inches. All staking shall be done immediately after the plants have settled. The Contractor shall stake the trees in an approved manner that will present the most satisfactory appearance from the highway. Retightening of the wires shall be done as many times thereafter as may be required.

(6) **Mulching.** Mulching shall be placed to a depth of 2 inches on top of the planted hole and fully intermixed with the upper layer of the soil. All plants shall receive mulching unless otherwise stated on plans.

(7) **Watering.** Water shall be applied at the time of planting, in quantities sufficient to fill the holes so that all air pockets are replaced with water. Water shall be applied as many times thereafter and in sufficient quantities as the seasonal conditions require to keep the ground moist well below the root system, until acceptance of the work.

(8) **Maintenance.** The Contractor shall maintain the planted area, keeping such areas within 3 feet of the planted material clean of weeds until date of acceptance. In cases where insects or diseases affect the plants after planting, the Contractor shall protect or treat the plants in accordance with approved methods of horticultural practice.

190.4. Measurement. Work and accepted materials as prescribed for this item will be measured as each living vine, shrub or tree in place at the time of the final inspection. After completion of all work provided for in the contract, the Engineer will make an inspection, and those plant materials not in acceptable living condition shall be replanted prior to the final inspection and acceptance.

190.5. 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 living "Vine", "Shrub", or "Tree" in place, which price shall be full compensation for all items necessary to complete the work.

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.

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 to 210.2

204.2. Materials. Water shall be furnished by the Contractor and shall be clean, 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.

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.

211.1 to .2

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.

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 rolling 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.

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 super-elevated 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

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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.

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. 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

213.4 to 214.1

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 3 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 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. 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 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 subgrades. 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 self-propelled type, and the roller, when drawn or propelled by either type of equipment, shall be considered a heavy pneumatic tire roller unit.

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

214.4 to 215.1

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, 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 1 ½ 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 a 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.

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 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.

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 to 216.2

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 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 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 uppermost 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 the 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.

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.

216.4 to 230.2

Flexible bases, foundation courses, roadbed treatments or asphalt 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.

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 objectional matter.

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

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.

230.4

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 road bed 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.

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; all stripping required; 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

232.1 to .3

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.

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".

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.

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 shall be approved by the Engineer at the source. 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 requirement 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 1¾ 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 tri-axial requirements and other specification data for Grade 2 flexible base material shall be as shown on the plans.

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 $\frac{1}{2}$ 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 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 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 $\frac{1}{4}$ 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 $\frac{1}{4}$ 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.

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.

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. 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 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.

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 ac-

234.1 to .2

cordance 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 loam 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 the 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 1¼ 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.

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 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.

(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 main-

tained 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 $\frac{1}{4}$ 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 $\frac{1}{4}$ 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

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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

236.1 to .3

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.

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 shall be approved by the Engineer at the source. 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 dimension 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. 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 1¼ 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.....	12

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.

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 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 $\frac{1}{2}$ 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 $\frac{1}{4}$ 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 $\frac{1}{4}$ 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.

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 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. 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 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.

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

238.2 to .4

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.

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 shall be approved by the Engineer at the source. 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. 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 $\frac{3}{4}$ inch sieve.....	0%
Retained on $\frac{3}{8}$ 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.....	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.

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 $\frac{1}{2}$ 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 $\frac{1}{4}$ 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 of 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 $\frac{1}{4}$ 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 re-finished 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.

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 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. 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 "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.

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.

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. Material shall be approved by the Engineer at the source. Material containing gravel or hard pieces of ore over 2½ inches 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 stand-

240.4 to .5

ard Texas Highway Department laboratory methods the flexible base material shall meet the following requirements:

Retained on 2½ 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.

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 2½ inches 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 ex-

cavated 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 $\frac{1}{2}$ 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 $\frac{1}{4}$ 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 $\frac{1}{4}$ 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 recompact 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.

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.

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. 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

242.1

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 "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 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.

242.2. Material. The material shall be crushed and shall consist of durable particles of stone mixed with approved binding material. The material shall be approved by the Engineer at the source. 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 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 1¾ 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

(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.

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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 $\frac{1}{2}$ 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 $\frac{1}{4}$ 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 $\frac{1}{4}$ 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 scari-fying 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.

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. 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 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.

244.1 to .2

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 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 shall be approved by the Engineer at the source. 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 $\frac{3}{4}$ inch sieve.....	0%
Retained on $\frac{7}{8}$ inch sieve.....	8 to 30%
Retained on $\frac{3}{8}$ 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 45 percent by weight, of the total sample tested.

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 to .6

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 $\frac{1}{2}$ 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 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 $\frac{1}{4}$ 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:

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 shall be approved by the Engineer at the source. 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.

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 slightly 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 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 suf-

ficient 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.

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. 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) "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.

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, 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. Material. 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. The material shall be approved by the Engineer at the source. 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 top soil. 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. Additives may be used with the written permission of the Engineer in order to meet these requirements.

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 Tests	Tex-117-E

Samples for testing the material shall be taken prior to the compaction operations.

PHYSICAL REQUIREMENTS FOR FLEXIBLE BASE MATERIALS

TYPES	GRADES								Grade 4
	Grade 1: (Triaxial Class 1) Min. compressive strength PSI: 45 at 0 lb. lateral pressure and 175 at 15 lb. lateral pressure		Grade 2: (Triaxial Class 1 to 2.3) Min. compressive strength, PSI: 35 at 0 lb. lateral pressure and 175 at 15 lb. lateral pressure		Grade 3: (Unspecified Triaxial Class)				
TYPE A	Retained on Sq. Sieve	%	Retained on Sq. Sieve	%	Retained on Sq. Sieve	%			
Crushed or Broken Aggregate	1 3/4".....	0	1 3/4".....	0-10	1 3/4".....	0-10			As Shown on Plans
	7/8".....	8-30	No. 4.....	45-75	No. 4.....	60-85			
	3/8".....	30-50	No. 40.....	60-85	Max LL.....	45			
	No. 4.....	45-55	Max LL.....	40	Max PI.....	15			
	No. 40.....	70-80	Max PI.....	12	Max Wet Ball Mill	55			
	Max LL.....	35	Max Wet Ball Mill	50					
	Max PI.....	12	Max LA Wear	40					
TYPE B			Retained on Sq. Sieve	%	Retained on Sq. Sieve	%			
Gravel Aggregate			1 3/4".....	0-10	1 3/4".....	0-05			As Shown on Plans
			No. 4.....	30-75	No. 4.....	30-75			
			No. 40.....	70-85	No. 40.....	65-85			
			Max LL.....	35	Max LL.....	35			
			Max PI.....	12	Max PI.....	12			
TYPE C			Retained on Sq. Sieve	%	Retained on Sq. Sieve	%			
Iron Ore Topsoil			2 1/2".....	0	2 1/2".....	0			As Shown on Plans
			No. 40.....	50-85	No. 40.....	45-85			
			Max LL.....	35	Max LL.....	35			
			Max PI.....	12	Max PI.....	12			
TYPE D			Retained on Sq. Sieve	%	Retained on Sq. Sieve	%			
Sand-Shell			1 3/4".....	0-10	1 3/4".....	0-10			As Shown on Plans
			No. 4.....	45-65	No. 40.....	45-65			
			No. 40.....	50-70	Max LL.....	35			
			Max LL.....	35	Max PI.....	12			
			Max PI.....	12					
TYPE E			Retained on Sq. Sieve	%	Retained on Sq. Sieve	%			
Shell with Sand and Caliche Admixture			1 3/4".....	0	1 3/4".....	0			As Shown on Plans
			No. 40.....	45-65	No. 40.....	45-65			
			Max LL.....	35	Max LL.....	35			
			Max PI.....	10	Max PI.....	12			

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 $\frac{1}{2}$ 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 $\frac{1}{4}$ 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 $\frac{1}{4}$ inch in cross section and in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and 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. 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 recompact 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 $\frac{1}{4}$ 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 Type A, Type B and Type 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 Type A, Type B and Type 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.

248.7. Measurement. Work and accepted material as prescribed for this item will be measured as follows:

Type of Materials	Method of Measurement
A, B and C	By the cubic yard in vehicles as delivered on the road or by the ton of 2000 pounds dry weight. 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.
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. 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 material source or sources and point of

delivery on the road. No direct measurement for hauling shell will be made.

(2) When provided by the plans, the combined shell and sand admixture shall be measured by the ton of 2000 pounds dry weight. No direct measurement for hauling the mixture will be made.

- E** The shell, sand admixture and caliche admixture shall be measured separately by the cubic yard in vehicles as delivered on the road. Measurement for hauling sand admixture material and caliche 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 material source or sources and point of delivery on the road. No direct measurement for hauling shell will be made.

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.

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), and grade; and "Additional Quarter Mile Haul".

- D (1) "Flexible Base" of the compaction method specified, type (when specified on the plans), and grade; "Sand Admixture"; and "Additional Quarter Mile Haul (Sand Admixture)". (Cubic yard measurement with the sand admixture and shell being measured separately).
- (2) "Flexible Base" of the compaction method specified, type (when specified on the plans), and grade. (Ton measurement of combined shell and sand admixture with no direct payment for hauling).
- E "Flexible Base" of the compaction method specified, type (when specified on the plans), and grade; "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 additives, if permitted; 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 "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

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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 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 $\frac{1}{4}$ 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 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 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.

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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 $\frac{1}{4}$ 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. 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.

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 $\frac{1}{2}$ 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.

(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 $\frac{1}{4}$ 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 scari-fying 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 $\frac{1}{4}$ 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 scari-fying 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 sur-

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facing 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.

252.4. Measurement. Work, as prescribed for this item, will be measured by the 100-foot station of base in its original position or by the cubic yard of material in vehicles as delivered on the road.

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 govern-

ing 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.

Prior to beginning any lime treatment, 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 to be treated shall then 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. The excavated material shall then be spread to the desired cross section.

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 screw type spreader box 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 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 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, scari-fying 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 $\frac{3}{4}$ " 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 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 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 or Grade 2 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 2,000 pounds based on the 31 percent lime content, 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 2,000 pounds based on the 35 percent lime content, 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 of 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,

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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 close 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 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 screw type spreader box 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 require-

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ments 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 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 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 or Grade 2 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.

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.

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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 $\text{Ca}(\text{OH})_2$	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.....	Max. 0.0%
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 $\text{Ca}(\text{OH})_2$ 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:

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Residue retained on a No. 6 (3360-micron) sieve.....	Max.	0.0%
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 two 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.

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.

Contractors, at their 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.

(1) **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 $\frac{1}{4}$ 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 pro-

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duced. 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 sec-

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tion 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.

Contractors, at their 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) or (b) below may be used at the option of the Contractor. Method (c) shall be used only when specified on the plans.

(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. Pres-

surized 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 mix-

ture 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 $\frac{1}{4}$ 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.

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 subbases 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 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

280.3

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 material 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.** Pulverized-mixers shall be of an approved type and be not less than 5 feet in width.

(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 tired 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

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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 ex-

isting 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. 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.

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 $3\frac{1}{2}$ 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 proper moisture content to the end that a uniform mass without laminations or cleavage planes in the completed layer is obtained having an apparent dry density of not less than 95 percent of the maximum dry density of such material. The maximum dry density shall be determined from a moisture-density curve run on road mix samples in accordance with 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. In no case shall the drying period for each course be less than 10 days. 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 recompact 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 will be measured in gallons at the applied temperature at the point of application on the road.

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 subsection 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 subsection 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:

290.2

Retained on 3 inch sieve.....	0%
Retained on $\frac{3}{4}$ inch sieve.....	12 to 37%
Retained on No. 4 sieve.....	95 to 100%
Passing No. 200 sieve.....	0 to 4%

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 subsection 360.2(4) of the Item, "Concrete Pavement (Water Cement Ratio)".

(5) **Water.** Water shall meet the requirements of subsection 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 subsections 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 subsection 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 subsection 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 subsection 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 subsections 360.2(14), (15) and (16) 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 subsection 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 0.85. The concrete shall contain not less than 4½ 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 10 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 subsections 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 subsection 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 subsection 360.6 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.7. Joints. Joints shall meet the requirements of subsection 360.7 of the Item, "Concrete Pavement (Water Ce-

290.8 to .13

ment Ratio)", except that the last sentence of this subsection 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 subsection 360.8 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.9. Curing. Curing of shell concrete base shall meet the requirements of subsection 360.9 of the Item, "Concrete Pavement (Water Cement Ratio)".

290.10. Protection of Shell Concrete Base and Opening to Traffic. Provisions of subsection 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 subsection 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 the 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 is 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.

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 and other miscellaneous asphaltic materials.

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:

(2) **Cut-back Asphalt.** The material shall be free from water and shall meet the requirements shown in the following table:

TYPE-GRADE	RC-1		RC-2		RC-3		RC-4		RC-5		MC-1		MC-2		MC-3		MC-5	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Flash Point, T. O. C., F.....	80	—	80	—	80	—	80	—	80	—	100	—	150	—	150	—	150	—
Furol Viscosity, sec.:																		
At 77 F.....	—	—	—	—	—	—	—	—	—	—	110	150	—	—	—	—	—	—
At 122 F.....	100	160	200	275	—	—	—	—	—	—	—	—	—	—	—	—	—	—
At 140 F.....	—	—	—	—	250	400	—	—	—	—	—	—	150	250	350	500	—	—
At 180 F.....	—	—	—	—	—	—	125	250	350	500	—	—	—	—	—	—	300	500

The Distillate, expressed as percent by volume of total distillate to 680 F, shall be as follows:

Off at 437 F.....	55	80	50	75	50	70	35	60	20	55	—	25	—	10	—	5	—	—
Off at 500 F.....	70	90	70	90	65	85	60	80	55	75	40	70	15	55	5	40	—	20
Off at 600 F.....	90	—	90	—	85	—	80	—	75	—	75	93	60	87	55	85	20	75
Residue from 680 F. Distillation, Volume, %.....	50	—	70	—	73	—	78	—	82	—	50	—	67	—	73	—	82	—

Tests of Distillation Residue:

Penetration at 77 F., 100g. 5 sec.	70	100	120	150	120	150	120	150	120	150	100	200	100	200	100	200	100	200
Ductility at 77 F., 5 cm./min., cms.	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—
Solubility in CCl ₄ , %.....	99.5	—	99.5	—	99.5	—	99.5	—	99.5	—	99.5	—	99.5	—	99.5	—	99.5	—
Spot Test.....	Neg.	—	Neg.	—	Neg.	—	Neg.	—	Neg.	—	Neg.	—	Neg.	—	Neg.	—	Neg.	—

(3) **Road Oils.** The material shall be free from water and shall meet the following requirements:

TYPE-GRADE	RO-3		RO-4		RO-95		RO-Special	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Asphalt content of 85 to 115 penetration by vacuum distillation	60	—	55	—	80	—	55	—
Flash Point, C.O.C., F.	225	—	175	—	250	—	225	—
Furoil 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, 100g., 5 sec.	—	—	—	—	175	250	—	—
Ductility of residue at 77 F., 5 cm/min., cms.	100	—	100	—	—	—	—	—
Solubility in CCl ₄ , %	99.5	—	99.5	—	99.5	—	—	—
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.,	—	—	—	—	100	—	—	—
Original Residue, cms.	—	—	—	—	100	—	—	—
Subjected to Thin Film Test, cms.	—	—	—	—	100	—	—	—

(4) **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	—	—	—
Furoil Viscosity at 77 F., Sec.	—	—	—	500
Furoil 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

(5) **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:

TYPE-GRADE	EA-HVRS		EA-HVMS		EA-10S		EA-11M	
	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	—	—	—	—
Residue by Distillation, %.....	60	—	60	—	57.5	—	57.5	—
Oil Portion of Distillate, %.....	—	—	—	—	—	2.0	—	2.0
Sieve Test, %.....	—	0.05	—	0.05	—	0.05	—	0.05
Miscibility (Standard Test).....	—	—	—	—	—	Passing	—	Passing
Coating.....	—	—	—	—	—	—	—	Passing
Cement Mixing, %.....	—	—	—	—	—	2.0	—	—
Demulsibility 50cc of N/10 CaCl ₂ , %.....	—	—	—	—	—	—	—	70
Demulsibility 35cc of N/50 CaCl ₂ , %.....	30	—	—	30	—	—	—	—
Settlement, 5 days, %.....	—	3.0	—	3.0	—	3.0	—	3.0
Freezing Test 3 Cycles (*).....	—	—	—	Passing*	—	Passing*	—	Passing*
Tests on Residue:								
Penetration at 77 F, 100g., 5 sec.....	100	200	100	200	100	175	100	175
Solubility in CCl ₄ , %.....	97.5	—	97.5	—	97.5	—	97.5	—
Ductility at 77 F, 5 cm./min., cms.....	40	—	40	—	40	—	40	—

*Applies only when Engineer designates material for winter use.

(6) **Flux Oil.** Fluxing material shall be free from foreign matter, practically free from water and shall meet the following requirements:

Type	Flux Oil	
	Min.	Max.
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	—

(7) **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.	Max.
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

This material shall be practically free from water.

(8) **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

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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	

300.3. 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 allowable temperatures:

TYPE-GRADE	Recommended Range, F.	Maximum Allowable, F.
OA-30	400-500	500
OA-55, 90 135, 175, 230	275-375	400
OA-400	220-300	350
RC-1	100-150	175
RC-2	125-180	200
RC-3	160-210	230
RC-4	180-240	270
RC-5	215-270	285
MC-1	70-150	175
MC-2	125-210	240
MC-3	175-260	275
MC-5	225-275	290
RO-3	160-210	250
RO-4	100-150	200
RO-95	230-300	325
RO-Special	160-220	260
Cracked Fuel Oil	160-220	260
Crude Oil	100-150	175
EA-10S, EA-11M	50-130	140
EA-HVRS, EA-HVMS	110-150	160
Cat. Blown Asp.	425-475	500
Special Precoat Material	125-250	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 inflammable. 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 302

AGGREGATE FOR SURFACE TREATMENTS

302.1. Description. This item establishes the requirements for aggregates to be used in the construction of surface treatments.

302.2. Materials. Aggregates shall be composed of sound and durable particles of gravel, crushed gravel, crushed stone, crushed slag, burned clay, burned shale or natural limestone rock asphalt. These materials 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 or soft particles of sandstone when tested in accordance with Test Method Tex-217-F.

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.

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.

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Crushed gravel shall have a minimum of 85 percent of the particles retained on the No. 4 sieve with at least one crushed face.

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.

Type F. Type F aggregate shall consist of burned clay or burned shale.

302.4. Grades. When tested by Test Method Tex-200-F, 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 $\frac{7}{8}$ " sieve	0-2
	Retained on $\frac{5}{8}$ " sieve	15-45
	Retained on $\frac{3}{8}$ " sieve	85-100
	Retained on No. 4 sieve	95-100
	Retained on No. 10 sieve	98-100
Grade 2:	Retained on $\frac{7}{8}$ " sieve	0
	Retained on $\frac{3}{4}$ " sieve	0-2
	Retained on $\frac{1}{2}$ " sieve	20-35
	Retained on No. 4 sieve	85-100
	Retained on No. 10 sieve	98-100
	Grade 3:	Retained on $\frac{3}{4}$ " sieve	0
Retained on $\frac{5}{8}$ " sieve		0-2
Retained on $\frac{1}{2}$ " sieve		5-20
Retained on No. 4 sieve		85-100
Retained on No. 10 sieve		98-100

Grade 4:	Retained on $\frac{5}{8}$ " sieve	0
	Retained on $\frac{1}{2}$ " sieve	0-2
	Retained on $\frac{3}{8}$ " sieve	5-25
	Retained on No. 4 sieve	85-100
	Retained on No. 10 sieve	98-100
Grade 5:	Retained on $\frac{1}{2}$ " sieve	0
	Retained on $\frac{3}{8}$ " sieve	0-2
	Retained on No. 4 sieve	40-85
	Retained on No. 10 sieve	98-100
Grade 6:	Retained on $\frac{1}{2}$ " sieve	0
	Retained on $\frac{3}{8}$ " sieve	0-2
	Retained on No. 4 sieve	5-40
	Retained on No. 10 sieve	70-100
	Retained on No. 20 sieve	99-100
Grade 7:	Retained on $\frac{1}{4}$ " sieve	0
	Retained on No. 4 sieve	0-10
	Retained on No. 20 sieve	25-55
Grade 8:	Retained on No. 4 sieve	0
	Retained on No. 10 sieve	0-10
	Retained on No. 20 sieve	10-55

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 304

AGGREGATE FOR SURFACE TREATMENTS (Precoated)

304.1. Description. This item establishes the requirements for precoated aggregates to be used in the construction of surface treatments.

304.2. Materials. Aggregates to be precoated shall be composed of sound and durable particles of gravel, crushed gravel, crushed stone, crushed slag or natural limestone rock asphalt. These materials 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 or soft particles of sandstone when tested in accordance with Test Method Tex-217-F.

304.3 to .4

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.

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.

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.

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 $\frac{7}{8}$ " sieve	0-2
	Retained on $\frac{5}{8}$ " sieve	15-45
	Retained on $\frac{3}{8}$ " sieve	85-100
	Retained on No. 4 sieve	95-100
	Retained on No. 10 sieve	98-100
Grade 2:	Retained on $\frac{7}{8}$ " sieve	0
	Retained on $\frac{3}{4}$ " sieve	0-2
	Retained on $\frac{1}{4}$ " sieve	20-35
	Retained on No. 4 sieve	85-100
	Retained on No. 10 sieve	98-100
Grade 3:	Retained on $\frac{3}{4}$ " sieve	0
	Retained on $\frac{5}{8}$ " sieve	0-2
	Retained on $\frac{1}{2}$ " sieve	5-20
	Retained on No. 4 sieve	85-100
	Retained on No. 10 sieve	98-100
Grade 4:	Retained on $\frac{5}{8}$ " sieve	0
	Retained on $\frac{1}{2}$ " sieve	0-2
	Retained on $\frac{3}{8}$ " sieve	5-25
	Retained on No. 4 sieve	85-100
	Retained on No. 10 sieve	98-100
Grade 5:	Retained on $\frac{1}{2}$ " sieve	0
	Retained on $\frac{3}{8}$ " sieve	0-2
	Retained on No. 4 sieve	40-85
	Retained on No. 10 sieve	98-100
Grade 6:	Retained on $\frac{1}{2}$ " sieve	0
	Retained on $\frac{3}{8}$ " sieve	0-2
	Retained on No. 4 sieve	5-40
	Retained on No. 10 sieve	70-100
	Retained on No. 20 sieve	99-100

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 Section 304.4 prior to the application of the precoat material or flux oil.

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(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 pre-coated 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

gate 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. The aggregate shall be separated into at least two bins when producing mixtures specified in this item.

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 2000 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.

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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 asphaltic material 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 pre-coating 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 Section 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 weigh-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,

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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 percent 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 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".

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 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. 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 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

310.5 to 312.3

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 and placed on shoulders at spacings designated by the Engineer. 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 to 314.3

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 be clear, free from industrial wastes and other objectionable matter.

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 on 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.

314.4. Measurement. Emulsified asphalt will be measured by the gallon.

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 including 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.

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

316.3

and grade or types and grades as noted on the plans and selected from those prescribed in the Item, "Aggregate for Surface Treatments", or in the Item, "Aggregate for Surface Treatments (Precoated)".

(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 shall 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.

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.

316.5 to 320.2

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 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.

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 Item, "Aggregate for Surface Treatments", or in the Item, "Aggregate for Surface Treatments (Precoated)".

(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 shall 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".

320.4 to .5

Temporary stockpiling of the aggregate on the roadway will be permitted provided the stockpiles are spaced not less than 1000 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 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 Item, "Aggregate for Surface Treatments", or in the Item, "Aggregate for Surface Treatments (Precoated)".

(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 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 shall 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 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

324.1 to .2

under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate" and "Aggregate (Stockpiled)", if required, of the 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, constructed 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 Item, "Aggregate for Surface Treatments", or in the Item, "Aggregate for Surface Treatments (Precoated)".

(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 shall 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

324.3

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 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 recommend-

ed 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 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 or soft particles or sandstone 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.

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. This percentage shall be adjusted within the grading limits to obtain an acceptable paving 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 be free from foreign matter, practically free from water and shall meet the 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-E, 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 1/4" sieve.....	25 to 35
Retained on No. 4 sieve.....	40 to 55
Passing No. 10 sieve.....	20 to 35

Type "D":

Retained on $\frac{3}{8}$ " sieve.....	0
Retained on $\frac{1}{4}$ " 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 that 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 $\frac{7}{8}$ " sieve.....	plus or minus 4
Retained on $\frac{5}{8}$ " sieve.....	plus or minus 4
Retained on $\frac{1}{2}$ " sieve.....	plus or minus 4
Retained on $\frac{3}{8}$ " sieve.....	plus or minus 4
Retained on $\frac{1}{4}$ " 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. Test values obtained on the first railroad car or truck load delivered to the job site shall be the designated grading and flux content, and the mixture produced shall conform to this designated grading and flux content during the construction of the project 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 as prescribed by THD Bulletin C-14. The water content shall be measured on representative samples, each representing approximately 200 tons. Not less than one sample shall be taken on each days run.

(6) 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.

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 $\frac{3}{8}$ 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 $\frac{1}{2}$ inch sieve and be retained on the $\frac{1}{4}$ 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 $\frac{7}{8}$ inch sieve and be retained on the $\frac{3}{8}$ 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 $\frac{3}{8}$ 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 $\frac{1}{2}$ inch sieve and be retained on the $\frac{1}{4}$ inch sieve.

Type "C" 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 $\frac{3}{8}$ 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 and an accurate fluxing material recording meter shall be placed in the fluxing material line leading to the spray bar so that the accumulative amount of flux oil used can be accurately determined.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 2000 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.

Fluxing Material Meter. An accurate fluxing material recording meter shall be placed in the fluxing material line leading to the spray bar so that the accumulated amount of flux oil 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. 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 Section 330.6(3), 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 the surface test.

(3) Forms. The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(4) 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.

(5) 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.

(6) Two Axle Tandem Roller. This roller shall be an ac-

ceptable power drive 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) **Straightedges and Templates.** The Contractor shall provide acceptable 16-foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(10) **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.

(11) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

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 shut-downs 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 0.10 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. 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.

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.

(4) **Compacting.**

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified 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 super-elevated curves, rolling shall begin at the low side and progress toward the high side. 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 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.

(c) **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 16-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 ¼ 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.

(1) The rock asphalt mixture will be measured by the ton of 2000 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.

(2) Tack coat will be measured at the point of application on the road in gallons at the applied temperature.

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When gasoline and/or kerosene is added to the cut-back asphalt for tack coat, as ordered, measurement for payment will be made after the mixing.

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, placing rock asphalt mixture; all blading, rolling and finishing; and for all labor, tools, equipment and incidentals necessary to complete the work.

(2) Tack coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", which price shall be full compensation for furnishing, preparing, hauling and placing the asphaltic material and for all labor, tools, equipment and incidentals necessary to complete the work.

(3) Prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(4) 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 332

COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT

332.1. 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, previously placed surface course, or, in the case of a bridge, on the prepared floor slab, all in accordance with these specifications and in conformity with the lines, grades, quantities and typical cross sections shown on plans.

332.2. Materials.

(1) **Rock Asphalt.** The rock asphalt mixture shall be uniform and well graded and shall be practically free from sulphates, iron pyrites, alumina or other objectionable matter.

The natural limestone rock asphalt furnished shall have from 5 to 9 percent of naturally impregnated asphalt as determined by Test Method Tex-215-F.

Prior to delivery of any rock asphalt, the Contractor shall designate to the Engineer in writing a definite percent of natural asphalt content of the material he desires to use and the natural asphalt content of all acceptable material shall not deviate from this designated percent by more than 1.5 percent. The designated natural asphalt content with the permitted variation of 1.5 percent shall be within the limits allowed by this provision and shall not be changed during construction of the project without the approval of the Engineer.

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 be free from foreign matter, practically free from water and shall meet the 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 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".

332.3. Paving Mixtures.

(1) **Types.** The paving mixture shall consist of a uniform mixture of crushed limestone rock asphalt, 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 aggregates. 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.....	20 to 40
Retained on No. 4 sieve.....	40 to 60
Passing No. 10 sieve.....	20 to 35
Type "AA":	
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.....	20 to 40
Retained on No. 4 sieve.....	40 to 60
Passing No. 10 sieve.....	30 to 45
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.....	35 to 60
Passing No. 10 sieve.....	20 to 35
Type "BB":	
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.....	35 to 60
Passing No. 10 sieve.....	30 to 40
Type "C":	
Retained on 1/2" sieve.....	0
Retained on 3/8" sieve.....	0 to 2
Retained on 1/4" sieve.....	25 to 35
Retained on No. 4 sieve.....	40 to 55
Passing No. 10 sieve.....	25 to 35
Type "CC":	
Retained on 1/2" sieve.....	0
Retained on 3/8" sieve.....	0 to 2
Retained on 1/4" sieve.....	25 to 35
Retained on No. 4 sieve.....	40 to 55
Passing No. 10 sieve.....	35 to 50

Type "D":

Retained on $\frac{3}{8}$ " sieve.....	0
Retained on $\frac{1}{4}$ " sieve.....	0 to 2
Retained on No. 4 sieve.....	2 to 10
Passing No. 10 sieve.....	35 to 50

(2) **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. 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 as prescribed in THD Bulletin C-14. The water content shall be measured on representative samples, each representing approximately 200 tons. Not less than one sample shall be taken on each days run.

(3) **Central Mixing Plants.** 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.

The type and amount of the mixture used shall be as specified on the plans.

Mixing plants that will not continuously produce a mixture meeting all of the above requirements will be condemned.

332.4. Equipment.

(1) **Mixing Plants.** 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.

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 and an accurate fluxing material recording meter shall be placed in the fluxing material line leading to the spray bar so that the accumulative amount of flux oil used can be accurately determined.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 2000 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. Any mixer that has a tendency to segregate the rock asphalt or fails to secure a thorough and uniform mixing with the flux will be condemned as inadequate to produce a satisfactory mix. The dump door or doors of the mixer shall be tight to the rock asphalt so that there will be no spilling from the pug mill. The flux shall be sprayed into the mixer through an approved spray bar that will distribute the flux uniformly throughout the length of the mixer.

(b) Continuous Mixing Type.

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.

Fluxing Material Meter. An accurate fluxing material recording meter shall be placed in the fluxing material line leading to the spray bar so that the accumulative amount of flux oil 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 an approved 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 materials shall not be used. The pumps used to introduce flux oil and water into the mix shall be provided with accurate recording meters so that control of the flux oil content of the mixture is comparable to that obtained by weight-batching. All requirements for determining the temperature of the various ingredients entering into the mixture, as specified for the weight-batching plant shall be met.

(2) **Spreading and Finishing Machine.** The spreading and finishing machine, if permitted by the Engineer, shall be of the screeding and troweling type or 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 the surface test.

(3) **Forms.** The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(4) **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.

(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.

(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 a sprinkler for

keeping the wheels wet and an adjustable road wheel so that roller may be kept level during rolling. The drive wheel shall be not less than 20 inches wide.

The roller shall produce 100 pounds to 325 pounds per linear inch of effective roller width and be so geared that a speed of 1.8 miles per hour is obtained in low gear.

(10) Straightedges and Templates. The Contractor shall provide acceptable 16-foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(11) 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.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

332.5. Storage, Proportions and Mixing.

(1) Storage of Rock Asphalt. Storage of the crushed limestone rock asphalt, or the rock asphalt mixture upon the ground will not be permitted except in an emergency, and then only with the written consent of the Engineer. Material that comes in contact with earth or other objectionable foreign matter shall be rejected. In case the rock asphalt or the rock asphalt mixture has set up in transit or in storage to the extent that it cannot be readily unloaded by normal means, mixed or handled on the road, it shall be reprocessed to conform to its original gradation before being used. 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.

(3) Proportioning. The crushed limestone rock asphalt and the flux shall be proportioned by weight or by volume based on weight. The exact proportion of each constituent

by weight of the paving mixture shall be as directed by the Engineer within the following limits:

Crushed Limestone Rock Asphalt, 96 to 97½ percent by weight.

Flux Material, 2½ 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 or other device 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 that do not remain workable a sufficient period of time to permit proper spreading and rolling will not be accepted.

332.6. Construction Methods. The rock asphalt mixture, tack coat or prime coat shall be placed only when the 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 0.10 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. When directed by the Engineer, the tack coat shall be rolled with pneumatic tires.

(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 pre-

vent 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 materials 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 of flush structure.

If, in the opinion of the Engineer, the mixture is suitable for placing without aeration, it may be spread with the specified spreading and finishing machine.

During the application of asphaltic material, care shall be taken to prevent splattering of adjacent pavement, curb and gutter or structures.

(4) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified 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 super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the 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 and at least one three wheel roller, as above specified, 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 two rollers be in use on each job. Additional rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. 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.

(c) **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 16-foot straightedge placed parallel to the center line 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 ¼ 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.

332.7. Measurement.

(1) The rock asphalt mixture will be measured by the ton of 2000 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

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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.

(2) Tack coat will be measured in gallons at the applied temperature at point of application on the road.

When gasoline and/or kerosene is added to the cut-back asphalt for tack coat, as ordered, measurement for payment will be made after mixing.

332.8. 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, placing rock asphalt mixture; all blading, rolling and finishing; and for all labor, tools, equipment and incidentals necessary to complete the work.

(2) Tack coat measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", which price shall be full compensation for furnishing, preparing, hauling and placing the asphaltic material and for all labor, tools, equipment and incidentals necessary to complete the work.

(3) Prime coat performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(4) 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 mixture when designed and tested in accordance with these specifications and methods outlined in THD Bulletin C-14, shall have the following laboratory density and stability:

Density, Percent			Stability, Percent
Min.	Max.	Optimum	
94	99	97	Not less than 30, unless otherwise shown on plans.

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 floor 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 Item 6 of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery. It shall contain not more than 1 percent by weight of organic matter, clays, loam or pebbles coated therewith as determined by Test Method Tex-217-F. Mineral aggregate from each source shall meet the quality tests specified herein.

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, when subjected to the sand equivalent test as outlined in THD Bulletin C-14.

(a) **Coarse Aggregate.** The coarse aggregate shall be that part of the aggregate retained on a No. 10 sieve; shall consist of clean, tough, durable fragments of stone, crushed blast furnace slag, crushed gravel, gravel or combinations thereof as hereinafter specified, of uniform quality throughout. Coarse aggregate will be tested in accordance with THD Bulletin C-11 (Decantation) and material removed shall not be more than 1 percent. The coarse aggregate shall have an abrasion of not more than 40 percent loss by weight when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A for all types except Type

"F" (Non-skid Surface Course), which shall have an abrasion of not more than 35 percent loss by weight when subjected to the same test. If gravel is used for Type "F", it shall be so crushed that 90 percent of the particles retained on the No. 4 sieve shall have more than one crushed face.

(b) **Fine Aggregate.** The fine aggregate shall be that part of the aggregate passing the No. 10 sieve and shall consist of sand or screenings or a combination of sand and screenings.

Sand shall be composed of durable stone 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 by Test Method Tex-106-E.

(c) **Mineral Filler.** The mineral filler shall consist of thoroughly dry stone dust, slate dust, portland cement or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter. When tested by the method outlined in THD Bulletin C-14, it shall meet the following grading requirements:

	Percent by Weight
Passing a No. 30 sieve	100
Passing a No. 80 sieve, not less than	90
Passing a No. 200 sieve, not less than	65

(2) Asphaltic Material.

(a) **Paving Mixture.** Asphalt for the paving mixture shall be of the types of 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 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 and asphaltic material. 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 THD Bulletin C-14, will conform to the limitations for master grading given below for the type specified:

Type "A" (Coarse Graded Base Course):	Percent by Weight
Passing 2" sieve	100
Passing 1 3/4" sieve	95 to 100
Passing 1 3/4" sieve, retained on 7/8" sieve	15 to 40
Passing 7/8" sieve, retained on 3/8" sieve.....	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve.....	10 to 25
Passing No. 4 Sieve, retained on No. 10 sieve. .	5 to 20
Total retained on No. 10 sieve	65 to 80
Passing No. 10 sieve, retained on No. 40 sieve	0 to 20
Passing No. 40 sieve, retained on No. 80 sieve. .	3 to 15
Passing No. 80 sieve, retained on No. 200 sieve	2 to 15
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 3 to 6 percent of the mixture by weight.

Type "B" (Fine Graded Base or Leveling-Up Course):

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

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Passing No. 80 sieve, retained on No. 200 sieve	3 to 20
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "C" (Coarse Graded Surface Course):

Passing $\frac{7}{8}$ " sieve	100
Passing $\frac{5}{8}$ " sieve	95 to 100
Passing $\frac{5}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	15 to 40
Passing $\frac{3}{8}$ " 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 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "D" (Fine Graded Surface Course):

Passing $\frac{1}{2}$ " sieve	100
Passing $\frac{3}{8}$ " sieve	95 to 100
Passing $\frac{3}{8}$ " 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 8

The asphaltic material shall form from 4.0 to 8.0 percent of the mixture by weight.

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.

Type "F" (Non-skid Surface Course):

Passing $\frac{3}{8}$ " sieve	100
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Passing $\frac{1}{4}$ " sieve	95 to 100
Passing $\frac{1}{4}$ " 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 8

The asphaltic material shall form from 3.5 to 6.5 percent of the mixture by weight.

(2) **Tolerances.** The Engineer will designate the exact grading of the aggregate and asphalt content to be used in the mixture. The paving mixture produced shall not vary from the designated grading and asphalt content by more than the tolerances allowed herein and shall remain within the limitations of the master grading specified. The respective tolerances, based on the percent by weight of the mixture, are listed as follows:

	Percent by Weight
Passing $1\frac{3}{4}$ " sieve, retained on $\frac{7}{8}$ " sieve.....	plus or minus 4
Passing $\frac{7}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve.....	plus or minus 4
Passing $\frac{5}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve.....	plus or minus 4
Passing $\frac{3}{8}$ " sieve, retained on No. 4 sieve.....	plus or minus 4
Passing $\frac{1}{4}$ " sieve, retained on No. 10 sieve.....	plus or minus 4
Passing No. 4 sieve, retained on No. 10 sieve.....	plus or minus 4
Total retained on No. 10 sieve.....	plus or minus 4
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 2
Asphalt Material	plus or minus 0.3

The type and amount of the mixture used shall be as specified on the plans.

(3) **Extraction Test.** Samples of the mixture when tested by the Extraction Test, THD Bulletin C-14, shall not vary

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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.

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 Section 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.

(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 "A", 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 needed an additional bin shall be provided. These bins shall contain the following sizes of aggregates:

Type "A" (Coarse Graded Base Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{2}$ 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 $\frac{7}{8}$ inch sieve and be retained on the $\frac{3}{8}$ inch sieve.

Bin No. 4—will contain aggregates of which at least 85 per cent by weight will be of such size as to pass the 2 inch sieve and be retained on the $\frac{7}{8}$ inch sieve.

Type "B" (Fine Graded Base or Leveling-Up Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ 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 $\frac{1}{2}$ inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1 inch sieve and be retained on the $\frac{7}{8}$ inch sieve.

Type "C" (Coarse Graded Surface Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ 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 $\frac{1}{2}$ inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1 inch sieve and be retained on the $\frac{3}{8}$ inch sieve.

Type "D" (Fine Graded Surface Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ 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 $\frac{1}{2}$ inch sieve and be retained on the No. 4 sieve.

Type "E" (Sheet Asphalt Surface Course):

Bin No. 1—will contain aggregates of which 90 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 No. 4 sieve and be retained on the No. 10 sieve.

Type "F" (Non-Skid Surface Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{3}{8}$ " 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".

Aggregate 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, and 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.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 2000 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 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 and shall be capable of producing a surface that

will meet the requirements of the typical cross section and the surface test.

(4) **Forms.** The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(5) **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.

(6) **Pneumatic Tire Rollers.** The rollers 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.

(7) **Two Axle Tandem Roller.** This roller shall be an acceptable power driven tandem roller weighing not less than 8 tons.

(8) **Three Wheel Roller.** This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(9) **Three Axle Tandem Roller.** This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(10) **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 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.

(11) **Straightedges and Templates.** The Contractor shall provide acceptable 16 foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

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 Types "A", "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 or provided for by special provision. Fine aggregate stockpiles may contain small coarse aggregate in the amount of up to 20 percent by weight, 100 percent of which shall pass a $\frac{1}{4}$ -inch sieve, 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 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 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 weigh-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 by more than the tolerances herein specified.

(d) 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.

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.

(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 prime 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 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 0.10 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 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, 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 in the forms, 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 eliminated 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.

(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 super-elevated curves, rolling shall begin at the low side and progress toward the high side. 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 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

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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.

(c) **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 compacted with 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 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 16-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 ¼ inch at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(7) **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.

340.7. Measurement.

(1) Asphaltic concrete will be measured separately by the ton of 2000 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. 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.

(2) Tack coat will be measured at the point of application on the road in gallons at the applied temperature. When gasoline and/or kerosene is added to the cut-back asphalt for tack coat, as ordered, measurement will be made after mixing.

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 each be full compensation for quarrying, furnishing all materials, freight involved; for all heating, mixing, hauling, cleaning the existing base course or pavement, placing asphaltic concrete mixture, rolling and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except tack coat and prime coat when required.

(2) The tack coat, measured as provided under "Measurement" will be paid for at the unit price bid for "Tack Coat", which price shall be full compensation for furnishing, preparing, hauling and placing the asphaltic materials of the grade used; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

(3) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(4) 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 346

HOT MIX ASPHALTIC CONCRETE PAVEMENT (Class AA)

346.1. 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

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asphaltic material. The mixture when designed and tested in accordance with these specifications shall meet the following requirements:

Laboratory Density (THD Bulletin C-14).

Min.	94 percent
Max.	99 percent
Optimum	97 percent

Stability (THD Bulletin C-14).

Not less than 30 percent, except when otherwise shown on the plans.

In Place density (Test Method Tex-207-F).

It is the intent of this specification that the material be placed and compacted to a density of 95 to 100 percent of that density developed in the laboratory test method for molding stability specimens. Sufficient density tests will be made in order to determine that the compaction procedure used by the Contractor is adequate and proper to accomplish the intent as stated above.

Cohesimeter (ASTM Designation: D 1560).

The paving mixture shall have a minimum cohesimeter value of 100, except when otherwise shown on the plans.

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 floor slab, as herein specified and in accordance with the details shown on the plans.

346.2. Materials.

(1) **Mineral Aggregates.** 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 Item 6 of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery. It shall contain not more than 1 percent by weight of organic matter, clays, loam or pebbles coated therewith as determined by Test Method Tex-217-F. Mineral aggregate from each source shall meet the quality tests specified herein.

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 50, when subjected to the sand equivalent test as outlined in THD Bulletin C-14.

(a) **Coarse Aggregate.** The coarse aggregate shall be that part of the aggregate retained on a No. 10 sieve; shall consist of clean, tough, durable fragments of stone, crushed blast furnace slag, crushed gravel, gravel, or combinations thereof as hereinafter specified, of uniform quality throughout. Coarse aggregate will be tested in accordance with THD Bulletin C-11 (Decantation) and material removed shall not be more than 1 percent by weight. The coarse aggregate shall have an abrasion of not more than 40 percent loss by weight when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A for all types except Type "F" (Non-skid Surface Course), which shall have an abrasion of not more than 35 percent loss by weight when subjected to the same test. If gravel is used for Type "F", it shall be so crushed that 90 percent of the particles retained on the No. 4 sieve shall have more than one crushed face.

(b) **Fine Aggregate.** The fine aggregate shall be that part of the aggregate passing the No. 10 sieve and shall consist of sand or screenings or a combination of sand and screenings. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6 when tested by Test Method Tex-106-E. Sand shall be composed of durable stone particles free from injurious foreign matter. Screenings shall be of the same or similar material as specified for coarse aggregate.

(c) **Mineral Filler.** The mineral filler shall consist of thoroughly dry stone dust, slate dust, portland cement or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter. When tested by the method outlined in THD Bulletin C-14, it shall meet the following grading requirements:

	Percent by Weight
Passing a No. 30 sieve	100
Passing a No. 80 sieve, not less than	90
Passing a No. 200 sieve, not less than	65

(2) **Asphaltic Material.**

(a) **Paving Mixture.** Asphalt for the paving mixture

shall be of the types of 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 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".

346.3. Paving Mixtures.

(1) **Types.** The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate and asphaltic material. 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 THD Bulletin C-14, will conform to the limitations for master grading given below for the type specified:

Type "A" (Coarse Graded Base Course):	Percent by Weight
Passing 2" sieve	100
Passing 1 $\frac{3}{4}$ " sieve	95 to 100
Passing 1 $\frac{3}{4}$ " sieve, retained on $\frac{7}{8}$ " sieve	15 to 40
Passing $\frac{7}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	15 to 40
Passing $\frac{3}{8}$ " sieve, retained on No. 4 sieve	10 to 25
Passing No. 4 Sieve, retained on No. 10 sieve	5 to 20
Total retained on No. 10 sieve	65 to 80
Passing No. 10 sieve, retained on No. 40 sieve	0 to 20
Passing No. 40 sieve, retained on No. 80 sieve	3 to 15

Passing No. 80 sieve, retained on No. 200 sieve	2 to 15
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 3 to 6 percent of the mixture by weight.

Type "B" (Fine Graded Base or Leveling-Up Course):

Passing 1" sieve	100
Passing $\frac{7}{8}$ " sieve	95 to 100
Passing $\frac{7}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	20 to 50
Passing $\frac{3}{8}$ " 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	60 to 75
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 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "C" (Coarse Graded Surface Course):

Passing $\frac{7}{8}$ " sieve	100
Passing $\frac{3}{4}$ " sieve	95 to 100
Passing $\frac{3}{4}$ " sieve, retained on $\frac{3}{8}$ " sieve	15 to 40
Passing $\frac{3}{8}$ " 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	60 to 75
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 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "D" (Fine Graded Surface Course):

Passing $\frac{1}{2}$ " sieve	100
Passing $\frac{3}{8}$ " sieve	95 to 100
Passing $\frac{3}{8}$ " 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	60 to 75
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 8

The asphaltic material shall form from 4.0 to 8 percent of the mixture by weight.

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.

Type "F" (Non-skid Surface Course):

Passing $\frac{3}{8}$ " sieve	100
Passing $\frac{1}{4}$ " sieve	95 to 100
Passing $\frac{1}{4}$ " 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 8

The asphaltic material shall form from 3.5 to 6.5 percent of the mixture by weight.

(2) **Tolerances.** The Engineer will designate the exact grading of the aggregate and asphalt content to be used in the mixture. The paving mixture produced shall not vary from the designated grading and asphalt content by more than the tolerances allowed herein and shall remain within the limitations of the master grading specified. The respective tolerances, based on the percent by weight of the mixture, are listed as follows:

	by Weight Percent
Passing $1\frac{3}{4}$ " sieve, retained on $\frac{7}{8}$ " sieve	plus or minus 4
Passing $\frac{7}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	plus or minus 4
Passing $\frac{5}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	plus or minus 4
Passing $\frac{3}{8}$ " sieve, retained on No. 4 sieve	plus or minus 4
Passing $\frac{1}{4}$ " sieve, retained on No. 10 sieve	plus or minus 4
Passing No. 4 sieve, retained on No. 10 sieve	plus or minus 4
Total retained on No. 10 sieve	plus or minus 4
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 2
Asphalt Material	plus or minus 0.3

The type and amount of the mixture used shall be as specified on the plans.

(3) **Extraction Test.** Samples of the mixture when tested by the Extraction Test, THD Bulletin C-14, 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.

346.4. 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 Section 346.5 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 "A", 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 needed, an additional bin shall be provided. These bins shall contain the following sizes of aggregates:

Type "A" (Coarse Graded Base Course):

- Bin No. 1—will contain aggregates of which 90 to 100 percent by weight will pass the No. 10 sieve test.
- Bin No. 2—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the $\frac{1}{2}$ 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 $\frac{7}{8}$ inch sieve and be retained on the $\frac{3}{8}$ 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 2 inch sieve and be retained on the $\frac{7}{8}$ inch sieve.

Type "B" (Fine Graded Base or Leveling-Up Course):

- Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ 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 $\frac{1}{2}$ inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1 inch sieve and be retained on the $\frac{3}{8}$ inch sieve.

Type "C" (Coarse Graded Surface Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ 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 $\frac{1}{2}$ inch sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1 inch sieve and be retained on the $\frac{3}{8}$ inch sieve.

Type "D" (Fine Graded Surface Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ 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 $\frac{1}{2}$ inch sieve and be retained on the No. 4 sieve.

Type "E" (Sheet Asphalt Surface Course):

Bin No. 1—will contain aggregates of which 90 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 No. 4 sieve and be retained on the No. 10 sieve.

Type "F" (Non-skid Surface Course):

Bin No. 1—will contain aggregates of which 90 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 $\frac{3}{8}$ 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 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, and 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.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 2000 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 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 and shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test.

(4) **Forms.** The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(5) **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.

(6) **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.

(7) **Two Axle Tandem Roller.** This roller shall be an acceptable power driven tandem roller weighing not less than 8 tons.

(8) **Three Wheel Roller.** This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(9) **Three Axle Tandem Roller.** This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(10) **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 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.

(11) **Straightedges and Templates.** The Contractor

shall provide acceptable 16-foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

346.5. 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 aggregate for Types "A", "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 or provided for by special provision. Fine aggregate stockpiles may contain small coarse aggregate in the amount of up to 20 percent by weight, 100 percent of which shall pass a $\frac{1}{4}$ -inch sieve, 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 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 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.

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(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 weigh-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 by more than the tolerances herein specified.

(d) **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.

346.6. 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 the moisture and temperature of the base, 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 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 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 0.10 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 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, 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 in the forms, 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 eliminated 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 to the required density. The specified rollers shall be used, except as provided in paragraph (c) below.

(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 super-elevated curves, rolling shall begin at the low side and progress toward the high side. 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 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 displace-

ment 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.

(c) **When indicated on the plans** or permitted by the Engineer in writing, the pavement may be compacted to the required density by the use of compacting equipment other than that specified herein.

(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 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 three wheel and tandem rollers.

(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 16-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.

(7) **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.

346.7. Measurement.

(1) Asphaltic concrete will be measured separately by the ton of 2000 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

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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.

(2) Tack coat will be measured at the point of application on the road in gallons at the applied temperature. When gasoline and/or kerosene is added to the cut-back asphalt for tack coat, as ordered, measurement will be made after mixing.

346.8. 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 type specified, which prices shall each be full compensation for quarrying, furnishing all materials, freight involved, for all heating, mixing, hauling, cleaning the existing base course or pavement, placing asphaltic concrete mixture, rolling and finishing, and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except tack coat and prime coat when required.

(2) The tack coat, measured as provided under "Measurement" will be paid for at the unit price bid for "Tack Coat", which price shall be full compensation for furnishing, preparing, hauling and placing the asphaltic materials of the grade used and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

(3) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(4) 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 com-

bination of these courses as shown on the plans, each to be composed of a compacted mixture of mineral aggregate and asphaltic material. The mixture, when designed and tested in accordance with these specifications and methods outlined in THD Bulletin C-14, shall have the following laboratory density and stability:

Density, Percent			Stability, Percent
Min.	Max.	Optimum	
93	96	95	Not less than 30, unless otherwise shown on plans.

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 floor 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 Item 6 of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery. It shall contain not more than 1 percent by weight of organic matter, clays, loam or pebbles coated therewith as determined by Test Method Tex-217-F. Mineral aggregate from each source shall meet the quality tests specified herein.

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, when subjected to the sand equivalent test outlined in THD Bulletin C-14.

(a) **Coarse Aggregate.** The coarse aggregate shall be that part of the aggregate retained on a No. 10 sieve; shall consist of clean, tough, durable fragments of stone, crushed blast furnace slag, crushed gravel, gravel or combinations thereof as hereinafter specified, of uniform quality throughout. Coarse aggregate will be tested in accordance with THD Bulletin C-11 (Decantation) and material removed shall not be more than 1 percent by weight. The coarse aggregate shall have an abrasion of not more than

40 percent loss by weight when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A for all types except Type "FF" and Type "FFF", which shall have an abrasion of not more than 35 percent loss by weight when subjected to the same test. If gravel is used for Type "FF" or Type "FFF" it shall be so crushed that 90 percent of the particles retained on the No. 4 sieve shall have more than one crushed face.

(b) **Fine Aggregate.** The fine aggregate shall be that part of the aggregate passing the No. 10 sieve and shall consist of sand or screenings or a combination of sand and screenings.

Sand shall be composed of durable stone 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 not be more than 6 when tested by Test Method Tex-106-E.

(c) **Mineral Filler.** The mineral filler shall consist of thoroughly dry stone dust, slate dust, portland cement or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter. When tested by the method outlined in THD Bulletin C-14, it shall meet the following grading requirements:

	Percent by Weight
Passing a No. 30 sieve	100
Passing a No. 80 sieve, not less than	90
Passing a No. 200 sieve, not less than	65

(2) Asphaltic Material.

(a) **Paving Mixture.** Asphalt for the paving mixture shall be of the types of 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 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 and asphaltic material. 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 THD Bulletin C-14, will conform to the limitations for master grading given below for the type specified:

Type "AA" (Coarse Graded Base Course):	Percent by Weight
Passing 2" sieve	100
Passing 1 3/4" sieve	95 to 100
Passing 1 3/4" sieve, retained on 7/8" sieve.....	15 to 40
Passing 7/8" sieve, retained on 3/8" sieve.....	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve....	10 to 25
Passing No. 4 sieve, retained on No. 10 sieve..	5 to 20
Total retained on No. 10 sieve.....	65 to 80
Passing No. 10 sieve, retained on No. 40 sieve.	0 to 20
Passing No. 40 sieve, retained on No. 80 sieve.	3 to 15
Passing No. 80 sieve, retained on No. 200 sieve	2 to 15
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 3 to 6 percent of the mixture by weight.

Type "BB" (Fine Graded Base or Leveling-up Course):

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

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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 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "CC" (Coarse Graded Surface Course):

Passing $\frac{7}{8}$ " sieve	100
Passing $\frac{5}{8}$ " sieve	95 to 100
Passing $\frac{5}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	15 to 40
Passing $\frac{3}{8}$ " 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 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "DD" (Fine Graded Surface Course):

Passing $\frac{1}{2}$ " sieve	100
Passing $\frac{3}{8}$ " sieve	95 to 100
Passing $\frac{3}{8}$ " 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 8

The asphaltic material shall form from 4.0 to 7.5 percent of the mixture by weight.

Type "DDD" (Fine Graded Surface Course):

Passing $\frac{3}{8}$ " sieve	100
Passing $\frac{1}{4}$ " sieve	80 to 100
Passing $\frac{1}{4}$ " 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 8

The asphaltic material shall form from 4.0 to 7.5 percent of the mixture by weight.

Type "FF" (Non-skid Surface Course):

Passing $\frac{1}{2}$ " sieve	100
Passing $\frac{3}{8}$ " sieve	95 to 100
Passing $\frac{3}{8}$ " 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 8

The asphaltic material shall form from 3.5 to 5.5 percent of the mixture by weight.

Type "FFF" (Non-skid Surface Course):

Passing $\frac{3}{8}$ " sieve	100
Passing $\frac{1}{4}$ " sieve	95 to 100
Passing $\frac{1}{4}$ " 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 8

The asphaltic material shall form from 3.5 to 5.5 percent of the mixture by weight.

(2) **Tolerances.** The Engineer will designate the exact grading of the aggregate and asphalt content to be used in the mixture. The paving mixture produced shall not vary from the designated grading and asphalt content by more than the tolerances allowed herein and shall remain within the limitations of the master grading specified. The respective tolerances, based on the percent by weight of the mixture, are listed as follows:

	Percent by Weight
Passing $1\frac{3}{4}$ " sieve, retained on $\frac{7}{8}$ " sieve	plus or minus 4
Passing $\frac{7}{8}$ " sieve, retained on $\frac{3}{4}$ " sieve	plus or minus 4
Passing $\frac{5}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	plus or minus 4
Passing $\frac{3}{8}$ " sieve, retained on No. 4 sieve	plus or minus 4
Passing $\frac{1}{4}$ " sieve, retained on No. 10 sieve	plus or minus 4
Passing No. 4 sieve, retained on No. 10 sieve	plus or minus 4

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Total retained on No. 10 sieve	plus or minus 4
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
Asphaltic Material	plus or minus 0.3
Passing No. 200 sieve	plus or minus 2

The type and amount of the mixture used shall be as specified on the plans.

(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 THD Bulletin C-14, 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 THD Bulletin C-14 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 by the Extraction Test, THD Bulletin C-14, 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.

350.4. Equipment.

(1) **Mixing Plants.** Mixing plants that will not con-

tinuously 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 Section 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 for 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 "AA", Type "BB" and Type "CC" mixtures and at least three bins when producing Type "DD" and Type "FF" mixtures, and at least two bins when producing the other types of mixtures. If mineral filler is needed, an additional bin shall be pro-

vided. These bins shall contain the following sizes of aggregates:

Type "AA" (Coarse Graded Base Course):

- Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{2}$ " 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 $\frac{7}{8}$ " sieve and be retained on the $\frac{3}{8}$ " sieve.
- Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 2" sieve and be retained on the $\frac{7}{8}$ " sieve.

Type "BB" (Fine Graded Base or Leveling-Up Course):

- Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ " 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 $\frac{1}{2}$ " sieve and be retained on the No. 4 sieve.
- Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1" sieve and be retained on the $\frac{3}{8}$ " sieve.

Type "CC" (Coarse Graded Surface Course):

- Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ " 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 $\frac{1}{2}$ " sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1" sieve and be retained on the $\frac{3}{8}$ " sieve.

**Type "DD" (Fine Graded Surface Course) and
Type "FF" (Non-skid Surface Course):**

Bin No 1—will contain aggregates of which 90 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 $\frac{1}{4}$ " 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 $\frac{1}{2}$ " sieve and be retained on the No. 4 sieve.

**Type "DDD" (Fine Graded Surface Course) and
Type "FFF" (Non-skid Surface Course):**

Bin No. 1—will contain aggregates of which 90 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 $\frac{3}{8}$ " 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 and 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.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 2000 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 the 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 and shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test.

(4) **Forms.** The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(5) **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.

(6) **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

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by the Engineer and this pressure shall not vary by more than 5 pounds per square inch.

(7) **Two Axle Tandem Roller.** This roller shall be an acceptable power driven tandem roller weighing not less than 8 tons.

(8) **Three Wheel Roller.** This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(9) **Three Axle Tandem Roller.** This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(10) **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 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.

(11) **Straightedges and Templates.** The Contractor shall provide acceptable 16 foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

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 Type "AA", Type "BB" and Type "CC" shall be separated into at least two stockpiles of different gradation, such as 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 or provided for by special provision. Fine aggregate stockpiles may contain small coarse

aggregate in the amount of up to 20 percent by weight, 100 percent of which shall pass a $\frac{1}{4}$ -inch sieve; 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 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 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

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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** 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.

350.6. Construction Methods. The prime coat, tack coat, or the asphaltic mixture 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 conditions of the base, 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 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 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 0.10 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) **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.

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, no succeeding course shall be placed until the preceding course has cured to the satisfaction of the Engineer.

(4) **Compacting.**

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified 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 super-elevated curves, rolling shall begin at the low side and progress toward the high side.

Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller, one pneumatic 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.

(c) **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 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 16-foot straightedge placed parallel to the center line 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 ¼ 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.

350.7. Measurement.

(1) **Asphaltic concrete** will be measured by the ton of 2000 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.

(2) **Tack coat** will be measured at the point of application on the road in gallons at the applied temperature. When gasoline and/or kerosene is added to the cut-back asphalt for tack coat, as ordered, measurement will be made after mixing.

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, placing asphaltic concrete mixture, rolling and finishing, and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work, except tack coat and prime coat, when required.

(2) The tack coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", which price shall be full compensation for furnishing, preparing, hauling, and placing materials and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

(3) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(4) 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 352

HOT MIX-COLD LAID ASPHALTIC
CONCRETE PAVEMENT

352.1. 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 mixture when designed and tested in accordance with these specifications and methods outlined in THD Bulletin C-14, shall have the following laboratory density and stability:

Density, Percent			Stability, Percent
Min.	Max.	Optimum	
93	96	95	Not less than 30 except when otherwise shown on plans.

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 floor slab, as herein specified and in accordance with the details shown on the plans.

352.2. Materials.

(1) **Mineral Aggregate.** The mineral aggregate shall be composed of a coarse aggregate and a fine aggregate and if required, a mineral filler. Samples of coarse aggregate and fine aggregate shall be submitted in accordance with the methods prescribed in Item 6 of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery.

(a) **Coarse Aggregate.** The coarse aggregate shall be that part of the aggregate retained on a No. 10 sieve; shall consist of clean, tough, durable fragments of stone, crushed blast furnace slag, or gravel, as hereinafter specified, of uniform quality throughout. Coarse aggregate will be tested in accordance with THD Bulletin C-11 (Decantation) and material removed shall not be more than 2 percent by weight.

The coarse aggregate shall have an abrasion of not more than 40 percent loss by weight when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A, for all types except Type "FF" and "FFF" which shall have an abrasion of not more than 35 percent loss by weight when subjected

to the same test. If gravel is used for Type "FF" or "FFF", it shall be so crushed that 90 percent of the particles retained on the No. 4 sieve shall have more than one crushed face.

(b) **Fine Aggregate.** The fine aggregate shall be that part of the aggregate passing the No. 10 sieve and shall consist of sand or screenings or a combination of sand and screenings. Sand shall be composed of durable stone 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 by Test Method Tex-106-E.

(c) **Mineral Filler.** The mineral filler shall consist of thoroughly dry stone, dust, slate dust, portland cement or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter. When tested as provided by THD Bulletin C-14, it shall meet the following grading requirements:

Percent by Weight

Passing a No. 30 sieve	100
Passing a No. 80 sieve, not less than	90
Passing a No. 200 sieve, not less than	65

(2) Asphaltic Material.

(a) **Paving Mixture.** Asphalt for the paving mixture shall be of the types of 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 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 asphalt 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 50-70 percent by volume of the asphaltic material as specified for the type or paving mixture with 30-50 percent by volume of gasoline and/or kerosene. If RC-2 Cut-

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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".

352.3. Paving Mixtures.

(1) **Types.** The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate and asphaltic material. 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 THD Bulletin C-14, will conform to the limitations for master grading given below for the type specified:

Type "AA" (Coarse Graded Base Course):	Percent by Weight
Passing 2" sieve	100
Passing 1 3/4" sieve	95 to 100
Passing 1 3/4" sieve, retained on 7/8" sieve.....	15 to 40
Passing 7/8" sieve, retained on 3/8" sieve.....	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve....	10 to 25
Passing No. 4 sieve, retained on No. 10 sieve .	5 to 20
Total retained on No. 10 sieve.....	65 to 80
Passing No. 10 sieve, retained on No. 40 sieve.	0 to 20
Passing No. 40 sieve, retained on No. 80 sieve.	3 to 15
Passing No. 80 sieve, retained on No. 200 sieve	2 to 15
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 3 to 6 percent of the mixture by weight.

Type "BB" (Fine Graded Base or Leveling-Up Course):

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	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 20
Passing No. 80 sieve, retained on No. 200 sieve	3 to 20
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "CC" (Coarse Graded Surface Course):

Passing $\frac{7}{8}$ " sieve	100
Passing $\frac{5}{8}$ " sieve	95 to 100
Passing $\frac{5}{8}$ " sieve, retained on $\frac{3}{8}$ " sieve	15 to 40
Passing $\frac{3}{8}$ " 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 65
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 8

The asphaltic material shall form from 3.5 to 7 percent of the mixture by weight.

Type "DD" (Fine Graded Surface Course):

Passing $\frac{1}{2}$ " sieve	100
Passing $\frac{3}{8}$ " sieve	95 to 100
Passing $\frac{3}{8}$ " 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 60
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 8

The asphaltic material shall form from 4.0 to 7.5 percent of the mixture by weight.

Type "DDD" (Fine Graded Surface Course):

Passing $\frac{3}{8}$ " sieve	100
Passing $\frac{1}{4}$ " sieve	80 to 100
Passing $\frac{1}{4}$ " sieve, retained on No. 10 sieve....	20 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 8

The asphaltic material shall form from 4.0 to 7.5 percent of the mixture by weight.

Type "FF" (Non-skid Surface Course):

Passing $\frac{1}{2}$ " sieve	100
Passing $\frac{3}{8}$ " sieve	95 to 100
Passing $\frac{3}{8}$ " 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 8

The asphaltic material shall form from 3.5 to 5.5 percent of the mixture by weight.

Type "FFF" (Non-skid Surface Course):

Passing $\frac{3}{8}$ " sieve	100
Passing $\frac{1}{4}$ " sieve	95 to 100
Passing $\frac{1}{4}$ " 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 8

The asphaltic material shall form from 3.5 to 5.5 percent of the mixture by weight.

The type and amount of the mixture used shall be as specified on the plans.

(2) **Primer.** The use of an asphalt 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 in accordance with THD Bulletin C-14, 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.**

(3) **Water.** Water in an amount not to exceed 3 percent of the mixture by weight as determined in accordance with THD Bulletin C-14 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, the water shall be administered to the mix through an approved spray bar.

(4) **Central Mixing Plants.** 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 proper spreading, blading and rolling will not be acceptable.

(5) **Extraction Test.** Samples of the mixture when tested by the Extraction Test, THD Bulletin C-14, shall not vary from the grading proportions of the aggregate specified by the Engineer by more than 5 percent in any particular.

The percentage of asphalt shall not vary more than 0.4 per cent from the proportions established by the Engineer.

352.4. 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. (See Article 352.5. 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 the aggregate will not be injured in 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 "AA", Type "BB" and Type "CC" mixtures and at least three bins when producing Type "DD" and Type "FF" mixtures, and at least two bins when producing the other types of mixtures. If mineral filler is needed, an additional bin shall be provided.

Type "AA" (Coarse Graded Base Course):

- Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{2}$ " 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 $\frac{7}{8}$ " sieve and be retained on the $\frac{3}{8}$ " sieve.
- Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 2" sieve and be retained on the $\frac{7}{8}$ " sieve.

Type "BB" (Fine Graded Base or Leveling-up Course):

- Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ " 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 $\frac{1}{2}$ " sieve and be retained on the No. 4 sieve.
- Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1" sieve and be retained on the $\frac{3}{8}$ " sieve.

Type "CC" (Coarse Graded Surface Course):

- Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ " 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 $\frac{1}{2}$ " sieve and be retained on the No. 4 sieve.

Bin No. 4—will contain aggregates of which at least 85 percent by weight will be of such size as to pass the 1" sieve and be retained on the $\frac{3}{8}$ " sieve.

**Type "DD" (Fine Graded Surface Course) and
Type "FF" (Non-skid Surface Course):**

Bin No. 1—will contain aggregates of which 90 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 $\frac{1}{4}$ " 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 $\frac{1}{2}$ " sieve and be retained on the No. 4 sieve.

**Type "DDD" (Fine Graded Surface Course) and
Type "FFF" (Non-skid Surface Course):**

Bin No. 1—will contain aggregates of which 90 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 $\frac{3}{8}$ " 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 and 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.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 2000 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 or other device 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 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 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 accumulated 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 and shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test.

(4) **Forms.** The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(5) **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.

(6) **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.

(7) **Two Axle Tandem Roller.** This roller shall be an acceptable power drive tandem roller weighing not less than 8 tons.

(8) **Three Wheel Roller.** This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(9) **Three Axle Tandem Roller.** This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(10) **Trench Roller.** This roller shall be an acceptable power driven trench roller equipped with sprinkler for keeping the wheels wet and an adjustable road wheel so that roller may be kept level during rolling. The drive wheel shall be not less than 20 inches wide.

The roller shall produce 100 pounds to 325 pounds per linear inch of effective roller width and be so geared that a speed of 1.8 miles per hour is obtained in low gear.

(11) **Straight Edges and Templates.** The Contractor shall provide acceptable 16 foot straight edges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(12) **All equipment** shall be maintained in good repair and operating condition and shall be approved by the Engineer.

352.5. Stockpiling, 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.

(2) **Storage and Heating of Asphaltic Material.** 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 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 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.

(4) **Proportioning.** The proportioning of the various material 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 by more than the tolerances herein specified.

(d) **The asphaltic mixture** 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.

352.6. Construction Methods. The asphaltic mixture, tack coat or prime coat, shall be placed only when the 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

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 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 0.10 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) **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 or gutter and structures.

If primer and water are not added to the paving mixture it may be placed with specified spreading and finishing machine.

(4) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified 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 super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the 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 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 two rollers be in use on each job. Additional rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. 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.

(c) **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 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 16-foot straight edge placed parallel to the center line of the road-

352.7 to .8

way, 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 straight edge shall not exceed $\frac{1}{4}$ 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.

352.7. Measurement.

(1) **Asphaltic concrete** will be measured by the ton of 2000 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.

(2) **Tack coat** will be measured in gallons at the applied temperature at point of application on the road. When gasoline and/or kerosene is added to the cut-back asphalt for tack coat, as ordered, measurement for payment will be made after mixing.

352.8. 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 prices 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, placing asphaltic concrete mixture, rolling and finishing; and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work, except tack coat and prime coat, when required.

(2) **The tack coat**, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", which price shall be full compensation for furnishing, preparing, hauling and placing materials; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

(3) **The prime coat**, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(4) **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.

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 5 percent from the specified weight may be rejected and if the average net

weigh 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. 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.

Coarse aggregate shall have a wear of not more than 45 percent when tested according to AASHO Designation: T 96, and when tested by standard laboratory methods shall meet the following grading requirements:

Retained on 2½" sieve.....	0%
Retained on 1¾" sieve.....	0 to 20%
Retained on ½" sieve.....	25 to 70%
Retained on No. 4 sieve.....	95 to 100%
Loss by Decantation (THD Bulletin C-11)	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 man-

ner 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 stock-piled for at least 24 hours prior to use.

(4) **Fine Aggregate.** Fine aggregate shall consist of sand or a combination of sands, and shall be composed of clean, hard, durable, uncoated grains.

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, THD Bulletin C-11, the fine aggregate shall not show a color darker than the standard.

When the fine aggregate is mixed with Type III cement in the proportion of 1:3, the average strength of not less than three standard mortar briquettes at the age of 3 days shall be equal to or greater than the strength of Ottawa sand mortar briquettes of the same proportions and consistency when tested at the age of 3 days.

Fine aggregate when tested in accordance with THD Bulletin C-11 shall meet the following grading requirements:

Retained on $\frac{1}{4}$ " sieve.....	0%
Retained on No. 4 sieve.....	0 to 5%
Retained on No. 20 sieve.....	15 to 50%
Retained on No. 100 sieve.....	85 to 100%

Material removed by decantation, THD Bulletin C-11, shall not exceed 4.0 percent by weight.

Mineral Filler. Mineral filler shall consist of clean stone dust, crushed sand, crushed shell or other approved inert material. When tested in accordance with THD Bulletin C-11, 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) **Water.** Water shall be reasonably clean and free from injurious amounts of oil, acid, salt, alkali, organic matter or other deleterious substances. Water suitable for drinking may be accepted for use without being tested. If in the opinion of the Engineer, the water is of questionable quality, it shall be tested 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.

Boards 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 over 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 Liquid Components—Synthetic Polymer Type).** This sealer shall conform to the requirements specified therefor under Article 420.2 of the Item, "Concrete Structures".

(b) **Class 1-b, (Two Components, Liquid and Solid, Synthetic Polymer Type).** This sealer shall conform to the requirements specified therefor under Article 420.2 of the Item, "Concrete Structures".

(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.

(9) **Asphalt Board.** Asphalt board when used in accord-

ance 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. Boards 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 $\frac{3}{4}$ inch in $3\frac{1}{2}$ 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:

(a) Steel Dowel Bars. 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, new billet steel of intermediate or hard grade conforming to requirements specified therefor under Article 360.2 (12) of this specification item. 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 $\frac{1}{16}$ 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 dowel 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 con-

sistency 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.

(b) **Corrugated Metal Contraction Joint Form.** Corrugated metal contraction joint forms, if used in accordance with the provisions of the project plans, shall conform to the size and detail dimensions shown in the plans. Steel sheets used for corrugated metal forms shall be made by the open-hearth, basic-oxygen or electric-furnace process, shall be of 28 gage minimum thickness, and shall be galvanized in accordance with the provisions of ASTM Designation: A 93, coating class of 1.25 ounces per square foot (commercial) or heavier.

(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.** Steel reinforcing bars as required, including tie bars, shall be of the type and size as shown on plans and shall be open-hearth, basic-oxygen or electric-furnace new billet steel of structural, intermediate or hard grade, or shall be rail steel bars for concrete reinforcement. All steel shall be bent cold. When bars are to be bent, they shall be of structural grade.

New billet steel shall conform to the requirements of ASTM Designation: A 15. Rail steel shall conform to the requirements of ASTM Designation: A 16 (Bars produced by the piling method will not be accepted). Unless otherwise designated on the plans, all reinforcing steel shall be deformed bars conforming to the requirements of ASTM Designation: A 305.

When fabricated steel bar or rod mats are specified, the mats shall meet the requirements of ASTM Designation: A 184.

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) Steel Tongue-and-Groove Form for Longitudinal Joints. The trapezoidal key joint form shall conform to plan requirements and shall be made from flat hot-rolled carbon steel sheets conforming to minimum requirements of ASTM Designation: A 245, or an approved equivalent thereof.

The gage or thickness of the material shall be at least the minimum indicated on plans.

(14) Polyethylene Film. Polyethylene film shall be opaque pigmented white in color, and shall be manufactured from virgin resin without additives or scrap. The film shall have a minimum thickness of 4 mils (0.004 inch), shall have a minimum tensile strength of 1700 psi at 77 F in the longitudinal direction and 1200 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.

(15) Membrane Curing Compound. The membrane curing compound shall comply with the requirements of the Item, "Membrane Curing", Type 2 white pigmented.

(16) **Asphalt Curing.** Where asphalt is used for curing concrete base, the material shall conform to the Item, "Asphalt, 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 condition before the Contractor will be permitted to begin construction operations on which the equipment is to 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 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 mixer shall be equipped with a power controlled boom and bucket, so designed as to permit uniform distribution of the concrete on the entire subgrade. The mixer shall be operated at a drum speed of not less than 16 revolutions per minute and not more than 20 revolutions per minute. Pick-up and throw-over blades in the drum of the mixer shall be replaced when worn down $\frac{3}{4}$ inch or more.

The 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.

Multiple drum mixers will be permitted provided their operation is properly synchronized and the mixing time shall be determined exclusive of the time required to transfer concrete from one drum to the next drum.

The paver 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 attached to the paver for checking the accuracy of water measurement without seriously delaying the paving operations.

(5) **Hauling Equipment.** Batch hauling equipment for the transportation of measured materials from the batching plant to the mixer shall be tight and so covered as to prevent excessive evaporation of moisture or any loss of material.

(6) **Subgrade Planer and Templates.** An approved subgrade 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, shall not develop a deflection of more than $\frac{1}{8}$ inch. Tractive power equipment used on the subgrade to pull the planer shall not be such as to produce ruts or indentations in the subgrade.

A template for checking the contour of the subgrade 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 $\frac{1}{8}$ 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.

(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 depths 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.

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 finishing machine. 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) Mechanical Vibratory Equipment. All concrete placed for pavement shall be consolidated by an approved mechanical vibratory unit, operated ahead of the transverse finishing machine and designed to vibrate the concrete internally. A vibratory member shall extend across the pavement practically to, but shall not come in contact with the side forms, 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. Mechanically operated vibrators shall be mounted in such manner, as not to come in contact with the forms or reinforcement and not to interfere with the transverse or longitudinal joints. The frequency of the vibratory units and the method of operation shall be as determined by the Engineer.

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 vibra-

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tors shall be sufficiently rigid to insure control of the operating position of the vibrating head.

(9) 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) **The Longitudinal Finishing Machine.** The longitudinal finishing machine shall be provided with a longitudinal float not less than 10 feet in length, adjusted to a true plane, 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 finish the pavement to the required grade.

Alternate floating and finishing equipment may be substituted for the equipment specified herein when approved by the Engineer in writing, provided the finished surface conforms to the surface test requirements of Article 360.8 (3).

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 $\frac{3}{8}$ inch in thickness. The Contractor shall also provide a longitudinal float of approved design and not less than 14 feet in length.

The Contractor shall furnish a canvas or canvas-rubber composition belt for finishing the pavement, to be of two to four ply construction, not less than 6 inches nor more than 10 inches wide, and at least 2 feet longer than the width of the pavement.

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, coarse aggregate, fine 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.

(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. 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 6.5 gallons. Concrete specimens shall be prepared, cured and tested as outlined in THD Bulletin C-11.

(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 6.5 gallons. 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.

(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 specifications for intentional stoppage of placement in Article 360.6. Section (5) "Concrete Mixing and Placing", 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 1½ 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 the most economical mix design possible 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 specified paver approved for use on this project and shall produce batches of the size to be used in paving operations. No additional compensation will be allowed for equipment, materials or labor involved.

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.

(6) **Test Specimens.** Two test beams for a flexural strength value shall be taken from the concrete for each 500 square yards or less of pavement placed each day. A flexural strength value shall be the average of the strengths of the two beams. 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.** 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. 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 $\frac{1}{8}$ 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 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.

360.6. Concrete Mixing and Placing.

(1) **Mixing Methods.** The concrete shall be mixed in a mixer conforming to the requirements of Article 360.3. (4) of this specification item. Ready-Mix concrete may be used 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.

(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, 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 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.

(3) **Placing.** Any concrete not placed as herein prescribed within 30 minutes after mixing shall be rejected and disposed of as directed. 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 when the air temperature falls to 32 F 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 the time of 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, and unless otherwise indicated on plans, the full width of the pavement shall be constructed monolithically. The concrete shall be deposited on the subgrade 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 $\frac{1}{2}$ 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.

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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 form and at all joints to prevent the forming of honeycombs and voids.

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 $\frac{1}{2}$ 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. Two mixers will be required if the concrete is placed in two passes.

When wire fabric reinforcement is used, the placement shall be accomplished in two passes (double strike-off method).

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 a 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.

(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 all intersections and 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 for 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. The load transmission devices, except when placed by vibratory methods, 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 portions 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 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, and of a section to form a key not less than 1 inch in depth and 2 inches in height at the center of depth 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; otherwise, the key in the first concrete must be carefully preserved. 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, 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.

(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 has 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 overhanging.

(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 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, and 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 paragraph (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 and is to be set in advance of concrete placement it shall be secured in position by a transverse metal brace or other approved device as required by Article 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 that all corrugations are filled with concrete. Over vibration shall be avoided in all cases.

If the metal contraction joint is to be installed by an approved vibrating machine, the form shall first be rigidly clamped, without deformation, to a flat metal plate of the approximate over-all dimensions of the form, and the plate and form so assembled shall be vibrated into the concrete as a unit. The purpose of the plate is to prevent the bending of the form during installation. The plate only shall then be vibrated and slowly withdrawn from the concrete, and immediately afterward the concrete adjacent to the form on the side previously in contact with the plate shall be vibrated for the full width of the pavement by means of a hand, tubular vibrator to the extent necessary that all corrugations are filled with concrete. Over vibration shall be avoided in all cases.

(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 as soon as possible after construction of the pavement. Sawing shall not cause damage to the pavement. No traffic (including construction traffic) shall be permitted on the pavement until the longitudinal joint is cut.

(c) **Joint Sealers.** Unless otherwise specified on the plans either Class 1-a, Class 1-b, Class 2 or Class 3 materials, designated by Article 360.2(8), "Joint Sealing Material", may be used at the option of the Contractor.

Class 1-a Material. This material shall be pumped, mixed and extruded into the joint with a suitable proportioning and mixing unit.

Class 1-b Material. This material shall be blended in the liquid component container, by pouring one-half of the preweighed powder into the premeasured liquid and stirring with a blade type, slow speed paint mixer, gas or air driven. The remaining one-half of the powder shall be blended in as the mixing proceeds. The material shall be thoroughly mixed until homogeneous, with a mixing time not to exceed 5 minutes. The material shall then be poured into the joint from a suitable container.

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.

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 preclude the tendency of the material to fall out of the joint.

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.

(4) **Curbs.** The curb shall be constructed in length equal to the adjoining pavement slab length, 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 curbs. The mortar shall be composed of one part of portland cement and two parts of fine aggregate.

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 vibrators, power-driven transverse strike-off, and screed, and a power-driven longitudinal float; or such alternate equipment as may be substituted and approved under Article 360.3 (9).

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, the longitudinal mechanical float shall be operated to smooth and finish the pavement to the required grade. The float shall be operated parallel to the centerline of the pavement with a short, quick motion, and shall travel slowly across the pavement, maintaining contact with the surface at all points. If this result is not attained, additional concrete

shall be placed if required, and screeded, and the float shall operate over the same area until a satisfactory surface is produced. The advance along the length of the pavement between successive passes of the float across the surface shall be such that the float shall continuously lap its previous position by not less than one-fourth its length.

After floating 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.

After completion of the straightedge testing, and just before the concrete becomes non-plastic, the surface shall be belted with an approved belt, operated with short transverse strokes and a rapid advance longitudinally. This operation shall produce a uniform surface of a gritty texture.

After completion of belting and about the time the concrete becomes hard, the edge of the slab and joints shall be carefully finished with an edger of the radius required by plans, 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) **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. 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.

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 one 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 5½ 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 ¾ 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 Article 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 barricades 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 construc-

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tion 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 Highway Department prior to final acceptance. The thickness of the pavement will be determined by measurement of the cores taken at such points as the Engineer may select. Cores will be drilled from the width of normal thickness of section, and the thickness of individual cores will be determined by averaging at least three measurements.

(2) Pavement of a thickness within $\frac{1}{4}$ inch of the thickness required by plans will be considered of a satisfactory thickness, and the contract unit price bid shall be used in payment.

(3) Pavement of a thickness less than the thickness shown on plans by more than $\frac{1}{4}$ inch, but less than $\frac{1}{2}$ inch, will be considered of a deficient thickness, and an adjusted unit price shall be used in payment, which price shall bear the same ratio to the contract unit price as the square of the actual average thickness of the slab bears to the square of the thickness shown on plans. The length of the area of

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such deficient thickness shall be determined by additional cores taken at intervals of 10 feet along the length of the pavement in each direction until cores are obtained which are at least plan thickness. The width of such area shall be the entire width of pavement as placed in one operation, and within the length thus determined.

(4) Payment will not be made for pavement which is found deficient in thickness $\frac{1}{2}$ inch or more. The length of the area of such unsatisfactory thickness shall be determined by additional cores taken at intervals of 10 feet along the length of the pavement in each direction until cores are obtained which are at least plan thickness less $\frac{1}{2}$ inch. The width of such area shall be the entire width of pavement within the length thus determined. Such pavement shall be removed and replaced by the Contractor with pavement of the specified thickness at his entire expense for removal and replacement. Provided the deficiency in thickness is not more than $\frac{3}{4}$ inch, the Contractor, if he so elects, may leave such pavement in place, relinquishing thereby any claim for any compensation incurred in its construction.

(5) 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 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.

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)" and "Monolithic Curb" (when pavement is measured by the square yard), as required, or the ad-

justed 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 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 with-

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out 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)", and pertinent special provision thereto 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 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	1, 2 or 3	1

All other materials shall conform to the requirements of Articles 360.2(6) to 360.2(16) 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 pave-

ment 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 preparation 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 Articles 360.2.(6) to 360.2(16) inclusive, of the Item, "Concrete Pavement (Water Cement Ratio)" except that where "high yield" reinforcing steel is specified longitudinal bars shall be either (1) open-hearth, basic-oxygen or electric-furnace new billet steel conforming to the requirements of ASTM Designation: A 432; or (2) rail steel bars for concrete reinforcement, Special Grade, conforming to the requirements of ASTM Designation: A 16 (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. Transverse bars may be any of the approved grades of reinforcing steel specified in the Item, "Concrete Pavement (Water Cement Ratio)", with the provision that bars that require bending shall be of structural or intermediate grade.

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 Article 360.4. (1), (4), (5) and (6) of the Item, "Concrete Pavement (Water Cement Ratio)" shall govern for this item. Article 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 concrete shall contain not less than 4½ sacks of cement per cubic yard. The concrete mixtures shall be designed to secure an air content by volume of between 3 percent minimum and 6 percent maximum based upon measurements 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 6.80 gallons. Con-

crete 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 Section (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 used 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.

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.

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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 "Monolithic Curb" is required, measurement 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 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 (Continuously Reinforced-Hard Grade Steel)", "Concrete Pavement (Continuously Reinforced-High Yield Steel)", 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 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 pro-

visions 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 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 op-

erated that the pressure shall be from 15 to 45 pounds. 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 1½-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, "Asphalt, 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 Emul-

sions". 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.

372.4 to .5

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 as directed by the Engineer. 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 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 all material obtained from such excavation; and for the backfilling around completed structures to the level of the original ground. The work to be done shall include all necessary pumping or bailing, sheathing, drainage, and the construction and removal of any required cofferdams. Unless othrewise provided, the work included hereunder shall provide for the removal of old structures or portions thereof (such as abutments, wingwalls, piers), trees, and all other obstructions necessary to the proposed construction.

Where excavation is not classified, all excavation will be grouped under the Item, "Unclassified Excavation" and this item 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 such firm and compact materials as cannot be excavated with a clam shell or orange peel bucket, slip, pick and shovel or dredge without first being loosened or broken by blasting, sledging, or drilling.

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 written permission to the contrary is given by the Engineer, no excavation shall be made outside a vertical plane 3 feet from the footing lines and parallel thereto. When caissons are provided, no excavation will be permitted outside the outer faces of the caissons.

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(2) In order that the Engineer may 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 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 at the time the excavation in each foundation is approximately complete.

(3) The final elevation to which a foundation is to be constructed shall be as shown on the plans or as raised or lowered by written order of the Engineer when such alterations are judged proper to satisfactorily comply with the design requirements for the structure. Should it be found necessary, in the judgment of the Engineer, to increase or decrease the depth of footings from that shown on the plans, the necessary alterations in the details of the structure shall be accomplished in a manner as directed by the Engineer. The Department shall have the right to substitute revised details resulting from consideration of the 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 removal of the foundation material to grade shall not be performed until just before the footing is to be placed.

(5) All rock or other hard foundation material shall be freed from all loose material, cleaned 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 rehandling of the material during the backfilling operations. The location of storage piles shall, however, 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 provisions of Item 5.7 of the specifications shall be complied with by the Contractor in locating storage piles for excavated materials.

(7) Excavated material required to be wasted shall be disposed of as directed by the Engineer, and the disposal shall be in such manner as not to 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:

All unstable soil shall be removed to a depth 2 feet below bottom of culvert for culverts 2 feet or more in height, and to a depth equal to the height of culvert for culverts 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 for compaction as directed by the Engineer, and 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 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.

(9) When the material encountered at footing grade of a culvert is found to be partially rock, or 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 foundation 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 which is constructed to hold the surrounding earth, water, or both, out of the excavation, whether

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such structure is formed of earth, timber, steel, concrete, or a combination of these. It thus 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 is always to 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 so constructed as to sink gradually into place as material is excavated within the area protected by its sidewalls. Such 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 facilitated by the following methods:

(1) Addition of weight by increasing the thickness of caissons, where such 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.

(2) Addition of removable loads to the caisson.

(3) The use of water or air jets placed around the caisson.

(4) The use of light charges of explosives placed in a manner that will 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 the use of explosives.

(5) Steel shell caissons may be driven with a drop or steam hammer if the Contractor will, at his own expense, provide a suitable driving ring. The driving ring shall be of sufficient strength, and the manner of driving shall be regulated to preclude damage to the caisson.

When no provision for caissons is shown on the plans, it shall be the intent of this specification to require that a suitable cofferdam be provided for all excavations where such cofferdam may be necessary in order to control water conditions 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 Item 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, in so far 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, but 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 such responsibility in any manner. The interior dimensions of cofferdams shall be such as to give 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 foundation piling are to be driven inside a caisson or cofferdam and when it is judged to be impractical by the Engineer to unwater the caisson or cofferdam before placing a concrete seal, the excavation may be extended below the footing grade to a depth sufficient to allow for swell of the material during pile driving operations. After the piling have been driven, all foundation material that has risen to a level more than 1 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 unwater the caisson or cofferdam before a seal is placed, it is considered practicable to remove the foundation material to exact footing grades after foundation piling are driven. Backfilling 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 base courses are placed, and the concrete quantities involved shall be at the Contractor's expense. The Engineer shall deduct from the pay quantities for concrete in seals when the thickness of the seal is reduced due to the swellage of foundation above the footing grade.

Caissons or cofferdams which tilt or move laterally during

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the process of sinking shall be righted or enlarged, as necessary, at the sole expense of the Contractor.

Unless otherwise provided, cofferdams shall be removed by the Contractor after the completion of the substructure. The removal shall be effected in such a manner as not to disturb or mar the structure. In lieu of the entire removal of the cofferdams, the Engineer may require the Contractor to remove any portion of such or to leave such entirely in place.

400.4. Pumping or Bailing. Pumping or bailing from the interior of any foundation enclosure shall be done in such manner as to 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 it is done from a suitable sump separated from the concrete work by a water-tight wall. Pumping or bailing to unwater 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 spaces excavated under this specification and not occupied by the permanent structure shall be backfilled. Backfill 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, in which case, and 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 6 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 the required 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 those portions which are accessible to such equipment. All portions of embankment which lie so closely adjacent to any portion of any structure as to prevent compaction by the use of the blading and rolling equipment used in compacting adjoining sections of embankment shall be placed and compacted in the same manner as specified above for backfill material. These provisions shall be construed to require the mechanical compaction, by means of either rolling equipment or mechanical tamps or rammers, of all backfill and embankment adjoining the barrels and wing walls 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 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.

All portions of fill and backfill described in the preceding paragraph shall be compacted to the same density requirements as 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 7 days. No backfill shall be placed adjacent to single and multiple boxes until the top slab has been in place at least 4 days.

Backfill placed around abutments and piers shall be de-

posited 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 wedge 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:

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. The method and degree of compaction shall be the same as specified in Section 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 Section 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. In the case of embankments, the remainder of the fill above the top of 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 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.

400.6. Determination of Excavation Quantities. Determination of Plan 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, except the barrels of pipe culverts, no material outside of vertical planes 1 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 1 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 2 feet beyond the horizontal projection of the outside surfaces of the pipe and parallel thereto will be included. (These limits apply only to the barrels. The limits described in paragraph (1) apply to the headwalls, wings, inlets, manholes, etc. of pipe culverts.)

(3) If a caisson, as herein defined, is shown on the plans, only material to the outside face of such caisson will be included.

(4) If a cofferdam, as herein defined, is used, the limitations of (1) above 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 1 foot beyond the face of the member and parallel thereto and will be limited vertically to a depth of 1 foot below the bottom of such member.

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(6) Except as allowed by the above conditions, no account will be taken of any excavation necessary for placing forms or falsework.

(7) On all structures, except side road culverts, where the contract plans call for road excavation at the structure site such road excavation 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 road excavation. Excavation for side road and private entrance pipe culverts shall not be measured for payment but shall be considered as part of the roadway excavation. Excavation for side road and private entrance pipe culverts will be measured for payment if no roadway excavation is involved at the culvert location.

(8) On all structures of bridge classification as defined in Item 1.31 of the Standard Specifications where the contract plans call for channel excavation at the structure site such channel excavation 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 Item 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) In all cases where excavation diagrams are shown on the plans, such diagrams 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) Measurements 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 or other incompressible material is under-cut in order to provide suitable foundation for pipe

or box culverts, such material below grade, as is ordered by the Engineer to be removed, will be measured for payment.

(13) 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. In addition, final determination of structural excavation 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 as 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 which is within the scope of this specification, additional measurement shall 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 shall be made by the addition to, or the deduction from, the original quantities for the volume of excavation involved in the authorized grade change.

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 Sections 400.6. (13) and (14) and paragraph 4 of this section, and for the removal of unstable and incompressible material as noted below. This payment shall be full compensation for all excavation and backfill including compaction; all soundings; sinking all caissons; constructing all cofferdams; all unwatering; 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 which follow, and except for materials used in caissons when shown on plans with provisions for separate payment therefor.

To avoid the grouping of excavation of widely different character into a single bid item, the proposal may show

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"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", and "Unclassified Structural Excavation-Culverts".

Payment for removal and replacement of unstable or incompressible material below the footing grades of culverts and box sewers as provided for in Section 400.2. will be made at a unit 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 the suitable material required to replace the unstable or incompressible material, and for all labor, equipment, tools, and incidentals necessary to complete the work.

Should it be necessary, in the opinion of the Engineer, 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 5 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 5 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 1 foot or more below the grade shown on plans.

In cases where the extra depths required for any footing or footings exceeds 10 feet, a supplementary 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 Item 4.3 will not apply to overruns due to extra depth of 10 feet or less.

Payment will be made for any cofferdam material required to be left in place but only to the extent that its salvage value exceeds the cost of removing it from the ground and from the site.

No direct payment will be made for filling or backfilling around structures. Payment for the backfilling and compacting of those areas which were removed as structural excavation shall be included in the unit prices bid for the various classes of structural excavation. 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."

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

401.2

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, 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 plus 1 foot on each side of the pipe, 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 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 accommodate the class of bedding indicated on the plans and conforming to bedding requirements of Item 464, "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

401.2

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

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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 Item 421, "Concrete for Structures". 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. Determination of Excavation Quantities.

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 sewers of 42 1/2 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 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 sewer appurtenances no material outside of vertical planes 1 foot beyond the edges of the footings and parallel thereto will be included.

(4) 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.

(5) For all sewers where the contract plans call for road excavation, such road excavation shall be assumed to have been completed before starting the sewer excavation and the measurement of sewer excavation will include only material below or outside the limits of the completed road excavation.

(6) Excavation quantities required for constructing sewers in fill above natural ground, as specified in Section 401.2. (1) paragraph 4, will be measured for payment. Quantities will include that area as specified in (1) or (2) above, plus 1 foot above the top of the pipe, regardless of the height of fill previously made.

(7) Cement stabilized backfill shall be measured as dimensioned on backfill diagrams as shown on the plans.

(8) In all cases where excavation diagrams are shown on the plans, such diagrams shall take precedence over these provisions.

(9) 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

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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 compacting of those areas which were removed in accordance with these specifications shall be included in the unit price bid for "Sewer Excavation".

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 the driving of piling.

The requirements herein are minimum. Strict compliance with these minimum requirements will not relieve the Contractor of the responsibility for 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 made to grade and thoroughly compacted as provided in the governing specifications prior to the driving of abutment piling.

Foundation piling shall not be driven until after the excavation is approximately complete.

All piling raised during the process of driving adjacent piling shall be driven again. Broken, split, or misplaced

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, and allowable variations from the plan alignment shall not exceed the following:

(1) In the direction of the center line of the structure, the top of the completed piling shall not be more than 2 inches from the position as shown on the plans.

(2) In the direction along the center line of the bent, the top of the completed 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 completed pile shall 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.

The minimum concrete cover for piling in footings shall be 5 inches and the pile shall be in such position to permit proper placement and cover of reinforcing steel.

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 pile being driven shall be used. Wood cushion blocks shall be used as necessary to prevent damage to the pile. Rope mat, belting, or other similar cushioning material may be used in addition to wood cushion blocks.

For concrete piling, a cushion block shall be provided for the top of the pile. This block shall be at least 4 inches in thickness and made of a material which will not compress to such an extent that the cushioning effect is lost. Green oak, gum, or similar material is usually satisfactory. Cushion blocks shall be changed as necessary to prevent damage to the pile.

404.5. Driving Equipment. The driving of piling shall be done with power hammers (steam or diesel). When specified on the plans, gravity hammers will be permitted.

Either steam or compressed air may be used as the operating medium for steam hammers.

Steam hammers shall be furnished with boiler or air compressor capacity at least equal to that specified by the manufacturers of the hammers to be used. The boiler or compressor shall be equipped with an accurate pressure gauge at all times.

Diesel hammers which have an enclosed ram shall be equipped with a gauge and charts which will evaluate the equivalent energy actually being produced under any driving condition.

The valve mechanism and other parts of all power hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed will be obtained.

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.

Type Piling	Type Hammer	Minimum Energy (Foot-pounds)	Weight Hammer or Ram (Power Hammer)		Maximum "h" in Feet
			Min.	Max.	
Timber	Gravity		2000 lb.	3500 lb.	15
	Power	6000 Min., 9000 Max.			
Steel H and Metal Shell	Gravity Required Bearing Under 30 tons 30-37 tons Over 37 tons		2000 lb. 2500 lb. 3000 lb.	5000 lb. 5000 lb. 5000 lb.	15 15 15
	Power	250 x R* or 2½ x Wp whichever is larger	Open end Diesel 2000 lb.		
Concrete (All Sizes)	Gravity		½ Wp but not less than 3000 lb.		8
	Power Single Acting or open end Diesel	10,000, but not less than one ft.-lb. per per lb. of Wp	Open end Diesel 2000 lb.		
(15-inch or smaller)	Double Acting or enclosed ram Diesel	8000, but not less than one ft.-lb. per lb. of Wp			
(16-inch or larger)	Power Single Acting or open end Diesel	15,000, but not less than one ft.-lb. per lb. of Wp	Open end Diesel 2700 lb.		
	Double Acting or enclosed ram Diesel	12,000, but not less than one ft.-lb. per lb. of Wp			

R*—Design load in tons.

Wp—Weight of piling in pounds.

TABLE 1
Size of Driving Equipment

When gravity (drop) hammers are used, the height of drop shall be regulated to avoid injury to the piling and in no case shall exceed the maximum drop shown in Table 1. The Contractor shall furnish the Engineer a certified scale weight of the hammer to be used.

Concrete piling shall not be subjected to excessive tensile stresses due to the combination of a particular hammer with the given soil conditions. When such damage occurs, the Contractor shall make such changes necessary to provide undamaged piling in place.

If such damage occurs, the Engineer may require:

- (1) Reduced energy delivered to the piling. This may be reduced stroke, change in cushioning, or a lighter ram.
- (2) Equivalent energy but with heavier or lighter ram with different stroke.
- (3) Smaller hammer for the easier initial driving.
- (4) Pilot holes or jetting equipment.

Where test piling or test loads are required, the hammer used in driving all other piling shall be of the same type and size as the hammer used in driving the test piling.

Pile drivers shall be equipped with leads which are constructed in such manner as to afford freedom of movement of the hammer and which provide adequate support to the pile during driving. The vertical axis of the leads and hammer shall coincide with the vertical axis of the pile.

Except where piling are driven through water, the leads shall be of sufficient length that a follower will not be necessary. Where a follower is required for the driving of piling under water, one piling in each ten, shall be of sufficient length that a follower is not required. This piling shall be driven as a test piling for proper correlation of the follower-driven piling in the group.

404.6. Penetration. The length of piling shown on the plans is the length which is estimated to give the required bearing and is 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 stability. Piling shall be driven to this "minimum penetration" and to such greater depths required to obtain the specified bearing resistance.

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For point bearing piling when the plans show a "required penetration" into a particular stratum of rock, shale, or other hard material, this penetration into the strata will be required although the strata may be found at a higher or lower elevation than is indicated on the plans.

Where no specific information is shown on the plans as to penetration, and where test piling are not required, the pile lengths shown shall be considered as the "plan penetration" and 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 required by the contract, the piling lengths and the penetration required will be established by the Engineer on the basis of the test pile or test load data. These lengths and elevation of penetration shall supersede all other requirements for penetration of the piling. In these cases, piling shall be driven to the approximate penetration and to such greater depths as are necessary to obtain the bearing resistance required by the plans.

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.

404.7. Pilot Holes. Pilot holes will be required when the material is not suitable for jetting.

The size and depth of pilot hole required or permitted shall be determined by the Contractor, with the approval of the Engineer, from the results of trial operations made on the first few piling driven. Generally, the diameter of hole permitted will be approximately 4 inches less than the diagonal of square piling or steel H piling, 2 inches less than the diagonal of octagonal piling, and one inch less than the diameter of round piling. These size requirements may be varied by the Engineer as may be necessary to obtain penetration and/or bearing values contemplated by the design.

Where pilot holes are required in granular material, and the materials cannot be sealed off by ordinary "mudding" drilling methods, a casing pipe of sufficient diameter shall be placed around the boring device. The casing shall be of sufficient length to extend down through the upper strata of loose materials to the firm material and be held in position until the pilot holes are completed and the driving of the concrete piling is started and has progressed to a sufficient

depth through the hard material to prevent sand and other loose material from dropping into the pilot hole.

In all cases, piling after being placed in the pilot holes shall be driven to the required bearing resistance with a minimum penetration of one foot below the pilot hole depth or 100 hammer blows.

404.8. Jetting. For jetting operations sufficient power shall be provided, in addition to that used for operating the hammer, to operate one or more pumps and a minimum of two 2½ inch diameter jets provided with three-fourths inch diameter nozzles. The plant shall be such that with two jets operating at the same time it shall be capable of delivering a minimum of 150 psi pressure at each nozzle.

The jetting operations may be done with the use of one or two jets as determined by the Contractor, and approved by the Engineer from the results of trial jetting operations. The required jetting may be done ahead of the actual pile-driving operations or simultaneously with the driving operations as determined by the Engineer from the results of trials.

If jets and hammers are used simultaneously, the jet shall be withdrawn and the final penetration of the pile obtained by driving with the hammer alone, with a minimum of one foot of penetration or 200 blows of the hammer with the required bearing resistance obtained.

404.9. Bearing Resistance. The bearing resistance of all piling will be determined by the following formulas:

For gravity hammers:

$$P = \frac{2WH}{S + 1.0}$$

When the energy delivered ($W \times H$) by the gravity hammer is 24,000 foot pounds or greater, and the penetration does not exceed one-half inch per blow for the last 40 blows delivered (without increasing), the bearing resistance will be determined by:

$$P = \frac{2WH \times N}{3S}$$

For single-acting power hammers:

$$P = \frac{2WH}{S + 0.1}$$

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For double-acting power hammers:

$$P = \frac{2E}{S + 0.1}$$

P = bearing resistance in pounds.

S = average penetration in inches per blow for the last 20 blows. (40 blows for special formula for gravity hammer).

W = weight of ram in pounds.

H = height of fall of ram in feet.

N = ratio of weight of ram to the weight of the pile. N will not be used when greater than 1.

E = manufacturer's rated energy in foot-pounds (for double-acting steam hammers).

E = the equivalent energy in foot-pounds, determined by gauge attached to the hammer taken during the period when the average penetration in inches per blow is determined. (for enclosed ram diesel hammer). The maximum value of E to be used shall not exceed that shown in Section 404.10 below.

404.10. Rating of Hammers. When rating diesel hammers for energy 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.

The maximum energy rating allowed for the double-acting (enclosed ram) hammer shall be approximately 85 per cent of the rated output given by the manufacturer.

404.11. Length Determination. Piling shall be driven and evaluated by one of the following:

(1) The piling shall be driven to the "minimum penetration", the "required penetration", or to the "plan penetration" as required by the plans and as defined in Section 404.6., Penetration. The pertinent formula for the hammer provided will be used to determine the bearing resistance.

(2) Test piling as specified on the plans shall be driven and the pile lengths determined from the test pile data. The pertinent formula for the hammer provided will be used to determine the bearing resistance.

(3) Test piling shall be driven and test loaded as required, and the pile lengths determined from the test load

data. The pertinent formula for the hammer provided will be used to determine the dynamic resistance.

For all driving subsequent to the load tests, the piling shall be driven to the approximate pile tip elevation as determined by the Engineer from the load test data. The bearing resistance of these piling will be determined using the pertinent formula for the hammer provided, modified by the factor

$$K = \frac{L}{P}, \text{ where:}$$

K = a factor which provides a static correction to an otherwise dynamic formula.

L = maximum safe static load proven by load test in accordance with Item 405, "Test Loading Piling".

P = dynamic resistance determined by the appropriate formula for the hammer used on the test loaded piling with no K factor applied.

This method will be required by the Engineer when it is determined that a load test is needed to establish the bearing capacity of the piling driven under one or more of the other Driving Methods.

(4) When the maximum safe static load of the piling has been predetermined by adequate soil tests, piling as specified on the plans shall be driven to the elevations shown. The pertinent formula for the type hammer provided will be used to determine the dynamic resistance.

For all driving subsequent to the selected piling, the piling shall be driven to the approximate elevations shown on the plans. The bearing resistance of these piling will be determined using the pertinent formula for the hammer provided,

modified by the factor $K = \frac{R}{P}$, where:

K = as defined in 404.11 (3) above.

R = maximum safe static load as predetermined by soil studies and designated on the plans.

P = dynamic resistance determined by the appropriate formula for the hammer used on the selected piling with no K factor applied. When several piling are driven, for this method, the average dynamic resistance for the selected piling will be used.

404.12. Measurement and Payment. No direct measurement or payment will be made for the work to be done or

405.1 to 405.3

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

TEST LOADING PILING

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.

The piling to be test loaded shall be as specified on the plans or as designated by the Engineer. A complete record of the driving resistance shall be made under the supervision of the Engineer.

The test load shall not be applied to the pile until 5 days after driving.

Unless otherwise specified, the Department will furnish the jacking equipment, suitable jacking beams, and extensometers.

The Contractor shall furnish and drive the piling to be test loaded and such anchor piling that may be necessary, and shall furnish all necessary material, labor, work, tools, equipment, 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, all materials shall be removed by the Contractor in a manner satisfactory to the Engineer.

The pile test load shall be that type shown on the plans, or as designated by the Engineer.

405.2. Piling. The test piling shall be of the same type and cross section as the piling specified for use in the structure. When precast concrete piling are to be test loaded, prestressed concrete piling of the same size and section may be used.

Permanent piling may be used as anchor piles. Piling other than permanent piling shall be removed or cut off at least 1 foot below the bottom of the footing or finished elevation of the ground upon completion of the test load.

The requirements for driving of piling to be test loaded shall be in accordance with Item 404, "Driving Piling".

405.3. Location. The test load shall be performed at

the locations and upon piling shown on the plans or as designated by the Engineer. At the discretion of the Engineer the number of test loads may be increased or decreased.

405.4. Method of Loading. Test loading piling shall consist of the application of incremental static loads to a pile and measuring the resulting settlements. The loads may be applied by jacks acting against suitable anchorage, by platform loading transmitting the load directly to the pile, or other methods designated by the plans or approved by the Engineer.

The test load shall be applied in increments as directed by the Engineer. The first increment shall consist of approximately the design load. Gross settlement readings, loads, and other data shall be recorded by the Engineer immediately before and after the application of each increment of load and at intermediate intervals of 15 minutes. Each succeeding increment of load shall consist of approximately one-third the design load. Loads shall not be applied until 2 hours after all measurable settlement due to the previous loading has ceased. Measurable settlement is considered to be 0.005 inch or more.

When the estimated net settlement reaches a value of 0.12 inch (recorded gross settlement minus estimated deformation computed by the elastic deformation formula) or the pile has been loaded to twice the design load, each succeeding increment of load shall consist of approximately one-fourth or one-fifth of the design load. These loads shall not be applied until 4 hours after all measurable settlement due to the previous loading has ceased.

All loads applied to the piling will be in multiples of 5 tons.

When the estimated net settlement reaches a value of 0.25 inch or a minimum of two times the design load is obtained, the loading shall be discontinued and a standard (AASHO) 48-24 hour test will be run.

The 48-24 hour test shall consist of maintaining the load on the pile at a constant value for a **minimum** period of 48 hours and until 24 hours have elapsed after all settlement of the pile has ceased. Readings for gross settlement will be made every 15 minutes during this period. A settlement of 0.005 inch or less for the final 24 hour period shall be classed as "no settlement." At the conclusion of the standard 48-24 hour test, all load shall be removed and the pile al-

405.5

lowed to recover. Readings shall be taken at 15 minute intervals for a period of 4 hours to establish the time at which the pile comes to rest.

When the recorded net settlement is found to be appreciably less than 0.25 inch, the pile shall be reloaded to the same load as before, and gross settlement readings made until 4 hours have elapsed after all settlement has ceased. Suitable increments of load as designated by the Engineer shall be added which is anticipated to give a final net settlement of 0.25 inch. The standard 48-24 hour test then shall be repeated at this higher load.

If the total gross settlement at the end of a successful 48-24 hour test is less than 0.30 inch, further loading shall be made without unloading and measuring of net settlement.

These tests at higher loads shall be repeated until the net settlement exceeds 0.25 inch or until the capacity of the test loading equipment is reached.

405.5. Evaluation of Tests. All test loads shall be carried to at least twice the design load, and to the point of theoretical failure which occurs when the net settlement exceeds 0.25 inch.

When the estimated net settlement exceeds 0.25 inch prior to reaching twice the design load, loading shall cease and the piling shall be unloaded and the recovery recorded. If the recorded net settlement exceeds 0.25 inch, the piling shall be further driven to a greater resistance as designated by the Engineer.

After five days the piling shall be test loaded further in accordance with the requirements outlined above.

The maximum safe static load shall be 50 percent of that load which, after a minimum of 48 hours after application (the last 24 hours of which is without increase in settlement), causes a permanent settlement of not more than 0.25 inch, measured at the top of the pile. If the test load causes a permanent net settlement in excess of 0.25 inch, having met all other test criteria, then the allowable design load shall be 50 percent of that load obtained by interpolation from the computed net settlement line value of 0.25 inch which was obtained by calculation based upon the actual recorded recovery.

This maximum safe static load will be the value used to establish a K factor for use with the dynamic hammer formula as specified in Item 404, "Driving Piling."

405.6. Measurement. Measurement for the test loading of piling will be made for each "Test Load" satisfactorily performed and accepted, except that those test loads designated to be performed in accordance with Item 9.4, Payment for Extra Work, will not be measured herein.

When additional driving and loading of a pile is required in order to satisfactorily complete a test load, this shall be considered a part of the original 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 and labor, for furnishing and driving all necessary anchor piling not a part of the permanent structure, for the use of all tools and equipment and for all incidentals necessary to complete this work.

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 Item 404, "Driving Piling", and Item 405, "Test Loading Piling".

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 Yellow Pine or Douglas Fir, impregnated with a preservative of such quantity and process as shown on the plans and/or as specified in the governing specifications. 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, 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 occurring 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 $\frac{7}{8}$ 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 summerwood measured over the third, fourth, and fifth inches from the center of the pile along a radial line. Where there are

les 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 1½ 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 per cent of the inner bark shall be removed. In no case shall any piece of inner bark be over ¾ 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 ¼ 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 shall be allowable, 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 from 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, 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 accepted. 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

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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 Section 406.5 of this specification. 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 the 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 Grade 1 creosote oil as provided in Item 492, "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.

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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 Item 9.4, Payment for Extra Work, 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 shown on the plans and in the locations as shown on the plans.

Driving and test loading of piling (when required), shall be in accordance with Item 404, "Driving Piling", and Item 405, "Test Loading Piling".

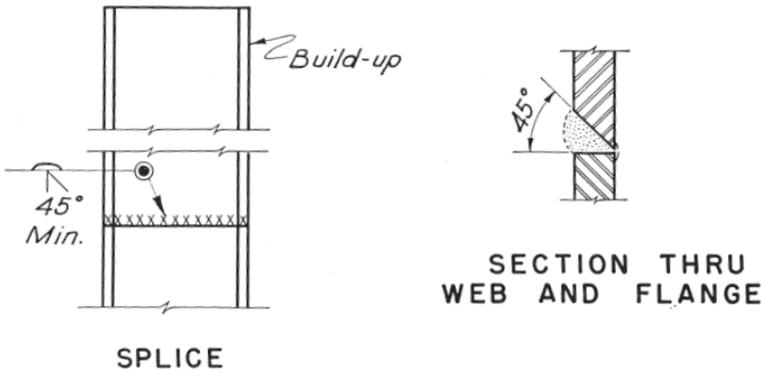
Unless otherwise shown on the plans, the embankment at bridge ends shall be in place, thoroughly compacted, and to grade prior to driving end bent piling.

407.2. Material. The steel H piling and steel sheet piling shall be manufactured in accordance with Item 441, "Steel Structures", and Item 442, "Metal for Structures".

407.3. Storing and Handling. 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 methods of handling shall be such that damage to the piling will not result. The stored piling shall be kept clean and fully drained at all times.

407.4. Cut-Offs, Splices, and Build-Ups. All splices for steel piling shall be made in accordance with the details as 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.



STEEL BEARING PILING DETAIL

After the piling has been driven to the approximate penetration and bearing resistance to satisfy the design requirements, the piling shall be cut off level, with a cutting torch, or by other acceptable methods, to the plan grade or the grade established by the Engineer. Where pile heads are required by the plans, the end surfaces of the piling shall be made as smooth as practicable before the pile head is welded in place. The pile head shall conform to the plan details.

If the head of the piling is appreciably distorted or otherwise damaged below cut-off level, the damaged portion shall be cut off and replaced with an undamaged section spliced in place at the Contractor's expense.

Welding shall be in accordance with Item 448, "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. Concrete for concrete collars shall be mixed and placed in conformance

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with Item 421, "Concrete for Structures", and Item 420, "Concrete Structures".

The surface of the piling to be covered by the concrete collar shall be cleaned thoroughly 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 that will 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 that portion of the collar below the permanent ground line. Where the sides of the hole are not stable the form shall extend to the bottom of the collar. All concrete in concrete collars shall be cured for a minimum of 4 curing days, in accordance with Item 420, "Concrete Structures".

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 with two field coats of 701 paint and one field coat of 702 or 802 paint, in accordance with the requirements of Item 446, "Paint and Painting". Painting shall extend to a point 1 foot below surface of ground unless 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 as shown on the plans or as designated by the Engineer.

The driving equipment shall be of such size as required to drive the piling to the required depths with no damage to the piling. The equipment shall be equipped with a head suitable to the shape of the sheet pile.

407.8. Measurement. Measurement of Steel H Piling will be made by the linear foot of acceptable piling in place after all cut-offs and build-ups have been made, to which measurement shall be added 2 feet for each authorized splice made.

For those piling specified to be driven to a "minimum penetration", no measurement will be made on that portion of piling 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 in the placing of collars and in 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". 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 pile splice 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 splice is made, except that no payment will be made for any splice on any pile whose actual length left in place, after all cut-offs, splices, or buildups have been made, is not greater than the length shown on plans or specified by the Engineer as the result of test pile investigations, nor will payment be made for more than one splice on any one pile.

No payment will be made for cut-off or splices of sheet piling.

The foregoing shall be full compensation for furnishing

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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 Item 9.4, Payment for Extra Work, 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 Item 404, "Driving Piling", and Item 405, "Test Loading Piling".

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.

All metal in the shell shall conform to Item 442, "Metal for Structures". All concrete materials and their preparation and placing shall be in accordance with the requirements of Item 420, "Concrete Structures", and Item 421, "Concrete for Structures", except that the use of a jointed pipe will not be required. All concrete shall be Class "A" unless otherwise shown on the plans. Reinforcement shall conform to the requirements of Item 440, "Reinforcing Steel". The sizes and dimensions of reinforcing steel shall be as shown on the plans. Welding shall be done in accordance with Item

448, "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 the 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 to .7

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 pouring concrete and 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 with two field coats of 701 paint and one field coat of 702 or 802 paint, in accordance with Item 446, "Paint and Painting" and in compliance with the following additional requirements.

Where the pile enters the ground at an elevation above the normal water level, the first coat of paint may be applied either before or after driving at the option of the Contractor, but in either case the cleaning and painting shall extend to a point not less than one foot below the surface of the ground.

Where the pile enters the ground at an elevation at or below normal water level, a portion of the shell of sufficient

length shall be cleaned and painted before driving to insure that, when the shell is driven to final position, the painted section will extend from a point at least 2 feet above normal water level to a point at least 3 feet below normal water level. The first coat may be applied to the remaining exposed surfaces of pile either before or after driving.

After the shells are driven, filled with concrete, and capped, any scars or marred places in first coat shall be corrected by spot painting. The second coat then shall be applied to all exposed surfaces of piling above a point 1 foot below ground level for piling not standing in water or above the normal water line for piling standing in water.

After the paint has dried, earth removed for the cleaning and painting shall be replaced in such manner as to build up the ground surface around the pile to a level slightly above the surrounding ground.

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 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.

409.1 to .3

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 Item 9.4, Payment for Extra Work, 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 as shown on the plans.

Driving and test loading of piling (when required), shall be in accordance with Item 404, "Driving Piling" and Item 405, "Test Loading Piling".

Unless otherwise shown on the plans, the embankment at bridge ends shall be in place, thoroughly compacted, and to grade prior to driving of end bent piling.

Precast concrete piling shall be cast on the job. Hauling to the project from a central casting plant will not be permitted.

409.2. Designation and Selection of Piling. For the purpose of these specifications, the Contractor may select Precast Concrete Piling which is governed by this specification, or may select Prestressed Concrete Piling in which case, Item 412, "Prestressed Concrete Piling" shall govern except that Section 409.6, Workmanship and Tolerances, and Section 409.7, Defects and Breakage, will govern for both types of piling bid under this item.

In either case, the piling shall be of the shape, size, and section as required by the plans, and reinforced in accordance with the plan requirements and the pertinent specifications.

409.3. Materials. All concrete shall be Class "A" unless otherwise shown on the plans. Concrete materials and their preparation and placing shall be in accordance with the requirements of Item 420, "Concrete Structures" and Item 421, "Concrete for Structures".

Reinforcement shall conform to the requirements of Item 440, "Reinforcing Steel". The sizes and dimensions shall be as shown on the plans.

409.4. Construction Methods.

(1) **Forms.** In addition to the applicable requirements for forms as provided in Item 420, "Concrete Structures", the following shall govern for precast concrete piling.

Forms shall be supported on an unyielding foundation. When timber sills are used, the sills shall be of dimensions that will support the weight of the concrete without settlement. The spacing of sills or joists shall be such to prevent sagging of the bottom forms. Where piling beds are to be located on a subgrade which may be softened and made yielding when wetted, the sills or joists shall be supported on stakes driven into the subgrade. The spacing of such stakes shall be as required to insure continuous uniform support to the piling.

Piling which are to be turned over for removal of a single unit steel form shall be cast on a sand bed of 6-inch minimum thickness above an unyielding foundation. The sand bed shall be kept clean and free of all coarse aggregate, extraenous concrete, or other hard material.

Form lumber for bottom and side forms shall be not less than $\frac{3}{4}$ inch thick after surfacing. Timber forms for piling shall be lined with an approved type of form lining material such as masonite, plywood, or equal; except that such lining will not be required on piling which are completely hidden from view in the finished structure, nor will lining be required on any portion of the piling in structures where the governing specifications do not require a similar lining for the forms for the pile caps. If desired by the Contractor, forms for concrete piling may be constructed of plywood not less than $\frac{1}{2}$ inch in thickness. The clear spacing of the supporting studs and joists shall not be more than 20 times the actual thickness of the lumber or plywood. The grain of the face plies on such plywood forms shall be laid parallel to the length of the pile between supporting studs and joists. All forms shall be constructed mortar-tight and shall be so maintained as to eliminate the formation of surface marks on the concrete due to the shrinkage of the lumber or plywood.

Unless otherwise provided, all corners of forms for square piling shall be chamfered, using a 1-inch chamfer strip.

When metal forms are used, these shall be of approved design conforming to the requirements for forms as provided in Item 420, "Concrete Structures", except that corners may be filleted or rounded.

Forms re-used shall be oiled and maintained in good condition as to accuracy of shape, rigidity, strength, mortar-tightness, and smoothness of surface. Any warped or bulged lumber must be properly sized and reconditioned before re-using.

Forms shall be so constructed as to provide accessibility for placing, tamping, and consolidation of the concrete. Side forms for piling 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 piling, provided that removal of forms is done in such a manner that curing is not interrupted on any piling for more than 30 minutes. In the process of removing the side forms, the pile shall not be moved on its supports, but shall remain supported throughout the minimum curing period specified.

With the use of a single unit steel form, piling may be turned over for removal of the form, after the concrete has attained a flexural strength of not less than 400 psi as evidenced by test beams made from the same concrete and cured in the pile bed under the same conditions as the piling. Upon removal of the forms, curing operations shall be continued.

(2) Casting. Reinforcement shall be spaced accurately and rigidly supported in accordance with the requirements of the specifications for "Reinforcing Steel". All longitudinal bars shall be uniformly spaced from the top ends of the piling.

Concrete shall be placed continuously in each pile and shall be carefully vibrated and special care shall be exercised to avoid horizontal or diagonal cold joints. Mechanical vibrators of an approved type shall be used. The operation of such mechanical vibrators shall be to the extent required for thoroughly compacting the concrete but shall be carefully done in order to avoid displacement of the reinforcing steel. On completion of the casting, the pile shall be date-marked.

Due to the close spacing of reinforcement in the pile tips, special care shall be taken in placing concrete to avoid the use of large sizes of aggregates in the tips. The concrete

shall be deposited and large particles shall be moved as required to insure complete filling of the space between the bars and to avoid honeycomb in the interior of the pile.

(3) **Curing.** Immediately following the completion of the casting operations, the top surface of the pile shall be struck off and hand floated. As soon as the casting operation is complete for each pile, the pile shall be covered with wet cotton mats. The wet cotton mats shall remain in place until such time as the side forms are removed. When the side forms are stripped, the entire pile or bed of piling, including the ends, shall be covered with wet cotton mats, or with wet earth, or by ponding. The mats or earth shall be maintained in a saturated condition throughout the curing period. If ponding is used, the piling shall be submerged throughout the curing period. In the process of removal of side forms and the placing of curing material, the piling shall be kept covered and wet to the greatest extent practicable, and in no case shall the piling surfaces be permitted to become dry. It is the intent of the curing provision to provide not only for keeping the piling wet, but also to provide for covering the piling for the purpose of maintaining the concrete under uniform curing conditions so that the heat resulting from the concrete setting process will be dispelled gradually and uniformly. Piling shall be cured for a minimum period of 6 days and until the concrete has attained a flexural strength of not less than 500 psi or a compressive strength of not less than 3000 psi, as determined by tests of specimens made and tested in accordance with the provisions of THD Bulletin C-11 and cured in the pile bed under the same conditions as the piling. During this curing period, piling shall remain in their original position on the casting platform and shall not be moved or shifted in any manner, except as specified above for use of single unit steel forms. The piling may be removed and driven immediately upon the completion of this curing period.

(4) **Finishing.** Portions of trestle piling which are exposed to view after the piling are driven shall be given a surface rubbing on completion of the placing of concrete in the structure, except that such rubbing will not be required on piling when the pile caps or the portions of slab units forming the pile caps are not required to be rubbed. The finishing shall be in accordance with the provisions of Item 420, "Concrete Structures".

Foundation piling or that portion of trestle piling which

409.5 to .7

will be below the ground surface will not be required to be given a rubbed finish.

The requirements herein for form construction and casting of piling are intended to provide for a completed pile free of porous or honeycombed areas or other surface imperfections which may require pointing or patchwork to be done on the concrete surfaces. In cases where such results are not obtained, it shall be the charge of the Contractor to accomplish the necessary pointing, trimming, and surface repairing by methods that will not defeat the requirements for continuous curing as specified.

409.5. Handling and Storing. The method of storing and handling piling shall be such as to minimize the danger of fracture by impact or undue bending stresses while being handled or driven. Unless otherwise provided, concrete piling shall be handled by means of a suitable bridle or sling attached to the pile at points indicated on the plans. Pick up lengths and other references to handling shown on the plans represent extremes under which the piling can be expected to withstand reasonably careful handling. In any case, broken or cracked piling shall be cause for immediate review and correction of the conditions leading to the failure. The use of chain slings will not be permitted.

After the curing and strength requirements have been met, the piling may be removed to a storage area if not designated for immediate use. In such case the piling shall be stored above ground on adequate blocking that will prevent undue stresses in the piling.

409.6. Workmanship and Tolerances.

The maximum sweep (curvature along the axis of the pile) shall not exceed $\frac{1}{4}$ inch per 10 foot of length of the pile.

The head of the pile shall be so constructed that it shall not be out of square by more than $\frac{1}{8}$ inch.

Small areas of honeycomb which are purely surface in nature (not over 1-inch deep) may be repaired. Honeycomb to an extent greater than that described above, shall be rejected temporarily, subject to structural review.

409.7. Defects and Breakage. Piling cracked in the process of curing, handling, or driving, whether or not the limiting stresses as specified on the plans have been exceeded, shall be subject to the following provisions:

(1) Any piling which is cracked to the extent that the crack shows severe spalling or is open sufficiently to indicate that the reinforcing has been permanently distorted shall be rejected if the crack occurs in a portion of the pile which will be below ground when the pile is driven.

(2) Piling cracked as described in (1) and on which the crack occurs in a portion of the pile which is not below ground when the pile driving is completed may be used in the structure provided that the Contractor will, at his own expense, cut the concrete of the pile back to the crack, and then treat the pile as a build-up as herein after provided in these specifications. The build-up shall be made to grade after the pile is driven, regardless of the amount of cut-off or build-up that would have been required had the pile not been cracked.

(3) Piling which have cracks that show spalling, and which cracks are closed sufficiently to indicate that no permanent distortion of the reinforcement has occurred, may be used in the structure, if the Contractor will, at his own expense, waterproof the area over the crack with an approved epoxy waterproofing material. For cracks $1/32$ inch in width or greater the crack shall have a vee formed $1/8$ inch in width and in depth so that the epoxy waterproofing will have depth and width over the crack.

The waterproofing shall be applied over the crack and an area at least 1-inch each way from the crack. If, in the process of pile driving, cracks develop in the portion of the pile which will be below ground, the driving operations shall be stopped for a sufficient length of time to permit the required waterproofing to be done before the crack enters the ground.

(4) Fine hair cracks or checks on the surface of the pile which, as determined by the Engineer, do not extend to the plane of the nearest reinforcing steel, will not be cause for extra treatment or for rejection of piling under these specifications, except that piling may be rejected if such cracks are numerous and extensive enough that inadequate curing is apparent.

(5) If any prestressing tendon or portion thereof is broken prior to placing of concrete, it shall be replaced with a satisfactory unit properly prestressed. The breaking of one wire of a seven wire strand during concrete placing operations will be subject to a structural review prior to acceptance.

409.8 to .9

(6) All replacements or repairs as herein specified as well as all other replacements due to faulty materials or construction methods shall be made at the Contractor's expense.

409.8. Cut-Offs, Splices, or Build-Ups. Extensions, splices, or build-ups of concrete piling, when necessary, shall be made in accordance with the details shown on the plans.

Welding of reinforcing steel shall be in accordance with the provisions of Item 448, "Structural Welding".

Concrete at the end of the pile shall be cut back the required amount leaving the reinforcing steel exposed. The final cut of the concrete shall be normal to the axis of the pile and any damage to the pile shall be remedied by further cut-back.

The form work necessary for the build-up shall then be placed, care being taken to prevent leakage along the pile. The concrete used for the build-up shall be of the same quality as that used originally in the pile. Just prior to placing the concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement grout.

If no further driving is required, the removal of forms, curing, and finishing shall be in accordance with the provisions governing concrete columns in Item 420, "Concrete Structures".

Where additional driving is required the build-up portion shall be water cured 6 curing days.

409.9. 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 provided for concrete 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.

Loading tests will be required when called for on the plans. When the required bearing, 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.

409.10. Measurement. Concrete piling will be measured by the linear foot of acceptable piling in place after all cut-offs and build-ups have been made, to which measurement shall be added 2 feet for each authorized splice made, other than those made necessary by improper casting or handling or driving of piling.

Measurement of the piling to be load tested will be made by the linear foot of acceptable test piling in place, prior to the cutting off of the piling to final plan grade. 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, to which measurement will be added 2 feet for each authorized splice made, other than those made necessary by improper casting, handling, or driving of the piling.

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 load tests will not be measured as cut-offs since payment for these portions of piling is provided for in the preceding paragraph.

When 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 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.

409.11. Payment. Concrete 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 and is structurally acceptable and driven to the required penetration and bearing.

Cut-offs for both regular piling and test piling will be paid for at one-half the unit price bid per linear foot for "Con-

410.1 to .2

crete 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 precast piling (cast, but not driven) in accordance with the provisions of Item 9.6, Partial Payments.

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 Item 9.4, Payment for Extra Work, 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 410

DISPLACEMENT PILING

410.1. Description. This item shall govern for the furnishing of displacement piling in place, of the types and sizes shown on the plans and described herein, and in the locations as shown on the plans.

Driving and test loading of piling (when required), shall be in accordance with Item 404, "Driving Piling", and Item 405, "Test Loading Piling".

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.

410.2. Designation and Selection of Piling.

Designation	Type Piling	Specification Item
A	Concrete	409 or 412
B, C, D, E	Metal Shell	408

The Contractor shall have the option of selecting the type of piling to be used subject to the following conditions:

(1) All trestle piling which will be exposed to view, in any particular structure, or in any pair of adjacent, parallel structures shall be of the same type.

(2) End bent piling, foundation piling, and other piling

not exposed to view may be of different types provided that all piling of the same substructure unit are of the same type.

(3) Where test piling or test loading is used or required, all piling shall be of the same type as the test pile which governs that structure, or that portion of the structure, except that a prestressed concrete pile of the same size and section may be used for a test pile when a precast pile is to be used.

(4) Where conditions make the use of certain types undesirable, the plans will so indicate and the type or types prohibited shall not be used.

410.3. Construction.

(1) Type A piling may be of either precast or prestressed concrete, of the dimensions shown on the plans. When used in the structure under this specification, all of the requirements of Item 409, "Concrete Piling", or Item 412, "Prestressed Piling", except as modified herein, shall apply.

It is the intent of this specification that the Contractor shall determine the lengths to which piling shall be cast. The Engineer shall furnish the Contractor with all boring data, soil test data, etc., that is available.

No piling shall be cast to a length less than that required for the minimum specified depth of penetration, or less than the lengths established by test piling, when test piling are required by the plans.

The Contractor may drive test piling to aid in determining the proper length for casting piling. No extra payment will be made for these test piling. If the test piling is driven in a correct location and is otherwise satisfactory, it shall be paid for as any other piling in the structure.

(2) Types B, C, D, and E piling shall consist of metal shells of the type as shown and detailed on the plans. When used in the structure under this specification, all of the requirements of Item 408, "Metal Shell Piling" except as modified herein, shall apply.

410.4. Measurement. Displacement piling will be measured for payment by the linear foot of acceptable piling in place after all cut-offs and build-ups have been made, except that where piling are driven to depths greater than required to meet the specified penetration and bearing re-

410.5 to 412.1

quirements, no measurement and payment will be made on that portion of piling below the level at which penetration and bearing requirements were first obtained. Portions of required test piling, directed by the Engineer to be driven below the level at which penetration and bearing were first obtained shall be measured for payment.

410.5. Payment. Displacement piling will be paid for at the unit price bid per linear foot for the specified size of "Displacement Piling", measured as designated above.

No 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 "Displacement Piling".

Test piling when shown on the plans, will be paid for at the unit price bid per linear foot for "Displacement Test Piling". When test piles are driven at the option of the Contractor, payment will be made at the unit price bid per linear foot for "Displacement 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.

A partial allowance will be made for materials and for precast or prestressed piling (cast, but not driven) in accordance with the provisions of Item 9.6, Partial Payments.

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 Item 9.4, Payment for Extra Work, 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 412

PRESTRESSED CONCRETE PILING

412.1. Description. This item shall govern for the furnishing of prestressed concrete piling, in place, of the size, type, and in the locations as shown on the plans.

The piling may be natural aggregate concrete, lightweight

aggregate concrete, pretensioned, or post-tensioned, as specified by the plans.

Driving and test loading of piling (when required) shall be in accordance with Item 404, "Driving Piling", and Item 405, "Test Loading Piling".

The piling shall be of the shape, size, and section and shall be reinforced and prestressed in accordance with the plan requirements.

Unless otherwise shown on the plans, the embankment at bridge ends shall be in place, thoroughly compacted, and to grade prior to driving of end bent piling.

412.2. Materials. All concrete shall be Class "F" or Class "Y" unless otherwise specified on the plans. Concrete shall be in accordance with Item 421, "Concrete for Structures" and/or Item 423, "Lightweight Concrete for Structures", as the case may be.

Prestressing materials and prestressing shall be in accordance with Item 426, "Prestressing". Unless otherwise specified on the plans, seven-wire strand shall be used in pretensioned piling.

Unprestressed reinforcement shall be in accordance with Item 440, "Reinforcing Steel".

412.3. Construction Methods. The design, mixing, hauling, placing, curing, quality, and finishing of concrete, construction and removal of forms, submission of hauling details, prestressing details and plant facilities plans, tensioning release of stress to the concrete, inspection facilities, and other pertinent requirements of Item 420, "Concrete Structures", Item 425, "Prestressed Concrete Structures", and Item 426, "Prestressing", shall apply to the construction of piling under this item.

Piling shall not be moved except as permitted for removal to a curing area or hauled from the casting yard until all tensioning, curing, and strength requirements have been met.

Piling will be considered adequate for strength requirements after curing and tensioning requirements are fulfilled and the strength of the concrete, as represented by test cylinders, has reached the "Design Strength" as specified by Item 425, "Prestressed Concrete Structures", or as designated on the plans.

412.4 to .5

Side forms for piling 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 piling, providing that removal of forms is done in such a manner that curing is not interrupted on any piling for more than 30 minutes.

The use of white pigmented membrane curing compound is authorized for use on piling to control shrinkage cracks. This does not eliminate or take the place of any other curing requirements, except that where steam curing is to follow the application of membrane curing, wet mat curing will not be required.

Piling may be driven seven days after casting provided all of the above requirements are met.

412.4. Cut-Offs, Splices, or Build-Ups. Where extensions or build-ups are required, such shall be made in accordance with the detailed requirements of the plans.

Concrete at the end of the pile shall be cut back the required amount leaving the prestressed strand exposed. The final cut of the concrete shall be normal to the axis of the pile and any damage to the pile shall be remedied by further cut-back.

The form work necessary for the build-up then shall be placed, care being taken to prevent leakage along the pile. The concrete used for the build-up shall be of the same quality as that used originally in the pile, except that if no further driving is required, Class "A" concrete may be used on piling made with Class "F" concrete. Just prior to placing the concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement grout.

If no further driving is required the removal of forms, curing, and finishing shall be in accordance with the provisions governing concrete columns in Item 420, "Concrete Structures".

Where additional driving is required, the build-up portion shall be water cured six curing days.

412.5. Handling and Storage. Pick-up lengths and other references to handling shown on the plans represent extremes under which the piling can be expected to withstand reasonably careful handling. In any case, broken or cracked piling shall be cause for immediate review and correction of the con-

ditions leading to the failure. The use of chain slings will not be permitted.

Piling shall be supported during hauling so as not to exceed the moments shown on the project plans. Piling may be hauled supported throughout the length of the pile or when hauled only partially supported, the overhang shall not exceed the lengths permitted for pick-up. When piling are to be hauled by any other method, drawings showing the points of support shall be submitted to the Engineer for approval prior to hauling, in accordance with Section 425.2. C.

412.6. Workmanship and Tolerances. Workmanship and tolerances shall be in accordance with Item 409, "Concrete Piling".

412.7. Defects and Breakage. Defects and breakage shall be in accordance with Item 409, "Concrete Piling".

412.8. 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 provided for prestressed concrete 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 shall be given the option of driving test piling for his own information in estimating the length of piling, even though such are not required or indicated on the plans.

Loading tests will be required when called for on the plans. When the required bearing, 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.

412.9. Measurement. Prestressed concrete piling will be measured by the linear foot of acceptable piling in place, after all cut-offs and build-ups have been made, to which measurement shall be added 2 feet for each authorized splice made, other than those made necessary by improper casting, handling, or driving of piling.

Measurement of the piling to be load tested will be made by the linear foot of acceptable test piling in place, prior to the cutting-off of piling to final plan grade. Measurement

412.10

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, to which measurement will be added 2 feet for each authorized splice made, other than those made necessary by improper casting, handling, or driving of the piling.

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 load tests, will not be measured as cut-offs since payment for these portions of piling is provided for in the preceding paragraph.

Where the Contractor chooses to cast piling to extra length to eliminate protrusion of reinforcing steel, such length will not be measured for payment as either piling or cut-offs.

When 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 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.

412.10. Payment. Prestressed concrete piling will be paid for at the unit price bid per linear foot for the specified size of "Prestressed Concrete Piling", or "Prestressed 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 "Prestressed Concrete Piling", if so located as to form a portion of the completed structure as shown on the plans and is structurally acceptable and driven to the required penetration and bearing.

Cut-offs for both regular piling and test piling will be paid for at one-half the unit price bid per linear foot for "Prestressed 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 prestressed concrete piling, (cast, but not driven) in accordance with the provisions of Item 9.6, Partial Payments.

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 Item 9.4, Payment for Extra Work, 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 shafts with or without bell type concrete footings. Concrete shafts shall be placed in drilled excavation when the shafts are without bell type footings and in drilled and under-reamed excavation when shafts are with bell type footings. Such foundations shall be constructed in accordance with this item and in conformance with the details and governing dimensions shown on the plans.

416.2. Materials. All concrete materials and their preparations shall be in accordance with the requirements of Item 421, "Concrete for Structures", and the additional requirements herein. All concrete shall be Class "A" unless otherwise shown on the plans.

When casing of the shaft is required, the following shall apply:

(1) The maximum size coarse aggregate shall be 1½ inches.

(2) The elapsed time from beginning of placement of concrete in the **cased** portion of the shaft until extraction of the casing is begun shall not exceed 30 minutes. If a cement dispersing agent is used, this time shall not exceed one hour. If non-agitating equipment is used to haul the concrete from a central mixing plant, the elapsed time from discharge of concrete from the mixer to placement in the shaft shall not exceed 10 minutes. If a cement dispersing agent is used, this time shall not exceed 30 minutes.

(3) When the temperature of the air or concrete is above 85 F, an approved cement dispersing agent will be required in all drilled shaft concrete.

Reinforcing steel shall conform to the requirements of Item 440, "Reinforcing Steel". The sizes and dimensions shall be as shown on the plans.

416.3. Construction Methods

(1) **Excavation.** The Contractor shall do all excavation required for the shafts and bell footings, through whatever substances encountered, and to the dimensions and elevations shown on the plans or required by the site conditions. Unless otherwise shown on the plans, all shafts shall be bored plumb to a tolerance of $1\frac{1}{2}$ inches for depths up to and including 10 feet plus an additional tolerance of 0.05 inch per foot for depths in excess of the first 10 feet. When bells are required, they shall be excavated so as to form a bearing area of the size and shape shown on the plans. Shafts and bells may be excavated either by hand or by mechanical methods. Blasting methods shall be used only with permission of the Engineer and when used shall be so conducted as to avoid disturbance of the formations below or outside the limits of the proposed shaft concrete.

The plans indicate the expected depths and elevations at which satisfactory bearing material will be encountered, and this information will be used as a basis for the contract. If satisfactory foundation materials are not encountered at plan elevations, the footings may be raised or lowered as determined by the Engineer. Alterations in plan depths shall be made as judged proper to satisfactorily comply with the design requirements.

Casings will be required for shaft excavations when such provision is necessary to prevent caving of the material or when necessary to shut off seepage water. Casings shall be of metal and of ample strength to withstand handling stresses, the pressure of concrete and of the surrounding earth or backfill materials, and shall be watertight. The inside diameter of casing shall not be less than the nominal size of shaft; otherwise, the size of casing and the size of drilled excavation in which the casing is to be placed will be left to the discretion of the Contractor, except as noted below. No extra compensation will be allowed for the concrete required to fill an oversize casing or oversize excavation.

When the drilling operation reaches a point where caving conditions and/or excess ground water is encountered, no further drilling will be allowed until a construction method is employed which will prevent any caving that tends to make the excavation appreciably larger than the size of casing to be used. Drilling in a mud slurry without removal of cuttings, or other construction methods which will control the size of excavation, will be permitted.

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 shall be required to control caving of any material into the freshly placed concrete.

Any excavation for the footing bells or shafts beyond the lines required by the plan dimensions, where casings are not required, shall be backfilled with Class "A" Concrete at the Contractor's expense. Where casings are used, the Contractor will be permitted to backfill around the upper portion of the casing with pea gravel or other granular material. Where a double casing is required for a portion of the shaft, no material shall be placed between the casings, but this area will be filled with Class "A" Concrete.

Under normal operations when the casing is to be removed, the removal shall not be started until all concrete placement is completed in the shaft. Movement of the casing for short pulls of a few inches, or rotating of the casing to insure the breaking of bond of the concrete to the casing will be permitted. When unusual conditions warrant, the casing may be pulled in partial stages. In all cases a sufficient head of concrete shall be maintained at all times above the bottom of the casing to overcome hydrostatic pressure. Extraction of the casing shall be at a slow, uniform rate and the pull shall be in a truly vertical direction. If any upward movement of the concrete and/or steel inside the casing occurs at any time during the pulling operation, the following criteria shall govern:

(a) If the upward movement is one inch or less, the casing may be left in place and the shaft used if the concrete is vibrated or rodded to reconsolidate the concrete. Vibration or rodding shall not be used to attempt to break the casing loose for extraction unless the entire shaft is to be replaced.

(b) If the upward movement is greater than 1 inch, all of the material shall be removed and the entire drilled shaft operation shall be redone.

Placing of drilled shaft concrete under water shall not be done without the permission of the Engineer. If such permission is granted, underwater concrete shall be placed in accordance with Item 420.14 and limited to placement with a tremie.

Material excavated from shafts and bells and not used in the backfill around the completed bents or piers shall be

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disposed of as directed by the Engineer. The disposal of such material shall be in such manner as not to obstruct 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 and all loose material shall be removed from the base area.

The Contractor shall provide suitable access and lighting for the Engineer to inspect the completed foundation excavation and check the dimensions and alignment of drilled shafts and the under-reamed excavation when under-reaming is required.

At any time when a person is in the hole, provisions shall be made for pumping fresh air to the workmen. Any required lighting shall be by electric lights. Any mechanical equipment used in the excavation shall be operated by air or electricity. The use of gasoline driven engines placed in 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 drilled shafts in the end bents, the embankment at the bridge ends shall be made to grade as shown and thoroughly compacted as provided in the governing specifications prior to drilling for end bent shafts.

(2) Reinforcing Steel. The reinforcing steel cage for the shaft consisting of longitudinal bars and spiral hooping or lateral ties shall be completely assembled and placed into the shaft as a unit. Generally, the reinforcing steel unit shall not be placed until immediately before concreting operations are to be started.

The longitudinal bars shall be tied or tack-welded to the spiral hooping at intervals not to exceed 12 inches on centers to provide a rigid unit.

For cased shafts where the reinforcing steel cage is over 30 feet in length, the longitudinal bars shall be tied or

tack-welded at each intersection of the spiral hooping for a distance of $L/5$ from the bottom of the cage.

The cage of reinforcing steel shall be supported from the top by some positive method, to prevent slumping downward during extraction of the casing.

In uncased shafts, side spacer blocks of concrete shall be used at intervals along the shaft to insure concentric spacing for the entire length of shaft. In cased shafts concrete spacer blocks shall not be used. Metal "chair" type spacers shall be placed vertically at 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 Item 420, "Concrete Structures", and in conformance with the requirements herein.

Preferably, concrete shall be placed immediately after all excavation is complete and reinforcing steel placed.

Concrete placing shall be continuous from the beginning of placing in the shaft or footing bell to the top of shaft or to construction joint as may be indicated on the plans. Time intervals will be allowed for pulling casings, for placing forms, and other operations necessarily carried on in sequence with the placing operations. The reinforcing steel cage shall be held vertical in some manner to restrain the steel from slumping during the concrete placement operation.

Concrete shall be placed through a suitable tube to prevent segregation of concrete materials and unnecessary splashing on the reinforcing steel cage. The tube shall be made in sections to permit the discharge and raising 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.

Wherever a casing is used, the casing shall be smooth and well oiled and shall extend sufficiently above the grade of the finished shaft to provide excess concrete to be placed for the anticipated slump due to the casing removal. Where a casing is to be pulled, the concrete placed in casing shall be of such workability as to require no vibrating or rodding.

Where a cap block or groundline strut is shown on the plans to be placed at the top of the drilled shaft, and the cap or strut is shown to be placed monolithic with the drilled shaft, a time interval will be allowed for placing the required form and reinforcing after any necessary casing removal.

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After a placement is completed, the top surface shall be cured and any construction joint area shall be treated as prescribed in Item 420, "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 to determine 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 under-reaming of bells, on specified test holes, will be required to establish the ability to under-ream in the soil strata present.

The diameter and shape of the test bell shall be as shown on the plans or as directed by the Engineer.

416.6. Measurement. Acceptable drilled shaft in place of the specified diameter will be measured by the linear foot. At interior bents and piers, shafts will be measured from a point 6 inches below the ground elevation at the center of shaft unless otherwise indicated on the plans. At highway-highway grade separations and at railroad underpasses, the ground elevation shall be the completed roadway section under the structure. At stream crossings and at railroad overpasses, the ground elevation shall be considered as the elevation existing at the time drilling begins. At abutment bents the length of shaft shall be measured from the bottom of cap elevation.

Footings bells, constructed to the specified dimensions, or to the altered dimensions as authorized by the Engineer will be measured by the cubic yard of concrete in the acceptable footings placed. The bell shall consist of the authorized footing volume outside the dimensions of the drilled shaft, which for the purpose of measurement will be considered as extending to the bottom of the bell.

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 of the specified diameter and shape will be measured by each test bell acceptably under-reamed.

416.7. Payment. Drilled shafts will be paid for at the unit price bid per linear foot of the specified diameter of "Drilled Shafts", subject to the following limitations for overruns authorized by the Engineer:

(1) Payment for individual completed shaft lengths up to and including 5 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 Shafts".

(2) Payment for that portion of individual completed shaft length in excess of 5 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 Shafts".

(3) Payment for individual completed shaft lengths over 15 feet in excess of the maximum plan length shafts as defined herein, will be in accordance with Item 9.4, Payment for Extra Work.

(4) For extra depth drilling for interior bents and piers, the maximum plan length shaft will be considered to be maximum length shaft, regardless of diameter, for all interior piers and bents of all bridges included in the contract.

(5) For extra depth drilling for abutment bents, the maximum plan length shaft will be considered to be the maximum length shaft, regardless of diameter, for all abutment bents of all bridges included in the contract.

The 20 percent limitation referred to in Item 4.3, Changes and Alterations, will not apply to overruns due to extra depth of drilled shafts.

· Footing bells, constructed to the specified dimensions or to the altered dimensions as authorized by the Engineer, will be paid for at the contract unit price bid per cubic yard for "Bell Footings". Authorized increase in footing bell diameters beyond three times the nominal shaft diameter, unless specified on plans, shall be considered as beyond the scope and intent of these specifications, and payment for such increased footing bells shall be in accordance with Item 9.4, Payment for Extra Work.

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 specified diameter, will be paid for at the contract unit price bid for each "Test Bell".

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Test holes or test bells required by the Engineer, but not otherwise specified by the contract plans, will be paid for in accordance with Item 9.4, Payment for Extra Work.

The foregoing unit prices shall be full compensation for making all excavations, for drilling all test holes and test bells, doing any necessary pumping, placing, and removing any required casings, furnishing, and placing all concrete and reinforcing steel except as noted below, all backfilling and furnishing all tools, labor, equipment, and incidentals necessary to complete the work. Where the bottom of drilled shaft is ordered to be placed at an elevation below plan grade and a splice of reinforcement is required, payment will be made at the unit price bid per pound for "Reinforcing Steel" for the extra reinforcement required to make one 20 diameter lap splice per bar. No extra payment will be made for casings left in place.

No partial estimates will be allowed for "Bell Footings" or for "Drilled Shafts" until the concrete has been placed, except that partial payments will be made for concrete and reinforcing steel materials delivered on the work in accordance with the provisions of Item 9.6, Partial Payments.

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 specifically waived or revised by another governing specification.

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 and 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 Item 421, "Concrete for Structures" or Item 423, "Lightweight Concrete for Structures".

The class of concrete for each type of structure or unit shall be as specified on the plans.

(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 the following types unless specifically noted otherwise on the plans:

1. "Preformed Bituminous Fiber Material" shall be formed from cane or other suitable fibers of a cellular nature securely bound together and uniformly impregnated with a suitable asphaltic binder and shall meet the requirements of the Standard Specifications for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction, ASTM Designation: D 1751.

2. "Preformed Non-Bituminous Fiber Material" shall be formed from cane or other suitable fibers of a cellular nature securely bound together with a suitable binder and shall meet the requirements of the Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction, ASTM Designation: D 1751, except that the requirements pertaining to bitumen content and the testing thereof shall be voided.

(b) Joint Sealing Material.

1. **Class 1-a.** (Two Liquid Component—Synthetic Polymer Type)

This sealer shall be a two liquid component, cold-extruded, synthetic polymer, which will form an effective seal against water and incompressibles. Curing is to be by polymerization and not by evaporation of solvent or fluxing of harder particles.

2. **Class 1-b.** (Two Components, Liquid and Solid, Synthetic Polymer Type)

This sealer shall be a two component (liquid and solid) cold-poured synthetic polymer, which will form an effective seal against water and incompressibles. Curing is to be by polymerization and not by evaporation of solvent or fluxing of harder particles.

3. **Performance Requirements.** The joint sealing materials, when tested in accordance with Test Method Tex-525-C shall meet the following requirements:

It shall cure sufficiently in three hours so that it will not pick up under wheels of traffic.

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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) **Asphalt Board.** Asphalt board shall consist of two liners of 0.016 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 three-fourths of an inch in three and one-half inches.

(3) Waterstop.

(a) Unless otherwise designated on the plans, copper waterstop shall be 16 ounce material conforming to Item 442, "Metal for Structures".

(b) Rubber waterstop or Poly-vinyl-Chloride (PVC) waterstop shall be in conformance with Item 435, "Elastomeric Materials".

(4) Curing Materials.

(a) Membrane curing shall conform to Item 531, "Membrane Curing".

(b) Cotton mats shall conform to the requirements of ASTM Designation: C 440.

(c) **Polyethylene Sheeting.** Polyethylene Sheeting shall be opaque pigmented white in color, and shall be manufactured from virgin resin without additives or scrap.

The film shall have a minimum thickness of 4 mils (0.004 inch), shall have a minimum tensile strength of 1700 psi at 77 F in the longitudinal direction and 1200 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.

(d) Burlap-Polyethylene Mats. Burlap-polyethylene mats shall be made from 9 ounce burlap suitable for curing concrete and impregnated on one side with a film of white opaque polyethylene. The polyethylene film shall be manufactured from virgin resin with no scrap or resin or additives other than pigments. The burlap-polyethylene mats shall be free of visible defects and shall have a uniform appearance.

Methods of Testing:

Moisture Retention. The moisture retention of the burlap-polyethylene mats will be determined by the current Method of Test for Water Retention Efficiency of Liquid Membrane-Forming Compounds and Impermeable Sheet Material for Curing Concrete, ASTM Designation: C 156.

Dimension. The thickness of the polyethylene film will be determined by the current Method of Test for Thickness of Solid Electrical Insulation, ASTM Designation: D 374.

Physical Requirements:

The burlap-polyethylene mats shall consist of burlap weighing not less than 9 ounces per linear yard, 40 inches wide, impregnated on one side with a 0.004 inch thick film of white opaque polyethylene material. The polyethylene material shall be bonded to the burlap so that there will be no separation of the materials during the handling of the mats and the curing of the concrete.

The burlap-polyethylene material shall be furnished in mats of convenient length and width to adequately fit the structure on which it is to be used.

When tested for moisture retention, the burlap-polyethylene mats shall restrict the moisture loss to not more than 2 percent after 24 hours and 4 percent after 72 hours.

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420.3. General Requirements. Before starting work, the Contractor shall inform the Engineer fully as to the methods of construction he proposes to follow and as to the amount and character of equipment he proposes to use, the adequacy of which shall be subject to the approval of the Engineer.

Before construction, plans shall be submitted to the Engineer for review and approval, covering forms and falsework for concrete piers and concrete superstructure spans over 20 feet in length and for all widening details. Similar plans shall be submitted for other units of the structure if requested by the Engineer. The plans shall be prepared on standard sheets 22 by 36 inches overall size. The plans shall be sufficiently complete to show all essential details of the proposed forms, falsework, and bracing so that a structural analysis may be made. In general, not over six sets of such plans will be required.

Concurrence on the part of the Engineer in any proposed construction methods, approval of equipment, or approval of form and falsework plans shall 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, the following requirements shall govern for the time sequence in which construction operations may be carried on and for the opening of completed structures to traffic.

Steel I-beams, plate girders, precast concrete members, or forms and falsework for superstructures shall not be erected on concrete substructures until the concrete in the substructure has cured at least 4 curing days. Concrete for concrete slab or girder spans or concrete slabs on steel I-beam, plate girder, or prestressed concrete spans, shall not be placed until the concrete in the substructure has cured at least 7 curing days.

Steel trusses or plate girders to be erected from the ground on approved falsework may be erected when the substructure has cured 4 curing days, but the falsework shall not be removed until the substructure has cured at least 7 curing days. Erection by means of a traveler on the span will not be permitted until the substructure has cured at least 7 curing days.

Forms for walls or columns shall not be erected on concrete footings until the concrete in the footing has cured at least 2 curing days. Concrete may be placed in the wall or

column as soon as the forms and reinforcing steel placement are approved.

The use of completed portions of a structure as the site for mixing operations or for storage of materials will not be permitted until the particular portion of the structure has aged at least 7 curing days.

A curing day shall be as defined in Section 420.21. In continued cold weather the construction operations may be authorized at the end of a period of calendar days equal to twice the number of curing days specified above.

Structures shall not be opened to construction traffic or to the traveling public until authorized by the Engineer. Such authorization may be given when the last concrete placed has cured at least 7 curing days but not until the requirements for form and falsework removal have been fulfilled. This authorization shall cover only such traffic that complies with legal load limitations.

420.4. Drains. Weep hole drains and roadway drains shall be installed and constructed as shown on the plans.

If not shown on the plans, weep holes shall be provided in all "U" type abutments, retaining walls, and in parallel wingwalls of culverts where the height of wall is over 5 feet. Weep holes shall be not less than 3 inches in diameter and not more than 10 feet apart. The outlet end of weep holes shall be placed just above the footing or natural ground line.

420.5. Expansion Joints. Expansion 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, prestressed concrete beams, girders, and slab and girder spans, shall be given a steel trowel finish. These areas shall be finished to the exact grades required. Separation of these surfaces from the substructure concrete shall be made in accordance with the plans. The material used to separate expansion surfaces shall be placed carefully so that concrete or mortar cannot be subsequently worked around or under the material.

Armor joints and finger joints shall be constructed carefully in order to avoid defective anchorage to the steel and to avoid porous or honeycombed concrete adjacent to same.

All open joints, and joints to be filled with joint sealing material, shall be constructed using forms adaptable to loosening or early removal. In order to avoid jamming such forms by the expansion action of the spans and the consequent spalling and/or cracking of the adjacent concrete, these forms shall be removed or loosened soon after the concrete has attained its final set. A provision for loosening the forms to permit free expansion of the span without the necessity for full removal is preferred.

When designated on the plans at a "Type A" joint, preformed fiber joint material shall be used in the vertical joints of the roadway slab, curb, median, and sidewalk. The top one inch of the joint shall be filled with joint sealing material. The premolded joint material may be set low, with removable form material filling the top one inch, or may be full height, and later routed out to the one inch depth.

All upper surfaces adjacent to the "Type A" joint shall be tooled to a one-quarter of an inch radius.

Prior to placing the joint sealing material, the vertical faces of the joint shall be cleaned of all laitance by sand blasting or by mechanical routing. Care shall be taken to prevent spalling of adjacent surfaces. Edges which are cracked or spalled shall be removed. The joint then shall be blown clean of all foreign material and the joint sealed.

When the joint is poured at temperatures less than 50 F, the material shall be poured one-fourth inch to three-eighths inch below the top of the slab.

Unless specified on the plans, either the 1-a or 1-b materials designated above by Section 420.2.(2)(b), Joint Sealing Material, may be used at the option of the Contractor.

Class 1-a Material. This material shall be pumped, mixed, and extruded into the joint with a suitable proportioning and mixing unit.

Class 1-b Material. This material shall be blended in the liquid component container, by pouring one-half of the pre-weighed powder into the pre-measured liquid and stirred with a blade type, slow speed paint mixer, gas or air driven. The remaining one-half of the powder shall be blended in as the mixing proceeds. The material shall be mixed thoroughly until homogeneous, with a mixing time not to exceed 4 to 5 minutes. The material shall then be poured into the joint from a suitable container.

For placement of the Class 1-b material 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 horizontal joint shall be poured and cured. The vertical faces then shall be taped or formed and the material poured into the vertical joint from the top.

Preformed fiber joint material, 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 preclude the tendency of the material to fall out of the joint.

Careful workmanship shall be exercised in the construction of all joints to insure that the concrete sections are separated completely by an open joint or by the joint material and to insure that the joints will be true to the outline indicated. Immediately after the removal of forms and again where necessary after surface finishing, all projecting concrete shall be removed along exposed edges in order 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. When concrete in a structure or a portion of a structure is specified to be placed monolithic, the term monolithic shall be interpreted to mean that the manner and sequence of concrete placing shall be such that construction joints will not be created.

Construction joints will be of the type and at the locations shown on the plans. Additional joints will not be permitted without written authorization from the Engineer. Any additional construction joints 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 horizontal joints.

When designated on the plans as a "Type B" joint, the groove may be either formed or sawed to a width of one-half inch and a depth of one inch. For roadway slab construction joints it is preferable to pour the slab without openings between the sections and saw the groove to the

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proper dimensions after the deck slab has been completed. The sawing shall be done in such manner to prevent spalling. When the joint is formed, the adjacent edges shall be tooled to a one-fourth inch radius. The faces of the formed or sawed joint shall be cleaned as specified in Section 420.5 above.

The joint then shall be filled with either Class 1-a or 1-b material. Methods of placement for either type of material shall be in accordance with Section 420.5 above.

Other joints requiring the use of joint sealing material shall be as detailed on the plans. The material will be designated by material class (i.e., 1-a or 1-b) without reference to joint type.

The top surface of a concrete placement which terminates at a horizontal construction joint shall have the surface cement film removed and shall be roughened thoroughly as soon as practicable after the concrete has attained initial set. The surfaces at bulkheads shall be roughened as soon as the bulkhead forms are removed.

Before joining plastic concrete to concrete that has already set, the surface of the concrete in place shall be free from all loose material, laitance, dirt, or foreign matter; shall be washed and scrubbed clean with stiff brooms and drenched thoroughly with water until saturated, and shall be kept wet until the plastic concrete has been placed. Immediately prior to the placing of additional concrete, all forms shall be drawn tight against the concrete in place, and the surface of the concrete in place shall be flushed with a coating of grout mixed in the proportions of one part of cement to two parts of sand.

If shown on the plans, construction joints shall be provided with concrete keyways, reinforcing steel dowels, and/or metal flashing strips or plastic waterstop. The method of forming keys in keyed joints shall be such as to permit the easy removal of forms without chipping, breaking, or damaging the concrete in any manner.

420.7. Foundations. Excavation for foundations shall be made in accordance with the requirements of Item 400, "Structural Excavation".

Caissons shall be constructed of the materials and to the dimensions and details shown on the plans. Forms for concrete caissons may be of wood or metal meeting the requirements hereinafter specified. The operation of sinking will be permitted to proceed immediately after form removal.

Where necessary, falsework shall be provided to support the caisson during the construction and lowering period. Such falsework shall be of the strength required to support the caisson in combination with the forces of wind, water currents, and drift.

Concrete foundation seals, if required, shall be of the thickness shown on the plans. Unless otherwise specified, the seals shall be Class "E" Concrete and shall be placed in accordance with the requirements herein for concrete placed in water, Section 420.14. The completed seal shall not be higher or lower than the plan grade or the grade established by the Engineer, by more than one foot.

The seal shall be allowed to set for at least 36 hours before the caisson or cofferdam is unwatered. After unwatering, the top of seal shall be cleaned off, all laitance or other soft material shall be removed, and all high spots which exceed the above limitation shall be cut off and removed.

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.

420.8 Falsework. All falsework shall be designed and constructed so that no settlement or deformation will occur, and so that the necessary rigidity will be provided. Details of falsework construction shall be subject to review and approval by the Engineer in accordance with the provisions of Section 420.3.

For calculating the loads on 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.

All timber used in falsework centering shall be sound, in good condition, and free from defects which will impair its strength. All timber for wedges shall be hardwood.

Timber piling may be of any species of wood which will withstand driving satisfactorily and which will adequately support the superimposed load.

Steel members shall be of adequate strength and of such shape as to be suitable for the purpose intended.

Where sills or timber grillages are used to support falsework columns, such sills and grillages, unless founded on solid rock, shale or other hard materials, shall be placed in excavated pits and backfilled to prevent the softening of the supporting material. Sills or grillages shall be of ample size to support the superimposed load without settlement.

Falsework which cannot be founded on a satisfactory spread footing shall be supported on piling which shall be 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 formula given in the pertinent specifications for Item 404, "Driving Piling".

In general, each falsework bent shall be capped transversely at the proper elevation by a cap of adequate size. If desired by the Contractor, however, a short cap section forming a T-head may be substituted at the top of each pile or column in order to permit the removal of portions of the forms without disturbing the falsework. Caps shall be fastened adequately to each pile or column in the bent and shall be set at the proper elevation to produce, in conjunction with the use of approved hardwood 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. Wedges shall be used in pairs and shall be so arranged as to insure uniform bearing. Each falsework bent shall be braced securely to adjacent bents by bracing material of ample size to provide the stiffness required. The bracing shall be spiked or bolted securely to each pile or column it may cross.

Unless otherwise provided, each slab or girder span shall be constructed with a permanent camber at the center equal to one-eighth inch for each 10 feet of span length with a proper additional allowance being made for settlement.

Unless otherwise shown on the plans, provision for dead load deflection only without additional camber shall be provided for prestressed concrete beam spans.

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 at the time the arch is swung. Falsework may be required to be placed on jacks to provide adjustment for correction of settlement during concrete placement.

Upon completion of the structure all falsework shall be removed to the ground level. Falsework piling shall be pulled or cut off a minimum of 6 inches below ground level. Falsework and piling in a stream, lake, or bay shall be removed completely to a point specified by the Engineer to prevent any obstruction to the waterway.

420.9. Forms.

(1) **General Requirements.** Except where otherwise specified, forms may be constructed of either timber or metal as elected by the Contractor.

Forms for precast prestressed concrete members and for prestressed trestle piling shall be made of steel.

Forms for round columns exposed to view shall be of steel except that other materials will be allowed with written permission of the Engineer.

Forms shall be built and maintained mortar-tight and of material sufficient in strength to prevent bulging between supports and shall be set and maintained to the lines designated until the concrete is sufficiently hardened to permit form removal. During the elapsed time between the building of the forms and the placing of concrete, the forms shall be maintained in a manner to eliminate warping and shrinkage. All details of form construction shall be subject to the requirements of Section 420.3.

Permission to place concrete will not be given until all of such work is complete to the satisfaction of the Engineer.

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. 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 State Highway Department for the design of structures.

If, at any stage of the work, the forms show signs of bulging or sagging, that portion of the concrete causing such condition shall be removed immediately, if necessary, and the forms shall be reset and braced securely against further movement.

Forms shall be constructed so that there is no offset at joints. Joints which are not mortar proof under normal

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working and vibration shall be filled with suitable material and backed.

(2) **Timber Forms.** Lumber for forms shall be seasoned properly and of good quality. It shall be free from loose or unsound knots, knot holes, twists, shakes, decay, and other imperfections which would affect its strength or impair the finished surface of the concrete. The lumber used for facing or sheathing shall be surfaced on at least one side and two edges and shall be sized to uniform thickness.

Timber forms for exposed concrete surfaces which are to receive either a Type 1, Type 2, or Type 3 Surface Finish under the provisions of Section 420.24 shall be lined with an approved type of form lining material such as masonite or plywood, except that no lining will be required on any portions of the areas inside of culvert barrels nor on any concrete surfaces of such dimensions that the face form is constructed of a single smooth board or plank of a width equal to or greater than the surface to be finished.

If desired by the Contractor, forms may be constructed of plywood not less than one-half inch in thickness, with no form lining required. The clear spacing of the supporting studs or joists shall not exceed twenty times the actual thickness of the plywood. The grain of the face plies on such plywood forms shall be laid parallel to the span between the supporting studs or joists.

Plywood used for forms for surfaces which remain exposed shall be equal to that specified as 'Exterior Type', of the grade "Concrete-Form Exterior", of the U.S. Department of Commerce, National Bureau of Standards, Commercial Standard, latest edition.

No form lining will be required for surfaces which are to receive a Type 4 Surface Finish under the provisions of Section 420.24.

Forms or form lumber to be re-used shall be maintained clean and in good condition as to accuracy, shape, strength, rigidity, tightness, and smoothness of surface. Forms shall be reworked between each use. Any lumber which is split, warped, bulged, marred, or has defects that will produce work inferior to that resulting from using new material shall not be used.

Studs and joists shall not be less than 2 inches by 4 inches nominal section and shall be spaced so that the clear span of the facing lumber between such shall not be more than

twenty times the actual thickness of the facing lumber. Studs shall be capped at the top with a plate of not less than 2 inches by 4 inches, nominal size, carefully selected as to straightness. All joints in plates shall be scabbed at least 4 feet each way to provide continuity.

Wales shall be spaced at such intervals as to hold forms securely to the designated lines. All wales shall be scabbed at least 4 feet on each side of joints to provide continuity. A row of wales shall be placed within 6 inches of the bottom of each placement.

Forms shall be braced rigidly to prevent movement while placing the concrete.

All face form material shall be fastened to all studs and shall have true horizontal and vertical joints. Facing material on horizontal and other surfaces shall be placed with parallel and square joints.

Forms on surfaces not to be finished but exposed to view, shall be placed so that the form panels are symmetrical, i.e., long dimensions set in the same direction. Horizontal joints shall be level and continuous.

Molding specified for chamfer strips or other uses shall be made of redwood, cypress, or pine materials of such grade that will not split when nailed and which can be maintained to a true line without warping. The 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. The strips shall be three-fourths inch measured 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 and of such design that the finished work shall be true, sharp, and clean cut.

All forms shall be so constructed as to permit removal without damage to the concrete. Particular care shall be exercised in framing forms for copings, offsets, railing, and all ornamental work, so that there will be no damage to or marring of the concrete when the forms are removed. If desired by the Contractor, 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. Such ties

shall be of a type as to permit ease of removal of the metal as hereinafter specified.

All metal appliances used inside of forms to hold them in correct alignment shall be removed to a depth of at least one-half inch from the surface of the concrete and shall be so constructed that the metal may be removed without undue injury to the surface by chipping or spalling. Such devices, when removed, shall leave a smooth opening in the concrete surface. Burning off of rods, bolts, or ties will not be permitted.

Metal ties shall be held in place by devices attached to wales. Each device shall be capable of developing the strength of the tie, and shall be the adjustable type to allow for lining forms.

Metal and wooden spreaders which are separate from the forms shall be removed entirely as the concrete is being placed.

When wire ties are used, all wires, upon removal of the forms, shall be cut back at least one-half inch from the face of the concrete with a sharp chisel or nippers.

Whenever practicable, forms shall be erected complete before the reinforcement is placed.

For narrow walls and other locations where access to the bottom of the forms is not readily attainable otherwise, adequate clean-out openings shall be provided.

At the time of placing concrete, the forms shall be clean and free entirely from all chips, dirt, sawdust, and other extraneous matter.

The facing of all forms shall be treated with oil before concrete is placed. In hot weather, both sides of face forms may be required to be treated with oil to prevent warping and to secure tight joints. The oil must be applied before the reinforcement is placed. The oil used for this purpose shall be a light clear oil which will not discolor or otherwise injuriously affect the concrete surface.

All forms shall be wetted thoroughly before the concrete is placed therein.

(3) **Metal Forms.** The foregoing specifications for timber forms as regards design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, re-use, oiling, and wetting shall apply equally to metal forms,

except that metal forms will not require lining, unless specifically noted on the plans.

The metal used for forms shall be of such thickness that the forms will remain true to shape. The minimum thickness of metal used in forms by cylindrical columns or shafts shall be three-sixteenths inch. Forms may be made in sections of such length as will facilitate the placing of concrete and the removal of forms. The fit of joints of sections shall not produce offsets. 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 material that will tend to discolor the concrete.

(4) **Form Supports for Overhanging Slabs.** Form supports which impart a horizontal force to a steel girder or beam will be permitted, but shall not be used until a structural check is made of the effect on the steel girder or beam.

Holes for support of overhang brackets may be punched or drilled full size or may be torch cut to one-fourth of an inch under size and reamed full size. In no case shall the holes be burned full size.

Holes shall be left open unless specified on the plans to be filled with a button head bolt. In no case shall the holes be filled by welding.

Any type of form support which transmits a force other than vertical will not be permitted on prestressed concrete members, unless adequate ties and struts are provided. A structural check will be required before permission to use such forms is given.

420.10. Placing Reinforcement. Reinforcement in concrete structures shall be placed carefully and accurately and rigidly supported as provided in Item 440, "Reinforcing Steel".

420.11. General. The Contractor shall give the Engineer sufficient advance notice before starting to place concrete in any unit of the structure to permit the inspection of forms, the reinforcing steel placement, and preparations for casting. No concrete shall be placed in any unit prior to

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the completion of the formwork and the placement of the reinforcement.

Concrete mixing, placing, and finishing shall be done in daylight hours. Placement shall not commence when it is evident that the work cannot be completed before dark, unless adequate provisions are made to light the entire site of all operations.

Concrete placement will not be permitted when impending weather conditions may result in rainfall or low temperatures which will impair the quality of the finished work. In case 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 Section 420.12 shall be applied.

The sequence of placing concrete shall be as provided on the plans or in the specifications. The operation of depositing and compacting the concrete shall be conducted to produce a compact, dense, impervious mass of uniform texture which shall show smooth faces on all surfaces. The placing shall be so regulated that the pressures caused by the plastic concrete shall not exceed the loads used in the design of forms.

The method and manner of placing shall be such as to avoid segregation or separation of the aggregate or the displacement of the reinforcement. Concrete shall not have a free fall of more than 3 feet except in the case of thin walls such as culvert walls. The spattering of forms or reinforcement bars shall be prevented if the concrete so spattered will dry or harden before being incorporated in the mass.

Each part of the forms shall be filled by depositing concrete directly 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 in the forms and running or working it along the forms will not be allowed.

After the concrete has taken initial set, the forms shall not be jarred or any strain placed on projecting reinforcement.

Chutes, troughs, or pipes used as aids in placing concrete shall be arranged and used so that the ingredients of the concrete will not be separated. When steep slopes are necessary, the chutes shall be equipped with baffle boards or be

made in short lengths that reverse the direction of movement. Open troughs and chutes shall extend, if necessary, down inside the forms or through holes left in the forms, or the ends of such chutes shall terminate in vertical downspouts. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by a thorough flushing with water before and after each placement. Water used for flushing shall be discharged clear of the concrete in place. The use of chutes in excess of 35 feet total length for conveying concrete will not be permitted except by specific authorization from the Engineer.

Where the Contractor's operations involve the placing of concrete from above, that is, directly into an excavated area or through the completed forms, particularly in the case of abutments, piers, columns, retaining walls, and deep girders, and excepting thin walls such as culvert walls, all concrete so placed shall be deposited through a jointed sheet metal or other approved pipe not less than 6 inches nor more than 10 inches in diameter. The pipe shall be adjusted to the proper heights during placing operations.

Concrete shall be placed in continuous horizontal layers approximately 12 inches in thickness. Not more than one hour shall elapse between the placing of successive layers of concrete in any portion of the structure included in a continuous placement. The Contractor shall avoid unauthorized construction joints by placing required portions of abutments, piers, walls, or superstructures in one continuous operation.

For mass placements, placements on falsework where differential setting time may induce stress cracking, placement in deep girder stems, etc., an approved retarder (cement dispersing agent) in accordance with Item 437, "Concrete Admixtures", shall be used to control stress cracks and/or unauthorized cold joints.

Laitance or foreign matter of any kind shall not be permitted to accumulate inside the forms; and openings in forms necessary for removal of same shall be provided.

All concrete shall be well compacted and the mortar flushed to the surface of the forms by continuous working with mechanical vibrators of an approved type. Vibrators of the type which operate by attachment to forms or reinforcement will not be permitted, except that external vibration will be allowed when the forms are of steel. For Class F, Class G, Class X, and Class Y concrete, vibrators of the

high frequency type with a minimum of 7,000 impulses per minute, shall be required.

At least one stand-by vibrator shall be provided for emergency use in addition to the ones required for placement. The vibrators shall be applied to the concrete immediately after deposit and shall be moved throughout the mass, thoroughly working the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms until it has been reduced to a plastic mass. The mechanical vibrator shall not be operated so that it will penetrate or disturb layers placed previously which have become partially set or hardened. The vibration shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures but shall not be done to an extent that will cause segregation. Vibration shall be supplemented by hand spading 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 may be formed by the insertion of oiled wooden plugs or metal sleeves in the plastic concrete. The plugs or sleeves shall be withdrawn after the concrete has set. When the holes are formed, these shall be of such diameter to permit horizontal adjustment of the bolts. The bolts shall be set carefully in mortar. In lieu of the above methods of placing, anchor bolts may be set to exact locations in concrete when it is placed.

The placing of concrete for floor slabs shall be done from a mixing plant located off the structure. If written permission is given by the Engineer to locate the mixer plant on the structure, it shall not be placed on a section of the roadway slab which has been in place for a length of time less than that specified in Section 420.3. Carting or wheeling concrete batches on a completed concrete floor slab will not be permitted until the slab has aged at least 2 full curing days. The carts shall be wheeled on timber planking so that the loads and impact will be distributed over the slab unless pneumatic tired carts are used. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.

Stockpiling of concrete aggregate or cement on bridge floors will be permitted only when authorized by the Engineer, and when permitted, the stock piles shall be distributed uniformly and shall be limited to not over 2 feet maximum depth. The storing of reinforcing or structural steel on completed roadway slabs generally shall be avoided and,

when permitted, such storage 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.** No concrete shall be placed when the atmospheric temperature (taken in the shade away from artificial heat) is below 40 F without permission of the Engineer. When such permission is granted, the aggregates and/or water shall be heated uniformly such that the temperature of the aggregate and water mixture at the time of introduction of cement, and the temperature of the concrete at the time of placement in the forms shall be not less than 60 F nor more than 90 F.

The aggregates shall be free from ice, frost, and frozen lumps when introduced into the mixture.

All concrete which has not attained an age of 24 hours before the atmospheric temperature falls below 40 F, shall be covered with frame work and satisfactory covering material, so that the air surrounding the concrete and forms may be heated and maintained at a temperature of not less than 50 F nor more than 90 F for a total of 5 days. When high-early strength concrete is used, the total protection time shall be a minimum of 3 days, but not less than the total curing time required.

Sufficient heating equipment such as stoves, salamanders, or steam equipment shall be provided to supplement the coverings to provide the above protection.

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 test specimens shall be cast and cured with the concrete placed in the structure to control the quality of the concrete.

When concrete control is by beam test, cylinders shall be required also, for control of concrete placement in cold weather.

(2) **Precast Concrete.** When precast products are produced in a fabricating plant which has adequate protection from cold weather in the form of permanent or portable framework and covering, which will protect the concrete when placed in the forms, and which is equipped with ap-

proved steam curing facilities, concrete may be placed under any low temperature conditions provided:

(a) The temperature of the concrete is not less than 60 F nor more than 90 F when placed in the forms.

(b) The framework and covering are placed and heat is provided for the concrete and the forms, within one hour after the concrete is placed in the forms. 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.

(c) The steam heat shall keep the air surrounding the concrete between 50 F and 90 F for a minimum of 2 hours prior to beginning the temperature rise which is required for steam curing.

(d) The temperature of the concrete shall not be less than 60 F at any time after all ingredients are added and mixing commenced.

For fabricating plants which do not provide the above facilities and for job-site precast products, the requirements of 420.12 (1) above shall apply except that prestressed concrete shall not be required to be protected more than nor less than the required total curing time.

It is understood that the Contractor is responsible for the protection of concrete placed under any and all weather conditions. Permission given by the Engineer to place concrete during freezing weather will in no way relieve the Contractor of the responsibility for producing concrete equal to the quality of concrete placed on the work when the temperature is above 40 F. Should concrete placed under such conditions prove unsatisfactory, it shall be removed and replaced.

420.13. Placing Concrete in Hot Weather. Concrete shall be placed in the forms without the addition of more water to the concrete than required by the design (slump and consistency), and adequately finished without adding excess water on 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 cement dispersing agent.

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	
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
40 F to 74 F	90 minutes

The use of an approved cement dispersing agent in the concrete will permit the extension of each of the above temperature-time maximums by 30 minutes, except that for non-agitated concrete, the maximum time shall not exceed 30 minutes.

The Contractor may have the option to use an approved cement dispersing agent although not specifically required by the above temperature-time table, to take advantage of the added working time.

Under extreme temperature, wind, or humidity conditions, when the specified temperature-time maximums are too long, the Engineer may require the use of the dispersing agent, or may suspend concreting operations if quality concrete is not being placed.

When the temperature of the air or concrete is above 85 F, an approved cement dispersing agent will be required in all slab and drilled shaft concrete.

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 while the concrete is being placed, nor until it has set for at least 36 hours.

The concrete shall be placed carefully in a compact mass by means of a tremie, closed bottom-dumping bucket, or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. Depositing shall

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be regulated to maintain approximately horizontal surfaces at all times.

When a tremie is used, it shall consist of a tube having a diameter of not more than 10 inches, constructed in sections having water-tight connections. The tremie shall be equipped with a device for sealing the bottom of the tube, and the positive opening thereof, for the placing of the filled tremie through the water to the point of placement. The means of supporting the tremie shall permit the movement of the discharge and over the entire top surface of the work and shall permit the tremie to be lowered rapidly when necessary to choke off or retard the flow. The number of times it is necessary to shift the location of the tremie, for any continuous placement of concrete, shall be held to a minimum. During the placing of concrete, the tremie shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be raised slightly, but not out of the concrete at the bottom, until the batch discharges to the level of the bottom of the hopper. The flow then shall be stopped by lowering the tremie. The placing operations shall be continuous, until the work is complete. The 10 inch diameter maximum size of tremie may be larger, if the placement is confined to a small area which requires very little movement of the tremie to place the concrete.

When concrete is placed by means of a bottom-dump bucket, the bucket shall have a capacity of not less than one-half cubic yard. The bucket shall be lowered gradually and carefully until it rests upon the concrete already placed. It then shall be raised very slowly during the discharge travel, the intent being to maintain still water at the point of discharge and to avoid agitating the mixture.

Although not specified by the plans, all concrete placed under water shall be Class "E" concrete.

420.15. Placing Concrete in Superstructure. Concrete in the superstructure shall be placed in longitudinal strips. Placing, preferably, shall be started at a point in the center of the span adjacent to one curb and the longitudinal strip thus started shall be completed by depositing concrete uniformly in both directions toward the ends of the span. The width of longitudinal strips shall be such that the concrete in any strip will not take its initial set before the adjacent strip is placed. The concrete in the curbs shall be placed in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs.

The forms for the bottom surface of the slab, girder, slab and girder, and overhangs shall be maintained true to the required vertical alignment during the placing of concrete in the span. For convenience in checking the vertical alignment, an approved system of "tell-tales" shall be installed and maintained by the Contractor. The "tell-tales" shall be attached to the form and shall provide a convenient means of matchmarking with reference to points set on stakes or other suitable reference points set independent of the forms and falsework for the span being placed. Unless otherwise provided, the girders, slab, and curbs of deck girder spans shall be placed in one continuous operation.

For spans on a grade of 1.5 percent or more, concreting shall be commenced at the low end of the span. The filling of the girder stems ahead of placing the concrete in the slab will be permitted provided the slab concrete is placed on the stem concrete not later than the time-temperature allowable as specified in Section 420.13 above.

The location of construction joints and the sequence of placements of the slab on steel and prestressed concrete beams shall be as shown on the plans. Where plans do not specify a particular sequence of placement, any logical sequence which will not result in the overstressing of any of the supporting members will be permitted subject to the approval of the Engineer.

On steel truss spans the falsework under the span shall be released and the span swung free on its permanent supports before placing any concrete in the floor slab.

Concrete placed around steel shapes shall be deposited on one side of the shape and shall be spaded or vibrated until it flushes up over the bottom flange on the opposite side of the member, after which, it may be placed on both sides to completion.

On completion of the filling of the curb forms, the curbs shall be brought to the correct camber and alignment, and then shall be struck off and float finished as described in Section 420.19.

As soon as concrete is placed in a longitudinal section of the slab of sufficient width to permit finishing operations, the slab shall be finished in accordance with the requirements of Section 420.20. When the surface of the slab is to receive an additional wearing surface or level-up (widening), the

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slab shall be given a reasonably smooth float or screed finish and shall not be finished as stated above.

Deflections due to cast-in-place concrete and railing shown in the dead load deflection diagram shall be taken into account in the setting of slab forms.

420.16. Placing Concrete in Concrete Arches. Concrete shall be placed in arch rings so that the loading is symmetrical to 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 that loading of the arch is approximately symmetrical.

Falsework plans shall include sequence of concrete placement, unless a placing sequence is shown on the plans.

420.17. Placing Concrete in Box Culverts. In general, construction joints will be permitted only at the points shown on the plans. Where haunched sidewalls are used, the lower haunches shall be placed monolithic with the bottom slab and the upper haunches monolithic with the top slab. Curbs shall be placed monolithic with top slab.

Where the top slabs and sidewalls are placed monolithic in culverts more than 4 feet in clear height, an interval of not less than one hour nor more than 2 hours shall elapse between the placing of the concrete in the walls and that in the top slab; such interval is to allow for shrinkage in the wall concrete.

The footing area joining the walls shall be cleaned thoroughly of all shavings, sticks, sawdust, or other extraneous material before placing concrete in the walls.

The top surface of the base slab shall be finished accurately by hand floating at the proper time to provide a smooth uniform surface. The top surface of the top slab which will carry direct traffic shall be finished in accordance with the provisions for finishing roadway slabs in Section 420.20. On a fill type culvert which does not carry direct traffic, the top slab shall be given a reasonably smooth float or screed 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.

The placing of concrete bases above 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 on the inside of cofferdams or caissons shall be constructed or adjusted as the work proceeds to the end that construction joints in bases or shaft in addition to those shown on the plans will not be necessary.

Concrete in foundations shall be placed in a manner that will avoid separation of the aggregates or displacement of the reinforcement. Suitable chutes or jointed pipes shall be provided.

When footings can be placed in dry foundation pits 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. Where this procedure is followed, no measurement for payment will be made for concrete placed outside of the footing dimensions shown on the plans.

Concrete in columns shall be placed monolithic unless otherwise provided. Unless a construction joint is provided at the top of columns, an interval of not less than one hour or more than 2 hours shall elapse between the placing of concrete in columns and the placing of concrete above the top of columns. Such interval is intended to allow for shrinkage of the column concrete.

420.19 Treatment and Finishing of Horizontal Surfaces Except Roadway Slabs. All upper surfaces not covered by forms, such as tops of railing posts, railings, caps, curbs, parapets, copings, bridge seats, and sidewalk areas shall be completed by placing excess material in the forms and removing or striking off such excess with a wooden template forcing the coarse aggregate below the mortar surface. The use of mortar topping for surfaces under this classification will not be permitted.

After the concrete has been struck off as described above, the surface shall be worked thoroughly and floated with a suitable float. After floating and before the finish has set,

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all surfaces, except sidewalks so finished, shall be striped lightly with a fine brush to remove the surface cement film, leaving a fine-grained, smooth but sanded texture. That portion of curbs or parapets which is to be the seat for concrete rail posts or webs of concrete railings shall be roughened in an approved manner.

420.20. Finish of Roadway Slabs. As soon as the concrete has been placed and vibrated in a longitudinal section of a sufficient width to permit working, the surface shall be approximately leveled, then struck off, screeded, and tamped with a longitudinal screed. The screed shall be of such design to provide the rigidity necessary to hold true to shape and shall have sufficient adjustments provided for such camber that is required. A vibrating screed may be used if the screed is sufficiently heavy to withstand distortion. The screeds shall be provided with a metal cutting edge.

The screed shall be moved forward across the concrete with a combined longitudinal and transverse motion with ends resting on headers or templates, set true to the roadway grade or on the adjacent finished slab. A slight excess of concrete shall be carried ahead of the screed to insure the filling of all low spots.

The surface of the concrete shall be screeded and tamped a sufficient number of times, (never less than three) and at such intervals to produce a uniform surface, true to grade, and free of voids.

Spans over 40 feet in length may be screeded in two or more sections if suitable intermediate templates are installed and if adequate equipment is provided. Unless otherwise provided, the templates shall be of such design as to permit early removal in order to avoid construction joints and to permit satisfactory finishing at and adjacent to the site of the template.

Following the screeding, the 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.

After the floating operation and while the concrete is still plastic, the Contractor shall have the surface checked with a long handled 10 foot straight edge. The check shall be made with the straightedge parallel to the centerline. Each pass of the straightedge 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 refloated. The checking and floating shall be continued until the surface is true to grade and free of depressions, high spots, voids, or rough spots.

The surface then shall be given a belt finish. The belting shall be done parallel to the centerline.

After the concrete has attained its final set, the roadway surface shall be tested again with a standard 10 foot metal straightedge for irregularities, and the surface shall be corrected, if necessary, to conform to the following:

The straightedge shall be placed parallel to the centerline of road so as to bridge any depressions and touch high spots. Ordinates measured from the face of the straightedge to the surface of the slab shall not exceed one-sixteenth inch per foot from the nearest point of contact and the maximum ordinate shall not be greater than one-eighth inch. The surface shall be corrected by grinding off the high spots as may be required in order to conform to these limits.

In case of concrete slab or girder spans on falsework, the floor shall be finished so as to provide a camber sufficient to offset the dead load deflection of the span; other spans shall be so finished if directed by the Engineer. Unless otherwise shown on the plans, the camber at the center of the span shall be made one-eighth inch for each 10 feet of span length with a maximum camber of one-half inch. When camber is provided, allowance for such camber will be considered when straightedging the slab for imperfections.

420.21. Curing Concrete. Careful attention shall be given to the proper curing of all concrete. The Contractor shall provide the proper equipment and material in adequate amounts to cure the concrete properly, prior to being given permission to place concrete.

The Contractor shall inform the Engineer fully as to the methods and procedures proposed for curing and have the full approval of the methods, equipment, and material prior to placing concrete.

Poor curing facilities or lack of attention to the proper curing of concrete, shall be cause for the Engineer to stop all construction on the job, until proper curing is provided.

All concrete except as noted herein, shall be cured for a period of 4 curing days.

A curing day is defined as a calendar day on which 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 air surrounding the concrete constantly above 50 F throughout the entire day.

Exceptions to 4 Day Curing

Description	Required Curing
Upper Surfaces of Bridge Roadway and Sidewalk Slabs	6 Curing Days
Prestressed Concrete (including piling)	See Item 425
Precast Piling (non-prestressed)	6 Curing Days

The following methods are permitted for curing concrete subject to the restrictions of Table 1 and the requirements of this specification for each method of curing.

1. Form Curing
2. Water Curing
 - a. Wet Mat
 - b. Water Spray
 - c. Ponding
3. Membrane Curing
4. Elevated Temperature Curing

When forms are left in contact with the concrete, these surfaces will not require other curing methods.

When water curing is used, all surfaces shall be kept wet continuously for the required curing time. The water used for curing concrete shall meet the requirements for concrete mixing water as specified in Item 421, "Concrete for Structures". Sea water will not be permitted.

(1) Wet Mat Method. Cotton mats, white polyethylene sheeting, or polyethylene burlap blankets may be used for this curing method.

The mats, sheets, or blankets shall not be placed in contact with the concrete until such time that damage will not occur to the surfaces. White pigmented curing compound will be required for interim curing when needed to prevent excess drying, cracking, etc. Mat curing shall commence no later than 3 hours after finishing of the roadway slab.

The mats, sheets, or blankets shall be weighted down adequately to provide continuous contact with all concrete surfaces. The surfaces of the concrete shall be kept wet for the required curing time.

Surfaces which cannot be cured by contact with the mats shall be enclosed with mats, anchored positively to the forms,

or to the ground, so that outside air cannot enter the enclosure. Saturated humidity shall be provided inside the enclosure.

STRUCTURE UNIT DESCRIPTION	Required		Permitted	
	Water	Membrane for Interim Curing ^{2,3}	Membrane for Complete Curing ²	Water
1. Upper Surfaces of Roadway & Sidewalk Slab.	X	X		
2. Other Superstructure Concrete including underside of slab and overhang.			X	X
3. Substructure Concrete. ¹			X	X
4. Prestressed Concrete Units Including Piling, except as noted in No. 5.	X			
5. Top Surface of Piling (Precast and Prestressed).	X	X		
6. Culvert & Box Sewer Floor Slabs and Risers.	X			
7. All other portions of Culverts & Box Sewers. All portions of inlets, manholes, retaining walls, concrete collars on piles, riprap.			X	X

Steam curing will be permitted on any concrete unit.

¹Forms for piers and columns shall not be removed in less than 24 hours.

²Membrane curing shall not be applied to any surface which is to bond to concrete placed at a later time.

³Temporary membrane curing will not be required except when cracking and/or checking occurs prior to the beginning of final curing.

TABLE 1
Type of Curing by Structure Unit

(2) When water spray is used, the curing will be accomplished by overlapping sprays or sprinkler, so that all surfaces are continuously wet. Water which stains or leaves unsightly residue shall not be used.

(3) Ponding, when used, shall require the covering of the surfaces with a minimum of 2 inches of clean granular material which is kept wet at all times, or a covering of a minimum of a 1 inch depth of water at all times. Satisfactory provisions shall be made to provide a 'dam' to retain the water or saturated sand.

(Both water spray and ponding shall require the temporary membrane application when required to prevent cracking).

Type II, white pigmented curing compound shall be required when this type of curing is permitted. Coverage will be as required by Item 531, "Membrane Curing". When membrane is used for complete curing, the film shall remain un-

broken for a minimum of 7 days. Membrane which becomes broken shall be corrected immediately by reapplication of membrane.

(4) Elevated temperature curing will be permitted as follows:

(a) **Steam Curing.** When steam curing of the concrete is provided, all surfaces of the concrete shall be at a saturated humidity and at a temperature not to exceed 150 F. If temperature charts indicate that temperature inside the curing jacket is in excess of that shown below, the concrete shall not be accepted.

151 F to 160F	1 hour
151 F to 170 F	30 minutes
151 F to 180 F	15 minutes
Over 180 F	None

If temperature charts indicate that temperatures inside the curing jacket have fallen below 40 F, 8 hours shall be added to the total curing time required, for each hour below 40 F. Sufficient moisture shall be provided inside the curing jacket so that all surface of the concrete are damp. An air space of not less than 6 inches shall be provided between all surfaces of the concrete and the covering material. Steam outlets shall be arranged so that no live steam is directed at the concrete or the reinforcing steel (tendons). Steam curing shall not be started until the concrete has been placed a minimum of 2 hours.

Steam shall be applied slowly so that the temperature rise inside the curing jacket is at the rate of not more than 10 F per hour. Temperature decrease at the end of curing shall be at the same rate. The location of steam lines, location of control points for output of steam into the curing jacket, and the number and type of openings for steam distribution inside the curing jacket shall be so arranged that variations of temperature between any two points in the enclosure shall be no more than 10 F.

(b) **Alternate Methods.** Other methods of elevated temperature will be permitted if temperature maximums, rate of temperature increase and decrease, etc., are in accordance with those in steam curing. Special permission shall be obtained from the Engineer for any alternate method.

420.22. Removal of Forms and Falsework. Except as hereinafter provided, forms for surfaces required to be sur-

face finished shall be removed when the concrete has aged not less than one nor more than 2 days, for normal concrete and not less than one-half nor more than 2 curing days, for high-early strength concrete. In order to facilitate slab finishing, forms for inside curb faces on roadway may be removed in not less than 3 hours if the concrete has set sufficiently to permit form removal without damage to the curbs.

Forms and falsework for the portions of structure which do not require surface finish may be removed as soon as the concrete has attained the flexural strength specified in Table 2, as evidenced by strength tests made in accordance with the provisions of Bulletin C-11 using test specimens made from the same concrete and cured under the same conditions as the portion of the structure involved.

When form removal is permitted by the beam break method and the forms are removed prior to the end of the curing period, other curing methods shall be used to complete the required curing period. Form removal from underneath roadway slabs and overhangs prior to the end of the curing period, shall require the use of membrane curing.

Class of Concrete	Required Flexural Strength
A	500 psi
B	375 psi
C	600 psi
D	250 psi
E	500 psi
F	See Item 425
G	See Item 425
X	500 psi
Y	See Item 423

TABLE 2

When the Contractor does not elect to follow the method of determining time for removal of forms as provided in the preceding paragraph, forms and falsework on portions of structures which do not require surface finish shall remain in place until the concrete has aged for the minimum number of curing days set forth in the following table:

Description	Min. Curing Days Required	Max. Curing Days Required
Bottom of Slabs and Girders or Beams 10-foot span and less (1).....	7	14
Over 10-foot span (1).....	7 plus 1 curing day for each additional 10-ft. span or part thereof	
Bottom of slabs with a cantilever of more than one foot (1).....	4	
Bottoms of caps and tie beams of: Frame Bents.....	5	
Pile Bents.....	3	
Bottom of web walls of piers.....	5	
Walls, sides of beams or girders, bottom of slabs with a cantilever less than one ft.....	2	
Concrete Caissons.....	2	
Columns and Piers.....	1	
Precast, Prestressed Concrete Units: Water Cure.....	12 hours as soon as possible and before application of steam curing	
Steam Cure.....		

TABLE 3

(1) These units shall require the minimum curing time shown regardless of whether the surface is to receive a rubbed finish.

No reduction of time for form removal will be allowed as such for concrete specified in the above table, using Type III cement. Early form removal will be allowed by beam break only.

The above provisions relative to form removal shall apply only to forms or parts of forms which are so constructed as to permit removal without disturbing forms or falsework which are required to be left in place for a longer period on other portions of the structures.

In continued cold weather, when artificial heat is not provided, the Engineer may permit the removal of forms and falsework at the end of a period of calendar days equal to twice the number of curing days stated in the preceding table.

420.23. Defective Work. Any defective work discovered after the forms have been removed shall be repaired immediately. If the surface of the concrete is bulged, uneven,

or shows excess honeycombing or form marks, which defects, in the opinion of the Engineer, cannot be repaired satisfactorily, the entire section shall be removed and replaced. In repairing honeycombed areas, all loose material shall be removed before the repair work is started. Either a latex base or epoxy base patching adhesive shall be used in the patching of defective areas when the size and/or depth warrants.

No extra compensation will be allowed for the extra work or materials involved in repairing or replacing defective concrete.

420.24. Finishing Exposed Surfaces. The type of surface finish shall be one of the four types described herein and designated on the plans. Where the plans do not specify the type of finish, a Type 1 finish shall be required.

(1) **Type I Finish.** The following areas shall require lining of the forms (Section 420.9) and shall receive a first and second rubbing.

The top, exterior, and roadway faces of curbs and parapet walls;

All concrete surfaces of railing;

The exterior vertical faces of slab spans, rigid frames, arches, and box girders;

The outside and bottom surfaces of fascia beams or girders (precast prestressed concrete beams excluded);

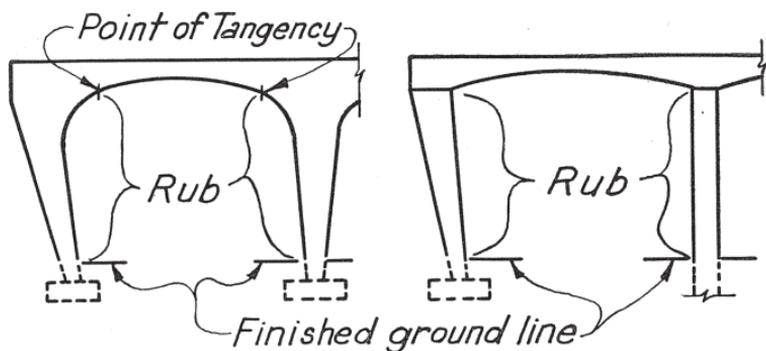
The underside of overhanging slabs to the point of juncture of the supporting beam;

All vertical surfaces of piers, columns, bent caps, (including the bottom sloped portions only of variable depth caps), abutments, wingwalls, and retaining walls, which are exposed to view after all backfill and embankment is placed.

On slab spans, box girders, and rigid frame structures the underside of the slab shall be finished for a width of 2 feet in from the outer edge.

Lined forms shall be required for the entire bottom surface. The bottom surface of all outside girders shall require lined forms.

For rigid frame structures, finishing shall be required on the inside sloping and vertical surfaces as shown below.



Culvert headwalls and wingwalls, inlets, manholes, and sewer appurtenances shall receive a first rubbing only.

No rubbing will be required on any area inside culvert barrels.

Horizontal surfaces of bridge sidewalk slabs shall be finished in accordance with Section 420.19.

The exterior surfaces of exterior prestressed concrete beams shall be made uniform in color and texture by brushing, buffing, partial rubbing (to blend imperfections), sand blasting (80 mesh material), or other means necessary to make the surface uniform in appearance but not necessarily to yield the same color or rubbed texture of the surrounding non-prestressed concrete.

When permitted by note on the plans, the exterior surfaces of the outer prestressed concrete members shall be painted with a latex base adhesive grout. The grout shall conform to the requirements of Item 421, "Concrete for Structures". The coating shall be approximately one-eighth of an inch in thickness and shall be applied after slab concrete is placed and all runs, drips, and mortar have been removed.

(2) **Type 2 Finish.** All concrete portions of railing and the top and roadway faces only of curbs, parapet walls, and wingwalls of bridges shall be given a first and second rubbing. All other surfaces described under Type 1 Finish shall be given a first rubbing only. Lining of forms shall be as required in a Type 1 Finish. Finish for prestressed concrete beams shall be as required under Type 1 Finish.

(3) **Type 3 Finish.** All concrete portions of railing and the top and roadway faces only of curbs, parapet walls, and wingwalls of bridges shall be given a first and second

rubbing. All other surfaces described under Type 1 Finish will not require rubbing but shall require lining of forms. Finish for prestressed concrete beams shall be as required under Type 1 Finish.

(4) **Type 4 Finish.** All concrete portions of railing and the top and roadway faces of curbs, parapet walls, and wingwalls of bridges and culverts shall be given a first rubbing only. No lining of forms will be required. No rubbing of culvert wingwalls will be required provided lining of forms is used.

After forms have been removed and all repair work and pointing has been done, the first rubbing shall be performed as follows:

When the pointing has set sufficiently to permit it, all surfaces requiring surface finish shall be wet with a brush and given a first surface rubbing with a No. 16 Carborundum Stone or an abrasive of equal quality. The rubbing shall be continued sufficiently to bring the surface to a paste, to remove all form marks and projections, and to produce a smooth dense surface without pits or irregularities. The use of cement to form a surface paste will **not** be permitted.

Where a second rubbing is not specified, chamfered corners shall be rubbed in the first rubbing and the material which has been ground to a paste in the rubbing process shall be spread uniformly over all rubbed surfaces by stripping with a brush, and the mortar on the surface shall be allowed to take a re-set. The surface then shall be washed down with clean water and all rubbed surfaces shall be left with a clean, neat, and uniform appearance and shall be uniform in color.

Where a second rubbing is to follow the first rubbing, the material ground into a paste during the first rubbing shall be spread carefully or brushed uniformly over the surface and allowed to take a re-set, but washing down following this first rubbing will not be required. Also, chamfered corners generally shall not be rubbed in the first rubbing if a second rubbing is to follow.

The second rubbing, when required, shall be performed as follows: During the process of conditioning the completed structure for final acceptance, the surfaces of the entire structure requiring finish shall be cleaned free from drip marks and discolorations and shall be given a final finish rubbing with a No. 30 Carborundum Stone or an abrasive of equal quality. On completion of this rubbing, the sur-

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face shall be striped neatly with a brush, and the mortar on the surface shall be allowed to take a re-set. The surface then shall be washed down with clean water. The entire structure shall be left with a clean, neat, and uniform appearing finish and shall be uniform in color.

When membrane curing is used on substructure concrete, it shall not be applied prior to the first rub (See Section 420.21) and Table 1. Prior to the second rub, or during final cleanup of structure if second rub is not required, if the pigmented curing compound has not disappeared from the surfaces, it shall be removed completely by brushing, buffing, or other means found to be necessary.

Rubbing of surfaces other than those herein specified will not be required unless such surfaces are not true or have porous spots or honeycombed areas. In case these defects occur, the areas affected immediately shall be given a first surface rubbing. Such rubbing shall extend over a sufficient area around the blemished portions to blend the rubbed area into the surrounding unfinished surface but this shall not be construed to require the rubbing of large areas of unblemished surfaces to gain absolute uniformity of color and texture on the entire surface of the portion of the structure in question. All surfaces shall be free of discolorations and should present a uniform appearance. Unsightly discoloration shall be removed prior to acceptance.

420.25. Special Surface Finishes. When so specified, special surface finishes shall be employed for ornamental panels, copings, and like construction. In general, the method and manner of performing this work will be fully provided for in the plans or special provisions to these specifications.

In case of special finishes, the Contractor will be required to prepare test or sample panels showing the method and manner of finish. The choice and selection of the aggregate and other features affecting the work shall be approved before any further work is done.

Rubbing of surfaces with Special Finishes will not be required.

420.26. 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 items required by the plans and the contract.

ITEM 421**CONCRETE FOR STRUCTURES
(Natural Aggregate)**

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, mineral filler, if necessary, natural aggregates (fine and coarse), and water, proportioned and mixed as hereinafter provided in these specifications.

Where references are made herein to wear of aggregates, the test for the wear as specified shall be made in accordance with "Standard Method of Test for Abrasion of Coarse Aggregate by the Use of the Los Angeles Testing Machine", Method T-96, of the AASHO.

421.2. Materials.

(1) **Cement.** The cement shall be either Type I, Type II, or Type III of a standard brand of Portland cement which shall conform to ASTM Designation: C 150.

Either the tensile or the compressive strength test may be used for the cement. Type I Portland cement shall be used except where Type II or Type III Portland cement (High Early Strength Cement) is required by the plans. The Contractor, if he so elects in order to facilitate his own operations, may use Type III cement in portions of the work other than where its use is required by plans. 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.

Different types of cement, as prescribed above, 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 except when otherwise authorized by the Engineer.

Cement may be delivered in bulk where adequate bin storage, batching and weighing equipment is provided. All other cement shall be delivered in bags on which shall be marked plainly 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

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cement. In general, bags shall contain 94 pounds net. All bags shall be in good condition at time of delivery.

Bags varying more than 5 percent from the specified weight may be rejected and if the average weight of bags in any shipment, as shown by weighing 50 bags taken at random, is less than 94 pounds, the entire shipment may be rejected.

All cement shall be properly protected against dampness, and no cement will be accepted which has become caked.

All cement shall be sampled and tested in accordance with the standard ASTM methods prescribed in the governing specifications.

Cement remaining in bulk storage at the mill, for a period greater than six months after completion of the tests may be retested and rejected if it fails to conform to any of the requirements of these specifications.

The Engineer shall be notified upon receipt of shipments of cement, in order that he may witness the opening of the car. Failure to comply with this requirement may be cause for the rejection of the entire shipment.

(2) **Mixing Water.** Water for use with cement shall be clean and free from injurious amounts of oil, acid, alkali, salt, organic matter, or other deleterious substances. When comparative tests are made with water of known satisfactory quality, any indication of unsoundness, marked change in the time of set, or reduction of more than 10 percent in mortar strength shall be sufficient cause for the rejection of the water under test. Water which is suitable for drinking or for ordinary household use may be accepted for use without being tested. Sea water will not be permitted.

Tests required by these specifications 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 the definite provisions of this specification.

Water from doubtful sources shall not be used until tested and approved. The Contractor shall not take water for use in concrete from shallow, muddy, or marshy sources.

(3) **Coarse Aggregate.** The coarse aggregate shall consist of gravel, crushed stone, blast-furnace slag, or combinations thereof.

Gravel shall consist of durable particles of crushed or uncrushed gravel of uniform quality throughout. It shall have

a wear of not more than 40 percent when tested according to AASHO Method T-96.

Crushed stone shall consist of durable particles of stone of uniform quality throughout, having a wear of not more than 40 percent when tested according to AASHO Method T-96.

Blast-furnace slag shall consist of durable particles of crushed blast-furnace slag of reasonably uniform quality throughout, having a wear of not more than 40 percent when tested according to AASHO Method T-96. Preferably, slag shall be 100 percent air cooled, but slag air cooled for the first 48 hours after removal from the furnace and subsequently water cooled will be acceptable if it meets the wear test requirement.

The coarse aggregate shall be free from an excess 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 of 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 (soft) particles.

The maximum size of aggregate shall be governed by the type of structure in which the concrete is to be used and as shown in Table 3.

When tested by approved methods, coarse aggregate shall conform to the grading requirements shown in Table 1.

Aggregate Grade No.	Maximum Size	Retained on Each Sieve							No. 4
		3 in.	2½ in.	2 in.	1½ in.	1 in.	¾ in.	½ in.	
1	2½ inch	0	0 to 5	0 to 20	15 to 50		60 to 80		95 to 100
2	1½ inch			0	0 to 5		20 to 70		95 to 100
3	1 inch				0	0 to 5	15 to 45	50 to 75	95 to 100

TABLE 1
Coarse Aggregate Gradation Chart

Unless otherwise specified on the plans the loss by decantation (Bulletin C-11) shall not exceed one percent.

(4) **Fine Aggregate.** Fine aggregate shall consist of natural sand, a combination of natural sand and manufactured

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sand or a combination of natural sand and mineral filler, or natural sand, manufactured sand and mineral filler.

The fine aggregate, prior to the addition of mineral filler, shall conform to the following:

At the time of its use, all fine aggregate shall be free from frozen material and all foreign materials, which may become mixed with the aggregate in the stock piles.

The fine aggregate shall be free from an excess 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 (ASTM Designation: C 40), the fine aggregate shall not show a color darker than the standard.

When the fine aggregate is mixed with High Early Strength Portland Cement in the proportion of 1:3, the average strength per square inch of not less than three standard mortar briquettes shall be equal to or greater than the strength of Ottawa Sand Mortar briquettes of the same proportions and consistency when tested at the age of 3 days.

When tested by approved methods, the fine aggregate shall conform to the grading requirements shown in Table 2.

Aggregate Grade No.	Use	Percent Retained on Each Sieve						
		3/8 in.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100
1	Concrete	0	0 to 5	0 to 20	15 to 50	40 to 75	70 to 90	90 to 100
2	Admixture Sand			0	0 to 5		0 to 25	40 to 85
3	Grout for Pre-stress Ducts			0	0 to 5		20 to 60	60 to 85
4	Mineral Filler					0 to 10		40 to 85

TABLE 2
Fine Aggregate Gradation Chart

Fine aggregate, meeting the grading requirements, may or may not be satisfactory for concrete production without admixture of a finer sand or mineal filler.

Sand shall consist of clean, hard, durable, uncoated grains. The material removed by decantation (THD Bulletin C-11) shall not exceed 4 percent.

Stone screenings shall consist of clean, hard, durable, uncoated fragments resulting from the crushing of stone.

For Class A, C, and E concrete, the fineness modulus as defined below for fine aggregates shall be between 2.20 and 2.90.

For Class F and G concrete, the fineness modulus of the fine aggregates shall be between 2.40 and 2.90.

For Class A, C, E, F, and G concrete, when the fineness modulus of the fine aggregate varies by more than 0.20 from the fineness modulus being used in the current design, the batch shall be redesigned in accordance with THD Bulletin C-11 before placing more concrete.

The fineness modulus of the fine aggregate shall 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 shell, crushed sand, or other approved inert material.

When tested by approved methods, the mineral filler shall conform to the grading requirements of aggregate No. 4, Table 2.

(6) **Mortar.** Mortar for general 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 the cement used will be approximately 60 percent regular cement and 40 percent white cement varied as required to produce the color required.

(7) **Grout.** Grout for grouting post-tensioned units shall consist of 1 part cement, 0.75 parts sand (Grade 3, Table 2), enough water (approximately 1 part) to make the grout pump properly and an approved non-shrink additive.

(8) **Adhesive Grout.** For the painting of concrete surfaces and for corrosion control of tendons in prestressed concrete, the mixture shall be: one part latex-base adhesive, two parts white cement, two parts natural cement, two parts fine masonry sand, and one part water. Mixture should have the consistency of a thick paint. Coverage for painting shall be approximately one-eighth of an inch. Coverage for corrosion control shall be in accordance with Item 426, "Pre-stressing".

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(9) **Admixtures.** An air-entraining admixture may be used with Type I, Type II or Type III Portland cement. The air-entraining admixture shall conform to the requirements of Item 437, "Concrete Admixtures".

Cement dispersing agents in accordance with Item 437, "Concrete Admixtures", may be used and with all classes of concrete at the option of the Contractor, and will be required for hot weather concreting in accordance with Section 420.13.

For all bridge superstructures air-entrained concrete will be required.

When air-entrainment is required or used, and the requirements of Section 420.13 for hot weather placement are also required, a cement dispersing agent which entrains the required amount of air or a cement dispersing agent and an air-entraining admixture shall be used. The air content will be checked by the method outlined in THD Bulletin C-11.

421.3. Storage of Cement. All cement shall be stored in well ventilated weatherproof buildings in approved bins, which will protect the cement from dampness. The floor supporting the cement shall clear the ground a sufficient distance to prevent the absorption of moisture by the cement. Provision for storage shall be ample, and the shipments of cement shall be segregated in such a manner as to provide easy access for identification and inspection of each shipment.

The Engineer may permit small quantities of sacked cement to be stored in the open for a maximum of 48 hours, if a raised platform and adequate waterproof covering are provided.

No cement shall be used which has become lumped or caked.

The Contractor shall keep accurate records of the deliveries of cement and of its use in the work. Copies of these records shall be supplied or made available to the Engineer.

421.4. Storage of Aggregate. The handling and storage of concrete aggregate shall be such as to prevent admixture with foreign materials. If the aggregates are stored on the ground, the sites for the stock piles shall be grubbed, cleaned of all weeds and grass, and leveled off. 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, the different sizes shall be stored in such a manner as to prevent intermixing.

Materials in all stock piles shall be handled and placed in such manner that segregation of materials within the pile will be avoided.

Unless otherwise authorized by the Engineer, all fine 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.

Allowance shall be made for the water content when moist aggregates are used. The quantities of each component material of the batch shall be determined by the Engineer, and no change shall be made therein except by his order.

Bags of cement varying more than 5 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 Item 500, "Weighing and Measuring Equipment".

421.7. Classification and Proportions. Concrete shall be proportioned as determined by the Engineer, using methods outlined in THD Bulletin C-11 for Design of a Concrete Batch to meet a Definite Specification, Absolute Volumes Methods, and in accordance with the requirements hereinafter set forth.

The concrete mix will be designed with the intent of pro-

ducing a concrete which, when cured and tested as outlined in THD Bulletin C-11, will comply with the requirements shown in Table 3, or as specified herein for flexural tests.

On isolated structures containing less than 25 C.Y. of concrete, the Engineer may waive the requirements for absolute volume batch design, in which case mix proportion shall be determined by trial mixes, but the requirements for weighing and measuring materials shall not be waived, except that, on projects where the total amount of concrete involved in entire project is less than 25 C.Y., the Engineer may waive requirements for weighing provided an acceptable method of measuring ingredients by volume is substituted.

The concrete shall be uniform and workable. The minimum cement content, maximum allowable water content, and maximum slump of the various classes of mixes shall conform to Table 3.

Class	Min.-Max. Sx. Cement Per C. Y.	Min. Comp. Strength 28-Day psi	Max. Water Cement Ratio	Slump Range	Coarse Aggregate No.	Fine Aggregate No.	Where Used
A	5.0	3000	7.0	2-3	1-2	1	Foundations Except Drilled Shafts
A	5.0	3000	7.0	3-4	2-3	1	General Structural Concrete Drilled Shafts
*A	5.0	3000	6.5	2-3	2-3	1	All Superstructure Concrete
B	4.0	2000	9.0	1-2	1-2	1	Riprap
C	6.0	3600	6.5	2-3	1-2-3	1	Special Concrete
D	3.0	1500	11.0	1-2	1-2	1	Riprap
E	6.0	3000	7.0	5-6	1-2	1	Seal Concrete Underwater
F	5.5-7.0	5000	5.75	2-3	3	1	Prestressed Concrete
G	6.0-7.0	6000	5.75	2-3	3	1	Prestressed Concrete

*Entrained Air.

TABLE 3
Classes of Concrete

The dry loose volume of coarse aggregate shall not be more than 0.82 cubic foot per cubic foot of finished concrete, except in cases where the voids in the coarse aggregate as determined by standard test methods exceed 48 percent

of the total dry loose volume. Where the voids exceed 48 percent of the total dry loose volume, the dry loose volume of coarse aggregate shall not exceed 0.85 cubic foot per cubic foot of finished concrete.

Where seal courses are required, and for all concrete placed under water, the concrete shall be Class E unless otherwise specified on the plans.

The net amount of water will be the amount added at the mixer, plus the free water in the aggregate, and minus the absorption of the aggregate based on a 30 minute absorption period (Tests to be made in accordance with Bulletin C-11). No allowance will be made for evaporation of water after batching.

Where flexural test beams are used the 7 day flexural strength shall be equal to or greater than one-sixth that of the required 28 day compressive strength.

If the strength required for the class of concrete being produced is not secured with the minimum cement content specified, additional cement shall be used or other aggregates provided at the Contractor's expense.

During the progress of the work the Engineer will maintain a careful check on the quantity of cement used in each structural unit. In calculations for the theoretical quantity of cement required, allowance shall be made for embedded reinforcing steel, embedded structural steel, and all panelling or chamfers more than 3 inches in width. Where the absolute volume mix design and the weighing of ingredients has been waived, the Engineer shall make adjustments in the proportions of ingredients to correct for any variations or more than 2 percent between the actual and the theoretical cement content when such variations are attributable to mix design. Cement wasted during the placing operations will not be included in calculations of the theoretical quantity of cement required.

421.8. Consistency. Concrete shall be of such consistency as to insure the required workability and result in compact masses having dense, uniform surfaces. The quantities of the ingredients shall be varied only with the authority of the Engineer. In cases where the characteristics of the aggregate are such that, with the maximum allowable amount of water the consistency requirements cannot be satisfied, the Contractor may furnish additional aggregates, mineral filler, or aggregates of a different character which will produce

421.9

the desired results. If the Contractor does not provide these materials, the Engineer will modify the mix design to insure proper workability by adding additional cement. The addition of water to the approved batch design to provide workability will not be permitted.

In general, the consistency of concrete mixtures shall be such that:

- (1) The mortar will cling to the coarse aggregate.
- (2) The aggregates will not segregate in the concrete when it is transported to the place of the deposit.
- (3) The concrete, when dropped directly from the discharge chute of the mixer, will flatten out at the center of the pile, but the edge of the pile will stand and not flow.
- (4) The concrete and mortar will show no free water when removed from the mixer.
- (5) The concrete will slide and not flow into place when transported in metal chutes at an angle of 30 degrees with the horizontal.
- (6) The surface of the finished concrete will be free from a surface film of "laitance".

Any concrete mix failing to meet the above outlined consistency requirements, although meeting the slump requirements, will be considered unsatisfactory; and the mix shall be changed to correct such unsatisfactory conditions. In cases where the characteristics of the aggregate furnished are such that, with the maximum allowable amount of water, the specified slumps and consistency requirements are not met, the Contractor may provide aggregates of an improved grading, or the Engineer will modify the mix design to meet the slump and consistency requirements by adding either cement or mineral filler, or both, as may be necessary. In case mineral filler is used, the combined total quantity of mineral filler and fine aggregate passing the 100 mesh sieve shall not exceed 20 percent of the weight of the fine aggregate.

The slump test will be made by the Engineer in accordance with the methods outlined in THD Bulletin C-11.

The limits allowed for slump are set forth in Table 3. The slump mold will be furnished by the State Highway Department.

421.9. Quality of Concrete. During the progress of the work the Engineer will cast test cylinders or beams for test-

ing to maintain 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 three cylinders or two beams as the case may be.

Test beams or cylinders shall be required for each 50 cubic yards, or portion thereof, placed each day. On small structures such as manholes, inlets, culverts, wingwalls, etc., the Engineer may vary the number for small placements to tests for each 25 cubic yards placed over a several day period.

For Class F, G and Y Concrete the control of the concrete shall be by compressive tests of cylinders and not by flexural tests. Two tests (six cylinders) may be made for each pertinent strength test required by Table 2 of Item 425 "Prestressed Concrete Structures" except for "Release Strength" as required by Table 2 of Item 425. For determining "Release Strength" of prestressed concrete members a test shall be defined as the breaking strength of one cylinder.

Test cylinders for Class F, G and Y Concrete will be required for each 50 cubic yards of concrete placed or portion thereof, and for each separate stressing line of beams, spans, members, piling, etc., as the case may be. Test cylinders for job site control will be tested on a compressive testing machine as specified in Item 498, "Plant Inspection Laboratory (Equipped)". This machine shall be automatically operated at the rates specified by ASTM Designation: C 39 "Method of Test for Compressive Strength of Molded Concrete Cylinders". Test cylinders shall be made and tested in accordance with Test Method Tex-704-I.

All test specimens, beams or cylinders representing tests for removal of forms and/or falsework, and Class F, G and Y Concrete for "Tension Release" shall be cured under the same conditions, subjected to the same curing materials and to the same weather conditions as the concrete represented.

"Design Strength" cylinders and beams 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. The cost of all materials used in test specimens and the cost of providing and maintaining curing facilities shall be in-

421.10 to .11

cluded in the unit price bid for concrete of the various classes.

421.10. Mixing Conditions. The concrete shall be mixed in quantities required for immediate use, and any concrete which is not in place within the limits outlined in Section 13, of Item 420, "Concrete Structures", 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 will order postponement of the work. Where work has been started and changes in weather conditions require protective measures to be used, the Contractor shall furnish adequate shelter to protect the concrete against damage from rainfall, or damage due to freezing temperatures as outlined in Section 420.12. In case it is necessary to continue operations during rainfall, the Contractor shall provide protective coverings for the material stock piles as well as for the concrete being placed. The covering for aggregate stock piles will be required only to the extent that may be necessary to control the moisture conditions in the aggregates so that adequate control of the consistency of the concrete mix may be maintained.

No concrete shall be mixed without the approval of the Engineer when the air temperature is at or below 40 F (taken in the shade away from artificial heat) and falling, except as provided in Section 420.12. If authorized by the Engineer, concrete may be mixed when the air temperature is at 35 F, and rising. When permission is given for mixing when the temperature is below 40 F, the following requirements shall govern:

All water used for mixing shall be heated to a temperature of at least 70 F but not over 180 F. Aggregates shall be heated either by steam or by dry heat to a temperature of at least 70 F but not over 150 F. The heating apparatus shall be such as to heat the mass of aggregate uniformly and preclude the occurrence of hot spots which will burn the material. When the water and/or aggregates are heated, the cement shall not be introduced to the batch until after the aggregates and water are batched into the mixing device. Temperature of mixed concrete shall not be less than 60 F nor more than 90 F at the time of placing in the forms.

421.11. Mixing and Mixing Equipment. All equipment, tools, and machinery used for hauling materials and per-

forming 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 which will insure the uniform distribution of the material throughout the mass so that the mixture will be uniform in color and smooth in appearance. Mixers may be either the revolving drum type or the revolving blade type, if the equipment is capable of producing concrete meeting the requirements of these specifications.

The minimum rated size of mixer permissible will be a 5 cubic foot batch mixer, which size may be used only on structures or units of structures involving a maximum continuous placement of not over 15 cubic yards of concrete. A 10 cubic foot or larger batch mixer shall be used where continuous placement of 15 to 50 cubic yards of concrete are involved. For larger placements, a 14 cubic foot batch mixer or larger batch mixer shall be used. The use of more than one 5 cubic foot or 10 cubic foot batch mixer to produce results equivalent to the above requirements as to sizes of mixers will be permitted.

The absolute volume of the concrete batch shall not exceed the rated capacity of the mixer. The continuous placements which govern the size of mixers required, shall be the placements between construction joints shown on the plans.

After all the ingredients are assembled in the drum, the mixing shall continue for a minimum time of $1\frac{1}{2}$ minutes.

The mixer shall operate at the speed and capacity as 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 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 without diminishing the mortar content of the mix.

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 so constructed that it is put into operation

421.12

when the skip is raised to its full height and dumping. This device shall lock the discharging mechanism satisfactorily to 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 in the drum has elapsed.

The water tank shall be arranged so that the amount of water can be measured accurately, and while the tank is discharging, the inlet supply shall be 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 throw-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.

Concrete improperly mixed shall not be placed in the new structure.

The use of ready-mixed concrete will be permitted provided the batching plant meets the requirements of Item 502, "Ready-Mix Plants".

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 Section 420.13.

Job mix concrete shall be that 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 carts, barrows, concrete buckets, etc.

Ready-mix concrete shall be as defined by Item 502, "Ready-Mix Plants."

Hand mixing of concrete will be permitted only for small placements or in the 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 Item 420, "Concrete Structures".

421.13. Measurement. The quantities of concrete of the various classifications which constitute the completed and accepted structure will be measured by the cubic yard in place. Only accepted work will be included, and the dimensions used will be those shown on the plans or ordered in writing by the Engineer. No deductions in measurement will be made for paneling less than 3 inches in width by one inch depth, for chamfers less than 2 inches, for embedded reinforcing steel, for embedded portions of structural steel members, or for embedded portions of steel H piling. Deductions will be made for embedded portions of all piling other than steel H piling.

421.14. Payment. The concrete quantities, measured as provided above, will be paid for at the unit prices bid per cubic yard for the various classifications of concrete shown, which prices shall be full compensation for furnishing, hauling and mixing all concrete materials; placing, curing, and finishing all concrete; all grouting and pointing; furnishing and placing all drains and expansion joints, except as hereinafter provided; furnishing and placing metal flashing strips; and for all forms and falsework, labor, tools, equipment, and incidentals necessary to complete the work.

The above provisions for payment shall not be interpreted to provide payment for concrete in railings, piling, concrete culvert pipe, precast prestressed concrete units, or other concrete items for which provision is otherwise made in the contract.

The above provisions for payment for drains and expansion joints shall not be interpreted to provide payment for cast iron or structural steel shapes used in drains; for structural steel, cast iron or cast steel bearing plates; or for steel members used in armoring roadway joints. Payment for these materials is provided for in Item 442, "Metal for Structures".

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, fine

and coarse lightweight aggregates, a cement dispersing agent, an air-entraining admixture, and water, proportioned and mixed as hereinafter provided.

At the option of the Contractor, fine aggregate, meeting the requirements of Grade 1 fine aggregate, as shown in Table 2 of Item 421, "Concrete for Structures", may be used to supplement or replace the lightweight fine aggregate, provided that the requirements for workability, compressive strength, and maximum air-dried weight are met.

Where references are made herein to wear of aggregates, the test for wear as specified shall be made in accordance with "Standard Method of Test for Abrasion of Coarse Aggregate by the use of the Los Angeles Testing Machine", AASHO Method T-96.

423.2. Materials.

(1) **Cement.** The cement shall be Type I, Type II or Type III Portland cement conforming to the pertinent requirements of Item 421, "Concrete for Structures".

(2) **Lightweight Aggregate.** Lightweight aggregate shall consist of burned clay or burned shale having strong durable particles, and conforming to the requirements of Standard Specifications for Lightweight Aggregates for Structural Concrete, ASTM Designation: C 330. It shall have a wear of not more than 40 percent when tested according to AASHO Method T-96.

When tested by approved laboratory methods, fine and coarse aggregates shall conform to the grading requirements shown in Table 1:

	Percent Retained on Sieve						
	1"	3/4"	3/8"	4	16	50	100
Coarse Aggregate.....	0	0-10	40-80	90-100			
Fine Aggregate.....			0	0-15	20-60	65-90	75-95

TABLE 1
Aggregate Gradation

(3) **Admixture Sand.** Admixture sand shall conform to the requirements for Grade 2 fine aggregate as shown in Table 2, of Item 421, "Concrete for Structures".

(4) Concrete admixtures shall conform to Item 437, "Concrete Admixtures".

A cement dispersing agent and an air-entraining admixture will be required in all lightweight concrete.

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 Item 421, "Concrete for Structures"; Item 502, "Ready-Mix Plants"; and Item 500, "Weighing and Measuring Equipment".

423.4. Storage of Aggregate. Storage of aggregates shall be in accordance with the pertinent requirements of Section 421.4 except as noted below.

Lightweight aggregates shall be stock piled on the job or at a central batching plant for a minimum time of 24 hours prior to its use in the project. The aggregate shall be wet to a uniform moisture content of 10 to 15 percent by volume at the plant before or while being loaded for shipment and care shall be exercised to maintain this uniformity of moisture until the aggregate is used in the mix.

Stock piles shall be wet as required to maintain the required uniform moisture content specified. Wetting of stock piles shall be done at least 12 hours prior to use.

Fine and coarse aggregates shall be stock piled separately.

423.5. Classification and Proportions. Lightweight concrete shall be proportioned by weight in such manner as to secure a uniform and workable mix which will produce cured concrete of the weight and strength specified herein. Prior to mixing any concrete which will be used in the structure, the Contractor shall prepare trial batches, proportioned and tested in accordance with THD Bulletin C-11. Admixture sand may be required to improve workability of the mix.

At the option of the Contractor, natural fine aggregate may be substituted for fine, lightweight aggregate provided such substitution does not result in producing concrete that has a weight in excess of the maximum permissible specified herein.

The Engineer will determine the amount of admixture required to produce concrete having the specified air content, and this amount shall not be varied except as directed by the Engineer. Proportions for the concrete to be used in the structure shall be determined by the Engineer, on the basis of results obtained from the trial batches.

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The cement content, maximum air content, and slump the various classes of concrete shall conform to Table 2:

Class	Min.-Max. Bags Cement Per C. Y.	Min. Comp. Strength 28-day psi	Slump Range	Air-Dried Weight Max.	Total Air Content Max.	Use
X	5.5-7.0	3000	2-3	105	9	General Structural
Y	6.0-8.0	5000	2-3	110	9	Prestressed Concrete

TABLE 2
Classes of Lightweight Concrete

The concrete mix will be designed with the intent of producing a concrete, which, when cured and tested as outlined in THD Bulletin C-11 will comply with the requirements shown in Table 2.

If the strength required for the class of concrete being 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 shall be of such consistency to insure the required workability and result in compact masses having dense, uniform surfaces. The proportions of the ingredients shall be varied only with the authority of the Engineer.

In general, the consistency of lightweight concrete should be similar to that of natural aggregate concrete. Batches which are harsh and unworkable will be redesigned by the Engineer. The Contractor shall provide other or additional materials required to produce a batch of a satisfactory consistency. These additional materials shall be provided at the Contractor's expense.

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 three cylinders.

For jobsite placement of lightweight concrete, two tests (six test cylinders) will be required for each 40 cubic yards, or portion thereof, placed in each day's placement. For small

placements, tests may be for each 25 cubic yards placed over a several day period. 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.

For prestressed lightweight concrete, two tests (six test cylinders) for each pertinent strength test required by Table 2 of Item 425, "Prestressed Concrete Structures", will be required for each separate stressing line of beams, spans, piling, etc., as the case may be.

Testing and curing of cylinders shall be in accordance with Item 421, "Concrete for Structures". Job control cylinders may be tested on a hand operated compression machine. Equipment shall be furnished by the Contractor.

Air content will be checked by use of a pressure type air meter, in accordance with ASTM Designation: C 231.

Tests for wet weight will be made in accordance with ASTM Designation: C 138.

The relationship between the air-dried weight of concrete and the wet weight of concrete will be established by the Engineer, based on trial batches and checks made during progress of the work. In general, concrete with a wet weight of over 108 pounds per cubic foot for Class X Concrete and 113 pounds for Class Y Concrete will require re-design of the batch.

For each change in batch design weight and for each 25 cubic yards of concrete placed in the structure, two tests for wet weight will be made. At any time that the average of these tests indicates a wet weight in excess of that which has been determined to produce air-dried concrete of the specified weight, the batch will be adjusted by the Engineer to reduce the wet weight of concrete by the amount required.

423.8. Mixing. The following shall govern the mixing of lightweight concrete.

(1) The cement dispersing agent and at least two-thirds of the total mixing water shall be introduced in the mixer and mixed for 15 seconds.

(2) The fine and coarse aggregates shall be added and mixed for 45 seconds.

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(3) The cement and final water 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 operated at high speed while charging it with aggregate. Cement shall be introduced into the mixing drum while it is rotating at slow speed. Immediately prior to discharge of the concrete, the drum shall be rotated at high speed for at least 30 seconds.

423.9. Placing, Curing, and Finishing. The placing of concrete, including construction and removal of forms and falsework, curing, and finishing shall be in accordance with Item 420, "Concrete Structures", except that floats used in finishing shall be metal shod.

423.10. Measurement. The quantity of concrete which constitutes the completed structure will be measured by the cubic yard of accepted work in place. The dimensions used will be those shown on the plans or ordered in writing by the Engineer. No deductions in measurement will be made for panelling less than 3 inches in width by 1 inch depth, for chamfers less than 2 inches, for embedded reinforcing steel or for embedded portions of structural steel members.

423.11. Payment. The concrete quantities, measured as provided above will be paid for at the unit price bid per cubic yard for Class "X" or Class "Y" Concrete which price shall be full compensation for furnishing, hauling and mixing all concrete materials, including trial batches; placing, curing, and finishing all concrete; for all grouting and pointings; furnishing and placing all expansion and construction joints, except as hereinafter provided; furnishing and placing metal flashing strips, and waterstops; and for all forms and falsework, labor, tools, equipment, and incidentals necessary to complete the work.

The above provision for payment for expansion joints shall not be interpreted to provide payment for cast steel or structural steel shapes and plates used in expansion joints and armored joints, or for structural steel, cast iron, or cast bearing plates. Payment for these materials are provided for in Item 442, "Metal for Structures".

The above provisions for payment shall not be interpreted to provide payment for concrete in railing, piling, precast

prestressed concrete units, or other concrete items for which provision is otherwise made in the contract.

ITEM 425

PRESTRESSED CONCRETE STRUCTURES

425.1. Description. This item shall govern for the complete construction, prestressing, and erection of prestressed concrete structures, both cast-in-place and precast, in accordance with the plans.

425.2. General. The method of construction and of prestressing shall be as shown on the project plans and on the approved shop drawings. Prior to beginning the casting of prestressed members, the Contractor shall give the Engineer ample notice as to the location of the casting site and the date on which work will begin so that arrangements may be made for inspection.

An inspection laboratory shall be furnished in accordance with Item 498, "Plant Inspection Laboratory (Equipped)".

For cast-in-place prestressed members, equivalent equipment and laboratory facilities may be provided in lieu of the above laboratory, subject to the approval of the Engineer. The cost of testing of compression cylinders shall be borne by the Contractor. The facilities for testing cylinders will be subject to the approval of the Engineer.

Shop plans showing the following information shall be submitted for approval. The number of copies required and routing shall be as shown in Table 1.

A. Erection Layout. An erection layout sheet showing information for field erection. (Location, type member, erection mark of member, bearing pads, etc.)

B. Fabrication Details. Complete information necessary for fabrication not shown on contract plans. (Member lengths, type, skew angle, dimensions for diafram holes, neoprene pad sizes, bevels and erection devices, inserts to be used in forming, etc.)

C. Method of Handling and Transporting. Method of transporting to the job site, including points of support, blocking used, tie down points, amount of cantilever, etc.

D. Facilities Plan. Prior to pretensioning of members, the producer shall submit a drawing showing the complete facilities to be used for stressing, including details of the pulling head, anchor plates, jacks, hold-downs, etc., with

425.2

dimensions and thicknesses of plates, bolts, etc., and types of materials used. This shall be in sufficient detail to allow accurate calculation of stresses in the stressing equipment and anchorages. Detailed drawings shall be submitted and approval of the system given prior to casting of beams.

E. Construction Details. For cast-in-place, post-tensioned structures, the Contractor shall furnish details of shoring and falsework together with any unusual construction methods proposed.

F. Prestressing Details. For post-tensioned members, pre-tensioned members with draped strands, for special and modified designs, for job site fabrication and for cast-in-place members, the Contractor shall submit to the Engineer, detailed fabrication plans showing details of the member and forms, devices for holding prestress steel in place, method and details of draping strand, anchorage details, method and details of prestressing the steel together with anticipated elongations and jack pressures, and all other features of proposed fabrication. Calculations may be included at the Contractor's option, or required at the Engineer's request where necessary to justify the system and method of prestressing to be used.

(See Explanation Below)	A	B	C	D	E	F		
Type of Member	Erection Layout Sheet	Fabrication Details	Method of Handling & Transporting	*Facilities Plan (Plant equipment & procedures)	Construction Details	Prestressing Details	Submit Direct to Resident Engineer	Submit Direct to Bridge Division
1. Precast Pretensioned Beams (Straight Strands)	6	6	6	4*			A, B, C	D
2. Precast Post-tensioned Beams, and Pretensioned Beams with draped strands	6	6	6	4*		6		A, B, C, D, F
3. Cast-in-place Beams, spans, slabs, etc., Post-tensioned					5	5	E	F
4. Precast Prestressed Piling. a. Pretensioned b. Post-tensioned			6 6	4*		6	C	C, D F

*For plant operations, submission need be made only once initially and thereafter for jobs only if type of product or method is altered.

TABLE 1
Required Shop Plans
(Numbers indicate the number of prints to be submitted.)

425.3. Materials. Except as specified herein, materials shall be in accordance with Item 426, "Prestressing".

The values indicated below shall govern for minimum concrete strengths during different phases of construction unless otherwise shown on the plans.

Class of Concrete	Post-Tensioned Members		Pretensioned Members	"Design Strength"
	"Partial Tensioning Strength" (For handling purposes only)	"Tensioning Strength"	"Release Strength"	
F	3500	4500	4000	5000
G	4000	5250	5000	6000
Y	3500	4500	4000	5000

TABLE 2

Minimum Concrete Cylinder Strengths—(pounds per square inch)

425.4. Construction Methods. The placing and curing of concrete, construction of forms, and finishing, shall be in accordance with Item 420, "Concrete Structures," and the notes shown on the plans with the further provisions contained herein.

Prestressing shall be in accordance with Item 426, "Prestressing".

For precast, prestressed concrete members, external bracing for aligning and holding of forms (whether steel or wood) shall be required. No device shall be used which requires that it be left in the member.

Top surfaces against which cast-in-place concrete will be placed later shall be rough floated with a wooden float to bring grout to the surface and cover all aggregate. At the time of initial set, laitance shall be removed by brushing transversely with a wire brush. Sound concrete shall not be removed or aggregate loosened.

The bed for casting prestressed members shall be so constructed and maintained to provide not more than $\frac{1}{4}$ inch vertical variation in any 50 foot length.

Side forms shall remain in place for a minimum of 12 hours when water curing is used. When steam curing is used, 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. Re-

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removal of the forms shall be done in such a manner that curing is not interrupted on any beam for more than 30 minutes. Cracks caused by form restriction will be cause for rejection.

Erection holes (lifting eyes, form anchors, etc.), in exterior beams shall be filled with mortar and the surface given a first surface rubbing to blend the area into the surrounding surface. Holes in interior girders need not be filled unless steel is exposed to corrosion. Erection or fabrication holes in the bottoms of all beams shall be filled with non-shrink mortar in such a manner as to prevent subsequent reopening of the hole.

Curing of the concrete shall be commenced prior to the formation of surface shrinkage cracks but in no case delayed longer than one hour after it has been placed in the forms.

The curing shall be an approved water or membrane curing (where allowed) as an interim measure prior to elevated temperature or other methods of curing.

Precast, pretensioned members (partially or fully pretensioned) shall be cured continuously, except as provided above for form removal, until the concrete strength, as indicated by compressive tests of cylinders, has reached the "Release Strength". Curing then may be interrupted for a time interval of not more than 2 hours for removal of the members from the casting bed to a curing area. Curing operations then shall be resumed for an additional 48 hours.

Precast, post-tensioned members shall be cured continuously, except as provided above for form removal, until the concrete strength, as indicated by compressive tests of stressing cylinders, has reached the "Partial Tensioning Strength". Curing then may be interrupted for a time interval of not more than 6 hours for partial tensioning and removal of the members from the casting bed to a curing area. Curing operations then shall be resumed for an additional 60 hours. Partial post-tensioning and removal to a curing area shall not be done at temperature below 40 F.

425.5. Handling and Erection. Care must be exercised at all times when handling members. In general, members should be lifted only near the ends and always in an upright position. Fabrication and erection plans shall indicate the method of handling in such detail as to preclude the possibility of overstressing any part of the member. An adequate factor of safety shall be included to cover dynamic forces or impact.

No structural member shall be moved from the casting yard until after all tensioning, curing, and strength requirements have been attained. Members shall be considered adequate for strength at any time after curing and tensioning requirements are fulfilled and the design-strength compressive cylinders indicate that the required design strength has been attained. An adequate number of cylinders shall be cast to insure that acceptance of members will be based on cylinder breaks.

425.6. Defects and Breakage. If any prestressing tendon or portion thereof is broken prior to placing concrete in the member, it shall be replaced with a satisfactory unit properly prestressed. The breaking of one wire of a seven wire strand in a unit during concrete placing operations will be subject to a structural review prior to acceptance.

Fine hair cracks or checks on the surface of the member which, as determined by the Engineer, do not extend to the plans of the nearest reinforcement, will not be cause for rejection unless such cracks are so numerous and extensive as to indicate inadequate curing, in which case the members will be rejected. Diagonal cracks on the vertical surfaces which indicate damage from torsion will be subject to a structural review prior to acceptance. Vertical and horizontal cracks which are one-sixteenth inch or less in width and which tend to close upon release of stress are acceptable. Cracks in excess of this are subject to review prior to acceptance. Cracks which extend into the plane of the reinforcement and/or prestressing steel and are acceptable otherwise, shall be repaired as required by Item 420, "Concrete Structures", cured and rubbed prior to acceptance.

All replacement as herein specified as well as all other replacements due to faulty materials or construction methods shall be made at the Contractor's expense.

425.7. Workmanship and Tolerances.

(1) Prestressed Beams, Girders, Spans, and Box-Type Beams.

- (a) Variation from shop plan lengths—Plus or minus 1 inch.
- (b) Variation from plan height—Box-Type Beams—plus or minus $\frac{1}{4}$ inch. Others—Plus or minus $\frac{1}{2}$ inch.

- (c) Maximum sweep $\frac{1}{4}$ inch per 10 ft. of length.
Box-Type Beams $\frac{3}{4}$ inch total sweep.
- (d) Out of square (vertical or horizontal) or deviation from plan skew angle—Maximum $\frac{1}{8}$ inch per ft. of dimension.
- (e) Bearings
 1. Out of perpendicular with vertical axis—Maximum $\frac{1}{16}$ inch.
 2. Honeycomb in bottom soffit of beams at the bearing, shall not exceed 15 percent of the bearing area (width x length). No tendons shall be exposed and the maximum depth of honeycomb shall not exceed 1 inch. Honeycomb shall be chipped out to sound concrete and repaired satisfactorily prior to acceptance.

(2) Piling.

Tolerances for piling shall be as specified in Item 409, "Concrete Piling".

(3) Small areas of honeycomb which are purely surface in nature (not over one inch deep) may be repaired. Honeycomb extending to the plane of the prestressed strands will be rejected tentatively, subject to structural review prior to acceptance.

Variations greater than specified above will be cause for rejection.

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, complete in place.

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.

Other precast, prestressed members of the type and size specified, cast and stressed as required by the plans may be measured by the linear foot or by each member as the case may be and as noted on the plans.

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 Item 426, "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 for "Prestressed Concrete Members" (specify name and type), or at the unit price bid for each "Prestressed Concrete Member" (specify name and type) as the case may be.

A partial allowance will be made for materials and for precast or prestressed concrete members (cast, but not erected) in accordance with the provisions of Item 9.6, Partial Payments.

The above prices shall be full compensation for constructing the members, furnishing and tensioning prestressed steel, furnishing and placing reinforcing steel, and conduit for same, attached bearing plates, etc., grouting holes, and for all bars, anchorage plates, and other appurtenances which become an integral part of the precast structure and for any special treatment of end anchorages and shoes as indicated on plans, and shall be full compensation for furnishing all material, 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, storing, and handling of materials for prestressing and for the prestressing of structural units except as otherwise shown on the plans.

426.2. Materials.

(1) **Concrete.** All concrete shall be Class F, G, or Y in accordance with the provisions of Item 421, "Concrete for Structures" and/or Item 423, "Lightweight Concrete for Structures".

The class of concrete will be designated on the plans.

(2) **Grout.** (For pressure grouting of ducts.) All grout shall conform to the provisions of Item 421, "Concrete for Structures".

(3) **Reinforcing Steel.** Reinforcing steel, not prestressed, shall conform to Item 440, "Reinforcing Steel".

(4) **Structural Steel.** Structural steel bearing plates, fittings, etc., shall conform to Item 441, "Steel Structures", and Item 442, "Metal for Structures".

(5) **Prestressing Steel.**

(a) **Post-Tension Method.** Alternate types of prestressing tendons and systems may be used as provided on the plans. End anchorages or connections shall develop at least 95 percent of the required ultimate strength of the tendon based on the gross area and the required minimum unit strength. Certification of the above by the manufacturer will be required.

Bearing and shim plates shall be structural steel in accordance with the provisions of Item 441, "Steel Structures", and Item 442, "Metal for Structures".

As used herein, "tendon" shall be defined as any single prestressing element used to apply prestressed forces to the member. For post-tensioned construction this shall be each group of wires, each large diameter strand, or each bar having common end anchorage.

All tendons shall be identified by heat number and tagged for identification purposes. Anchorage assemblies shall be identified in a like manner. The Contractor shall furnish, free of additional charge, one representative specimen of each size of tendon from each 10 tons of each heat. These specimen are to be obtained at the casting yard or at the tendon fabrication plant. Each specimen shall be 4 feet in length.

When required by the Engineer, the Contractor shall furnish, free of charge, two specimen of each size of prestressing unit of the selected type, with end fittings attached, for tensile tests to be performed by the Engineer. These specimens 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 additional cost.

For prestressing systems previously tested and approved on Department projects complete tendon samples need not be furnished, provided there is no change whatsoever in the material, design, or details previously approved. Shop drawings shall contain an identification of the project on which approval was obtained, otherwise sampling will be necessary.

When testing as a complete unit is not required, the tendon shall be tested and specimen submitted as specified above.

For prefabricated tendons, the Contractor shall give the Engineer at least 10 days notice before commencing the installation of end fittings or the heading of wires. The Engineer will inspect all end fittings, installations, and wire headings while such fabrication is in progress at the plant and will arrange for all required testing of the material to be shipped to the site.

All tendons, anchorage devices, and metal conduit shall be free of lubricant, oil, loose rust, or other deleterious material at the time of placing in the precast member.

1. Steel Wire. Parallel steel wire shall conform to ASTM Designation: A 421. Type BA shall be used for "Button" anchorages and Type WA shall be used for "Wedge" anchorages. Samples for testing shall be as specified in Section 426.2(5)(a).

2. Manufactured Steel Twisted Wire Strand (Large Diameter Strand). Unless otherwise specified on the plans, strand shall not be galvanized. The minimum ultimate strength shall be 220,000 pounds per square inch based on the gross section of the tendon.

The minimum ultimate elongation over a gage length of 10 inches shall be 3 percent. After tendons are fabricated, such shall be prestretched at sufficient stress and for sufficient length of time to equalize the stress in all wires and to reduce creep to a minimum.

Tendons shall be shipped to the job site with end fittings attached and encased in the flexible metal conduit described elsewhere in these specifications.

3. Prestressing Bars. The minimum ultimate tensile strength based on the gross section of the bar shall be 145,000 pounds per square inch. The minimum ultimate elongation in 20 bar diameters shall be 4 percent. Each bar shall be proof loaded by the manufacturer to 90 percent of its required ultimate strength. Bars using threaded end connections or splices of any kind will not be permitted, unless otherwise shown on the plans. If splices are allowed, test reports showing complete chemical analysis of the bar and of the splicing device shall be submitted for approval, prior to their use. If splices are used, tensile specimen submitted shall develop 95 percent of the required ultimate

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when tested with a 2 degree cold bend in the bar at the root of the thread or at the end of the splicing device.

(b) **For Pretension Method.** As used herein, "tendon" shall be defined as "any single prestressing element used to apply prestressed forces to the concrete". For pretensioned construction, this shall be each strand of straight wire.

1. **Steel Wire.** The requirements for steel wire shall be the same as the requirements for steel wire for the post-tension method as specified above. Samples for testing shall be as specified in Section 426.2.(5)(a).

2. **Manufactured Steel Seven Wire Strand.** Seven wire strand shall conform to the requirements of ASTM Designation: A 416. The Contractor shall furnish, free of charge, a representative sample of each size of wire or strand from each reel up to a lot of three reels. In lots of four reels or more, one sample shall be furnished from each third reel or fraction thereof. Each sample shall be 4 feet in length.

3. **Prestressing Bars.** Bars will not be allowed in the pretension method.

(6) **Bearing Pads.** Bearing pads shall conform to the requirements of Item 435, "Elastomeric Materials".

426.3. Construction Methods.

(1) **General.** The following paragraphs are primarily intended to apply to the prestressing of concrete structures. However, the methods of tensioning and other requirements where applicable shall apply to the prestressing of any type of structure or member, subject to special requirements on the plans.

Calculations of anticipated losses, spacings, clearances, etc., shall be in accordance with the latest AASHTO Tentative or Standard Specification for Highway Bridges, unless otherwise shown on the plans.

(2) **Post-Tensioning.** Each prestressing tendon shall be encased in a flexible metal conduit of a diameter sufficiently large to allow complete grouting of the void, but not smaller than recommended in the latest AASHTO Tentative or Standard Specifications for Highway Bridges. The metal conduit shall be rigid enough to maintain the desired profile between points of support and shall be completely sealed

against leakage of mortar into the conduit. The conduit shall be increased in size near the ends as necessary to provide free movement of end anchorage devices.

Pressure fittings for grout injection shall be provided at each end of conduits 100 feet and less in length and at each end and at the approximate center of conduits longer than 100 feet.

When tendons are to be deflected, the metal conduit shall be set low enough to offset the eccentric position of the tendons or bars in the conduit after stressing. Unless otherwise specified, the location of the prestressing units with respect to the member being prestressed as shown on the plans shall be construed to be the final location after stressing.

After tendons have been stressed to the required tension, each conduit shall be flushed out with clean water and then blown out with compressed air. The conduit then shall be completely filled with grout under a pressure of not less than 50 pounds per square inch. Grout shall be pumped from one end and expelled at the other end of members 100 feet or less in length. For members over 100 feet in length, grout shall be pumped from each end simultaneously and under approximately the same pressure and expelled at the center fitting.

Precautions shall be taken to prevent clogging of the grout pumps to insure that the grouting operation is uninterrupted. After all water and air has been expelled, the escape hole shall be plugged and the pressure maintained for at least one minute. After the grout has attained its set, any voids around the fittings shall be filled flush with the end of the unit.

If end anchorages permit, tendons may be inserted in the member after placing of the concrete. In all cases, the flexible metal conduit previously described shall be used. If tendons are to be inserted later, a stiffening bar shall be placed inside the metal conduit prior to placing of 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 to the Engineer for approval.

After the concrete has reached a compressive strength equal to the "Partial Tensioning Strength" specified in Item 425, "Prestressed Concrete Structures", or on the plans, as indicated by compressive cylinder tests, the members may be partially prestressed for the purpose of removal of members

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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.

If all stressing cylinders are broken and a strength equal to the required "Partial Tensioning Strength" has not been attained, curing shall be continued one curing day for each 100 psi deficiency prior to partial tensioning. Concrete which does not reach the "Partial Tensioning Strength" in 10 days shall not be accepted.

The Contractor shall furnish hydraulic jacks for stressing the steel. These jacks shall be of a type suitable to the purpose and shall be equipped with gauges graduated to read directly to 1 percent of the total load applied, and calibrated to measure accurately the stress induced in the steel.

In all methods of tensioning, the stress induced in the prestressed steel shall be measured by elongation of the steel and checked by gauge pressure. The results shall be within 5 percent of each other. 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.

Prior to stressing any tendon, the Contractor shall furnish the Engineer certified copies of load calibration curves for all jacks and gauges to be used in the work certified by a Testing Laboratory acceptable to the Engineer. Jacks and gauges shall be recalibrated when directed by the Engineer.

The temporary overload force, when required, and the post-tensioning force as shown on the plans may be applied at a minimum age of 10 days, but not before the concrete has reached a compressive strength equal to the "Tensioning Strength" and after all curing requirements have been met. These forces shall be applied to both ends of the tendon simultaneously for all deflected units and for other units when necessary to eliminate friction. The temporary overload force shall be held for a period of 2 minutes before reducing to the post-tensioning force required. The sequence

of post-tensioning the units shall be such as to prevent overstressing the beam by vertical or lateral bending at anytime, and shall be so indicated on the prestressing details submitted to the Engineer for approval.

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 is completely cured, 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 the 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 uniform 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 group shall be stressed to a total tension as required by the plans by means of hydraulic jacks equipped with gauges graduated to read directly to 1 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 tendons and checked by gauge pressure. The results shall be within 5 percent of each other.

Means shall be provided for measuring the elongation to an accuracy of one-sixteenth of an inch for each 100 feet of length between jacking heads. In the event of apparent discrepancies of more than 5 percent between stresses indicated by gauge 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 deflected tendons is used, the stress indicated by total elongation shall not vary by more than 5 percent from that indicated by gauge pressure. Measurements on individual tendons to establish differential stresses at different points in the beam shall be averaged at a cross section of the beam and the averages

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shall be within 5 percent of the computed elongation. No individual tendon shall vary from the computed 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 stressed to full tension 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.

The tendon stress shall be maintained between anchorages until the concrete has reached a compressive strength equal to the "Release Strength" specified in Item 425, "Prestressed Concrete Structures," or on the plans, as determined by compressive cylinder tests. If all test cylinders for tension release are broken and the strength required for release of tension has not been attained, then the tendon stress will be maintained and curing continued for a period of 24 hours for each 100 psi deficiency, prior to release of tension. If the cylinders indicate a strength of less than the "Release Strength" in 10 days, the members shall not be accepted for use.

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 elevated temperature curing is used, the release of stress shall be prior to the beginning of temperature reduction. Members shall remain protected until there is a differential of temperature inside the curing jacket and air temperature of not more than 15 F.

At the ends of members, a minimum area of one inch around each tendon shall be recessed approximately three-eighths of an inch and the tendon cut off as nearly flush as possible. The recessed area shall then be filled so as to provide a coverage of the tendon end with a minimum of one-eighth of an inch of adhesive grout. The grout shall be in conformance with Section 421.2 (h), Adhesive Grout. Curing of the grout shall be adequate to prevent shrinkage and/or cracking.

When draped tendons are used, positive external hold

downs shall be provided to offset the vertical forces in the beam at the time of stress release.

Prior to stressing the tendons, the Contractor shall furnish the Engineer certified copies of load calibration curves on all jacks and gauges to be used in the work. Jacks and gauges shall be recalibrated when required by the Engineer.

(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.

426.4. 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 Item 425, "Prestressed Concrete Structures". Prestressed piling will be measured and paid for as specified in Item 409, "Concrete Piling", or Item 412, "Prestressed 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 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 the prestressing of the cast-in-place structures or units will not be measured, but will be considered as one unit for "Prestressing" each different structure type or unit as itemized on the plans and in the proposal.

426.5. Payment. Payment for the work and all materials for prestressing of cast-in-place members as specified above will be made at the lump sum price bid for "Prestressing".

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, and anchorages, bearing plates, and all tools, labor, and incidentals necessary to complete the work.

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
Reinforcing Steel	440

430.3. Construction Methods. The work shall be performed in accordance with the provisions of Item 420, "Concrete Structure", 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 the materials so removed shall be disposed of as shown on the plans or as directed by the Engineer. 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.

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 moved 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.

The use of a demolition ball or other swinging weight, will be allowed for use on those portions of the structure not immediately adjacent to the 'break-out' line of the concrete.

The concrete shall be severed at the 'break-out' 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-out' line shall be with pneumatic tools. Damaged concrete shall be treated as specified above.

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 non-shrinkage 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 I of Item 440, "Reinforcing Steel", or by welded splices conforming with Item 448, "Structural Welding".

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 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 wetted and painted with a thin coat of neat cement mortar immediately in advance of the placing of concrete.

Roadway slabs shall be given a reasonably smooth surface finish by longitudinal or transverse strike-off. The finished concrete shall not deviate from the theoretical grade by more than $\frac{1}{4}$ inch. Belting and straightedging of roadway will not be required.

430.4. Measurement. The quantities of concrete which constitute the completed 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.

430.5. Payment. The concrete quantities, measured as provided above, will be paid for at the unit price bid per cubic yard for the specified class of "Concrete for Extending Structures", which price shall be full compensation for furnishing, hauling, and mixing all concrete materials; placing, curing, and finishing all concrete; all grouting and pointing; furnishing and placing all drains and expansion joints; re-

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moving the designated portions of the existing structures; moving of headwall units for reuse; cleaning, bending, and cutting of exposed reinforcing steel; welding of new reinforcing steel to old; all drilling and grouting for dowels; cleaning and painting old concrete with neat cement mortar; and all forms and falsework, labor, tools, equipment, and incidentals necessary to complete the work except that payment for excavation and for new reinforcing steel will be made in accordance with the pertinent specifications for these items.

Excavation and backfill necessary will be measured and paid for under Item 400, "Structural Excavation".

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, and 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 Item 421, "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 Item 440, "Reinforcing Steel".

Expansion joint material shall conform to the requirements of Item 420, "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 de-

forming or otherwise becoming unsuitable for the purpose intended. The pins shall have a minimum diameter of $\frac{1}{8}$ 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 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 —1 part cement (minimum) to 4 parts sand (by volume)

Type II —1 part cement (minimum) to 5 parts sand (by volume)

Type III—1 part cement (minimum) to 7 parts sand (by volume)

At the time of mixing, the sand shall contain from 3 to 6 per cent 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 $\frac{1}{4}$ inch sieve before being placed in the machine. The minimum mixing time for each batch shall be not less than $1\frac{1}{2}$ minutes after the sand and cement are in the drum when the drum rotates at a peripheral speed of about 200 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 using the gun. Mixed material that has stood for 45 minutes without being used 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

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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 especially constructed cylinders 6 inches in diameter and 12 inches high, made of $\frac{3}{4}$ 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 Item 437, "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 $2\frac{1}{2}$ 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 $\frac{3}{4}$ 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 $\frac{1}{2}$ inch in diameter shall be provided in the webs of the members as near as practicable to the flanges for the purpose of attach-

ing the reinforcing fabric. These holes shall be spaced approximately 3 feet on centers. The welded wire fabric shall be held securely about $\frac{3}{4}$ 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, $\frac{3}{8}$ 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 of these 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 $\frac{3}{4}$ 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 compressor 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 five 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 per cent 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 Item 420, "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 (two or four 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, it shall be removed and replaced with a new coat of pneumatically placed concrete.

Before channel or canal lining or riprap is placed, the earth canal, 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 40 F. After placing, the concrete shall be protected from freezing or quick drying.

(8) **Workmen.** Only experienced foremen, gunmen, nozzle-men, 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 Item 120, "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 Item 400, "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

432.3 to .4

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 Section 432.8.

Materials for concrete, grout, and mortar shall conform to the requirements of Item 421, "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 Item 440, "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 Item 420, "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 $\frac{1}{3}$ 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 and 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 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 Item 421, "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 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 Item 420, "Concrete Structures".

432.10. Pneumatically Placed Concrete Riprap, Type I and Type II. Pneumatically placed concrete for riprap shall be

432.11 to .12

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 Item 431, "Pneumatically Placed Concrete". Reinforcement shall conform to the details of the plans and with Item 440, "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 Item 431, "Pneumatically Placed Concrete".

Immediately following the finishing operation, the riprap shall be cured with membrane curing compound in accordance with Item 420, "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 Section 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 Item 420, "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 pre-molded 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 Item 400, "Structural Excavation".

ITEM 435

ELASTOMERIC MATERIALS

435.1. Description. This item shall govern the materials, fabrication, and placement of elastomeric materials except as may otherwise be covered in other particular specifications or on the plans.

435.2. Materials.

(1) **Bearing Pads.** When so specified on the plans, concrete beams, steel shoes, steel bearing plates, rail posts, and other structural members shall be seated on, or cushioned by, elastomeric bearing pads.

The pads shall be specified on the plans by hardness (Durorometer) and by size and configuration.

(a) **Materials.** Unless otherwise specified on the plans, the rubber constituent of the compound shall be 100 percent

virgin neoprene stock. No natural rubber, reclaimed rubber (natural or synthetic) or other synthetic rubber shall be used.

Tests of the material shall be made in accordance with the ASTM test methods indicated in Table A. In so far as possible, all tests shall be made on the finished product. In the case where special molded specimens are required, they shall be molded in accordance with Part B, ASTM Designation: D 15, Tentative Methods of Sample Preparation for Physical Testing of Rubber Products. Where the plans indicate a hardness between two of the values listed, values for each requirement shall be interpolated proportionally from Table A. (e.g. original tensile strength of 55 durometer material must be 2750 psi).

(b) Manufacturing Processes. The pads shall be molded homogeneously by either the transfer or compression molding techniques under heat and pressure of not less than 250 psi. No previously cured sheets or slabs shall be laminated to form pads except as otherwise provided in this specification.

(c) Test Samples and Certification of Materials. Each formulation of each compound produced by a manufacturer must be approved prior to its first use on Department projects. Samples of the material together with certified test results indicating compliance with each physical and chemical property by the manufacturer required by this specification shall be furnished to the Department Laboratory, Camp Hubbard, Austin, Texas. The samples shall consist of at least two slabs of the material of sufficient size to allow cutting of all necessary test specimens together with at least two sets of molded samples, molded and/or cut in accordance with the applicable ASTM specification listed herein. The manufacturer shall certify also, that these samples are the same material and of equivalent cure to that to be used in the finished project.

After this initial approval, routine tests may be made on the samples taken at random from the finished pieces. In addition, at anytime, the Department may request complete samples be prepared at the time of production in the same manner as for the initial approval.

(d) General Requirements.

1. When the plans specify a product to be made of an elastomer vulcanized to fabric or to metal plates, a consistent and uniform bond shall be attained.

The bond between the elastomer and the fabric or metal shall be such that when a sample is tested for separation in accordance with Test Method, Tex-601-J, failure shall occur within the elastomer and not between the elastomer and the metal or fabric. Where fabric or metal plates are vulcanized between two sheets or slabs of elastomer, the assembly shall be fabricated in such manner as to provide at least $\frac{1}{8}$ inch thickness of elastomer covering all edges of the plate, fabric, etc., to deter subsequent atmospheric attack.

2. Allowable Dimensional Tolerances:

a. Constant Thickness Bearing Pads

Variation in thickness (from plan dimension):

Plus $\frac{1}{8}$ " minus 0"

Variation in thickness (between any two points of the same pad): $\frac{1}{32}$ "

Variation in length or width:

Plus or minus $\frac{1}{8}$ "

Variation in diameter of holes:

Plus or minus $\frac{1}{16}$ "

Variation in distance center to center of holes:

Plus or minus $\frac{1}{8}$ "

Variation in distance from edge of pad to center of hole: Plus or minus $\frac{1}{8}$ "

b. Beveled Bearing Pads.

Same as above for constant thickness pads except that while the thickness of the pad as a whole may vary plus $\frac{1}{8}$ " minus 0" from the thicknesses shown on the plans, the variation from plan thickness at one point shall not vary more than $\frac{1}{16}$ " from the variation from plan thickness at any other point in the same pad.

c. For products other than those specified above, tolerances in accordance with usual good manufacturing practice will be allowed unless otherwise indicated on the plans.

Hardness (Durometer)	50	60	70	80	90
Original Physical Properties					
Hardness ASTM D 676	50 ± 3	60 ± 3	70 ± 3	80 ± 3	90 ± 3
Tensile Strength, minimum psi ASTM D 412	3000	2500	2500	2000	2000
Elongation at Break, minimum percent	400	350	325	150	100
Accelerated Tests to Determine Long-Term Aging Characteristics Oven Aged—70 Hrs. at 212°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	± 15	± 15	± 15	± 15	± 15
Elongation at Break, % change maximum	— 40	— 40	— 40	— 40	— 40
Ozone: 1 PPM 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 Hrs. at 158°F. ASTM D 395 (Method B) % Maximum					
	30	25	25	25	20
Low Temperature Stiffness — ASTM D 797					
At — 40°F., Young's Modulus, max. psi	10,000	10,000	10,000	10,000	10,000
Tear Test — ASTM D 624 — Die "C"					
Pounds per linear inch, minimum	225	250	275	275	275

*Samples to be solvent wiped before test to remove traces of surface impurities.

†Interpolate between values shown where other hardnesses are specified on the plans.

TABLE A

(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 B 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 Elongation, % change, Maximum	35 35	35 —

TABLE B
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 No. 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) **Construction Requirements.**

1. **Rubber Waterstops.** Waterstops shall be manufactured with an integral cross section which shall be uniform within $\pm \frac{1}{8}$ inch in width, and the web thickness or bulb diameter, within $+1/16$ inch and $-1/32$ inch. No splices will be permitted in straight strips. Strips and special connection pieces shall be well cured in a manner such 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.

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 of not less than 50 percent of the unspliced material.

435.3 to 437.2

2. PVC Waterstops. Requirements shall be as in 1. above for Rubber Waterstops except that splicing of PVC shall be performed 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) Other Elastomeric Products. Other elastomeric products shall be in accordance with the requirements on the plans.

435.3. Construction. Placing of elastomeric products in the field shall be in accordance with the plans and specifications covering the other items of work included in this contract.

435.4. Measurement and Payment. No direct payment will be made for elastomeric products, but will be considered subsidiary items to the various bid items in the contract.

ITEM 437

CONCRETE ADMIXTURES

437.1. Description. This item shall govern for the materials to be used, methods of tests, and the construction methods for the use of admixtures in concrete.

437.2. Definitions.

(1) An "air-entraining admixture" is defined as a material which, when added to a concrete mix in the quantity as recommended by the manufacturer, will entrain uniformly dispersed microscopic air.

(2) A "cement dispersing admixture" is defined as a material which, when added to a concrete mix in the quantity as recommended by the manufacturer, will change the physical characteristics and properties of the concrete as prescribed under Section 437.3.

The general terms applied to proprietary compounds such as "retarders", "retarding densifiers", "water reducing agents", "wetting agents", etc., will be classed as cement dispersing admixtures for use by the Department, only if all the specific requirements as outlined in Section 437.3 below are met.

Cement dispersing admixtures may or may not entrain air.

437.3. Cement Dispersing Admixtures.

(1) Cement Dispersing Admixtures shall produce the following results when compared to a reference concrete and tested as prescribed under 437.3 (2).

(a) Reduce the required water content of the concrete by a minimum of 10 percent.

(b) Increase the 3 day compressive strength of the concrete by a minimum of 15 percent. (The calcium chloride content of the admixture shall be limited to 1/10 of 1 percent of the dry weight of the admixture or its equivalent amount in manufacturer's recommended solution.)

(c) The 28 day compressive strength of the concrete shall be equal to or more than that of the reference concrete.

(d) Retard the initial set of the concrete by a minimum of two hours.

(2) Tests for compressive strengths shall be standard 6 x 12 cylinders made and cured in accordance with ASTM Designation: C 192. A minimum of three cylinders of reference concrete (without admixture) and three cylinders of test concrete (with admixture) will be made and tested for 3 day and 28 day compressive strength in accordance with ASTM Designation: C 39. The test concrete and the reference concrete will be identical with regard to cement factor, type of aggregates, and slump. The addition of entrained air and/or increased workability shall be taken into account in the design of the test concrete by a reduction in the unit water content and fine aggregate to the extent dictated by yield, consistency, and slump. The quantity of admixture added to the test concrete shall be as specified by the manufacturer.

Rate of hardening will be tested in accordance with ASTM Designation: C 403.

437.4. Air-Entraining Admixture.

(1) The air-entraining admixture, when used in the correct quantities to produce 3 to 6 percent entrained air, shall produce 7 day compressive strengths not less than 85 percent of the 7 day compressive strengths of the non-air-entrained concrete.

(2) The tests for compressive strengths shall be standard

437.5 to .6

6" diameter x 12" length cylinders made and cured in accordance with ASTM Designation: C 192. A minimum of three cylinders of the reference concrete and three cylinders of the test concrete will be tested at the age of 7 days. Equal slump will be maintained within one-half of an inch for the test and reference concrete.

437.5. Approval of Admixtures. The manufacturer shall furnish the Department Laboratory, Camp Hubbard, Austin, Texas, with three copies of test reports from a recognized laboratory, showing that the admixture meets the requirements of this specification and in addition, in the case of air-entraining agents, that it meets the requirements of ASTM designation: C 260. No admixture will be considered for approval that has not been commercially available for a period of at least 2 years with a record of satisfactory service in concrete during that period.

A recognized laboratory shall be a laboratory of any State Highway Department, the Bureau of Public Roads, or any cement or concrete laboratory regularly inspected by the Cement Reference Laboratory of the National Bureau of Standards.

In addition to the above the manufacturer shall furnish the following:

(1) At the time of original request for approval of the admixture, in addition to the above test reports, the manufacturer shall supply a one gallon sample of the material to the Department Laboratory, Camp Hubbard, Austin, Texas.

(2) Each six months after approval of the material, the manufacturer shall furnish a notarized certification showing that the material originally approved has not been changed or altered in any way.

A list of approved admixtures will be maintained by the State Highway Engineer, Austin, Texas.

437.6. Construction Use of Admixtures. When used in concrete construction in conformance with the basic reference specifications, the Contractor will be allowed the use of any admixture which has been approved for use by the Department.

Admixtures which contain calcium chloride will not be permitted in prestress concrete.

The Contractor shall submit to the Engineer a notarized

certificate that the product proposed for use is the same material as tested and approved by the Department.

Trial designs as required by THD C-11, shall be made and tested with the use of the admixture, prior to use in the field. Amounts to be used will be as recommended by the manufacturer unless specific changes, based on tests, have been made by the Department. Allowance for the volume of liquid of the admixture shall be taken into account in the batch design by a corresponding reduction of the mixing water, in addition to the required reduction of water from the effect of the admixture itself.

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 readily adjustable mechanical dispensing equipment capable of being set to deliver the required amount and cut off the flow automatically. The equipment shall be of the type where the amount to be dispensed is visible in the container for ready check by the Engineer. For contract work, where the individual placements of concrete are less than 25 cubic yards and the concrete is batched on the job site, the Engineer may waive the requirements for mechanical dispensing equipment.

All admixtures shall be measured and dispensed in the liquid state. Powdered admixtures shall be mixed with water in the proper amounts prior to use.

When deemed necessary by the Engineer, the Contractor shall furnish additional quantities of the admixture being used for further testing. In such case, 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 or methods required in the use of "concrete admixtures", but shall be considered subsidiary to the various items included in the contract.

ITEM 440

REINFORCING STEEL

440.1. Description. This item shall provide for the furnishing and placing of reinforcing steel of the size and quantity designated for use in structures as shown on the plans and in accordance with these specifications.

440.2

440.2. Materials. Unless otherwise designated on the plans, the metal for all bar reinforcement shall be one of the following:

(1) Open hearth, basic oxygen, or electric furnace new billet steel of intermediate or hard grade, ASTM Designation: A 15, or ASTM Designation: A 408.

(2) Open hearth, basic oxygen, or electric furnace new billet steel ASTM Designation: A 431, or ASTM Designation A 432. Steel conforming to ASTM Designation: A 431 and A 432 shall be further identified by a special marking rolled into each bar for each revolution of the final mill roll.

(3) Axle steel of intermediate or hard grade, ASTM Designation: A 160.

(4) Rail Steel, ASTM Designation: A 16.

Rail steel, when used for bent bars, shall meet the bend test for hard grade billet steel concrete reinforcement as specified in ASTM Designation: A 15.

Rail or axle steel will not be permitted for use in railroad underpass structures.

Unless otherwise designated on the plans, all reinforcing steel shall be deformed in accordance with the requirements of ASTM Designation: A 305, or ASTM Designation: A 408. Twisted bars are not considered deformed and shall not be used. The form of deformed bars shall be such as to provide a net sectional area at all points equivalent to that of plain square or round bars of equal nominal size.

Spiral reinforcement shall be smooth (not deformed) bars or wire of the minimum diameter as shown on the plans. The steel 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 Sections 3, 4, 5, and 7 through 15 of ASTM Designation: A 15. Wire shall be cold-drawn from rods that have been hot-rolled from billets and shall comply with Sections 5 through 11 of ASTM Designation: A 82. The material shall have the following minimum physical properties:

Tensile Strength, psi.	55,000
Yield Point, psi	33,000
Elongated in 8 in., Percent	10

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 analyses, showing the percentages of carbon, manganese, phosphorus, and sulphur will be required for all reinforcing steel, when the work involves the extension or widening of structures by the welding of the reinforcing steel.

The nominal size and area and the theoretical weight of reinforcing steel bars covered by this specification are as follows:

Size	Bar Size Number	Nominal Area Sq. In.	Weight Per Linear Foot
¼" Round	2	0.05	0.167
⅜" Round	3	0.11	0.376
½" Round	4	0.20	0.668
⅝" Round	5	0.31	1.043
¾" Round	6	0.44	1.502
⅞" Round	7	0.60	2.044
1" Round	8	0.79	2.670
1" Square	* 9	1.00	3.400
1½" Square	*10	1.27	4.303
1¾" Square	*11	1.56	5.313
1¾" Round	14S	2.25	7.65
2¼" Round	18S	4.00	13.60

*These bar designations correspond to the former square sizes shown and are equivalent to those former standard bar sizes in weight and nominal cross sectional areas.

When wire is ordered by gage numbers, the following relation between number and diameter, in inches, shall apply unless otherwise specified:

Gage Number	Equivalent Diameter Inches	Gage Number	Equivalent Diameter Inches
0	.3065	8	.1620
1	.2830	9	.1483
2	.2625	10	.1350
3	.2437	11	.1205
4	.2253	12	.1055
5	.2070	13	.0915
6	.1920	14	.0800
7	.1770		

440.3 to .5

440.3. Bending. The reinforcement shall be bent cold to shapes shown on the plans. All bending of hard grade and rail steel bars shall be done in the shop. Bending of other grades preferably shall be done in the shop. Bends shall be true to the shapes indicated on the contract plans, and irregularities in bending shall be cause for rejection.

Unless otherwise shown on the plans, bends shall be made according to the latest code of Standard Practice of the Concrete Reinforcing Steel Institute.

440.4. Tolerances. Fabricating tolerances for bars shall not be greater than that shown in Figure 1.

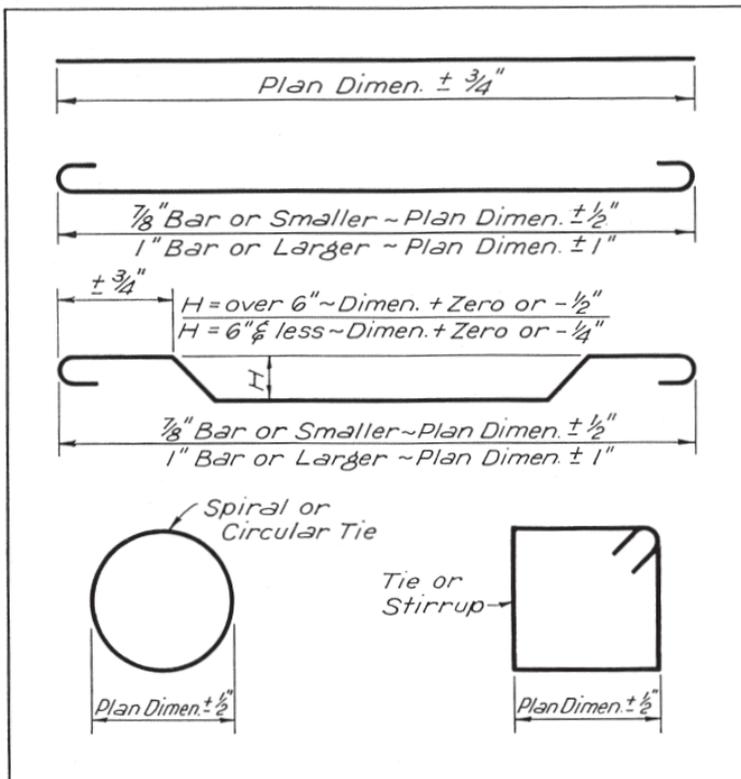


FIGURE 1

440.5. Storing. Steel reinforcements 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. Before being placed in the work, reinforcement shall be cleaned of all loose mill scale and rust. 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.

440.6. Splices. No splicing of bars, except when shown on the plans, will be permitted without the written approval of the Engineer. For bars exceeding 60 feet in length, one splice per bar will be permitted and measured for payment. Splices which are permitted shall be made in accordance with Table 1, except in the case of welded splices, and shall be well distributed or else located at points of low tensile stress. No splices, except welded splices, will be permitted at points where the section is not sufficient to provide a minimum distance of 2 inches between the splice and the nearest bar or the surface of the concrete. The bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer.

Bars in bottom of beams and girders	20 Bar Diameters
Bars in top of beams and girders and Slabs with more than 12 inches of concrete below the bar	35 Bar Diameters
Slabs on Stringers	20 Bar Diameters
Vertical Dowels or bar laps in Columns and Footings	30 Bar Diameters
Horizontal Dowels	One Foot
Longitudinal bars for widening box culverts	More than 1' Fill—6" Lap Less than 1' Fill 20 Diam. Lap

TABLE 1
Minimum Lap Requirements
(Bar Sizes 3 thru 11 only)

Where shown on the plans or required by the provisions of this item or other pertinent specifications, welded bar splices shall be used. All welding operations, processes, equipment, materials, workmanship, and inspection shall conform

to the requirements of Item 448, "Structural Welding". All splices shall be of such dimensions and character as to develop the full strength of the bar being spliced.

440.7. Placing. Reinforcement shall be placed as near as possible in the position 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 never less than one inch cover shall be provided.

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 face of the forms by means of approved galvanized metal spacers or approved precast mortar or concrete blocks. Unless provision for welding is made, all reinforcing steel shall be wired together at all intersections. 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 until aged sufficiently to be removed from the molds, at which time the blocks shall be immersed in water for the remainder of at least a four-day curing period. The blocks shall be cast with the sides beveled in such manner that the size of the block increases away from the area to be placed against the forms. Blocks in the form of a frustrum of a cone or pyramid are preferred. A suitable tie wire shall be provided in each block, such wire to be used for anchoring the block to the steel in order to avoid displacement in placing the concrete. 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.

Reinforcements shall be supported and tied or welded in

such manner that a practically 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 operations, 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 Section 440.7. above.

Sheets 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 shall have inspected the final placement of the reinforcing metal and given permission to place concrete.

440.8. Measurement. The measurement of the quantities of bar reinforcement furnished and placed will be based on the calculated weights of the steel actually placed in accordance with the plans and these specifications, 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 Section 440.2, with no allowance for overruns or underruns.

440.9. Payment. Reinforcing steel used in structures, measured as provided above, will be paid for at the unit price bid per pound of "Reinforcing Steel" which price 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.

Reinforcement for concrete railing, pipe, piling, riprap, and prestressed concrete products will be paid for as provided in the specifications for those items.

ITEM 441

STEEL STRUCTURES

441.1. Description. This item shall govern for the fabri-

441.2 to .4

cation and erection of structural steel and other metals, except reinforcing steel, which are used for steel structures or steel portions of structures.

441.2. Materials. The metal used for the various portions of the structure shall be as specified and shall conform to the requirements of Item 442, "Metal for Structures".

441.3. Loading, Design, and Workmanship. For railroad underpass structures, the dead load and live load unit stresses for proportioning of parts and details of design and shop workmanship shall be in accordance with the latest American Railway Engineering Association Specification for Steel Railway Bridges for Fixed Spans not Exceeding 400 feet in Length.

441.4. 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 stream, span length, name of Fabricator, and name of Contractor.

All shop drawings shall be checked by the Fabricator before being submitted for approval by the Engineer. Submission shall be made to the State Highway Engineer, Austin, Texas. Six copies of shop drawings will be required, except for railroad underpass structures, in which case seven copies will be required.

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.

Inked linen tracings or reproductions on linen of approved shop drawings will be required for railroad underpasses only, upon completion of fabrication, unless otherwise noted on the plans.

When structural members are fabricated by welding, a welding procedure shall be submitted and approved in ac-

cordance with Item 448, "Structural Welding", and THD Bulletin C-5, prior to the beginning of fabrication. The procedure shall be submitted on separate sheets from the regular shop drawings in the quantity required by the regular shop drawings.

Contract plans indicate details of joints to be used with manual welding. When the use of submerged arc welding is anticipated, the welding procedure shall reflect the correct joint details to be used.

When structural members are fabricated by riveting or bolting, a fabrication procedure, including a list of equipment to be used, will be required of all fabricators who are new to Department construction and may be required of all fabricators when deemed to be necessary.

441.5. Notice of Beginning Work. The Contractor shall give the Engineer ample notice of the beginning of work in the shop so that 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.

441.6. Inspection and Testing. The Contractor shall furnish facilities for the inspection of material and workmanship in the shop, and he shall furnish the Inspector with as many helpers as may be needed to properly inspect the work. The Inspectors 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.

If the scale weight of any member is more than 2 percent less than the computed weight, it may be cause for rejection.

The Contractor shall furnish the Engineer with the following information in the number of copies specified.

- 3 copies of Fabricator's mill order.
- 3 copies of mill shipping invoice.
- 4 copies of mill test reports.
- 4 copies of Fabricator's shipping invoice.

The Fabricator's mill order together with the mill shipping invoice shall reflect:

441.7

Designation of member by nominal size, length, and weight.

Intended use for member (i.e., stringer, floor beam, diaphragm, gusset plate, shoes, pins, etc.)

The Fabricator's shipping invoice shall reflect:

Material specification to which the material is ordered.

Total calculated or scale weight covered by shipment.

The mill test report shall reflect:

Specification to which material is produced.

Heat number of material.

Chemical and physical properties required by material specification.

Fabricator's mill order, mill shipping invoice, mill test reports, and shipping notice will not be required for such items as miscellaneous hardware, bolts, nuts, washers, rivets, screws, fasteners, clamps, brackets and sign post connections.

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.

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.

441.7. Workmanship, General. All structural materials, before fabrication 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, built-up welded girders, and other welded assemblies shall be in accordance with the requirements of Appendix D of THD Bulletin C-5, with these specifications and as required by the contract plans.

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 be such that 75 percent of the long

dimension shall be true to one thirty-second inch, with the balance of the long dimension true to one-sixteenth inch. The top bolster 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 1 degree while the rocker is moved through its full 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 to the above tolerances shall be with heat, external pressure, or both. Corrections shall not be done by grinding or milling.

Rolled material, before being laid off or worked, shall be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends may be cause for rejection.

Workmanship and finish shall be equal to the best general practice in modern bridge shops.

441.8. Rivets and High Strength Bolts. Unless prohibited by the plans, High Strength Bolts may be used where rivets are designated. In these specifications where reference is made to pitch, edge distance, preparation of holes, etc., for rivets, the same criteria shall govern for High Strength Bolts.

441.9. Pitch and Edge Distance of Rivets. Pitch and edge distance not shown on the plans shall be in accordance with AASHTO Standard Specifications for Highway Bridges.

441.10. 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

441.11

diameter of the rivets whenever the thickness of the metal is not greater than three-fourths inch for structural steel or five-eighths inch for alloy steel. When there are more than five thicknesses or when any of the main material is thicker than three-fourths inch in structural steel or five-eighths inch in alloy steel, or when required under Section 441.11, 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 the diameter of the punch by more than one-sixteenth inch. If any holes must be enlarged to admit the rivets, the holes 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 not more than one-sixteenth inch larger than the nominal diameter of the rivets. Reamers and drills shall be guided by mechanical means. Only those 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 reaming of holes which are poorly aligned, 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 while being reamed or drilled and shall be match-marked before disassembling.

441.11. 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 Section 441.10) 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 for assembly of field splices to be drilled full size may be employed provided the tack welds are held to a minimum and conform to the requirements of Item 448, "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 commenced.

All holes for floor beams and stringer end connections shall be subpunched and reamed to a steel template of not less than 1 inch thickness or reamed while assembled.

Holes for secondary members such as diaphragms, laterals, sway bracing, etc., may be punched full size unless subdrilling and reaming is required by Section 441.10.

441.12. Accuracy of Holes.

(1) All holes punched full size, subpunched, or subdrilled, shall be made accurately so that after assembling (before any reaming is done) 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 continuous holes in the same plane. Pieces not meeting this requirement will be rejected. If any hole will not pass a pin three-sixteenths inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

(2) When holes are reamed or drilled, 85 percent of the holes in any continuous group shall, after reaming or drilling, show no offset greater than one thirty-second inch between adjacent thicknesses of metal.

(3) Layout of shop work shall be done in such manner that gage lines for rivets shall not vary from plan dimensions more than one-sixteenth inch. Full size holes in any continuous 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 gage.

Not more than 10 percent of the holes may vary as much as one-eighth inch from plan gage.

Holes varying more than one-eighth inch from plan gage will not be accepted.

441.13. Shop Assembling. Each truss shall be assembled full length in the shop before reaming is commenced. Adjacent sections of beam and girder units shall be assembled in the proper relative positions that each will take in the structure before reaming is commenced. 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. Reaming of assembled parts or assembled members shall be done after the parts or members are so firmly bolted or clamped together that the surfaces are in close contact. Parts shall be separated before riveting, if neces-

441.14 to .15

sary, for removal of any shavings. When drilling is done from the solid metal, disassembling after reaming shall be required. Tack welding for the purpose of eliminating bolts for assembling will not be permitted except as provided in Section 441.11 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.

Preparatory to the shop riveting of full-sized punched material, the rivet holes, if necessary, shall be spear-reamed for the admission of rivets. 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, the holes shall be reamed.

441.14. 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. Rivets, when heated and ready for driving, shall be free from slag, scale, and other adhering matter. When driven, the rivets shall completely fill the holes. 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 buckler shall be used.

441.15. Bolted Connections. When High-Strength Bolts are required or permitted, the bolts shall be in conformance

with Item 442, "Metal for Structures" and with Item 447, "Structural Bolting".

441.16. 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 one-half inch.

Flame cutting of structural steel will be permitted when done with a machine guided torch. Flame cut edges shall have a finish not less than ASA 1000.

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 ASA 250 finish.

Surfaces of bearing plates intended for sliding contact shall have an ASA 125 finish.

In planing the surfaces of expansion bearings, the cut of the tool shall be in the direction of expansion.

Abutting joints in compression members, girder flanges, and in tension members where so specified on the plans, shall be milled and brought to an even bearing. Where joints are not faced, the openings shall not exceed one-fourth inch.

Floor beams and girders having 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 having a single rivet connection shall have the ends rounded to a radius equal to one-half the width of the bar.

In girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than one-eighth inch below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. 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

441.17 to .18

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.

Bearing stiffeners of girders and stiffener angles supporting concentrated loads shall be milled to a ASA 500 finish to secure an even bearing against the flanges. Tight fit for intermediate stiffeners shall be defined as having at least a one point bearing of the stiffener on the flange, with a maximum clearance of one-sixteenth inch at any point.

Finished members shall be true to line and free from twists, bends, and open joints.

441.17. Welding. All welding operations, processes, equipment, materials, qualifications of welders, workmanship, and inspection shall be in accordance with Item 448, "Structural Welding", and THD Bulletin C-5.

441.18. Preparation of Material for Welding. Dimensional tolerances, straightness, and flatness of structural shapes and plates shall be within the limits prescribed by Section 441.7.

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. Surfaces within 2 inches of any weld location shall be free from any paint or other material that would prevent proper welding or produce objectionable fumes while welding.

Edges of material thicker than specified by the following shall be trimmed to produce a satisfactory welding edge wherever a weld along the edge is to carry calculated stress:

Sheared edges of material thicker than	$\frac{1}{2}$ inch
Rolled edges of plates (other than Universal Mill plates) thicker than	$\frac{3}{8}$ inch
Toes of angles or rolled shapes (other than wide flange sections) thicker than	$\frac{5}{8}$ inch
Universal Mill plates or edges of flanges of wide flange sections thicker than	1 inch

Sheared plates to be used for webs of built-up members shall be of sufficient additional width to allow for trimming of edges where built-in camber is required. Plates with

rolled edges shall be trimmed. Trimming shall be by flame cutting.

Universal Mill plates to be used for webs of built-up members shall be of sufficient additional width to allow for trimming of both edges by flame cutting.

Preparation of edges by flame cutting shall be in accordance with Section 441.16. Manual cutting shall be permitted only where machine cutting is not practicable and then only with the approval of the Engineer. Surfaces prepared by manual cutting shall be further treated by milling, grinding, or chipping and grinding. All re-entrant corners shall be filleted. The cut lines shall not extend beyond the fillet and all cutting shall follow closely the lines prescribed.

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.

441.19. Assembly of Parts. The parts to be joined by fillet welds shall be brought into as close contact as practicable, and in no event shall 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 a backing structure shall not exceed one-sixteenth inch. The fit of joints which are not sealed by welds throughout their length shall be sufficiently close to exclude water after painting. Where irregularities in rolled shapes or plates, after straightening, do not permit contact within the above limits, the procedure necessary to bring the material within these limits shall be subject to the approval of the Engineer. The use of fillers is prohibited except as specified on the drawings or as specially 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. When welding girder flanges to web, adequate clamps must be provided to prevent cupping or warping of the flanges. The clamping devices must be so designed as not to interfere with the operation or guiding of the automatic welding equipment.

Temporary stiffeners to be used for jigs and/or warpage control shall not be tack welded to the flange material. Tacking to the web may be done if the tack 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 for shrinkage shall be made, and in no case shall the joint be restrained against shrinkage on both sides of the joint.

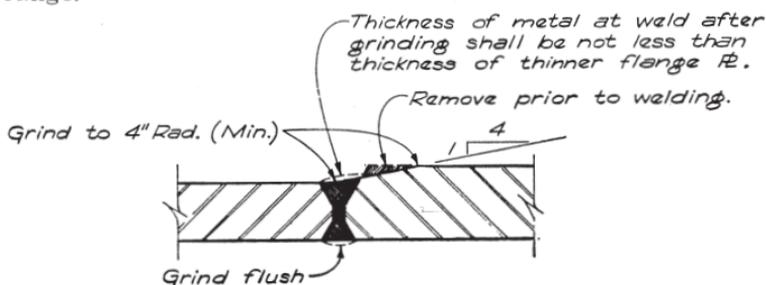
Abutting parts to be joined by butt welds shall be aligned carefully. Regardless of the range of stress, all shop butt welds in flange plates shall be ground smooth and flush with the base metal on all surfaces. This shall apply to both parts of equal thickness and parts of unequal thickness. (See Figure 1).

The surfaces shall be ground so that the radii at the points of transition will be not less than 4 inches.

When butt welds are used to join materials of different thickness or width, there shall be a smooth transition between offset surfaces at a slope of not greater than 1 in 4 with the surface of either part.

Butt welds in web plates need not be ground unless shown on the plans.

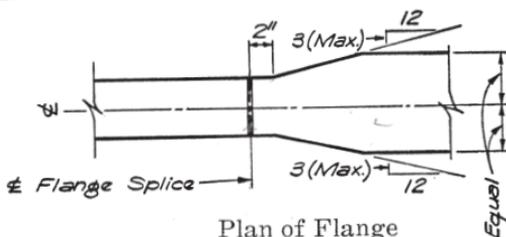
Grinding shall be done in the direction of stress, and in such a manner that the metal is kept below the blue brittle range.



Section Thru Flange

FIGURE 1

Transition of width shall be in accordance with Figure 2.



Plan of Flange

FIGURE 2

Bearing stiffeners shall be milled to an ASA 500 finish to secure even bearing on the flanges. The bearing stiffeners shall not be shop welded to the flanges.

Intermediate stiffeners within 12 inches of a splice point shall be shipped tacked in place but not welded. The welding shall be done in the field after the splice is made.

Tight fit for intermediate stiffeners shall be defined as having at least a one point bearing of the stiffener on the flange, with a maximum clearance of one-sixteenth of an inch at any point.

441.20. End Preparation and Shop Assembly. Ends of beams and girders shall be prepared in accordance with Figure 3 and the requirements herein.

The bevel of webs and flanges shall be such that the centerline of the root face of a web or flange does not deviate from the centerline of the root face of the opposing web or flange by more than one-sixteenth of an inch.

The fit at splices shall be such that when the root faces of opposing members are fit up, the deviation from a uniform opening shall not exceed one-sixteenth of an inch. Corrections by additional cutting and/or grinding shall be made to bring the splice within the above tolerance. Finish of bevels of butt splices shall be milled or ground. Flame cut bevels without grinding will not be allowed.

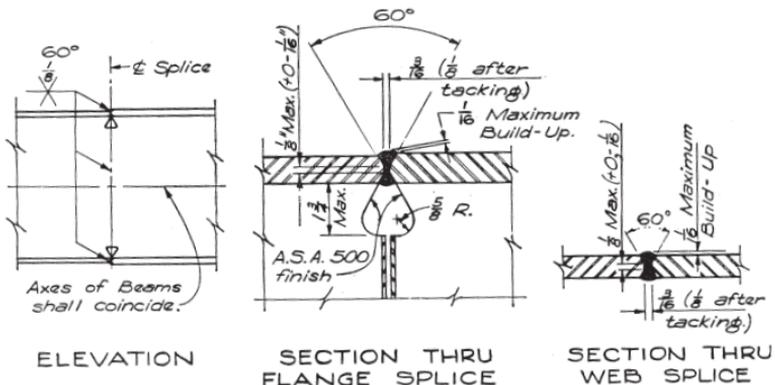


FIGURE 3

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

441.21 to .24

match-marked while assembled by stamping in the metal. Extension bars shall be used in making the butt welds in the flanges in accordance with THD Bulletin C-5.

441.21. Special Requirements. ASTM Designations: A 94, or A 440 steel shall not be welded. Sheared or flame cut edges of plates and sections of the A 94, and A 440 classification considered to be stress carrying members shall be annealed or flame softened by heating the edges uniformly at a temperature of 1100 F to a depth of one-eighth of an inch.

A color code system shall be required for all steels to be used in structures for the Department. The shop shall establish a distinct color code for each ASTM grade of steel used. This color 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 shall require testing of the material prior to its use, to re-establish positive identity of the material to the satisfaction of the Engineer.

441.22. Straightening Bent Material. No member which is bent or twisted shall be put in place until its defects are corrected, and members seriously damaged in handling shall not be used. The straightening of plates and angles or other shapes shall be done by methods which will not produce fracture or other injury. The metal may be cold-straightened or heat-straightened. Heat-straightening shall be at a temperature no higher than 1200 F as determined by a Tempil Stick or equivalent. After heating, the metal shall be allowed to cool as slowly as possible.

Following the straightening of a bend or buckle, the surface of the metal shall be inspected carefully for evidence of fracture or other injury.

441.23. 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. Finish for pins and pinholes shall be ASA 125.

The diameter of the pinhole shall not exceed that of the pin by more than one-fiftieth of an inch for pins, 5 inches or less in diameter, or one thirty-second of an inch for larger pins. Finish for rockers shall be ASA 250.

441.24. Shop Painting. The application of shop paint

shall conform to the requirements of Item 446, "Paint and Painting".

Surfaces to be in contact after shop riveting is completed shall be cleaned but shall not be painted.

441.25. Marking and Shipping. All structural members shall be marked in accordance with the erection diagram. The markings shall be over the painted surface and 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 Section 441.13 and 441.20.

Members weighing more than 3 tons shall have the weight marked thereon. 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 contained material shall be plainly marked on the outside of each package.

Anchor bolts, washers, and other anchorage or grillage materials shall be shipped in time to suit the requirements of the masonry construction.

The loading, transportation, unloading, and storing of structural material shall be conducted so that the metal will be kept clean and free from injury.

441.26. Methods and Equipment. Before starting work, the Contractor shall inform the Engineer fully as to the method of erection he proposes to follow and as to the amount and character of the equipment he proposes to use; the adequacy of which shall be subject to the approval of the Engineer. The approval of the Engineer shall not be considered as relieving 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 erection plans for the erection of plate girders (riveted, bolted, or welded), trusses, and for all railroad underpass structures. Field erection plans for I-beam units will not be required unless specified on the plans. The plans shall be complete in all details of procedure, sequence of work, equipment to be used etc., so that a check can be made of the adequacy of the proposed erection procedure.

441.27 to .30

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 appliances, 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.

441.27. Storing Materials. All material shall be handled in such manner that no injury will result. Material to be stored shall be placed on skids above the ground and shall be 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.

441.28. Falsework. The falsework shall be properly designed for the loads to be supported and shall be constructed substantially and maintained. The Contractor shall prepare and submit plans for falsework to the Engineer for approval.

The falsework plans shall be complete in all details of members, connections, equipment, etc., so that a structural check can be made of the falsework.

Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility.

441.29. Straightening Bent Material. The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury, in accordance with Section 441.22.

Following the straightening of a bend, the surface of the metal shall be inspected carefully for evidence of fracture or other injury.

441.30. 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 placed as to give the trusses proper

camber. The blocking shall be left in place until the tension chord splices are fully riveted 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 cylindrical 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, and cylindrical erection pins shall be one thirty-second inch larger.

441.31. 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 only such as 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 shall be driven while hot. Rivets shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have 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.

441.32. Field Welding. Welding shall be in accordance with Item 448, "Structural Welding".

441.33. Bearing and Anchorage. Castings, bearing plates, or shoes shall not be placed upon bridge seat bearing areas which are improperly finished, but shall be set in exact position and shall have a full and even bearing upon the masonry. Castings, bearing plates, or shoes shall be placed on one of the following materials:

(1) **Canvas and Red Lead.** The bridge seat bearing area shall be swabbed thoroughly with red lead paint and placed

upon three layers of 12 to 14 ounce canvas, each layer being swabbed thoroughly on its top surface with red lead paint. The castings, bearing plates, or shoes shall be placed in position while the paint is plastic.

(2) **Preformed Fabric Pad.** This material shall consist of a single one-eighth of an inch sheet using 8 ounce duck and high quality natural rubber in seven plies. Each piece shall be the same size as the base of the casting or bearing plate it is to support. The holes to accommodate the anchor bolts shall be not more than one-fourth inch larger than the diameter of the bolts.

The breakdown stress for compression perpendicular to the plane of lamination shall be not less than 10,000 psi. A tolerance on thickness of plus or minus one-sixteenth of an inch will be permitted.

(3) **Preformed Rubber Fabric Pad.** These preformed pads shall be made with new unvulcanized rubber and new fabric fibres. The hardness shall be from 85 to 95 Shore A Durometer. The holes to accommodate the anchor bolts shall not be more than one-fourth inch larger than the diameter of the bolts.

The compressive breakdown stress shall not be less than 10,000 psi. A tolerance on thickness of plus or minus one-sixteenth inch will be permitted.

(4) **Lead Sheets.** Lead shall be a single one-eighth inch sheet of soft lead the same size as the base of the casting or bearing plate it is to support. Holes to accommodate the anchor bolts shall be not more than one-fourth of an inch larger than the diameter of the bolts.

(5) **Portland Cement.** The maximum amount of cement which will be permitted under castings or bearing plates will be no more than necessary to remove irregularities in the masonry with no intention of raising the bearing above the normal elevation of the cap. Portland cement shall be placed in stiff paste form immediately prior to setting of bearing plates.

(6) **Portland Cement Mortar.** When the masonry 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 a greater distance above the masonry than that provided by the allowable thickness of the above described materials, 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 shims shall be made to provide bearings to the tolerances given above.

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.

The shop coat of tallow, white lead, and oil, applied in accordance with Item 446, "Paint and Painting", shall be removed from machine-finished surfaces immediately prior to placing it in the structure. Surfaces designed for sliding movement, one upon the other, when placed in the structure, shall be given a field coat of graphite spring lubricant. 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 in the fresh concrete of oiled and tapered wooden plugs or tapered metal sleeves which are withdrawn subsequently after the concrete has set partially. 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 70 F.

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441.34. Grading Deck on Continuous Units. Forms shall not be erected or concrete placed 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.

441.35. 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, and his approval of the method of correction shall be obtained. 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.

441.36. Paint and Painting. Unless otherwise provided, the application of field paints shall conform to the requirements of Item 446, "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. Those surfaces which are inaccessible for painting in the final position shall have the final paint coat applied prior to move-in. Touch up of paint which is damaged due to move-in to final position will be done, and the final field coat applied.

441.37. 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 Steels.**(1) Carbon Steel.**

(a) Unless otherwise shown on the plans, structural steel for all main load carrying members which consist of members with welded cover plates, built-up members fabricated by welding plates or shapes together, or members which are connected or spliced by welding, shall conform to ASTM Designation: A 373. Structural steel produced under other specifications, but shown to meet all the requirements of ASTM Designation: A 373, will be acceptable. For secondary members, such as diaframs, stiffeners (except bearing stiffeners), lateral bracing, armor joints, finger joints, etc., used in welded construction, and for riveted or bolted construction, steel shall conform to ASTM Designation: A 7, or ASTM Designation: A 36. In all cases, ASTM Designations: A 373 or A 36 may be used in lieu of A 7.

(b) Unless otherwise shown on the plans, steel for shoes and bearing plates shall conform to ASTM Designation: A 7, ASTM Designation: A 36, or may be cast ductile iron ASTM Designation: A 395, Grade 60-45-15.

(c) Rivet steel shall conform to ASTM Designation: A 141 unless otherwise noted on the plans.

(2) The following structural or alloy steels, when specified on the plans or by these specifications as designated below, shall conform to the requirements of the ASTM Designation shown.

Material	Designation	ASTM No.
(a) Structural Carbon Steel	Carbon Steel or C.S.	A 7
(b) Carbon Structural Steel	High Yield Carbon or H.Y.C.	A 36
(c) Structural Steel for Welding	Welding Steel or W.S.	A 373
(d) Corrosive Resistant Low Alloy	Corrosive Resistant or C.R.L.A.	A 242
(e) High Strength Steel for Riveted Construction	High Strength Riveted or H.S.R.	A 440
(f) High Strength Low Alloy Structural Manganese Vanadium Steel	Low Alloy or L.A.	A 441
(g) Structural Silicon Steel	Silicon Steel or S.S.	A 94
(h) High Strength Alloy Steel	High Strength Alloy or H.S.A.	(See Special Provisions)

(3) **High Strength Bolts.** High strength bolts shall conform to ASTM Designation: A 325.

(4) **Deck Plates.** Material for deck plates shall conform to one of the following:

(a) Wrought Iron conforming to ASTM Designation: A 42. 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.

(b) Corrosive resistant structural steel conforming to ASTM Designation: A 242. The material must be of weldable quality, and must be of such alloying content that it furnishes corrosion resistance at least twice that of copper bearing structural steel.

The type of material to be used and the trade name of the structural steel (if used) shall be stated on the shop plans.

(5) **Steel Piling.** Steel piling shall conform to the following Specifications:

Type	ASTM No.	Grade or Class
Steel H Piling	A 7	
Metal Shell Piling (heavier than 10 gage)	A 252*	2
Sheet Piling (Rolled)	A 328*	
Sheet Piling (Formed)	A 415* with min. tensile strength of 45,000 p.s.i. Galvanizing, if required, to conform to ASTM Designation: A 93 (Cl. 2.00) or A 123	

*A mill certificate shall be furnished by the manufacturer certifying to the results of tests required by the governing specifications.

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 Locomotives, ASTM Designation: A 235, Class C1. The above will govern for all Railroad underpass structures.

For other structures, for pins 7 inches in diameter or less, material conforming to ASTM Designation: A 108, Grades 1016-1025, 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.

442.5. Steel Castings. Steel castings shall conform to the specifications for Mild to Medium Strength Carbon Steel Castings for General Application, ASTM Designation: A 27, Grade 65-35.

When specified on the plans as Class 70, Class 90, or Class 120, the steel castings shall conform to the specified class of the AASHTO Specifications for Steel Castings.

No sharp unfilleted angles or corners will be allowed. The surface shall have a workmanlike finish.

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.

No sharp unfilleted angles or corners will be allowed. The surface shall have a workmanlike finish.

The castings specified shall conform to the following ASTM Designations:

Material	ASTM No.	Grade
Gray-Iron Castings	A 48	Class 20
Malleable Castings	A 47	35018
Ductile Iron Castings	A 395	60-45-15

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: A 42 and A 72, respectively. Transverse ductility of wrought iron plates shall not be less than 3 percent 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: B 22. 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

442.9 to .12

Bronze Bearings and Expansion Plates for Bridges and Structures, ASTM Designation: B 100. Alloy 1 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: B 29.

442.10. Copper. Sheet copper shall conform to ASTM Designation: B 152.

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: A 7; headed bolts and nuts shall conform to requirements of ASTM Designation: A 307, Grade A. All anchor bolts shall be galvanized. (Section 442.17)

A certificate from the manufacturer will be required certifying that the material conforms to the above requirements.

442.12. Steel Pipe. Steel pipe for railing shall conform to the requirements of ASTM Designation: A 53. The pipe shall be "Standard Weight", welded or seamless. High strength, thin wall API tubing conforming to the requirements of API Standard 5LX, Grade 52, except as noted herein, may be used in lieu of the "Standard Weight" pipe if produced by a mill recognized as "authorized to produce pipe with API monogram", and listed as such in the standard API Specifications.

The following exceptions to the requirements of API Standard 5LX, Grade 52 will be allowed:

(1) Hydrostatic tests will not be required.

(2) In lieu of mill test report, a certificate from the manufacturer will be required for each lot or shipment, certifying that the pipe meets the requirements stated above.

"Equivalent" API tubing shall be in accordance with the following table:

Standard Pipe		Equivalent API Tubing	
Size (Nominal Inside Dia.) Inches	Weight of Pipe (P.L.F.)	Size (Nominal Outside Dia.) Inches	Weight of Pipe (P.L.F.)
2	3.65	2-3/8	2.64
2-1.2	5.79	3	3.36
3	7.58	3-1.2	5.30
4	10.79	4-1.2	7.25
	18.97	6-5/8	12.89

442.13. Steel Tubing. Steel sheet for formed railing shall conform to ASTM Designation: A 245, Class "C", or ASTM Designation: A 7.

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 of the size and weight indicated.

If cold pressed, the design of the press and dies shall be such as to 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 Beam Rail.

(1) The rail element shall be formed from proprietary steel complying with Section 442.2., Process. The rail element shall not be less than 10 gage. (0.1345 inches nominal thickness, exclusive of protective coating.) 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.

(2) The terminal section shall be of the same material, but shall not be less than 12 gage.

442.16. Aluminum.

(1) Rail members and cast rail posts shall conform to the following ASTM Designation:

Material	ASTM	Alloy
Tubing	B 235	GS-11C-T6
Sand Castings	B 26	G-10A-T4
Permanent Mold Castings	B 108	SG-70B-T6
Shims	B 209	990-A-0

For castings using alloy SG-70B-T6, the elongation in 2 inches shall not be less than 8 percent.

(2) **Aluminum Beam Rail.** The rail element shall conform to the following ASTM Designation:

Material	ASTM	Alloy
Beam	B 209	CG-42A-T3
Terminal Sections	B 209	CG-42A-T42

Unless otherwise shown on the plans the minimum thickness for rail elements shall be 0.156 inches (Nominal thickness). 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.

(3) Cast Rail Posts. Castings may be either sand castings or permanent mold castings. The castings shall be of uniform quality and condition, free from cracks, and shall not contain defects such as blow holes, porosity, hard spots, or shrinkage effects which, due to the degree or extent, will materially affect the suitability of the casting for its intended use. The castings shall be free of all burrs, fins, discolorations, and mold marks. The finished castings shall have a smooth and uniform appearance and texture.

Aluminum castings shall not be repaired by plugging, welding, or other methods.

Castings shall be produced under radiographic control. This shall consist of radiographic examination of castings until proper foundry techniques are established for each mold, and of production castings as necessary to insure that satisfactory quality is maintained. Mill test reports shall be furnished for each heat for all cast posts (steel, iron, aluminum).

A minimum of 5 percent of aluminum posts from any one heat, but not less than three posts, shall be furnished with a test coupon attached to the base which has been integrally cast with the post. Coupons shall not be detached from these posts until after these arrive at the job site. The test coupons shall be sufficiently large to permit obtaining a 0.350 inch diameter test specimen as defined in ASTM Designation: E 8.

All castings shall be permanently marked on the web or base as well as on the test coupon when applicable with the heat number and the heat-treat lot identification which shall correlate with the test bar and test report identification.

442.17. Fabrication, Erection, and Painting. Fabrication, welding, and erection of structural metal shall be in accordance with Item 441, "Steel Structures", Item 448, "Structural Welding", and THD bulletin C-5. Paint and painting

shall be in accordance with Item 446, "Paint and Painting". Aluminum and 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: A 123. Galvanizing of steel or iron castings shall conform to ASTM Designation: A 153, Class A. Galvanizing of bolts, nuts, screws, washers, and other miscellaneous hardware, shall conform to ASTM Designation: A 153, Class C or D.

Except for anchor bolts, 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, and all boxes, crates, or other containers used for packing, together with sills, blocking, and rods used for supporting or protecting members during transportation shall be excluded. When increases in size or weights of members have been made which were not ordered by the Engineer, but approved by him, 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 as shown on the standard shoe details, or as specified for castings above, if weights are not shown.

Deductions will be made for all cuts, copes, perforations, and all holes except rivet or bolt holes. The weight of rivet heads will be included for payment. No weight shall be allowed for weld metal.

When computed, the weight of metal will be based on the following:

Pay Weights—Lbs per Cu Inch					
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 included for payment.

(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 included for payment.

A change in design which either increases or reduces the quantity of metal going into the structure or structures, will be measured by the 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, I-beam", "Structural Steel, Plate Girder", or for such other classifications of metal as shown on the plans and in the proposal.

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.

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 Section 442.19, Measurement, 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 detail drawings.

(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 Section 442.19, Measurement.

(3) Adjustments of quantities will be subject to the provisions of Item 4.3, Changes and Alterations.

This price shall be full compensation for furnishing all materials and for all fabrication, shopwork, transportation, erection, paint and painting, galvanizing, and for furnishing all equipment, tools, labor, and incidentals necessary to complete the work.

ITEM 446

PAINT AND PAINTING

446.1. Scope. This item shall govern for the type, quality, and testing of paints, their source, and for the application of paint to structures. The painting of structures shall include, unless otherwise provided in the contract, the preparation of the surfaces, the application, protection and drying of the paint coatings, the protection of all traffic upon, underneath, or near the structure, the protection of all parts of the structure against disfigurement by any and all of the painting operations, and the supplying of all tools, tackle, scaffolding, labor, workmanship, paint, and materials necessary for the entire work.

446.2. Intent. The coating design herein specified has been effected by means of carefully controlled formulation

446.3 to .4

and durability testing methods. The intent is to procure the paints in place on structures so that the durability and protective value of these designs will be realized in service. Accordingly, the best quality materials and workmanship are implied throughout.

Surface conditions and application requirements are specified with the intent to obtain full adhesion of paint to clean, dry, firm surfaces, and between coats. This will require careful attention to preparation of surface, to prevention of contamination and marring of coating during and after drying, and to uniform, skilled application.

Portions of structures entailing difficult application of the field coats after erection, may be completely painted before assembling or erection at the discretion of the Engineer.

446.3. Formulation. The raw materials, formulae for finished paints, methods of manufacture, and methods of testing paint and paint products, shall be in accordance with Department Paint Specifications D-9-1, or with Federal Specifications as required. The latest revision of the above specifications, at the time of the contract bidding, shall govern. Copies of Department specifications are available from the Department Laboratory, Camp Hubbard, Austin, Texas.

446.4. Source of Supply.

(1) All paint required to comply with Federal Specifications shall be purchased on the open market.

(2) For State financed contracts, the Contractor shall purchase paints from the Department.

(3) For Federal Aid contracts, the Contractor may purchase the prescribed paints either from the Department or on the open market. If the Contractor elects to purchase paints on the open market, all costs of testing paints, whether performed directly by the Department or by commercial laboratories designated by the Department, will be charged against the Contractor and deducted from the amounts due him on monthly and final estimates.

(4) For State financed work combined with Federal Aid work in the same contract, purchase shall be in accordance with 446.4.(3) above.

(5) All paints purchased from the Department will be charged to the Contractor at prices in accordance with the

Special Provisions to this item which forms a portion of this contract. Reimbursement to the State will be accomplished by making deductions from the Contractor's estimates for the actual cost of paints purchased. Paint is stored by the Department in warehouses located at Seguin, Athens, and Post, Texas.

Every effort will be made to maintain a complete stock of paint at each location and paint 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 destination designated by the Contractor with transportation charges to be paid by the Consignee. 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 and which does not constitute a part of this contract. Paints in unopened containers, which were purchased from the Department shall be returned to the District Warehouse upon completion of the contract and credit given.

(6) All tests of paint, paint products, raw materials, and methods of manufacture will be made by the Department or by a commercial laboratory designated by the Department. The cost of testing of paints purchased from the Department is included in the price of the paint.

(7) Paints purchased on the open market shall not be used unless they have been inspected or tested as required. It is the *Contractor's* responsibility to order paints sufficiently in advance of work to insure delivery of paints meeting specification and inspection requirements.

446.5. Cleaning and Preparation of Surface.

(1) **Regular Cleaning.** Throughout paint application, including shop and field painting, no paint shall be applied over a surface which evidences a loose, scaly, or flaking condition. The most effective and practical methods shall be employed to remove all loose mill scale, all rust, dirt, and all other foreign substances which would be deleterious to the procurement of a firm paint coating. The original cleaning and preparation of the surface must be done at the fabricating plant before application of the shop coat, but the same general requirements for painting over a clean, firm surface shall be applicable to all coats.

The Engineer will look for evidence of faulty surface

preparation preceding each paint coat by close inspection of the surface directly prior to application of the next succeeding paint coat. This inspection directly in advance of paint application may disclose not only loose, scaly conditions on the surface as result of faulty preparation, but also failure of the paint to adhere and protect because of contamination and changes which have taken place beneath the paint film as a result of rusting and loosening of mill scale after paint has been applied. Whenever the Engineer has a doubt as to the firm condition of the surface at any time throughout the application of any of the coats, he shall explore underneath the surface of any of the paint coats already applied so as to uncover evidences of infirmity and shall direct remedial measures when necessary.

Any effective methods for removal of rust, scale and dirt, such as the use of sand blast, hand or rotating metal brushes, scrapers, chisels, hammers, flame-cleaning, or other effective means will be acceptable. Undesirable contaminants such as grease, oil, dirt, and moisture must be removed prior to paint application. Condensed moisture shall be avoided as directed in Section 446.6. Grease-like contaminants shall be removed with clean petroleum solvents, such as cleaning naphtha, applied with clean rags in such manner that the oil substance is actually removed and not simply diluted or spread out over a greater area.

All welds shall be flushed thoroughly with clean water before painting so as to remove any alkaline residue; the flushed surfaces then shall be allowed to become thoroughly dry before paint application. Paint will not be applied to welds prior to 3 days after welding. Particular attention shall be given to the cleaning of fillets, riveted areas, rivet heads, bolt heads, nuts, washers, drilled or punched holes, and welds, where loose mill scale, rust, oil, and flux are likely to be present.

Where cleaning is required, paint shall not be applied closer than 6 inches to a surface which has not been cleaned.

(2) Required Sand Blast-Cleaning. In addition to the requirements of 446.5 (1) above, the following additional requirements shall govern when sand blast-cleaning is required, or used at the option of the Contractor with spray application of paint:

a. All deposits of oil, grease, and similar deleterious matter shall be removed by solvent cleaning prior to sand blasting.

b. All mill scale shall be removed. Uniformity of color or contour is not required.

c. The maximum height of profile of the anchor pattern shall not exceed 2.5 mils. In case of dispute, anchor pattern height will be determined by grinding a spot on the blasted surface to the bottom of the deepest valley. The height shall be measured by micrometer depth gage graduated to 0.001 inch.

d. Sand blast-cleaned surfaces shall be covered completely with the initial coat of paint within 8 hours after cleaning, or shall be recleaned by sand blasting immediately prior to painting.

446.6. Weather Conditions and Dryness of Surface. Paint shall not be applied to any surface containing moisture discernible with the eye or by the following test for condensation: If temperature and humidity conditions are such that moisture is condensing upon the surface, a small area on the surface shall be moistened with damp cloth so as to apply a clearly defined, thin film of water; if this thin film evaporates after 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 order that paint shall not be applied when impending weather conditions might result in injury to fresh paint.

446.7. Care of Paints. 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 when not in use.

446.8. 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 VM&P Naphtha, Mineral Spirits, Toluene, or Xylene. Test for contaminants to the above thinners shall be that it will evaporate from paper without leaving a visible oily spot. Such adjustment of consistency described above shall be done only with the specific permission of the Engineer. The Engineer shall assure that

446.9 to .10

the equipment being used is adequate and suitable for the type of paint in question, that the gun is not clogged with dried or semi-dried paint, and that the required air pressure is being delivered at the gun before approving thinning.

446.9. Brush Application. It shall be mandatory to apply No. 700 shop coat by brush or roller, except that spray application will be permitted on sandblasted surfaces. Painting shall be done by workmen skilled in the craft of structural metal painting. Good workmanship by skilled workmen is evidenced by the following outstanding features; all crevices, such as around rivet heads, sharp angles, etc., are first traced; the entire surface is then coated without attempt to "lay-off" the paint in one direction; lastly, runs from crevices are picked up and the paint is laid-off in one direction so as to leave a uniform film, free from runs, sags, or brush-marks caused by not "feathering" or blending one lap into another. Brushes, preferably shall be round or oval in shape, but if flat brushes are used, they shall not exceed 4 inches in width; brushes should be springy and not flabby. Brushes shall be kept free of all contaminants.

446.10. Spray Application. All coats may be applied by roller, spray, brush, or a combination thereof subject to the provisions of Items 446.9 and 446.11, except that No. 800 shop coat, No. 802 field coat, and GR-3 field coat shall be applied by spray only.

Spray painting shall be done by skilled workmen. Good workmanship is evidenced by the painter's ability to correctly adjust his equipment, by his application techniques, and by his equipment maintenance.

A good painter will adjust his spray pattern to correspond with the size and shape of the surface being painted. He will adjust the quantity of material being delivered to the gun to correspond with production speed by adjusting the tank pressure and will maintain a ratio of tank pressure to gun pressure that will give maximum atomization of the paint particles with the least vaporization of the thinner. Too high an air pressure at the gun will cause the painted surface to appear dry and grainy. Too low an air pressure will result in the painted surface appearing too heavy and too wet.

A spray gun correctly held is approximately 8 inches from and always perpendicular to the surface being painted. The good painter will steadily move the gun through a deliberate pattern that permits overlapping of the previous pass by 50

percent and at a speed that will leave a full, uniform coat. Overspray will be held to a minimum.

The equipment used for spray painting shall meet with the approval of the Engineer and shall have adequate provision for separation of moisture from any air stream in contact with the paint. All spray guns shall be adequate for the type of paint being used and shall be equipped with suitable spray heads as necessary to obtain the application of an even, smooth coat of paint.

Some of the paints are very harmful to the health of humans and animals if allowed to enter the alimentary tract by way of nose or mouth. Therefore, if spray application is used, workmen shall be adequately protected with respirators and provisions shall be made to prevent infliction of harm upon all other humans and/or animals which might be exposed to the fumes or might eat food upon which the fumes have deposited. This warning shall absolve the State from blame in the event of harm to persons or property from the above-named cause and full responsibility for any such harm shall rest upon the Contractor.

446.11. Shop Coat. When all fabrication work is completed and has been tentatively accepted as such, all surfaces not painted before assembling shall be cleaned as provided in Section 446.5 and painted with the required shop coat. Pieces shall not be loaded for shipment until thoroughly dry. No painting shall be done after loading material on cars. Erection marks for the field identification of members shall be painted upon previously painted surfaces. Surfaces to be in contact after shop riveting shall be cleaned but not painted.

When field rivets or high-strength bolts are to be used, shop paint shall be omitted from contact surfaces to connections and splices of truss members, girder splices, floor beam connections, and stringer connections.

The shop coat of paint shall be omitted from the surfaces of steel members which will be in contact with the slab concrete in the finished structure. At the time concrete is placed, such surfaces of structural steel shall be free from dirt, scale, rust, paint, oil, or other foreign material.

Machine finished surfaces which are to be in sliding contact in the structure shall be coated with a hot mixture of white lead and tallow before being removed from the shop. This refers particularly to pins and holes for pins. The composi-

446.11

tion 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.

All metal surfaces which will be within 2 inches of field welds shall be coated with linseed oil in advance of the application of shop coat paint and left bare of paint until field welding is completed. All surfaces other than those above mentioned shall receive a shop coat of paint regardless of whether or not the surface in question will be in direct contact with concrete or other masonry in the finished structure. Unless otherwise shown on the plans, 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 regardless of whether or not such surfaces are milled, except those surfaces in closed, sliding contact as described above.

On non-sandblasted surfaces No. 700 shop coat shall be applied as uniformly as possible by brush or roller to provide a minimum dry film thickness of 1.8 mils. The approximate wet film thickness will be 3.0 mils, or a maximum coverage of 500 square feet of surface per gallon of paint.

No. 700 or 800 shop coats applied to sandblasted surfaces shall provide a minimum dry film thickness of 2.2 mils, and shall cover all peaks of the anchor pattern with a theoretical coverage of 330 square feet of surface per gallon of paint.

Spray application of shop coat will be permitted only when the surfaces are cleaned by sand blasting.

When two shop coats are required, the second coat will be applied in the same manner, with the same required coverage as the first. The addition of a small amount of lamp black will be required in the paint for the second shop coat to alter the color slightly for ease in inspection.

No. 700 shop coat is an olive green color, which should harden to the touch in 24 hours and dry for handling or further painting in 4 days.

No. 800 shop coat is a burnt orange color, which should harden to the touch in 4 hours and dry for handling or further painting in 24 hours.

Deterioration of the paint film or painted surfaces shall be cared for, prior to shipment, by such methods as are

necessary to restore the surface to its original condition of cleanliness and paint quality. A light application of shop coat paint may be required if conditions warrant.

446.12. Field Cleaning and Spot Painting. When the erection or maintenance work is complete, including all riveting, straightening of bent metal, etc., the previously painted face shall be restored to a serviceable condition acceptable to the Engineer by means of preparation of surface as outlined in Section 446.5 and by smoothing and touching up marred places in the previously applied paint film with No. 700 shop coat unless otherwise specified. Heads of field rivets and bolts, field welds and surrounding unpainted areas, and any other surfaces to be painted which have not been painted shall be painted with No. 700 shop coat unless otherwise specified. The coating of white lead and tallow specified in Section 446.11 shall be removed completely as directed for removal of grease and oil in Section 446.5.

446.13. First Field Coat. When field cleaning and restoration of shop coat has been completed and the shop coat is thoroughly dry, the first field coat of paint may be applied. Finished surfaces intended for sliding contact shall be given a coat of approved graphite grease immediately prior to being placed in the structure. Graphite greases shall be composed of dry graphite flakes mixed with sufficient light grease or heavy oil so as to form a thick paste suitable for the purpose. Field coats will not be required on the bottom surfaces of shoe castings or bearing plates in direct contact with concrete nor on the top surfaces of beams, girders, etc., on which a concrete slab is to be placed in direct contact.

The 701 field coat shall be applied as uniformly as possible by spray, brush, or roller to provide a minimum dry film thickness of 1.8 mils. The approximate wet film thickness will be 3.0 mils, or a maximum coverage of 500 square feet of surface per gallon of paint.

No. 800 shop coat may be applied for the first field coat in lieu of the No. 701 field coat option of the Contractor. Application shall be by spraying and coverage shall be the same as required when using No. 701 field coat.

446.14. Aluminum Paint. When the first field coat, including all touched up marred areas, has hardened completely, the finishing field coat or coats of Aluminum Paint

446.15 to .17

may be applied. Cracks and cavities which have not been sealed in a water-tight manner by the first field coat shall be filled with Red Lead Paste, containing 92-94 percent Red Lead and 8-6 percent Linseed Oil, and this shall be allowed to sufficiently surface-dry before the first aluminum coat is applied. After application of the final aluminum coat, the painted portion of the structure shall present a uniform color appearance throughout.

Each aluminum paint coat shall be applied as uniformly as possible by spray, brush, or roller application (except as noted below) to provide a dry film thickness of 1.0 mil. Theoretical coverage for these two paints are 800 square feet per gallon for No. 702-APE-1 and 330 square feet per gallon for the No. 802-APE-2.

No. 702-APE-1 designation is used for the standard, slow-dry, aluminum paint which is adaptable to the painting of wood and steel surfaces. Application may be by spray, brush, or roller. Spray application of 702-APE-1 paint is not recommended in congested areas where damage to property from overspray and blowing paint is a factor.

No. 802-APE-2 designation is used for a fast-drying aluminum paint which is to be applied to structural steel by spray application only. Paint overspray will normally dry and not adhere to any surface beyond 25 feet. Spray technique for the application of No. 802-APE-2 is more critical than for 702-APE-1.

446.15. GR-3 Field Coat. The previous paint coat shall be restored as prescribed by Section 446.12 of this Specification. After the necessary spot painting has dried completely, the surfaces which are to receive the GR-3 field coat shall be cleaned and the GR-3 field coat applied by spraying. The rate of application shall be such as to obtain an adequate and uniform coverage of metal and shall be not less than $\frac{1}{2}$ gallon of paint per 100 square feet of surface of metal. Application shall be in accordance with the provisions of Section 446.10.

446.16. Special Paints. Special protective coatings may be required for protection under certain conditions of service. These special coatings will be designated under the paint schedule (446.18) as No. 10. Materials and methods for these special coatings will be covered on the plans or in special provisions.

446.17. Cleaning and Painting Existing Structures. All

structural steel to be painted shall be cleaned thoroughly in accordance with Item 446.5 to prepare the surfaces to receive new paint. Rust spots shall be cleaned to bare metal. The steel shall be spot-painted with No. 700 shop coat prior to the application of paint to the entire surface unless otherwise specified. Spot-painting shall be done as specified in Item 446.12 above. After the cleaning and spot-painting has been done to the satisfaction of the Engineer, and the spot paint has dried thoroughly, application of the required coat or coats designated on the "Estimate and Quantity" sheet of the plans by designation number as shown in Item 446.18 shall be applied. Paints and their application shall conform to the pertinent sections of this specification.

446.18. Type, Number of Coats, and Cleaning Designation. The type of paint, the cleaning, and the number of coats required shall be designated on the Specification Data Sheet of the plans, by number, according to the paint schedule

PAINT SCHEDULE

Paint Type	700	700 or 800	*Red Lead	GR-3	701	701 or 800	702 or 802
Place of Application	Shop			Field			
Paint Schedule	Number of Coats Required						
1	1					1	1
1-S		1				1	1
2	2					1	1
2-S		2				1	1
3	2					1	2
3-S		2				1	2
4	1			1			
4-S		1		1			
5			†2				2
5-S			†2				2
6				1			
7					1		1
8				1			1
9					1		2
10	See plans and special provisions.						

*Red Lead paint shall conform to Federal Specification TT-P-86, Type 1.
 †Second coat of Red Lead Paint shall be applied in the field.

446.19 to .21

shown above. If a paint schedule is not designated, Schedule 1 paint shall be required.

Regular cleaning of the steel (sandblast-cleaning not required) shall be indicated by number only.

When sandblast-cleaning of all surfaces is required, the letter S after the paint number will be shown.

Sand blast-cleaning may be used at the option of the Contractor where regular cleaning is specified.

The sequence of paint application shall be from left to right in the above table.

446.19. Removal of Paint Improperly Applied. All applied paint which has been applied improperly and fails to dry and harden properly, or to adhere tightly to underlying metal or other paint film, or does not evidence a normal, workmanlike appearance in conformance with the intent of these specifications, shall be remedied 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 are necessary. Removal of freshly applied paint which has not yet set shall be effected with the use of naphtha, gasoline, or turpentine. Removal of dried paint films shall be effected either by means of sand blast, scraping, or flame torches meeting the approval of the Engineer.

446.20. Measurement. When so designated by the bid item, "Cleaning and Painting Existing Structures", completed work will be measured by lump sum for all cleaning and painting of structural steel.

446.21. Payment. Unless otherwise provided on the plans or in the special provisions, payment for furnishing all paint materials and all tools, equipment, labor, scaffolding, protection of traffic, and incidentals necessary to complete the work, and for cleaning all surfaces and for the application of paint shall be included in the unit price bid per pound of structural metal, or per linear foot of steel piling or railing or per mfbm of timber, as the case may be.

When bid as the item "Cleaning and Painting Existing Structures", the completed and accepted work as provided herein will be paid for at the lump sum price bid, which price shall be full compensation for cleaning, spot-painting, for

application of paint, and for furnishing all labor, equipment, material, scaffolding, protection of traffic, tools, and incidentals necessary to complete the work.

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 "Quenched and Tempered Steel Bolts and Studs with 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 American Standards Association (ASA Standard B18.2).

(3) When specified on the plans, interference-body bolts, with heads conforming to the dimensions for driven button heads of the American Standards Association (ASA 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 of the American Standards Association (ASA Standard B18.2) or to the requirements for finished hexagon nuts of the American Standards Association (ASA 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 ASA Standard B27.2 Type A washer tolerances applied to these nominal dimen-

447.3 to .4

sions. 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.

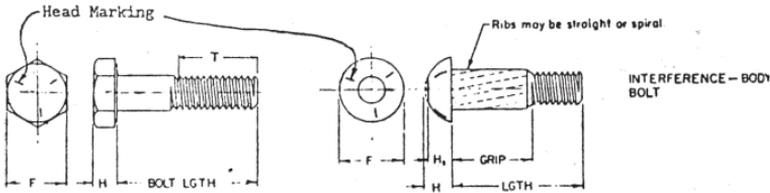
(6) Bolts and nuts of any of the types specified above may be furnished except that all bolts and nuts shall be the same for any one structure.

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 Item 441, "Steel Structures". Holes shall be of a nominal diameter not more than 1/16 inch in excess of the nominal bolt diameter. Field erection and fit-up of joints and splices shall conform to the requirements of Item 441, "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 3 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.

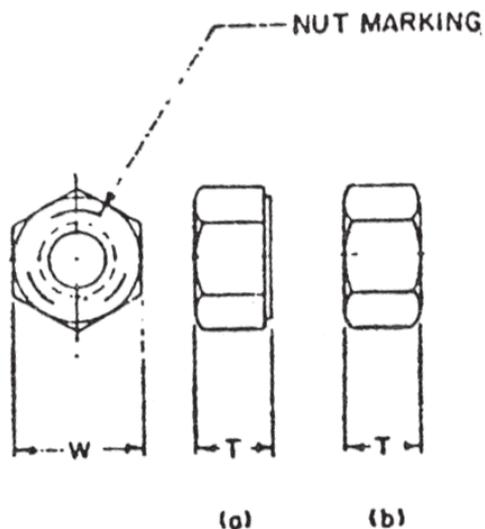


Nominal Bolt Size	Column 1		Column 2		Thread Length	Column 3		
	Regular Semifinished Hexagon		Heavy Semifinished Hexagon			Interference-body		
	Width Across Flats	Height H	Width Across Flats	Height H	T†	F	H ₁ *	H
1/2	3/4	5/16	7/8	5/16	1	59/64	5/16	11/32
5/8	15/16	25/64	1 1/16	25/64	1 1/4	1 9/64	25/64	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 1/4 inch.

TABLE 1
Bolt Dimensions
(inches)



NUTS MAY BE
WASHER FACED AS
IN (a) OR DOUBLE
CHAMFERED AS
IN (b)

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)

Bolt Size	Inside Dia.*	Circular Washers Flat Surfaces			Square or Rectangular Washers for American Standard Beams and Channels Beveled Surfaces†		
		Minimum Nominal Outside Dia.	Nom. Thick. Gage 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 1/8 inch.

To determine the required length of interference-body bolts the value shown in the above table, less 1/8 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 Tensions* (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 Article 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.

447.8

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 Article 477.7 (1) above.
- (c) Follow steps (d) and (e) shown in Article 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 field 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 Item 442, "Metal for Structures".

ITEM 448

STRUCTURAL WELDING

448.1. Description. This item shall govern for the field welding of structural steel and reinforcing steel as noted under Article 448.9. Unless otherwise specified, these provisions shall apply to both carbon and alloy steels.

Submerged arc welding and manual welding pertinent to shop fabrication of welded structures shall be in accordance with Item 441, "Steel Structures" and THD Bulletin C-5.

448.2. General. All welds including tack welds that are to be incorporated in the final welds, shall be made by a

certified welder and shall be of sound quality. Tack welds shall be cleaned and fused thoroughly with the final weld. Defective, cracked, or broken tack welds shall be removed before final welding.

Welds shall be as required by the design 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 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.

448.3. Filler Metal. Electrodes shall conform to the requirements of ASTM Designation: A 233 (AWS Designation: A 5.1). Class of electrode required will be as shown herein. Electrodes shall be used only with the type of current, the polarity, and in the positions permitted by the subject specifications.

Type of Steel and Thickness	Type of Weld	
	Groove Welds	Fillet Welds
A 373 Under 1 1/4" A 53 Pipe Railing	E6010, E6011, E7015, E7016, E7018	E6010, E6011, E6012, E6013, E6014, E7015, E7016, E7018
A 373 1 1/4" and over	E7015, E7016, E7018	
A 441, A 36 & A 242 Deck Plates API Pipe Railing	E7015, E7016, E7018	E7015, E7016, E7018
A 7 and A 373 (Secondary Members)		E6010, E6011, E6012, E6013, E6014, E7015, E7016, E7018
A 441 and A 36 (Secondary Members)		E7015, E7016, E7018
Reinforcing Steel	E7015, E7016, E7018	E7015, E7016, E7018

TABLE 1
Classifications of Electrodes Permitted

Electrodes which have dried out and cracked or those which have been wet shall not be used.

Electrodes of the low hydrogen type shall be dried for at least two hours at a temperature above 250 F before such are used. Electrodes so dried that are not used within 4 hours after this drying is completed shall be redried before being used. Electrodes which have been wet shall not be used. Storage of all low hydrogen electrodes shall be in suitable ovens.

448.4. Assembly and Fit-Up. The parts to be joined by fillet welds shall be brought into as close contact as possible, and in no case shall 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.

Abutting members to be joined by butt welds shall be carefully aligned. In aligning splices of beams and girders, the center of gravity of both members shall coincide or each flange shall be offset equally. Beams and girders with offset webs shall be fit with the webs aligned and the flanges offset.

When flanges are offset, or when parts abutting edge to edge differ in thickness by more than one-eighth inch, the joint shall be such that the slope of either surface through the transition does not exceed 1 in 4.

For groove welds of butt joints, members shall be spaced to provide a three-sixteenths inch root opening at the nearest point. When the three-sixteenths inch opening at the nearest point allows more than one-fourth inch opening at the other points, correction shall be made to provide the correct root opening, prior to welding of the joint. Additional build-up of bevels to provide proper root opening shall not exceed one-fourth inch. Rebeveling by cutting and grinding will be required for correcting openings wider than one-fourth inch.

Members to be welded shall be brought into correct alignment and held in position by acceptable clamps. Clamps may be removed after members are tack welded sufficiently to hold the members in place.

Suitable allowance for shrinkage shall be made, and in no case shall the joint be restrained against shrinkage on both sides of the joint.

All butt splices shall be made before welding of diaphragms and before welding of beams or girders to shoes.

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.

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 build-up on one flange edge.

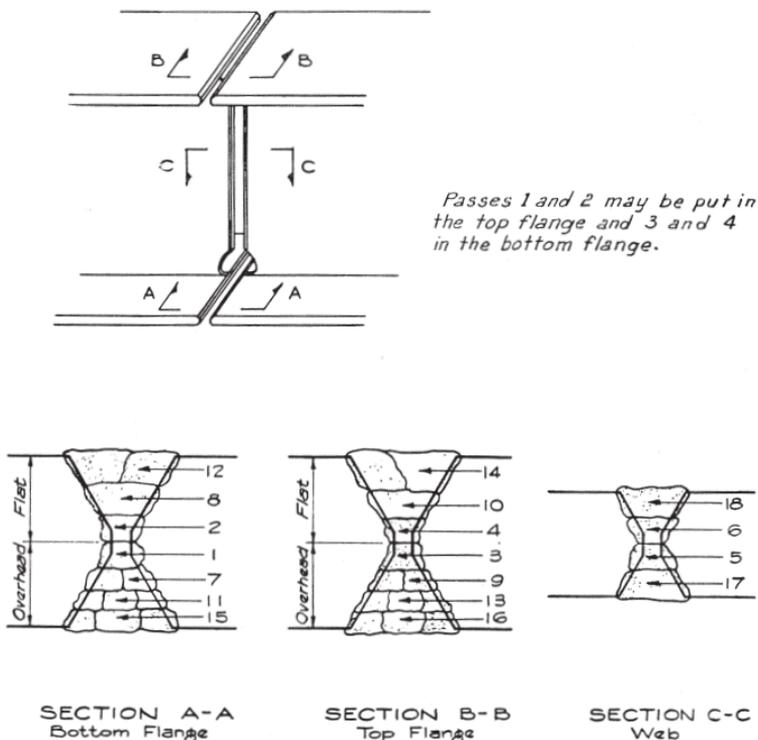


Figure 1
Welding Procedure for Splices

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.

The maximum size electrode used shall be as follows:

- (1) one-fourth inch for flat and horizontal fillet welds.
- (2) three-sixteenths inch for vertical and overhead fillet welds.
- (3) three-sixteenths inch for groove welds made in the flat position.
- (4) five-thirty-seconds inch for groove welds made in the vertical and overhead position, using E^{xx} 15, E^{xx} 16 or E^{xx} 18 electrodes on all thicknesses of material.
- (5) five-thirty-seconds inch for groove welds made in the vertical and overhead position on material less than one inch in thickness, using electrodes other than those specified under (4) above.
- (6) three-sixteenths inch other than low hydrogen electrodes for groove welds made in the vertical and overhead position on material one inch and over in thickness provided the welder has been certified for the use of 3/16 inch electrodes by the Department.

The maximum thickness of layers subsequent to the root pass in fillet welds and of all layers in groove welds shall be:

- (1) one-fourth inch for root passes of groove welds.
- (2) one-eighth inch for subsequent layers of welds made in the flat position.
- (3) three-sixteenths inch for subsequent layers of welds made in the vertical, overhead, or horizontal position.

The minimum size of a root pass shall be such as to prevent cracking.

The maximum size of fillet weld, which may be made in one pass, shall be five-sixteenths inch.

For vertical welding, the progression for all passes shall be upward with a back step sequence being employed.

Before welding over previously deposited metal, all slag shall be removed and the weld and adjacent base metal shall be brushed clean. This requirement shall apply not only to successive layers, but also to successive beads and to the crater area when welding is resumed after an interruption.

All butt welds, except when produced with the aid of backing, shall have the root of the initial weld gouged, chipped, or ground to sound metal before welding is started from the second side.

448.6 to .7

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 ground 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.

Preheat ahead of welding of both fillet and groove welds will be required as follows:

Thickness at Point of Welding Plates-Shapes or Bars	Minimum Preheat and Interpass Temperature		
	A 373 Steels		A 441 & A 36
	Low Hydrogen Electrodes	All Other Electrodes	Low Hydrogen Electrodes
Less than one inch	None	None	100F
1 inch to 2 inch	None	100F + 25F per 1/4" over 1" thickness	100F + 25F per 1/4" over 1" thickness
Over 2 inch	100F + 25F per 1/4" over 2" thickness	200F + 25F per 1/4" over 2" thickness	200F + 25F per 1/4" over 2" thickness

TABLE 2
Preheat and Interpass Temperatures
for Manual 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 undercutting.

All craters shall be filled to the full cross section of the welds.

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:

Where requirements prescribe the removal of part of the weld or a portion of the base metal, such removal shall be by oxygen gouging or arc-air gouging.

Where corrections require the deposition of additional weld metal, the sides of the area to be welded shall have not less than a 1 to 1 slope to allow sufficient room for 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 removal of excess weld metal by grinding.

Shrinkage cracks, cracks in base metal, craters, and excessive porosity. Remove defective portions of base and weld metal down to sound metal and deposit 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 those parts of the weld containing slag and fill with sound weld metal.

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 the electrode used for making the 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 subsequent to the making of a deficient weld has rendered the weld inaccessible or has caused new conditions which would make 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 care-

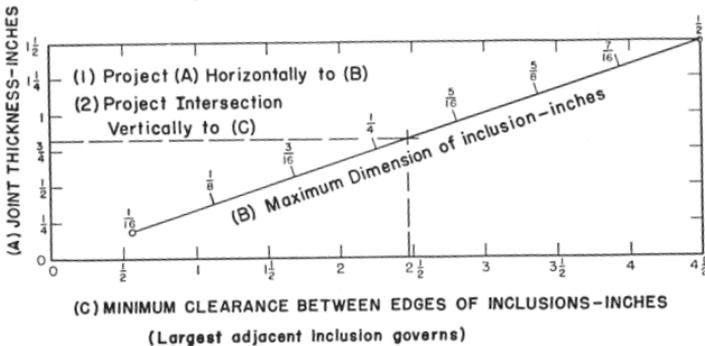
fully supervised application of a limited amount of localized heat. Heated areas shall not exceed 1200 F as measured by Tempil-sticks. Parts to be heated for straightening shall be substantially free of stress from external forces, except when mechanical means are used in conjunction with the application of heat.

448.8. Radiographic Inspection. All butt welds designed to carry primary stresses shall meet the following radiographic standards. When subjected to radiographic inspection, 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 that are shown by radiography to have any of the following imperfections shall be judged unacceptable:

Cracking, regardless of length or location, incomplete fusion, overlapping, or inadequate penetration.

(2) (a) 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



NOTES:

1. The distance from the edge of an inclusion to the free edge of plate or toe of a flange fillet weld shall be equal to or greater than the clearance between inclusion.
2. Inclusions with any dimension greater than 1/2" are not acceptable.
3. For joint thicknesses greater than 1-1/2", the minimum allowable dimension and spacing of inclusions shall be the same as for 1-1/2" joints.
4. Values of (B) obtained by projecting horizontally from (A) are maximum values. 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 2
Radiographic Standards for Allowable Inclusions

linear inch of welded joint shall not exceed three-eighths inch.

(b) Inclusions one-sixteenth inch or larger in greatest dimension shall be permitted providing such defects do not exceed the limits shown on Figure 2 or in paragraph (a) above.

(c) 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.

REINFORCING STEEL

448.9. Chemical Requirements for Welding. Unless otherwise shown on the plans, welding of reinforcing steel will not be permitted except on widening projects, repair work, and for capping and splicing of piling which are not to be redriven. The reinforcing steel furnished for welding shall be new billet steel only. Furnishing of rail or axle steel for welding will not be permitted. When welding is permitted, mill test reports will be required in accordance with Item 440, "Reinforcing Steel".

For any chemical range of the steel, low hydrogen electrodes as specified in Table 1 will be required.

Preheat will be required for varying carbon ranges as specified in Table 3.

Bar Size	Joint Type	Carbon Range	Preheat
All	Lap (fillet) and Butt (Groove)	Less than 0.55 0.55 to 0.70 Over 0.70	None 200F 400F

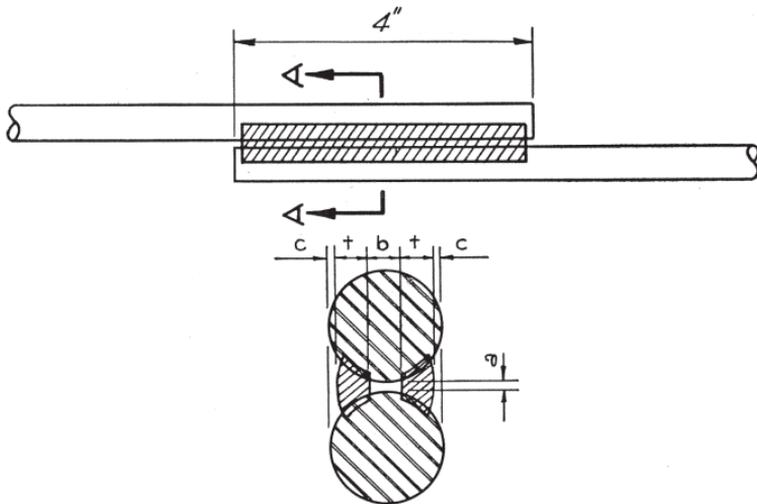
TABLE 3
Preheat Requirements

448.10. Joint Types. For all bars, No. 8 and larger, butt splices will be required. For Number 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. In such case, the weld shall be a minimum of 6 inches in length.

Lap welds shall meet the requirements specified in Table 4.

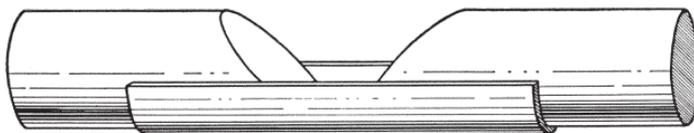
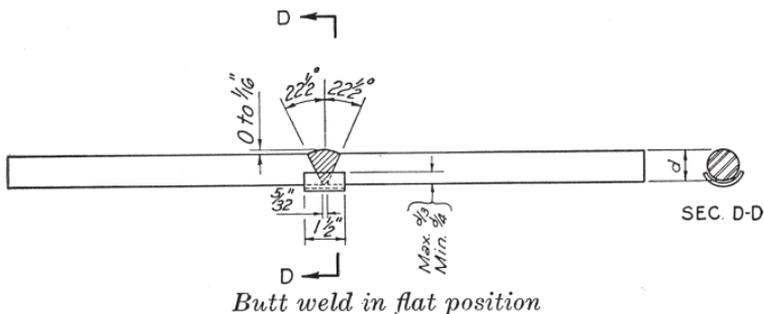
Bar Size	"a"	"b" (Max.)	"t" (Min.)	"c" (Max.)	Electrode Size
No. 4	.04 in.	1/8 in.	1/8 in.	1/16 in.	1/8 in.
No. 5	.05 in.	1/8 in.	3/16 in.	1/16 in.	5/32 in.
No. 6	.06 in.	1/8 in.	1/4 in.	1/16 in.	5/32 in.
No. 7	.07 in.	3/16 in.	5/16 in.	1/16 in.	5/32 in.



SEC. A-A (ENLARGED)

TABLE 4

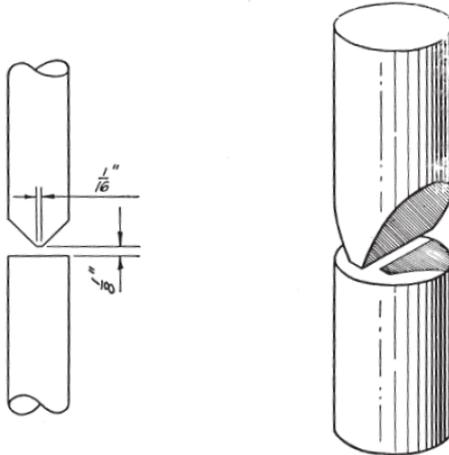
Required Dimensions for Lap Splices



BAR TO BE BUTT WELDED IN HORIZONTAL POSITION

FIGURE 3

Where possible, all butt splices shall be made in the flat position. All butt splices, except horizontal, shall be of the type shown in Figure 3, with the back-up strip required. Horizontal splices may be of either type shown in Figure 3 or Figure 4.



BAR TO BE BUTT WELDED IN VERTICAL POSITION

FIGURE 4

448.11. Construction Methods. 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 the structure to be widened is found to be of the wrong spacing, dowel bars of such length required to develop the welded lap or butt splice and of such additional length to develop the bar in bond, as required in Item 440, "Reinforcing Steel" shall be welded to the old steel, with the new reinforcement being placed at the correct spacing without welding to the old steel. Measurement and payment of the dowels will be made in accordance with Item 440, "Reinforcing Steel".

The old reinforcement, as well the the new, shall be cleaned thoroughly prior to the preparation of the joint (beveling or tying, as the case may be).

STRUCTURAL AND REINFORCING STEEL

448.12. Welder Qualification. All welders shall be certified before working on any material which is to be incorpo-

448.13 to 450.1

rated into a Department project. Each welder must have certification papers which will show the type of work for which he is certified. A welder will not be permitted to do any type of work not covered by the certification papers.

Tests for certification of welders shall be as prescribed by THD Bulletin C-6. Tests shall be given by a commercial laboratory with an approved ASTM rating. For field welding, certification by a commercial 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 the welder does satisfactory work during this period, the Department will issue certification papers to the welder. These certification papers will permit the welder to work on Department projects as long as the welder continues to do satisfactory work.

In order to be certified for the use of three-sixteenths inch electrodes in the vertical and overhead position, a welder must have passed the Basic Qualification Test for Structural Welding in accordance with THD Bulletin C-6, using three-sixteenths inch electrodes. Also the welder must demonstrate to a Department welding inspector a thorough knowledge of the required welding procedures together with his ability and desire to follow such procedures and the welds shall be of sound quality and good appearance. Quality of the weld will be checked by radiographer.

The certification papers issued by the Department are the property of the Department and may be cancelled at any time for proper cause.

448.13. 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, cast iron, 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 approach railing erected on the embankment, but connected to the bridge railing.

Railing shall be constructed in accordance with the details shown on the plans, including the necessary anchorage.

450.2. Materials. All materials shall conform to the requirements of Item 420, "Concrete Structures", Item 421, "Concrete for Structures", Item 423, "Lightweight Concrete for Structures", Item 440, "Reinforcing Steel", and Item 442, "Metal for Structures", as the case may be. Material for steel structural shapes and base anchorages shall be ASTM Designation: A 7, or as designated on the plans.

450.3. Construction. (1) General. Railing shall be of the classification and type specified, and constructed in accordance with details shown on the plans and in conformance with the requirements herein. It shall be constructed to the alignment, grade, and camber as designated on the plans. Shop fabricated railing shall be of such uniformity as to insure good joints and continuous lines after erection on the structure. Any appreciable amount of cutting, bending, or filling required on erection to produce a reasonable fit will be cause for rejection of the rail. Unless otherwise provided, railing shall not be placed until after the falsework for the span has been released. During construction of railings, care shall be exercised to insure proper functioning of expansion joints.

Unless otherwise shown on the plans, rail posts shall be erected vertically with the tops on a level line, or parallel to the roadway grade indicated on the plans.

The fabrication and erection of metal for railing shall conform to the pertinent provisions of the Item 441, "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.

450.3

For metal railings, shop drawings shall be prepared and forwarded for approval in accordance with the requirements of Item 441, "Steel Structures".

Welding shall be in accordance with Item 448, "Structural Welding", and THD Bulletin C-5.

Railing materials shall be stored above the ground on platforms, skids, or other supports. The materials shall be 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, upon arrival at job site, shall be in accordance with manufacturer's recommendations.

Aluminum members shall be separated from concrete or steel by a bearing pad conforming to the requirements for preformed rubber-fabric pads in accordance with Item 441, "Steel Structures", or of 70 durometer neoprene in accordance with Item 435, "Elastomeric Materials". The material shall be one-eighth of an inch in thickness, unless otherwise specified.

To facilitate bending or straightening, aluminum materials other than castings may be heated to a temperature not exceeding 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 in which no welding flux is used. 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 Item 420, "Concrete Structures", and to the requirements herein. Provision shall be made in the construction of railing forms to provide for the checking and correction of the lines and grades of the railing after concrete has been placed, but before initial set, and the operation required for floating the top of railings shall be conducted in such manner as not to disturb the form alignment after the final check. Particular care shall be exercised in carrying on other construction operations adjacent to railings being placed, in order to avoid disturbing or vibrating the span on which the railing is newly placed. Before concrete is placed in rail posts, the area on top of the curbs to be covered by the railing shall be cleaned, wetted, and covered with grout in accordance with the provisions for treatment

of construction joints in Section 420.6. In curing and handling 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 Item 440, "Reinforcing Steel".

(3) Prestressed Concrete Railing. Railing shall be of the shape, size, and length as shown on the contract plans.

The design, mixing, hauling, placing, curing, quality, and finishing of concrete, construction and removal of forms, submission of hauling details, prestressing details, plant facilities plans, tensioning, release of stress to the concrete, inspection facilities, and other pertinent requirements of Item 420, "Concrete Structures", Item 425, "Prestressed Concrete Structures", and Item 426, "Prestressing", shall apply to the construction of railing under this item.

(4) Pipe Railing. Pipe shall be fabricated from the material and to the shape and dimensions shown on the plans and governing specifications.

Where the pipe rail and posts must be shop fabricated into panels, these shall be mounted in a jig so constructed that the posts and pipe will be clamped in their true relative position, accurately spaced with respect to each other. Thus assembled in the jig, the railing members shall be *completely* welded or bolted, as the case may be. As each rail section is completely assembled and connected, and when required by the plans, the next succeeding section shall be set in its proper relative position with the ends engaged, and shall remain in this position until completely connected. The two sections then shall be matchmarked so that they may be erected in the same order in which they were fabricated.

(5) Metal Beam 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 inch.

The rail elements shall be jointed and connected to the rail posts as shown on the plans. When the elements are lapped, the lap shall be in the direction of traffic in the lane adjacent to the railing.

450.4 to .5

(6) **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.

450.4. Tests. For cast aluminum posts, the test coupons, which were cast integrally with the posts, shall be removed at the job site by the Contractor and at least one test specimen from each heat shall be made and tested. The tensile properties shall be determined in accordance with ASTM Designation: E 8.

If the results of any tests do not conform to the requirements prescribed, two additional tests shall be taken from the same heat and the average of the three tests must meet the requirements or the posts from this heat will be rejected.

For Metal Beam Rail, a sample of the rail and terminal section may be taken from each project or for each shipment to a project. Samples of bolts and nuts may also be required. A test coupon cut from the material and tested as specified in ASTM Designation: E 8 shall elongate not less than 12 percent in a 2 inch gage length.

For all cast posts, when specified on the plans, a minimum of one post per heat but not less than three per project, shall be furnished to the job site for test purposes.

All samples and coupons required to be furnished shall be sent to the Department Laboratory, Camp Hubbard, Austin, Texas.

450.5. Protective Coating. When specified on the plans, railing shall be galvanized in accordance with ASTM Designation: A 123 or A 153, whichever is pertinent, except that the coating for Metal Beam Rail only shall be a minimum of 2½ ounces per square foot of double exposed surface.

When galvanizing is not specified, railing (except aluminum) shall be given a Schedule 1 or Schedule 1-S paint in accordance with Item 446, "Paint and Painting".

Steel Beam Rail may be given one coat of Primer Protective Coating in lieu of No. 700 or 800 shop coat. This coating shall be of sufficient quality and coverage to protect the metal from corrosion. The railing shall then be cleaned, spot painted, and painted in accordance with Item 446, "Paint and Painting".

Aluminum and galvanized railing shall require no field painting. Prior to acceptance, extrusion marks, grease, dirt, and grime shall be cleaned from the aluminum rail. After

erection, all parts of galvanized steel posts and rail elements on which the galvanizing has become scratched, chipped, or otherwise damaged shall be thoroughly cleaned by wire brushing in 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: MIL-P-15145. The paint shall be furnished by the Contractor at his expense.

450.6. Designation of Railing. Railing will be designated by the general classification shown on the plans, i.e., Metal Pipe Railing, Parapet Railing, Pedestrian Railing, Metal Channel Railing, Metal Beam Railing, etc., and by the type within these classifications. When a classification and type is designated which has optional designs of railing, any of the types shown may be furnished at the option of the Contractor. When a specific type and classification or material is specified, only that railing shall be permitted.

When the railing is designated by the "Metal" classification, the rail member only may be furnished either in aluminum or steel, i.e.,

"Metal Beam Railing", (Type 6) (Aluminum or Steel may be furnished)

"Steel Beam Railing", (Type 6) (Steel only shall be furnished)

"Aluminum Beam Railing", (Type 6) (Aluminum only shall be furnished)

Railing, except aluminum, shall be furnished painted unless the plans require the railing to be galvanized.

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 iron, cast steel, pipe, anchor bolts, and all other materials required in the finished railing, and for all labor tools, hardware, equipment, paint and painting, galvanizing,

451.1 to .2

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, modifications 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 with a Schedule 7 paint in accordance with Item 446, "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 recoated with a liquid or stick-type galvanizing material applied in conjunction with heat, in accordance with the particular manufacturer's recommendation. The material to be used will require approval of the Engineer prior to its use.

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 with a Schedule 7 paint in accordance with Item 446, "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.

452.3 to 453.2

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 430, "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 re-finishing 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 such places as shown on the plans and in conformity with the plan details and the requirements of this item.

453.2. Material. Temporary railing may be either timber or metal. The Contractor may use metal railing which is to be later used in the permanent structure, subject to the requirements of this Item.

When a portion of the temporary railing is to be furnished by the Department, such portions furnished will be shown on the plans.

Railing to be used later as a part of the permanent structure shall conform to the requirements of Item 450, "Railing."

Timber posts and timber rail members shall be commercial grade lumber in satisfactory condition for the use intended on the basis of field inspection.

Paint and painting shall be in accordance with Item 446, "Paint and Painting."

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 details shown on the plans.

After erection, all parts shall be cleaned thoroughly and painted with one coat of No. 702 or 802 aluminum paint.

After completion of the initial widening of one side, the temporary railing shall be moved to the other side and erected, prior to the removal of the railing and curb.

Any portion of the railing which is to become a part of the permanent structure shall be maintained and 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.

Any railing material furnished by the State will be delivered free of charge to the bridge site.

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 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.

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, for all preparation, hauling and erection, painting, maintaining, moving from one side of the bridge to the other and for removing, 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 waterproofing for structure decks, walkway surfaces, backs of abutments and retaining walls and for substructure footings of the type shown on the plans in accordance with these specifications.

When shown on the plans, a base course of asphalt mastic and/or a protective course of asphalt plank of the thickness shown on the plans shall be furnished and placed in accordance with the plans and these specifications.

Where the base course and/or protective course is required by the plans and is used in conjunction with membrane waterproofing, the base course of asphalt mastic and/or the protective course of asphalt plank is considered incidental to the type of membrane waterproofing specified and no direct payment will be made therefor.

Waterproofing shall consist of one of the following types as shown on the plans.

Membrane Waterproofing

Type A which consists of two layers of bitumen-treated cotton or glass fabric and three moppings of bitumen.

Membrane Waterproofing

Type B which consists of three layers of bitumen-treated cotton or glass fabric and four moppings of bitumen.

Membrane Waterproofing

Type C which consists of two layers of bitumen-treated felt, one middle layer of bitumen-treated cotton or glass fabric and four moppings of bitumen.

Membrane Waterproofing

Type D which consists of one layer of bitumen-treated felt and two moppings of bitumen.

Waterproofing

Type E which consists of one asphaltic primer coat and one mopping of asphalt.

Waterproofing

Type F which consists of one asphaltic primer coat and a course of asphaltic mastic.

458.2. Materials:

(1) **Bitumen.** Bitumen shall consist of asphalt or coal-tar pitch. The mopped-on material shall be of the same type of bitumen as that with which the felt or fabric is treated.

Where deck waterproofing is carried over the parapet 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 bitumen as hereinafter described shall be used.

In cases where waterproofing is required by the plans as a protection for back of abutments, retaining walls or footings, "Below Ground" moppings of bitumen as hereinafter provided shall be used.

(2) **Asphalt for Saturant and Mopping Above Ground.** Asphalt for saturant and 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:

- (a) Softening point (ring and ball method)—145 to 170 F. (62.8 to 76.7 C.)
- (b) 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
 60 40
 at 32 F. (0 C.) 200 g., 60 sec.—not
 less than 10

- (c) Flash point (open cup—not less than 400 F. (204.4 C.)
- (d) Loss on heating at 325 F. (163 C.), 50 g., 5 hr.—not more than 0.5 percent.
- (e) 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.
- (f) Ductility: at 77 F. (25 C.) elongated at rate of 5 cm. per min. not less than 10 cm.
- (g) Solubility in carbon tetrachloride—min. 99 percent.

(3) **Asphalt for Mopping Below Ground.** Asphalt for mopping below ground shall be either (a) a native refined asphalt fluxed with a petroleum flux, this flux to have a penetration at 77 F. of not less than 350 under a weight of 50 grams for one second; or (b) 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:

	Fluxed Native Asphalt	Petroleum Asphalt
(a) Specific gravity at 60 F.	1.04 to 1.07	1.03 to 1.06
(b) Penetration at 77 F., 100 grams, 5 sec.	85 to 100	85 to 100
(c) Softening point (ring and ball method)	110 to 125 F.	110 to 125 F.
(d) Ductility of pure bitumen at 77 F. (25 C.) elongated at rate of 5 cm. per min.	Min. 100 cm.	Min. 100 cm.
(e) Flash point	350 to 450 F.	Min. 450 F.
(f) Loss on heating at 325 F. 50 gr., 5 hr.	Max. 2.0 %	Max. 1.0%
(g) Penetration at 77 F., 100 g., 5 sec. of residue after heating at 325 F. as compared		

- | | | | |
|-----|--|----------|-----------|
| | with penetration of asphalt before heating | Min. 60% | Min. 60% |
| (h) | Pure bitumen soluble in carbon tetrachloride | Min. 95% | Min. 99½% |
| (i) | Inorganic matter, insoluble | Min. 1½% | ..... |
| (j) | Paraffine scale (Holde method) | Max. ½" | ..... |

(4) **Coal-Tar Pitch for Saturant and Mopping.** Coal-tar pitch for saturant and mopping shall be homogeneous and free from water. It shall meet the following requirements:

	For use Above Ground	For use Below Ground
(a) Specific gravity at 77/77 F. (25/25 C.) ..	1.25 to 1.35	1.21 to 1.30
(b) Softening point (cube in water method) ...	130 to 155 F.	110 to 140 F.
(c) Distillation Test; Total distillate by weight 32 to 572 F. (0 to 300 C.)	Max. 10%	Max. 15%
Residue by weight ..	Min. 90%	Min. 85%
(d) Specific gravity, at 100/77 F. (38/25 C.) of total distillate to 572 F. (300 C.)	Min. 1.03	Min. 1.03
(e) Ductility at 77 F. (25 C.)	Min. 20 cm.	Min. 50 cm.
(f) Solubility in carbon tetrachloride	63% to 78%	75% to 90%

(5) **Asphaltic Primer.** Asphaltic primer shall be composed of asphalt that conforms to the foregoing requirements for asphalt for mopping below ground and a solvent. It shall meet the following requirements:

- | | | |
|-----|---|----------|
| (a) | Water | None |
| (b) | Asphaltic Base:
Percent asphalt is of primer by weight | 30 to 45 |

- (a) Thread count in either direction: Min. 26; Max. 32.
- (b) Average weight per square yard: Not less than 4 ounces including not to exceed 6 percent moisture regain.
- (c) Ash: Not more than one percent of dry weight of fabric.

(9) **Untreated Glass Fabric.** Untreated glass fabric shall contain no oil. It shall meet the following requirements:

- (a) Thread count in either direction: Min. 18; Max. 32.
- (b) Average weight per square yard: Min. 1.2 oz.
- (c) Ash: Not more than one percent of dry weight of fabric.

(10) **Treated Cotton Fabric.** Treated cotton fabric shall meet the following requirements:

- (a) Width of roll: Min. 30 in.; Max. 38 in.
- (b) Gross weight of roll: Min. 35 lbs.; Max. 80 lbs.
- (c) Average weight per square yard: Not less than 10 ounces.
- (d) Moisture content: Not more than four percent of net weight.
- (e) Tensile strength at 70 F. in either direction (grab method): Not less than 50 lbs. per linear inch.
- (f) 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.
- (g) Pliability at 32 F.: Shall not crack when bent over a 1/16 inch mandrel through an arc of 180° in one direction and then through 360° over the same mandrel in the opposite direction.
- (h) Average loss on heating asphalt treated fabric (exclusive of moisture): Not more than 4 percent.
- (i) Weight of saturant in square yard of treated fabric: Not less than one and three-fourths times the weight of a square yard of untreated moisture-free fabric.

(11) **Treated Glass Fabric.** Treated glass fabric shall meet the following requirements:

- (a) Width of roll: Min. 30 in.; Max. 38 in.
- (b) Gross weight of roll: Min. 7 lbs.
- (c) Average weight per square yard: Not less than 3.5 oz.
- (d) Moisture content: Not more than one percent of net weight.
- (e) Tensile strength at 70 F. in either direction (grab method): Not less than 50 lbs. per linear inch.
- (f) Elongation without fracture: Not less than 3 percent.
- (g) Pliability at 32 F.: Shall not crack when bent over a 1/16 inch mandrel through an arc of 180° in one direction and then through 360° over the same mandrel in the opposite direction.
- (h) Average loss on heating asphalt treated fabric exclusive of moisture): Not more than 4 percent.
- (i) Weight of saturant in square yard of treated fabric: Not less than one and three-fourths times the weight of a square yard of untreated moisture-free fabric.

There shall be sufficient space between the threads of the untreated cotton or glass fabric to allow the saturant to pass through. The surface of the saturated fabric shall be smooth and free from folds, knots and excess saturant.

(12) **Felt.** Felt shall be rag-felt saturated, but not coated, with either asphalt or refined coal-tar; or asbestos felt saturated, but not coated, with asphalt. Rag felt shall be produced by felting vegetable and animal fibers.

Saturation shall be accomplished by passing the dry felt in single thickness through the saturant at a temperature and speed that will not injure the felt, and then calendaring it between heated cylinders. It shall then be cooled and wound into rolls.

Rag felt shall meet the following requirements:

	Asphalt Saturated	Coal Tar Saturated
Desaturated		
(a) Average weight of moisture-free felt . . . per 100 sq. ft.	Min. 5.2 lb.	Min. 5.2 lb.
(b) Ash in moisture-free felt	Max. 10%	Max. 10%

Saturated

(a)	Width of roll	32 in. - 36 in. ± ¼ in.	32 in. - 36 in. ± ¼ in.
(b)	Gross weight of roll	40-80 lb.	40-80 lb.
(c)	Weight of material per 100 sq. ft. exclu- sive of wrapping and packing	14 lbs. ± 1 lb.	14 lbs. ± 1 lb.
(d)	Loss on heating at 221 F. (105 C.) for 5 hours	Max. 4%	. . . . .
(e)	Moisture		Max. 2½% of net weight
(f)	Distillate, percent by weight to 210 C. cal- culated on extracted saturant		Max. 2%
	Distillate, percent by weight to 235 C. cal- culated on extracted saturant		Max. 5%
(g)	Pliability at 77 F. (25 C.)	At least four strips out of five shall not crack when bent thru 180° over a 1/16 in. mandrel.	At least four strips out of five shall not crack when bent thru 180° over a 1/16 in. mandrel.
(h)	Saturant in mois- ture-free felt, by weight	Min. 140%	Min. 140%

Asbestos shall meet the following requirements:

Desaturated

- (a) Average thickness—Not less than 0.045 in.
- (b) The relative proportion of the organic and asbestos fibers based on a microscopic count:
Organic—Not more than 10%
Asbestos and hair—Not more than 90%
- (c) The felt shall contain cattle hair uniformly distributed. The amount of cattle hair shall be from

10 to 15 percent, by weight, of the asbestos fiber content.

Saturated

- (a) Width of roll—32 to 36 in. \pm $\frac{1}{4}$ in.
- (b) Gross weight of roll—48-80 lbs.
- (c) Weight of roll per 108 sq. ft., exclusive of wrapping and packing—30 lb. \pm 2.4 lb.
- (d) Loss on heating at 221 F. (105 C.) for 5 hrs.—Not more than 4%
- (e) Moisture content—Not more than $\frac{1}{2}$ % of net weight.
- (f) Weight of saturant, not less than 55% of the weight of moisture-free desaturated felt.
- (g) Mullen test to show a strength of 45 lb. minimum and 55 lb. maximum at 70 F. (21 C.).

The surface of the felt shall be uniformly smooth and upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock, i.e., stock that has not been beaten or shredded into fiber in the process of manufacture, and from particles of foreign substance, such as fragments of stone, metal, leather, rubber, straw, wood, etc.

Felt shall be saturated thoroughly and uniformly and shall show no unsaturated spots at any point upon cutting 2 in. strips at random across the entire sheet and splitting them open for their full length.

Finished fabric or felt shall be free from visible defects, such as holes, ragged or untrue edges, breaks, rents or cracks, and shall not be coated or covered with talc or other substance that will interfere with adhesion between the fabric or felt and the bitumen.

Saturated fabric shall be wound on mandrels not less than 2 in. in diameter and extending from 2 in. to 4 in. beyond the ends of the roll. Saturated felt need not be wound on cores.

Rolls of fabric or felt shall be wrapped securely or tied to prevent unrolling in transit. It shall be of such quality that it may be unrolled easily at atmospheric temperatures above 50 F. without injury from sticking.

Fabric, felt, asphalt and coal-tar pitch shall be delivered

on the work in the original packages bearing the manufacturer's brand or label. The kind of material and the purpose for which it is to be used shall be indicated on the label.

(13) **Insulating Paper.** Insulating paper shall be a water-proof paper 36 in. wide, weighing not less than 10 lb. per 100 sq. ft.

(14) **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 either a fluxed native asphalt or a straight steam-refined asphaltic petroleum residual that has not been oxidized or blown, the pure bitumen of which shall meet the following minimum requirements:

Penetration at 77 F., 100 grams, 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
Fluxed Native or Steam-refined Petroleum asphalt, not less than	38 percent
Short Fiber Asbestos, not less than	25 percent
Petroleum Solvent, not more than	25 percent

Plastic cement shall be of such consistency that it can be spread readily with a trowel without drawing or pulling, or can be extruded through a suitable nozzle under a pressure of 50 lb. or more per square inch.

When applied in a layer 1/16 to 1/8 in. 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 1/16 to 1/8 in. thick, applied to the material upon which it is to be used, shall not blister or sag more than 1/4 in. upon exposure at a temperature of 140 F. for five hours.

After drying for 72 hours, and exposure at a temperature of 140 F. for 5 hours, a patch of the cement 1/16 to 1/8 in. thick shall be plastic and adhere well to saturated fabric,

saturated felt, 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 1/16 to 1/8 in. thick shall not crack or break from the saturated fabric, saturated felt or metal, when bent over a mandrel 1 in. in diameter.

(15) **Asphaltic Mastic.** Asphaltic mastic shall be used in the form of premoulded blocks or shall be poured in place. Poured-in-place mastic shall be composed of (a) asphalt mixed with mineral aggregates, or (b) mastic cake mixed with asphalt and mineral aggregates.

(16) **Asphalt for Mastic.** Asphalt for mastic shall be homogeneous and free from water. It shall meet the following requirements:

Penetration at 77 F. (25 C.) 100 g., 5 sec. 25 to 30
Flash point (Open cup) . . . Not less than 347 F. (175 C.)
Loss on heating at 325 F. (163 C.)

50 g., 5 hr. Not more than 2 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 60 percent

Ductility at 77 F. (25 C.) Not less than 10 cm.

Proportion of bitumen soluble in
carbon tetrachloride Not less than 99 percent

Note—When less than 99 percent of asphalt is soluble in carbon tetrachloride, the percent of bitumen (solubility in carbon disulphide) shall be reported.

(17) **Coarse Mineral Aggregate.** Coarse mineral aggregate shall be well graded crushed stone or washed gravel that will pass a $\frac{3}{8}$ inch screen and be retained on a No. 10 screen. It shall be free from soft particles and organic matter.

(18) **Fine Mineral Aggregate.** Fine mineral aggregate shall be well graded washed sand or crushed stone that will pass a No. 10 screen. It shall be free from soft particles and organic matter.

(19) **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

(20) **Mastic Cake.** Mastic cake shall contain from 14 to 18 percent, by weight of matter soluble in pure benzol. The soluble matter shall be asphalt that will meet the requirements of "Asphalt for Mastic". The insoluble matter other than that inherently present in the asphalt used, shall be granular mineral matter that will meet the requirements of "Fine Mineral Aggregate" and "Mineral Filler".

(21) **Premoulded Asphalt Blocks.** Premoulded asphalt blocks shall meet the following requirements:

They shall be 4 in. wide, 8 in. long and $1\frac{1}{4}$ in. thick unless otherwise shown on the plans. Blocks with a deviation of $\frac{1}{4}$ in. in length or $\frac{1}{8}$ in. in width or thickness either way from these dimensions shall be rejected.

The blocks shall be formed in moulds, under a pressure of not less than 3,300 lb. per sq. in. of surface.

An absorption test shall be made on blocks dried for 24 hrs. at a temperature of 150 F. (65 C.) and then immersed in water seven days. The absorption of moisture under this test shall not exceed 1 percent of the weight of the block.

(22) **Asphalt Plank.** Asphalt plank shall be a mixture of asphalt, mineral matter and organic fiber, but not wood fiber. It shall be of the thickness shown on the plans, and shall weigh not less than 85 lbs. per cu. ft. The average of three tests shall show the following proportions by weight:

Asphalt (by Soxhlet extraction apparatus): Min. 40%;
Max. 48%; average 42.5%

Mineral Matter (Measured as ash): Between 35% and 45%.

Organic fiber, etc. (sum of asphalt and ash subtracted from 100): 8% to 22%.

The percent of ash shall not exceed the percentage of asphalt.

From each shipment two finished planks shall be selected at random, one for penetration and one for impact tests. One specimen shall be cut from each plank. If the specimens fail to meet the requirements of the respective tests, the shipment will be rejected.

(a) The specimen for the penetration test shall be 6 in. by 6 in. It shall be kept at a temperature of 140 F. for $1\frac{1}{2}$ hours immediately preceding the test. The test shall be made by placing the specimen under a freely moving

plunger 1 in. in diameter, actuating a micrometer gage. The end of the plunger that is in contact with the specimen shall be convex with a radius of curvature of 2 in. A weight of 56 lb. shall be placed on the plunger and readings on the gage shall be taken 15 sec. and 75 sec. after the weight has been applied. The difference between these readings shall be the penetration of the specimen. To meet the requirements of this test the penetration shall not exceed the following:

½" Plank	0.05"
¾" Plank	0.06"
1" Plank	0.07"
1¼" Plank	0.08"
1½" Plank	0.09"
2" Plank	0.10"

(b) The specimen for the impact test shall be 2 in. in diameter. It shall be kept at a temperature of 32 F. for 2 hours immediately preceding the test. The test shall be made by placing the specimen under a plunger 1 in. in diameter, which shall be seated exactly on center with the specimen. The end of the plunger that is in contact with the specimen shall be a plane surface perpendicular to the axis of the plunger. After the plunger is seated, a weight of 10 lbs. shall be dropped on it from a height of 15 in. To meet the requirements of this test, the specimen shall neither fracture nor crack.

The asphalt 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 be as follows:

Thickness	Width	Length
½"	12"	48"
¾"	12"	48"
1"	8"	72"
or 1"	10"	60"
1¼"	8"	72"
1½"	8"	72"
2"	8"	72"

The asphalt plank shall be so loaded for shipment as to avoid deformation by irregular supports. The load shall be blocked, if necessary, to prevent shifting while in transit.

(23) **Inspection and Tests.** Except as otherwise provided, materials shall be sampled and tested for the specified prop-

erties by the current methods recommended by the American Society for Testing Materials.

The acceptance of any materials by the Inspector shall not be a bar to their subsequent rejection if found defective. If the tests show that any material does not meet the specification requirements, the Contractor shall remove such material immediately from the work at his own expense.

All materials to be furnished by the Contractor shall be delivered on the work not less than three weeks before they are to be applied, in order that they may be tested and analyzed. No materials shall be used until they have been accepted by the Engineer.

458.3. Construction Methods. Membrane waterproofing shall not be applied in wet weather, or when the atmospheric temperature is below 50 F., without written permission of the Engineer. The waterproofing shall be free from punctures, pockets, or folds.

Surfaces 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 well cured before waterproofing is applied.

The waterproofing shall be turned without break into drainage castings. 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.

On surfaces that are vertical or nearly so, the strips of fabric or felt shall be laid vertical or with the slope; on other surfaces the strips shall be laid shingle fashion, beginning at the lowest part of the surface to be waterproofed. Sufficient fabric or felt shall be allowed for suitable lap or anchorage at the upper edge of the surface to be waterproofed.

Surfaces of concrete or steel coming in contact with asphalt waterproofing shall be given one coat of asphaltic primer before the first mopping of asphalt, or one coat of creosote primer before the first mopping of the coal-tar pitch, except where insulation is to be used at expansion joints. The primer shall be well worked in to give a uniform coating. The priming coat shall be applied approximately 24 hours before applying the waterproofing membrane and shall be dry before the first mopping is applied.

Surfaces to be waterproofed shall be mopped in sections. While the first mopping of bitumen is still hot, a strip of fabric or felt 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 fabric or felt. The amount of bitumen used for each mopping shall be not less than $4\frac{1}{2}$ gal. for each 100 sq. ft. of surface.

Asphalt shall not be heated above a temperature of 350 F., and coal-tar pitch not above 300 F. The bitumen shall be stirred frequently while being heated. Kettles shall be equipped with armored thermometers.

Two-ply work shall be started by mopping a section of the surface 2 in. wider than half the width of the fabric or felt. On this hot mopping a half-width of the fabric or felt shall be laid. The top surface of this fabric or felt and an adjacent section of the surface 2 in. wider than a half-width of the fabric or felt shall then be mopped. On this mopping shall be laid a full width of the fabric or felt, completely covering the first strip. Thereafter full widths of fabric or felt shall be laid in hot moppings and in such manner that each strip will lap the second preceding strip 2 in. Side laps shall be not less than 2 in. and end laps not less than 12 in.

The procedure for 3-ply work shall be the same as for 2-ply work, except that the first strip shall be a one-third width of the fabric or felt; the second strip a two-thirds width; and the third and succeeding strips, full widths.

The second full strip shall lap the first strip at least 2 in. Each succeeding strip shall lap the third preceding strip at least 2 in.

Membrane waterproofing consisting of more than three plies shall be built in shingle fashion similar to 3-ply work by addition of as many plies as required.

The work shall be so regulated that at the end of the day all fabric or felt that has been laid will have received the final coat of bitumen.

Patching shall not be done without permission from the Engineer. Where patching is permitted for defective waterproofing, it shall extend at least 12 in. beyond the outermost edge of the defective portion. The second and each succeeding ply of the patch shall extend at least 3 in. beyond the preceding ply.

At construction joints the primer shall be omitted for a

width of 18 in. of the surface and a strip of insulating paper laid thereon before waterproofing is applied.

Expansion joints shall be filled with plastic cement conforming to these specifications. Joints shall be dry and clean immediately before they are filled. They shall be over-filled slightly to allow for shrinkage in drying.

When a protective cover for the waterproofing is required by the plans, it shall be placed as soon as practicable after the membrane has been laid. Dirt and other foreign material shall be removed from the surface of the membrane immediately before the protective cover is placed. The method and thickness of protection shall be as shown on the plans and will generally consist of one of the following methods:

(1) A layer of poured-in-place asphalt mastic.

(2) A layer of asphalt blocks or a layer of asphalt plank, laid in an extra heavy mopping of asphalt with joints filled with hot asphalt.

(Note: A protective cover containing asphalt shall be placed on only a membrane in which the bitumen used is asphalt.)

Poured-in-place mastic shall be laid on one thickness of insulating paper placed on the membrane. It shall be made as follows:

The asphalt and mineral aggregates shall be mixed in the following proportions, varied within the specified limits, to give a mastic of the greatest density and stability:

Asphalt meeting the requirements of "Asphalt for Mastic"—9 to 12 percent

Coarse mineral aggregate..... 33 to 40 percent

Fine mineral aggregate..... 33 to 37 percent

Mineral filler 15 to 19 percent

Mastic cake, asphalt and mineral aggregates shall be mixed in approximately the following proportions, varied to give a mastic of the greatest density and stability:

Mastic cake 48 percent

Asphalt meeting requirements of "Asphalt for Mastic" 5 percent

Coarse mineral aggregate..... 28 percent

Fine mineral aggregate, and mineral filler... 19 percent

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The asphalt and mastic cake shall be heated together to a temperature not above 350 F. The aggregates shall be mixed and heated and then placed in the kettle of melted asphalt. The ingredients shall be well mixed with iron stirring rods until all pieces of the aggregate are covered with asphalt and the aggregates distributed uniformly throughout the mixture. During the mixing process care shall be taken to avoid burning the asphalt. After the mastic has been mixed, it shall be poured into place while hot. It shall be placed in layers not more than $\frac{3}{4}$ in. thick. The thickness shall be gaged by wooden strips held in position by suitable weights. The layers shall be brought to the required thickness with wooden spreaders and floats, and shall lap joints not less than 6 in. The top layer shall be finished to the required grade and to a smooth surface. As soon as the top layer of the mastic is finished, it shall be given a mopping of hot asphalt sanded to a walking surface while hot.

Premoulded block protection shall be laid over the entire membrane except around drainage castings and other places shown on the plans. In such places, poured-in-place mastic or concrete shall be used. The blocks shall be laid in hot asphalt and the joints filled immediately with hot asphalt.

Asphalt plank protection shall be laid in hot asphalt. The asphalt shall be applied not less than 50 lbs. to the square (100 sq. ft.) and the placing of the plank shall follow immediately. As successive planks are laid, the edges and ends of adjacent planks already laid shall be coated heavily with hot asphalt. The planks shall be laid tight against those previously laid so that the asphalt will completely fill the joints and be squeezed out the top. After all planks have been laid, any joints not completely filled shall be filled with hot asphalt.

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 "Membrane Waterproofing" or "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 and shall include the cost of furnishing and placing a protective course and/or base course for the "Membrane Waterproofing" when so shown on the plans.

ITEM 459

DAMPPROOFING

459.1. Description. This specification shall govern for the furnishing and placing of dampproofing for backs of retaining walls, wingwalls, stair walls, and surfaces of structures as indicated on the plans or as directed by the Engineer. Except at construction joints, dampproofing shall consist of one coat of asphaltic primer and two moppings of asphalt. At construction joints at the junction of footings with pier and abutment shafts, the primer and two moppings of asphalt shall be supplemented by two layers of treated cotton fabric 15" wide with a third mopping of asphalt placed over the outer layer of fabric.

459.2. Materials. The asphaltic primer shall conform to the requirements of Asphaltic Primer, asphalt for the moppings shall conform to the requirements for asphalt for Mopping Below Ground and the treated cotton fabric shall conform to the requirements for treated cotton fabric of the Item 458, "Waterproofing".

459.3. Construction. Dampproofing shall not be applied in wet weather or when the atmospheric temperature is below 50 F without written permission of the Engineer. Surfaces to be dampproofed shall be dry and clean. Concrete shall be well cured before dampproofing is applied. The use of hand bellows is recommended for removing dust and loose dirt from corners and joints and cleaning naphtha shall be used for removing grease by swabbing or brushing. A blow torch or gasoline fire shall not be used.

The asphalt shall be heated in kettles provided with thermometers and shall be stirred frequently to avoid local overheating. At no time shall the temperature of the asphalt exceed 350 F, nor shall it be below 250 F at the time the asphalt is being applied.

The coat of asphaltic primer shall be applied on the concrete surfaces to be dampproofed immediately before the first mopping of asphalt is applied. The primer shall be worked into the surface thoroughly until a uniform coating is obtained and shall be dry before the first mopping of asphalt is applied.

Surfaces to be dampproofed at construction joints 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 ap-

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plied that it will completely cover and seal the cotton fabric. End laps of the cotton fabric shall be not less than 12 inches.

The top moppings of asphalt on the concrete surfaces shall be thorough so that no gray spots will appear. Not less than 4½ gallons of asphalt shall be used in each mopping for each 100 square feet of surface covered.

459.4. Measurement. Measurement of dampproofing will be made by the square yard of surface dampproofed complete and accepted in place.

459.5. Payment. Payment for dampproofing will be made at the contract unit price bid per square yard for "Dampproofing" measured as prescribed above, which 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 and of the sizes and dimensions required on the plans, and installing such pipe where and as designated on the plans or by the Engineer and 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 furnished under this specification shall be of the riveted type, with lap joint construction, and shall be perforated when shown on the plans. Pipe shall be full circle or pipe arch type as shown on the plans.

460.2. Material and Manufacture.

(1) **Materials.** Corrugated metal pipe shall be fabricated from corrugated galvanized sheets which shall comply with the requirements of AASHO Designation: M 36, as to base metal, sampling, analysis of finished sheet, rivets, spelter coating, tests for spelter coating, accepted brands, certified analysis, guarantee, identification, corrugation, gage determination, and tolerances. Corrugated metal pipe under 24 inch diameter conforming to AASHO Designation: M 136 will be permitted.

In lieu of the requirements of AASHO Designation: M 36, 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: MIL-P-15145, or with an approved cold-galvanizing compound. The paint or galvanizing compound shall be furnished by the Contractor at his entire expense.

(2) **Fabrication.** Fabrication of corrugated metal pipe shall comply with the requirements of AASHO Designation: M 36, as to rivets, length of pipe, and finish, field joints, workmanship, visual inspection, mill and factory inspection.

(3) **Dimensions and Weights.** The length of sheets, width of laps, gages, and computed weights per linear foot of the finished pipes, shall be as specified in the following table. The nominal diameters given refer to net inside diameters. The average weight per linear foot of a finished pipe, exclusive of end finish, shall not underrun the computed weight specified by more than five per cent:

(a) In cases of the 42 and 48 inch sizes, two sheets may be used by allowing sufficient total sheet lengths to provide for an additional standard lap.

Nominal Diameter	Length of Sheet Before Forming	Minimum Width of Lap	Galvanized Sheet Gage Number	Computed Weight Per Linear Foot of Finished Pipe Exclusive of End Finish	Connecting Bands Galvanized Sheet Gage Number (or heavier)
Inches	Inches	Inches		Pounds	
8	28 1/2	1 1/2	16	7.3	16
10	35	1 1/2	16	9.0	16
12	41	1 1/2	16	10.5	16
15	50 1/2	1 1/2	16	12.9	16
18	60	1 1/2	16	15.3	16
21	69 1/2	1 1/2	16	17.7	16
24	80	1 1/2	16	20.4	16
30	98	2	14	30.9	16
36	117	2	14	37.1	16
42	137	3	12	59.5	14
48	156	3	12	68.0	14
54	1-80	3	12	77.8	14
	1-98				
60	2-98	3	10	108.9	12
66	1-98	3	10	120.6	12
	1-117				
72	2-117	3	10	130.4	12
78	1-117	3	8	172.8	12
	1-137				
84	2-137	3	8	185.2	12

(b) The gage of the sheets shall be increased over that shown above if required for pipes under high fills in accordance with the following table. Such increases shall be noted by designation on the plans.

Area (sq. ft.)	Diameter (inches)	Height of Cover Above Top of Culvert (feet)													
		1-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-60	61-70	71-80	81-100	
0.4	8	16	16	16	16	16	16	16	16	16	16	16			
0.5	10	16	16	16	16	16	16	16	16	16	16	16			
0.8	12	16	16	16	16	16	16	16	16	16	16	16			
1.2	15	16	16	16	16	16	16	16	16	16	16	16		12	12
1.8	18	16	16	16	16	16	16	16	16	16	16	16		12	12
2.4	21	16	16	16	16	16	16	16	16	16	16	16		12	10
3.1	24	16	16	16	16	16	16	16	16	16	16	16		12	10
4.9	30	14	14	14	14	14	14	14	14	14	14	14		10	8
7.1	36	14	14	12	12	12	12	12	12	12	12	12		8	8
9.6	42	12	12	12	10	8	8	8	8	8	8	8		8	8
12.6	48	12	12	12	10	8	8	8	8	8	8	8		8	8
15.9	54	12	12	10	8	8	8	8	8	8	8	8		8	8
19.6	60	10	10	8	8	8	8	8	8	8	8	8		8	8
23.8	66	10	10	8	8	8	8	8	8	8	8	8		8	8
28.3	72	10	10	8	8	8	8	8	8	8	8	8		8	8
33.2	78	8	8	8	8	8	8	8	8	8	8	8		8	8
38.5	84	8	8	8	8	8	8	8	8	8	8	8		8	8

*Use Elongated Corrugated Metal Pipe for tabular values below heavy line. Strutting of pipe will be in accordance with manufacturer's recommendation.

Corrugated Metal Pipe
Gage Table for H-20 Live Load

(4) **Pipe Arches.** Pipe arches shall conform to all the requirements of the equivalent size of the full circle, riveted type, pipe with lap joint construction. The lapped joints shall be staggered so as to alternate on each side of the center of the top of the pipe arch. The minimum radius of curvature of any part of the pipe arch section shall be 3 inches.

Pipe arches, their respective minimum gages and the equivalent sizes of full circle pipe are as follows:

Design Size	Area Square Feet	*Span Inches	*Rise Inches	Galvanized Sheet Gage Number	Equivalent Diameter Full Circle Pipe Inches
1	1.1	18	11	16	15
2	1.6	22	13	16	18
3	2.8	29	18	14	24
4	4.4	36	22	14	30
5	6.4	43	27	12	36
6	8.7	50	31	12	42
7	11.4	58	36	12	48
8	14.3	65	40	12	54
9	17.6	72	44	10	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 gage of the sheets shall be increased over that shown above if required for pipe arches under high fills or shallow cover in accordance with the following table. Such increase in gage shall be noted by designation on the plans.

Design Size	Minimum Gage				
	Height of Cover (Feet)				
	1	2-4	5-9	10-15	16-20
1	16	16	16	16	16
2	16	16	16	16	16
3	14	14	14	14	14
4	14	14	14	14	14
5	12	12	12	12	12
6	12	12	12	12	10
7	10	12	12	10	10
8	10	12	12	10	8
9	8	10	10	8	—

Corrugated Metal Pipe-Arches
Gage Table for H-20 Live Load

(5) Protective Coatings.

(a) **General.** Where conditions warrant, protective coatings shall be applied to corrugated galvanized metal pipe and pipe arches. The protective coatings shall be indicated

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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)

(b) **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 per cent soluble in carbon bisulphide. The pipe shall be uniformly coated inside and out to a minimum thickness of .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 following tests: Shock Test and Flow Test.

Testing shall be done in accordance with Test Method Tex-522-C.

(c) **Paved Invert.** Where a paved invert is specified, the pipe, 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 $\frac{1}{8}$ inch above the crests of the corrugations.

(d) **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 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.

460.3. 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 Item 400, "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 per cent 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. 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 eight inches. 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 provisions, such unstable soil shall be removed and replaced in accordance with the requirements of Item 400, "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. Unless otherwise specified, perforated pipe shall be laid with perforations in the bottom of the pipe.

Multiple installations of corrugated galvanized metal pipe and pipe arches 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 pipes shall be maintained:

Diameter of Pipe	Clear Distance Between Pipes		Pipe Arch Design No.
	Circular	Pipe Arch	
18"	0'-9"	1'-0"	2
24"	0'-11"	1'-0"	3
30"	1'-1"	1'-1"	4
36"	1'-3"	1'-3"	5
42"	1'-5"	1'-5"	6
48"	1'-7"	1'-7"	7
54"	1'-11"	1'-11"	8
60"	2'-0"	2'-0"	9
66"-84"	2'-0"		

(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) 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 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 aprons 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.

(6) **Backfilling.** Backfilling shall be in accordance with the provisions of Item 400, "Structural Excavation".

460.4. Measurement. Corrugated Galvanized Metal Pipe will be measured by the linear foot of complete and accepted pipe in place in accordance with these specifications. Such measurements 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 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, catch basins, manholes, junction chambers, 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 pipe and excavation for installing headwalls will be measured as prescribed in Item 400, "Structural Excavation".

460.5. 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 of the items of "Corrugated Galvanized Metal Pipe" or "Corrugated Galvanized Metal Pipe Arch", or with or without protective coating as indicated in the proposal which payment shall be compensation for furnishing and transporting the pipe; for all bituminous coating, asbestos bonding and invert paving; the 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 pipes; for all connections to existing structures; for moving and reusing headwalls, 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 Item 400, "Structural Excavation". Where pipes are laid on a skew, full compensation for cutting the ends parallel with the center line of the highway 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 461

STRUCTURAL PLATE PIPES, PIPE ARCHES,
AND ARCHES

461.1. Description. This item shall consist of furnishing structural plate pipes, pipe arches, and arches, conforming to these specifications and of the sizes and dimensions required on the plans and installing such structures at the places designated on the plans or by the Engineer in conformity with the lines and grades established by the Engineer. Structural plate pipes shall be furnished round or elongated, as indicated on the plans.

Plates for pipe-arch shall form a cross section made up of four circular arcs tangent to each other at their junctions and symmetrical about the vertical axis. The top shall be an arc of not more than 180 degrees nor less than 155 degrees. The bottom shall be an arc of not more than 50 degrees nor less than 10 degrees. The top shall be joined at each end to the bottom by an arc having a radius between 16 and 21 inches and not more than $87\frac{1}{2}$ degrees nor less than 75 degrees.

461.2. Materials and Manufacture.

(1) Structural plate pipes, pipe arches, and arches shall be fabricated from corrugated galvanized plates, the base metal of which shall be made by either the open hearth process or a process which produces genuine wrought iron. The base metal shall conform to one of the following requirements.

	Chemical Composition by ladle analysis (Position of base metals does not indicate preference).						Tolerance by check analysis of finished plates
	Kind of Base Metal						
	Pure Iron	Copper Bearing Pure Iron	Copper Iron	Copper Molybdenum Iron	Copper Steel	Genuine Wrought Iron	
Percent	Percent	Percent	Percent	Percent	Percent	Percent	
Carbon—Maximum	—	—	—	—	—	.05	.01
Manganese—Max.	—	—	—	—	—	.06	.01
Phosphorus—Max.	.015	.015	.015	.015	—	.12	—
Sulphur—Max.	.040	.040	.040	.040	.050	.04	.01
Silicon—Max.	—	—	—	—	—	.15	—
Copper—Minimum	—	.20	.20	.40	.20	—	.02
Molybdenum—Min.	—	—	—	.05	—	—	—
Sum of First Five Elements—Max.	—	.10	.25	.25	.70	.42	.04
Sum of First Six Elements—Max.	.10	—	—	—	—	—	.04

(2) **Spelter Coating.** The base metal plates shall be galvanized on both sides by the hot-dip process. A coating of prime western spelter or equal shall be applied at a rate of not less than 2.0 ounces per square foot of double-exposed surface. If the average spelter coating as determined from the required sample is less than 2.0 ounces, or if any one specimen shows less than 1.8 ounces, the lot sampled shall be rejected. The spelter coating shall be of first-class commercial quality, free from injurious defects such as blisters, flux, and uncoated spots.

(3) **Galvanizing.** The corrugated plates for pipes, pipe arches, and arches, may be fabricated from galvanized sheets or plates, and no further galvanizing will be required after fabrication if the spelter coating has not been injured in the fabrication process.

(4) **Accepted Brands of Metal.** No metal will be accepted under this specification and no bids will be considered for the material above described until after the plate manufacturer's certified analysis and manufacturer's guarantee has been passed upon by the Engineer and accepted. Misbranding or other misrepresentation and nonuniformity of product will each be considered sufficient reason to discontinue acceptance of any brand under this specification, and notice sent to the plate manufacturer of the discontinuance of acceptance of any brand will be considered to be notice to all companies which handle that particular brand. The kind of base metal which it is proposed to furnish shall be designated by the Bidder. One brand, and one brand only, shall be approved for any kind of base metal furnished by each of the actual manufacturers of the base metal.

(5) **Plate Manufacturer's Certified Analysis.** The manufacturer of the base metal shall file with the Engineer a certificate setting forth the name of brand of metal to be furnished and a typical analysis showing the percentage of carbon, manganese, phosphorus, sulphur, silicon and copper; also molybdenum, when provided for under the particular kind of base metal. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company.

(6) **Plate Manufacturer's Guarantee.** The manufacturer of the plates shall submit with the certified analysis a guarantee providing that all metal furnished shall conform to the certified analysis filed, shall bear a suitable identification brand or mark, and shall be replaced without cost to the

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purchaser when not in conformity with the specified analysis, gage, or spelter coating, the cost to be limited to the replacement of structural plate material only; and the guarantee shall be so worded as to remain in effect so long as the manufacturer continues to furnish material.

(7) **Identification.** No plates will be accepted unless the metal is identified by a stamp on each plate showing:

- First: Name of base metal manufacturer.
- Second: Name of brand and kind of base metal.
- Third: Gage number.
- Fourth: Weight of spelter coating.
- Fifth: Identification symbols showing heat number.

The identification brands shall be so placed that when the structure is erected, the identification will appear on the inside of the structure. Plates not so stamped shall be rejected promptly.

(8) **Corrugations.** Corrugations shall have a pitch of 6 inches with a tolerance of $\frac{1}{4}$ inch and a depth of 2 inches with a tolerance of $\frac{1}{8}$ inch. The radius on the inside of the corrugation shall be at least 1-1/16 inch.

(9) **Gage Determination and Tolerance.** The gage of the plates shall be based on the weight of the fabricated galvanized plates. The theoretical weight per sq. ft. of the flat galvanized sheet and tolerances shall be as follows:

Gauge	Theoretical Wt. after Galvanizing (lbs./sq. ft.)	Permissible variation ave. wt. of lots* (in percent)	
		Over	Under
1	11.406	5.5	3
3	10.156	5.5	3
5	8.906	5.5	5
7	7.656	5.5	5
8	7.031	5	5
10	5.781	5	5
12	4.531	5	5

*The term "lot" means all the plates of one gauge in the shipment for gauges 7 and heavier, and not less than 6,000 pounds constitutes a "lot" for gauges 8 and lighter. Individual plates shall not underrun the theoretical weights by more than 10 percent.

(10) **Bolts (for connecting plates).** Bolts for connecting plates shall be not less than $\frac{3}{4}$ inch in diameter and shall be hot-dip galvanized. The threads shall be American Standard Coarse Thread series, Class 2 free fit. Bolt and nut material shall conform to the requirements of the current edition of ASTM Designation: A 325.

The bolts may be sampled and tested before erection is commenced, or the bolts may be accepted on the manufacturer's certification.

(11) **Nuts and Bolt Heads.** Bolt heads and nuts shall be shaped to provide adequate bearing, or standard type bolts and nuts with special washers shall be used in lieu thereof.

(12) **Description of Plates.** Plates shall consist of structural units of galvanized corrugated metal. Single plates shall weigh not more than 750 pounds and 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.

(13) **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 $1\frac{3}{4}$ 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.

(14) **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 bruised or broken either in the shop or in shipping, or which shows defective workmanship, shall be rejected. The requirement applies not only to the individual plates but to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual culvert plate or in general in any shipment shall constitute sufficient cause for rejection:

1. Uneven laps
2. Elliptical shaping (unless specified)
3. Variation from a straight center line
4. Ragged edges
5. Loose, unevenly lined or spaced bolts
6. Illegible brand
7. Bruised, scaled or broken spelter coating
8. Dents or bends in the metal itself

(15) **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 meet these requirements, the entire shipment may be rejected.

(16) **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.

(17) **Sampling.** For testing the weight of spelter coating and for chemical analysis, when required, a sample shall be provided for each 100 plates of a shipment or fraction thereof. For testing material galvanized before fabrication, a cou-

pon approximately 3 inches square shall be cut from the corner of a plate. For testing material galvanized after fabrication, a coupon approximately 6 inches square of the same gage and base metal as the material sampled shall be attached to the center of one edge prior to galvanizing. If the result of a weight of coating test for any coupon does not conform to the requirements specified, retests of two additional samples cut from the product plates for the order shall be made, each of which shall conform to the requirements specified.

(18) **Analysis of Finished Plate.** When required, the chemical analysis of base metal shall be made in accordance with ASTM Designation: E 30.

(19) **Test for Spelter Coating.** The test for weight of spelter coating shall be made in accordance with ASTM Designation: A 90.

461.3. Design.

(1) **General.** (a) **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 inch hooked bolts at not over 24 inch centers.

(b) **Multiple Structures Installed in Parallel Lines.** Where multiple lines of structures are installed, the adjacent sides shall be one-half diameter apart to permit careful tamping of the filling material, except that the clear distance between adjacent sides need not be more than four feet.

(2) Structural Plate Pipes and Pipe Arches.

(a) **Gage for Structural Plate Pipes (Round).** The minimum gage for side and top plates shall be in accordance with Table A.

(b) **Gage for Structural Plate Pipes (Elongated).** The

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minimum gage for side and top plates shall be in accordance with Table B.

(c) **Gage for Structural Plate Pipe Arches.** The minimum gage for side and top plates shall be in accordance with Table D.

(d) **Intermediate Gage Determination.** For sizes of pipe, and pipe arches between those in the tables, the gage shall be determined by interpolation.

(3) Structural Plate Arches.

(a) **Gage for Structural Plate Arches.** The minimum gage for plates in structural plate arches shall be in accordance with Table E.

(b) **Ratio: Rise to Span.** The designs of arches given in Table E are based on ratios of rise to span varying from 0.2 to 0.5 inclusive. In cases where the ratio is less than 0.3, in combination with a height of cover of 3 feet or less, the gage of the plates shall be the next heavier than required by the table and those for which number one gage is specified shall not be used.

(c) **Anchors.** Each side of each arch shall be anchored to the foundation by either a galvanized angle or channel securely anchored or embedded in the substructure. The angle or channel shall be not less than three-sixteenths of an inch in thickness with the horizontal leg securely anchored to the substructure on a maximum of 24 inch centers. When the metal bearing is not embedded in a groove in the substructure, one vertical leg shall be punched to allow bolting to the bottom row of plates.

(d) **Substructure Design.** The substructure for structural plate arches shall be designed in accordance with the requirements of the current AASHO Specifications for the design of bridge substructures.

461.4. Construction Methods. Structural plate pipe, pipe arches and arches 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 Item 400, "Structural Excavation". When pipes or pipe arches are laid in a trench, the trench when completed 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 pipe or pipe arch. 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) **Foundation: Structural Plate Pipes and Pipe Arches.** The pipe or pipe arch shall be bedded in an earth foundation of uniform density. Where rock in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with selected materials in such a manner as to provide a compacted earth cushion having a thickness under the structure of not less than 8 inches. Where a firm foundation is not encountered at the established grade due to soft, spongy, or other unstable soil, special construction methods as ordered by the Engineer shall be used to provide adequate support for the structure.

(3) **Foundation: 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 Item 420, "Concrete Structures", Item 421, "Concrete for Structures", and Item 440, "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 ends are skewed and hook bolts are required, three-fourths of an inch hook bolts on not more than 24 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 minimum of three days. Wherever practicable, plates shall be assembled in accordance with manufacturer's recommendation.

Where circular structural plate pipe is used and strutting is specified, the pipe shall be strutted so that the vertical diameter is 3 percent greater than the nominal diameter. Table C shows the required sizes, lengths and spacing of struts. The pipe shall be deformed the required amount by means of suitable jacks. The method of jacking shall be subject to the approval of the Engineer. A tolerance of 25 per-

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cent above or below the specified amount will be allowed. Where pre-ellipsed pipe is furnished, strutting will not be required.

Strutting shall be carried uniformly from end to end of pipes where headwalls are not used. Where headwalls are used on circular pipe, the amount of jacking and the length of struts may be reduced gradually under the side slopes of the embankment so that the ends of the pipe at the headwalls are circular. The struts shall be left in place until the embankment is complete and compacted, unless otherwise directed by the Engineer.

(5) **Backfilling and Filling.** Backfilling and filling shall be performed in accordance with the requirements for backfill of the pertinent specifications for structural excavation as contained in the contract and the additional requirements herein specified. After all plates for the completed structure have been installed 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 structure 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 $\frac{3}{4}$ point of the structure, the fill shall be placed uniformly on each side of the pipe in layers not to exceed 12 inches. No construction traffic will be permitted to cross any structure until the specified minimum depth of cover has been obtained.

In the case of 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 above specified 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.

(6) **Minimum Fill.** Structural plate pipes, pipe arches, and arches shall be placed so that the minimum distance from the finished surface of the road bed to top of structure shall be as shown on Table F.

461.5. Measurement. Structural plate pipe, pipe arch and arch will be measured by the linear foot of each separate structure across the roadbed, or if a series of structures, by the sum of the linear feet of each structure, across the roadbed, in place, in accordance with these specifications, complete and accepted. Such measurement shall be made as follows:

Structural Plate Pipe	The average to 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.

Excavation for installing structural plate pipes, pipe arches, or arches, concrete foundation for structural plate arches and headwalls will be measured as prescribed in Item 400, "Structural Excavation".

Concrete and reinforcing steel in headwalls and footings will be measured as prescribed in Item 421, "Concrete for Structures", and Item 440, "Reinforcing Steel".

461.6. Payment. Payment for structural plate pipes, pipe arches and arches measured as prescribed above, will be made at the contract unit price bid for the various sizes of the items of "Structural Plate Pipe", "Structural Plate Pipe Arch", and "Structural Plate Arch", which payment shall be full compensation for furnishing, transporting, and erecting, for handling and placing of select fill material; for all bolts, nuts, washers, hook 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.

Diameter Inches	Height of Cover—Feet															
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-70	71-80	81-90	91-100
60	12	12	12	12	12	10	10	10	10	10	8	8	8	7	7	5
66	12	12	12	12	10	10	10	8	8	8	8	8	8	7	7	5
72	12	12	12	10	10	10	10	8	8	8	7	7	7	5	5	3
78	12	12	12	10	10	10	8	8	8	7	7	5	5	3	3	1
84	10	12	10	10	10	8	8	8	8	7	7	5	5	3	3	1
90	10	12	10	10	8	8	8	7	7	7	5	5	3	3	1	-
96	10	12	10	10	8	8	8	7	7	5	5	5	3	3	1	-
102	10	10	10	8	8	8	7	7	5	5	5	5	3	3	1	-
108	10	10	10	8	8	7	7	5	5	5	3	3	3	1	1	-
114	10	10	10	8	8	7	5	5	5	3	3	3	1	1	1	-
120	8	10	8	8	7	5	5	5	3	3	3	1	1	1	-	-
126	8	10	8	8	7	5	5	5	3	3	3	1	1	1	1	-
132	8	10	8	7	5	5	5	3	3	3	1	1	1	1	1	-
138	8	10	8	7	5	5	5	3	3	3	1	1	1	1	1	-
144	8	8	8	7	5	5	3	3	3	1	1	1	1	1	1	-
150	7	8	7	5	5	3	3	3	1	1	1	1	1	1	1	-
156	7	8	7	5	5	3	3	3	1	1	1	1	1	1	1	-
162	7	8	7	5	3	3	3	1	1	1	1	1	1	1	1	-
168	5	8	5	5	3	1	1	1	1	1	1	1	1	1	1	-
174	5	7	5	3	3	1	1	1	1	1	1	1	1	1	1	-
180	5	7	5	3	3	1	1	1	1	1	1	1	1	1	1	-

Gages for finished construction; during construction adequate cover must be provided to protect the structure from damage.
 For minimum height of cover see table "Minimum Height of Cover".
 Plates are standard with four bolts per foot in each longitudinal seam.

TABLE "A"
 STRUCTURAL PLATE PIPE (ROUND) — GAGE TABLE FOR H-20 LOADING

Diameter Inches	Height of Cover—Feet												Height of Cover Limit Feet 1 Gage —6 Bolts				
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60		61-70	71-80	81-90	91-100
60	12	12	12	12	12	12	12	12	12	12	10	10	8	7	5	5	200
66	12	12	12	12	12	12	12	12	12	12	10	8	8	7	5	3	180
72	12	12	12	12	12	12	12	12	10	10	8	8	7	5	3	1	165
78	12	12	12	12	12	12	12	10	10	8	8	8	5	3	1		150
84	12	12	12	12	12	12	10	10	8	8	8	7	5	3	1		140
90	12	12	12	12	12	12	10	8	8	8	7	5	3	1	-		130
96	12	12	12	12	12	10	10	8	8	7	7	5	3	1	-		125
102	12	12	12	12	10	10	10	8	8	7	5	5	3	1	-		115
108	12	12	12	10	10	10	10	8	7	5	5	3	3	1	-		110
114	10	12	10	10	10	10	8	8	7	5	5	3	3	1	-		105
120	10	12	10	10	10	10	8	7	5	5	3	3	1	-			100
126	10	12	10	10	10	10	8	7	5	3	3	1	-				95
132	10	10	10	10	10	8	8	7	5	3	3	1	1	-			90
138	10	10	10	10	10	8	8	7	5	3	3	1	1	-			85
144	10	10	10	10	8	8	8	7	5	3	3	1	1	-			80
150	10	10	10	8	8	8	8	7	5	3	1	1	-				80
156	10	10	10	8	8	8	8	5	3	1	1	1	-				75
162	10	10	10	8	8	7	5	3	3	1	-	-					70
168	10	10	10	8	8	7	7	5	3	1							70
174	8	10	8	8	8	7	5	3	3	1							65
180	8	10	8	8	8	5	3	1	-	-							65

For structures in this zone use
1 gage with six bolts per foot of
longitudinal seams with height of
cover limits as shown in column
at right.

For minimum height of cover see table "Minimum Height of Cover".
Plates are standard with four bolts per foot in each longitudinal seam.

Bolts are $\frac{3}{4}$ inch diameter, high strength to meet ASTM A 325 and galvanized to meet ASTM A 153.
The last column shows the greatest height of cover that can be placed on pipes specially fabricated to have six bolts per foot in each longitudinal seam in 1 gage metal.

TABLE "B"
STRUCTURAL PLATE PIPE—GAGE TABLE FOR H-20 LOADING
FLONGATED (5% if pre-ellipsed—3% if field struttet)

Height of Cover in Feet	Least End Dimension of Sill, * Cap, * and Strut *	Diameter of Pipe in Inches										
		60	72	84	96	108	120	132	144	156	168	180
		Length of Struts in Inches †										
5	49 3/4	62 1/8	74 1/2	86 7/8	99 1/4	111 1/2	124	136 1/4	148 3/4	161	167 1/2	
	43 3/4	56 1/8	68 1/2	80 7/8	93 1/4	105 1/2	118	130 1/4	142 3/4	155	161 1/2	
		50 1/8	62 1/2	74 7/8	87 1/4	99 1/2	112	124 1/4	136 3/4	149		
10	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x6	
	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	
	4x4	4x4	4x4	4x4	4x6	4x6	4x6	4x6	4x6	4x6	6x6	
	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	
15	4x4	4x4	4x4	4x4	4x4	4x6	4x6	4x6	4x6	4x6	4x6	
	6.0	6.0	5.5	4.5	3.5	4.5	4.0	3.5	3.0	4.5	4.0	
	4x4	4x4	4x6	4x6	4x6	6x6	6x6	6x6	6x6	6x6	6x8	
	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	
20	4x4	4x4	4x4	4x4	4x6	4x6	4x6	4x6	4x6	4x6	4x6	
	6.0	5.5	4.5	3.5	4.5	6.0	3.5	3.5	4.0	4.5	4.5	
	4x6	6.0	4x6	4x6	4x6	6x6	6x6	6x6	6x6	6x8	6x8	
	6.0	6.0	6.0	5.5	6.0	6.0	6.0	6.0	6.0	5.5	5.0	

30	4x4	4.5	4x4	3.5	4x4	3.0	4x6	4.0	4x6	3.0	6x6	4.5	6x6	4.0	6x8	4.0	6x8	3.5
	4x6	6.0	4x6	5.5	4x6	4.5	6x6	6.0	6x6	5.0	6x8	6.0	6x8	5.5	8x8	5.0	8x8	5.0
40	4x4	3.5	4x6	4.0	4x6	4.5	6x6	4.5	6x6	4.0	6x6	3.5	6x8	3.0	6x8	3.0	6x8	3.0
	4x6	5.0	6x6	6.0	6x6	6.0	6x8	6.0	6x6	5.5	6x8	4.5	6x8	4.0	8x8	4.5	8x8	4.0
50	4x4	3.0	4x6	3.5	6x6	4.0	6x6	3.5	6x6	3.0	6x8	4.0	6x8	3.0	8x8	3.5	8x8	3.0
	4x6	4.0	6x6	5.0	6x8	5.5	6x8	5.0	6x8	4.5	8x8	5.5	8x8	4.5	8x8	4.5	8x8	3.0
60	4x6	3.5	6x6	4.0	6x6	3.5	6x8	4.5	6x8	4.0	6x8	3.0	8x8	3.0	8x8	3.5	8x8	3.0
	6x6	5.5	6x8	5.5	6x8	4.5	8x8	5.5	8x8	5.0	8x8	4.5	8x8	4.0	8x8	3.0	8x8	3.0
70	6x6	4.5	6x6	3.5	6x8	4.0	6x8	3.5	6x8	3.0	8x8	4.0	8x8	3.0	8x8	3.0	8x8	3.0
	6x8	6.0	6x8	5.0	8x8	5.5	8x8	5.0	8x8	4.5	8x8	4.5	8x8	3.5	8x8	3.0	8x8	3.0
80	6x6	4.0	6x8	4.0	6x8	3.5	6x8	3.0	8x8	4.0	8x8	3.5	8x8	3.0	8x8	3.0	8x8	3.0
	6x8	5.0	8x8	5.5	8x8	5.0	8x8	4.5	8x8	4.5	8x8	3.5	8x8	3.0	8x8	3.0	8x8	3.0
100	6x6	3.0	6x8	3.5	8x8	4.0	8x8	3.5	8x8	3.0	8x8	3.5	8x8	3.0	8x8	3.0	8x8	3.0
	6x8	4.0	8x8	4.5	8x8	4.5	8x8	4.5	8x8	3.0	8x8	3.5	8x8	3.0	8x8	3.0	8x8	3.0

*Transverse cap and sill should be placed with least dimension vertical.

†Length of struts based on 3% elongation or $L = D + 3\%$ — 3 times the least dimension of the strutting material.

All timber dimensions are assumed as exact rather than nominal.

TABLE "C"

LENGTH AND SPACING OF STRUTS FOR STRUCTURAL PLATE PIPE

Span	Height of Cover—Feet														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5'-0"	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
5'-6"	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
6'-0"	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
6'-6"	12	12	12	12	12	12	12	12	12	12	12	12	12	12	10
7'-0"	10	12	12	12	12	12	12	12	12	12	12	12	12	10	10
7'-6"	10	10	12	12	12	12	12	12	12	12	12	12	10	10	10
8'-0"	10	10	10	12	12	12	12	12	12	12	12	10	10	10	10
8'-6"	10	10	10	10	10	10	10	10	10	10	10	10	10	10	8
9'-0"	10	10	10	10	10	10	10	10	10	10	10	10	10	8	8
9'-6"	8	10	10	10	10	10	10	10	10	10	10	10	8	8	8
10'-0"	8	8	10	10	10	10	10	10	10	10	10	8	8	8	7
10'-6"	8	8	8	10	10	10	10	10	10	10	10	8	8	8	7
11'-0"	8	8	8	10	10	10	10	10	10	8	8	8	7	7	5
11'-6"	7	8	8	8	10	10	10	10	8	8	8	8	7	7	5
12'-0"	7	8	8	8	8	8	8	8	8	8	8	7	5	5	3
12'-6"	7	7	8	8	8	8	8	8	8	8	7	7	5	5	3
13'-0"	5	7	8	8	8	8	8	8	8	7	7	5	5	3	1
13'-6"	5	5	7	8	8	8	8	8	8	7	5	5	5	3	1
14'-0"	5	5	7	7	8	8	8	7	7	5	5	3	3	1	1
14'-6"	3	5	5	7	7	7	7	7	5	5	3	3	3	1	1
15'-0"	3	5	5	7	7	7	7	7	5	3	3	1	1	-	-
15'-6"	3	3	5	5	7	7	7	7	5	3	3	1	1	-	-
16'-0"	1	3	5	5	7	7	7	5	3	3	1	1	-	-	-
16'-6"	1	3	3	5	5	5	5	3	3	1	1	-	-	-	-

For minimum height of cover see table, "Minimum Height of Cover".

Plates are standard with four bolts per foot in each longitudinal seam. Bolts are $\frac{3}{4}$ inch diameter, high strength to meet ASTM A 325 and galvanized to meet ASTM A 153.

PIPE-ARCHES are available in a range of spans, rises and areas; tabular values are for gage determination.

TABLE "D"
STRUCTURAL PLATE PIPE-ARCHES
GAGE TABLE FOR H-20 LOADING

Span Feet	H-15 Loading										H-20 Loading									
	Height of Cover in Feet										Height of Cover in Feet									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
4-10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
11	12	12	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10	10	10
12	12	12	12	12	12	12	12	12	12	12	10	10	10	10	10	10	10	10	10	10
13	10	10	12	12	12	12	10	10	10	10	8	8	10	12	12	12	10	10	10	8
14	10	10	12	12	12	12	10	8	8	8	7	8	8	10	10	10	8	8	8	7
15	8	10	10	12	12	12	10	8	7	7	5	7	8	10	10	10	10	8	8	7
16	8	8	8	10	10	10	10	8	7	7	5	5	7	8	8	10	8	7	5	5
17	7	8	8	10	10	10	8	7	5	5	3	3	5	7	8	8	7	5	3	3
18	7	7	7	8	8	8	7	5	3	3	3	3	5	7	7	8	7	5	3	3
19	5	5	5	7	8	8	7	5	3	3	1*	1*	1*	3	5	7	5	3	3	1
20	3	5	5	7	8	8	5	3	3	1	-	-	-	1*	3	5	5	3	1	-
21	3	3	5	5	7	7	5	3	3	-	-	-	-	1*	3	5	5	3	-	-
22	1*	3	3	5	5	5	3	3	1	-	-	-	-	1	3	3	3	1	-	-
23	1*	1*	3	3	3	3	1	-	-	-	-	-	-	-	1	3	1	-	-	-
24	-	1*	1	1	1	1	1	-	-	-	-	-	-	-	1	1	1	-	-	-
25	-	-	-	1	3	3	3	-	-	-	-	-	-	-	-	1	-	-	-	-
26	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-
27	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-
28	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

For minimum height of cover see table "Minimum Height of Cover"
 Plates are standard with four bolts per foot in each longitudinal seam. Bolts are 3/4 inch diameter high strength to meet ASTM A 325 and galvanized to meet ASTM A 153.
 Range of rise to span is from .2 to .5.
 *Use only when R/S is .3 or more.
 Arches are available in a range of sizes; tabular values are for gage determination.

TABLE "E"
 STRUCTURAL PLATE ARCHES — GAGE TABLES

Load	Surface	Base of Measurement	Round Pipe		Pipe Arches	Arches
			To 120"	Over 120"		
Highway H-15 and H-20	Unpaved and Flexible Pavements	Top of Surface	D/5 12" Minimum	24" Minimum	S/10 12" Minimum	S/15 12" Minimum
	Rigid Pavements	Top of Slab	D/7	18" Minimum	S/14	S/20
Minimum of 6" cushion below slab.						

*Covers shown are for finished construction. During construction adequate cover must be provided to protect the structure from damage.

D = Diameter of Pipe.

S = Span of Pipe Arch or Arch.

TABLE "F"
MINIMUM HEIGHT OF COVER*
FOR
STRUCTURAL PLATE STRUCTURES

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.

464.2. Materials.

(1) **General.** Except as modified herein, materials, manufacture and design of pipe shall conform to ASTM Designation: C 76, Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe. Unless otherwise specifically permitted in writing by the Engineer, all pipe shall be machine-made 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.

(2) **Design.** The pipe shall be of two classes designated as Class III and Class IV. The class to be furnished shall

be as shown 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 herein.

(3) **Physical Test Requirements.** The acceptability of the pipe shall be determined by the results of the three-edge-bearing or sand-bearing tests for the load to produce the 0.01-inch crack and the ultimate load; by such material tests as are required in Sections 5, 6, and 7 of ASTM Designation: C 76; 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 the 0.01-inch crack only shall be performed on 0.8 percent of the pipe joints. Three-edge-bearing tests for both the 0.01-inch crack and the ultimate load shall be performed on 0.2 percent of the pipe joints. Pipe which have been tested only to the formation of a 0.01-inch crack and meet the requirements for this test will be accepted for use. Tested pipe accepted for use shall be marked "TEST" or otherwise appropriately identified so that such may be used at the end of the structure or other location not subject to impact loads. The methods of testing shall conform to ASTM Designation: C 76.

As an alternate to the three-edge-bearing or sand-edge-bearing or sand-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 Section 5, 6, and 7 of ASTM Designation: C 76; 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 core-holes 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. Pipe sections, so sealed, will be accepted for use.

DESIGN REQUIREMENTS FOR CLASS III REINFORCED CONCRETE PIPE.*

NOTE.—The strength test requirements in pounds per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack.....	1350
D-load to produce the ultimate load.....	2000

Test loads for sand-bearing tests shall be one and one-half times those specified for the three-edge-bearing test.

The minimum compressive strength of the concrete at the time of acceptance shall be as shown in this table.

Minimum Reinforcement, sq. in. per linear foot of pipe barrel								
Internal Diameter of Pipe, in.	Wall A				Wall B			
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi			
	Minimum Wall Thickness, in.	Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Minimum Wall Thickness, in.	Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
		Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.08	....	....	2	0.07	....	....
15	1 7/8	0.09	....	....	2 1/4	0.08	....	....
18	2	0.11	....	0.09	2 1/2	0.09	....	0.07
21	2 1/4	0.14	....	0.11	2 3/4	0.12	....	0.09
24	2 1/2	0.17	....	0.14	3	0.14	....	0.12
27	2 5/8	0.18	....	0.16	3 1/4	0.16	....	0.14
30	2 3/4	0.19	....	0.18	3 1/2	0.18	....	0.15
33	2 7/8	0.21	....	0.20	3 3/4	0.15	0.11	0.17
36	3	0.21	0.16	0.23	4	0.17	0.13	0.19
42	3 1/2	0.25	0.19	0.28	4 1/2	0.21	0.16	0.23
48	4	0.32	0.24	0.35	5	0.24	0.18	0.27
54	4 1/2	0.38	0.28	0.42	5 1/2	0.29	0.22	0.32
60	5	0.44	0.33	0.49	6	0.34	0.26	0.38
66	5 1/2	0.50	0.37	0.55	6 1/2	0.41	0.31	0.46
72	6	0.57	0.43	0.63	7	0.49	0.37	0.54
	Concrete Strength, 5000 psi							
78	6 1/2	0.64	0.48	0.71	7 1/2	0.57	0.43	0.63
84	7	0.72	0.54	0.80	8	0.64	0.48	0.71
	Concrete Strength, 5000 psi							
90	7 1/2	0.81	0.61	0.90	8 1/2	0.69	0.52	0.77
96	8	0.93	0.70	1.03	9	0.76	0.57	0.84

*Steel Areas may be interpolated between those shown for variations in diameter.

Elliptical steel in circular pipe over 60 in. in diameter or circular steel in elliptical pipe over 60 in. in diameter must be held in place by means of holding rods or chairs or other positive means throughout the entire length of the pipe and throughout the entire casting operation and remain in place until the concrete has taken its initial set.

DESIGN REQUIREMENTS FOR CLASS IV REINFORCED CONCRETE PIPE.*

NOTE.—The strength test requirements in pounds per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce 0.01-in. crack.....	2000
D-load to produce the ultimate load.....	3000

Test loads for sand-bearing tests shall be one and one-half times those specified for the three-edge-bearing test.

The minimum compressive strength of the concrete at the time of acceptance shall be as shown in this table.

Minimum Reinforcement, sq. in. per linear foot of pipe barrel								
Internal Diameter of Pipe, in.	Wall A				Wall B			
	Concrete Strength, 5000 psi				Concrete Strength, 4000 psi			
	Minimum Wall Thickness, in.	Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Minimum Wall Thickness, in.	Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
		Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.15	....	....	2	0.09	....	....
15	1 7/8	0.16	....	....	2 1/4	0.12	....	....
18	2	0.17	....	0.15	2 1/2	0.15	....	0.12
21	2 1/4	0.23	....	0.21	2 3/4	0.20	....	0.17
24	2 1/2	0.29	....	0.27	3	0.27	....	0.23
27	2 5/8	0.33	....	0.31	3 1/4	0.31	....	0.25
30	2 3/4	0.38	....	0.35	3 1/2	0.35	....	0.28
33	....	....	....	....	3 3/4	0.27	0.20	0.30
36	....	....	....	....	4	0.30	0.22	0.33
42	....	....	....	....	4 1/2	0.35	0.26	0.39
48	....	....	....	....	5	0.42	0.32	0.47
54	....	....	....	....	5 1/2	0.50	0.37	0.55
Concrete Strength, 5000 psi								
60	....	....	....	....	6	0.59	0.45	0.66
66	....	....	....	....	6 1/2	0.69	0.52	0.77
72	....	....	....	....	7	0.79	0.60	0.88

*Steel Areas may be interpolated between those shown for variations in diameter.

The elliptical steel in circular pipe over 42 in. in diameter or the circular steel in elliptical pipe over 42 in. in diameter must be held in place by means of holding rods or chairs or other positive means throughout the entire length of the pipe and throughout the entire casting operation and remain in place until the concrete has taken its initial set.

(4) Sizes and Permissible Variations.

(a) Pipe of the internal diameters listed for Classes III and IV shall be the standard sizes for culvert, storm drain, and sewer pipe construction. In elliptical pipe the inside diameter of the minor axis of the pipe shall be equal to the diameter of the corresponding size of circular pipe. The internal diameter of 12 inch to 24 inch pipe shall not vary more than ± 1.5 percent from the nominal diameter. The internal diameter of 27 inch to 84 inch pipe shall not vary more than ± 1 percent from the nominal diameter. The wall thickness shall not be less than that shown in the design by more than 5 percent or $3/16$ inch, whichever is the greater. A wall thickness in excess of that required by the design shall not be cause for rejection. Wall thicknesses required by the design are those shown in tables herein for the appropriate size and class of pipe.

(b) Variations in laying lengths of two opposite sides of pipe shall not be more than $1/8$ inch per foot of diameter with a maximum of $5/8$ inch in any length of pipe, except where beveled or skewed ends are required. The underrun in length of a section of pipe shall not be more than $1/8$ inch per foot of diameter with a maximum of $1/2$ inch in any length of pipe.

(c) Where rubber gasket pipe joints are required by the plans, the pipe ends shall be smooth and concentric. The annular space must be constant. For 24 inch diameter pipe and larger the annular space shall be $3/16$ inch to $1/4$ inch. For 21 inch diameter and smaller the annular space shall be $1/8$ inch to $5/32$ inch.

(d) Variations in the amount and positioning of reinforcing steel shall not exceed the allowance made in ASTM Designation: C 76.

(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 Section 464.2 (4)(b) above.

(6) Curing. Pipe shall be cured by one of the following methods at the option of the manufacturer.

(a) Pipe may be placed in a curing chamber, free from outside drafts and cured in a moist atmosphere, maintained at a temperature between 100 and 140 F by the injection of steam for a period of not less than 24 hours or

for such additional time as may be needed to enable the pipe to meet the strength requirements. The curing chamber shall be so constructed as to allow full circulation of steam around the entire pipe.

(b) Concrete pipe may be cured by covering with water saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose, or by any other approved method that will keep the pipe moist for a period of not less than 72 hours or for such additional time as may be needed to enable the pipe to meet the strength requirements.

(c) Concrete pipe may be cured by a combination of methods specified above in which case the minimum curing time shall be the equivalent of 72 hours of water curing computed on the basis that one hour of steam curing is equal to three hours of water curing.

(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. Markings 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 such conform 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 these specifications.

(a) **Rejections.** All rejected pipe shall be plainly marked by the Engineer and shall be replaced by the Contractor with pipe which meet the requirements of these specifications. Such rejected pipe shall be removed immediately from the site of work.

(12) **Jointing Materials.** Unless otherwise specified on the plans or in the special provisions, pipe joints shall be made with Portland cement mortar. Where required by the plans, joints for reinforced concrete pipe siphons shall be made using rubber gaskets.

(a) Mortar for joints shall be in accordance with Item 421, "Concrete for Structures".

(b) Rubber gaskets shall be as shown on the plans.

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 Item 400, "Structural Excavation", except where tunneling or jacking methods are shown on the plans or permitted by the Engineer. When pipe 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.

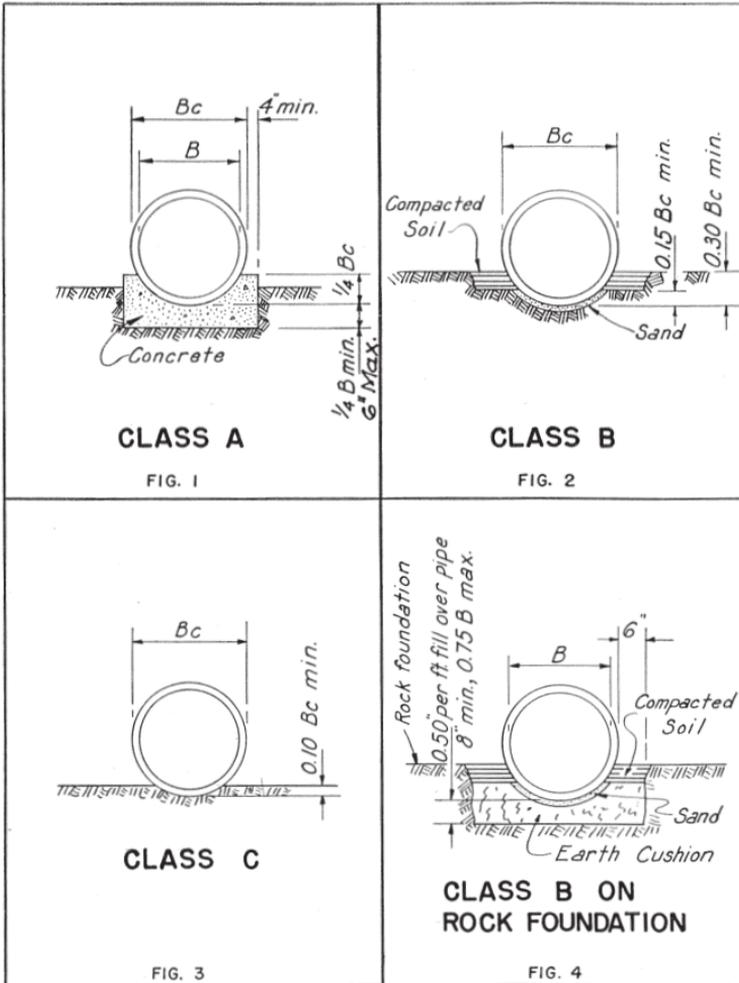
(2) **Bedding.** The pipe shall be bedded in accordance with the classification shown on the plans. In the absence of plan requirement for specific bedding classification, the pipe shall be bedded in accordance with the requirements for Class "C" Bedding. The various classes of bedding shall be prepared 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 having a minimum thickness under the pipe of $\frac{1}{4}$ the nominal inside diameter or a maximum thickness of 6 inch whichever is less, and extending up the sides of the pipe for a height equal to $\frac{1}{4}$ 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 $\frac{1}{2}$ inch for each foot of fill over the top of the pipe, whichever is greater, but not more than $\frac{3}{4}$ 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 Item 400, "Structural Excavation".

(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 such 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 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

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.** 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 watertight 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 finish 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 $\frac{1}{2}$ inch and not more than $\frac{3}{4}$ 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 Section 464.3 (4).

The Contractor shall make available for the use of the Engineer an appropriate rolling device such as a mechanic's "scooter" for conveyance through the smaller size pipe structures.

(5) **Rubber Gasket Joints.** 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. Mortaring of such joints will not be required.

(6) 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 Item 400, "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. When rubber gasket joints are used, immediate backfilling will be permitted.

(7) 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

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requirements for joining sections of pipes as designated herein or as shown on the plans. 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.

(8) Pipe damaged by the movement of the Contractor's equipment over a culvert shall be removed and replaced by the Contractor at his entire expense.

464.4. Measurement. Reinforced concrete pipe will be measured by the linear foot of pipe complete in place in accordance with these specifications. Such measurement will be made between the ends of the pipe barrel along the central axis as installed.

Excavation in natural ground for installing concrete pipe and excavation for installing headwalls will be measured as prescribed in Item 400, "Structural Excavation".

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" of the class specified, which payment shall be full compensation for furnishing and transporting the pipe; the excavation, hauling, and placing of earth cushion material where required for bedding pipe in rock excavation; the preparation and shaping of beds; 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 Item 400, "Structural Excavation". The excavation of rock or other incompressible materials, as may be required by Section 464.3. (2) (d) will be measured and paid for as "Structural Excavation". Where pipes are laid on a skew, full compensation for cutting the ends parallel with the centerline of the highway 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 Item 401, "Excavation and Backfill for Sewers", and Item 464, "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 Item 464, "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

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shall be Class "C" concrete conforming to the requirements of Item 420, "Concrete Structures", and Item 421, "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 Item 421, "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 per cent by weight of the total dry mix.

(4) Reinforcing Steel.

(a) Reinforcing steel and the placing thereof shall conform to the requirements of Item 440, "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 there-

of 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 grouting of the joints. Pipes shall be fitted together and matched so that when laid in the work, the pipes shall form a sewer with a smooth and uniform invert.

(2) Joints. All joints shall conform to the requirements of Item 464, "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 Item 401, "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 gage.

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 Item 401, "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, but not the furnishing of frames, grates, rings and covers. Junction boxes shall be classed 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

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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 Item 420, "Concrete Structures", and Item 421, "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 Item 421, "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 Item 440, "Reinforcing Steel".

(4) **Structural Steel.** Structural steel shall conform to the requirements of Item 441, "Steel Structures" and Item 442, "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 Item 471, "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 shall conform to the requirements of ASTM Designation: A 48, Class 30, "Gray Cast Iron".

(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 Item 420, "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 ½-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 Item 400, "Structural Excavation".

(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 Item 400, "Structural Excavation".

(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 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 extension separately from the inlet.

Excavation and backfill will be measured and paid for as required by Item 400, "Structural Excavation", or Item 401, "Excavation and Backfill for Sewers", as the case may be.

Frames, grates, rings and covers will be measured and paid for as required under Item 471, "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", of the type involved. 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.

471.1 to .2

(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.

(7) **Scope of Payment.** 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 Item 471, "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 7.

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 65-35 shall be furnished unless otherwise specified.

Cast iron castings shall conform to the requirements of the

Standard Specification for "Gray Iron Castings", ASTM Designation: A 48, Class No. 30.

Ductile iron castings shall conform to the requirements of the Standard Specifications for "Nodular Iron Castings", ASTM Designation: A 339. Grade 60-45-10 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 Item 448. "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, 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. 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 pro-

472.2 to .3

vided 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 in-

cluded 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 to be relaid will be measured as prescribed in Item 400, "Structural Excavation".

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", or "Relaying Culvert Pipe Over 18 inch Diameter" 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 Item 400, "Structural Excavation". Where pipes are laid on a skew, full compensation for cutting the ends parallel with the centerline of the highway 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 Item 464, "Reinforced Concrete Pipe Culverts" and corrugated gal-

473.3 to .4

vanized metal pipe shall be installed in accordance with the requirements of Item 460, "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 Item 400, "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 Item 400, "Structural Excavation". Where pipes are laid on a skew, full compensation for cutting the ends parallel with the centerline of the highway 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 Item 460, "Corrugated Galvanized Metal Pipe", or reinforced concrete pipe, conforming to Item 464, "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

476.3

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 of 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 opera-

tions 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 approximately a 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% 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.

476.4 to 479.3

Access holes for pouring concrete shall be spaced at maximum intervals of ten 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 Item 464, "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 for and adjusting the tops, abandoning, or capping, existing sewer manholes or inlets, where required by the plans. Manhole and inlet tops shall be adjusted to 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 Item 470, "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 one inch horizontal to two 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 Item 401, "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 Item 470, "Manholes and Inlets".

Excavation and backfill shall conform to the requirements of Item 401, "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 Man-

490.1 to .5

holes 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 Item 491, “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 as shown on the plans in the manner and by one of the processes specified in Item 492, “Timber Preservative and Treatment”, or other pertinent specifications.

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 piled to shed water and prevent warping. It shall be protected from the weather by suitable covering.

Treated timber shall be close-stacked, and piled 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 in such manner 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 gage 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 then with a coat of hot tar pitch over which shall be placed a cover as specified for untreated material above.

490.10 to .14

490.10. Caps. Timber caps shall be placed so as 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 $\frac{1}{2}$ 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 $\frac{1}{4}$ 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 2 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 $\frac{1}{8}$ 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 2 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 plank 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 $\frac{1}{8}$ inch thick floor plates, slotted to fit the flange of the stringer and punched for 2 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 $\frac{1}{16}$ inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or

490.18

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 1/16 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 ½ inch deeper than the penetration of the lag screws.

For treated timber, hot creosote oil shall be injected under pressure into the bolt hole in such a manner that the entire surface of the hole shall receive a coating of the oil before the insertion of the bolt.

All cuts in treated piling or timbers and all abrasions, after having been trimmed carefully, shall be brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

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 ¼ 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, with subsequent revisions thereto, issued by the Society prior to the date of the receipt of bids on which the contract award is made.

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.

Creosote oil used for treatment of cuts, bolt holes, etc., shall conform to the requirements of Grade 1 creosote oil as provided in Item 492, "Timber Preservative and Treatment".

Railings shall be painted as provided in the plans. The materials and application shall conform to the requirements of Item 446, "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 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 (Douglas Fir and Southern Yellow Pine)

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 Yellow Pine or Coast Region Douglas Fir, of the grades shown in the following tabulation.

Structural Purpose	Size of Member	Species	Standard Grade
(1) Stringers, caps, flooring, posts, railing, wheel guards, and fender timbers	4" thickness and smaller	Longleaf Southern Pine	2050f Longleaf Str. 65
		Dense Southern Pine	2050f Dense Str. 65
		Douglas Fir	1900f Select Str.
	5" thickness and larger	Longleaf Southern Pine	1800f Longleaf Str. 65
		Dense Southern Pine	1800f Dense Str. 65
		Douglas Fir	1900f Select Str.
(2) Nailing strips, sway bracing, bulkhead plank, bridging, edging strips, cleats, and blocks	4" thickness and smaller	Longleaf Southern Pine	1750f Longleaf Str. 58
		Dense Southern Pine	1750f Dense Str. 58
		Douglas Fir	1700f Dense No. 1
	5" thickness and larger	Longleaf Southern Pine	1600f Longleaf Str. 58
		Dense Southern Pine	1600f Dense Str. 58
		Douglas Fir	1700f Dense No. 1

The dressing of all timber shall be as indicated on plans or bills of material. When not 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 $\frac{1}{8}$ inch in excess of full nominal width or thickness or more than $\frac{1}{4}$ 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:

- (1) 4 inch thickness and smaller
 Southern Yellow Pine
 2050f Longleaf Str. 65 and
 2050f Dense Str. 65.
 Douglas Fir
 1900f Select Str.
- 5 inch thickness and larger
 Southern Yellow Pine
 1800f Longleaf Str. 65 and
 1800f Dense Str. 65.
 Douglas Fir
 1900f Select Str.

Slope of Grain: Not greater than 1 in 12
 Maximum Permissible Size of Knots; Shakes, Checks
 and Splits; and Wane:

Nominal Width of Face	Knot Size at the Edge of Wide Face	Knot Size on the Narrow Face and Along the Center of Wide Face	Shakes and Checks		Wane at any Point on any Face
			Dry	Green	
2"	5/16"	5/8"	5/8"	5/8"	1/4"
3"	5/8"	1 15/16"	1 1/4"	1 1/4"	3/8"
4"	25/32"	1 1/4"	1 5/8"	1 1/4"	1/2"
5"	15/16"	1 9/16"	2"	1 5/8"	5/8"
6"	1 1/4"	1 7/8"	2 3/8"	1 7/8"	3/4"
8"	1 9/16"	2 1/2"	3 1/8"	2 5/8"	1"
10"	1 7/8"	2 13/16"	4"	3 1/4"	1 1/4"
12"	2 3/16"	2 31/32"	4 3/4"	3 3/4"	1 1/2"
14"	2 1/2"	3 1/8"	5 1/2"	4 1/2"	1 3/4"
16"	2 1/2"	3 7/16"	6 1/4"	5"	2"
18"	2 13/16"	3 3/4"	7"	5 1/2"	2 1/4"
20"	2 13/16"	4 1/16"	7 3/4"	6 1/4"	2 1/2"

(2) 4 inch thickness and smaller

Southern Yellow Pine

1750f Longleaf Str. 58 and

1750f Dense Str. 58.

Douglas Fir

1700f Dense No. 1.

5 inch thickness and larger

Southern Yellow Pine

1600f Longleaf Str. 58 and

1600f Dense Str. 58.

Douglas Fir

1700f Dense No. 1.

Slope of Grain: Not greater than 1 in 10.

Maximum Permissible Size of Knots; Shakes, Checks
 and Splits; and Wane:

Nominal Width of Face	Knot Size at the Edge of Wide Face	Knot Size on the Narrow Face and Along the Center of Wide Face	Shakes and Checks		Wane at any Point on any Face
			Dry	Green	
2"	3/8"	3/4"	3/4"	3/4"	5/16"
3"	3/4"	1 1/8"	1 3/8"	1 1/8"	1/2"
4"	15/16"	1 1/2"	1 7/8"	1 5/8"	11/16"
5"	1 1/8"	1 7/8"	2 3/8"	2"	13/16"
6"	1 1/2"	2 1/4"	2 7/8"	2 1/2"	1"
8"	1 7/8"	3"	3 3/4"	3 1/4"	1 1/4"
10"	2 1/4"	3 3/8"	4 3/4"	4"	1 5/8"
12"	2 5/8"	3 9/16"	5 3/4"	5"	2"
14"	3"	3 3/4"	6 3/4"	5 3/4"	2 3/8"
16"	3"	4 1/8"	7 1/2"	6 1/2"	2 3/4"
18"	3 3/8"	4 1/2"	8 1/4"	7 1/4"	3"
20"	3 3/8"	4 7/8"	9"	8"	3 1/4"

491.4 to 492.1

491.4. Treated Timber. Treated timber shall be impregnated with the kind of preservative specified, in the amount and by the process designated on the plans.

491.5. Workmanship. Timber structures, whether treated or untreated, shall be constructed in accordance with the requirements of Item 490, "Timber Structures".

491.6. Timber for Sign Posts. Lumber for sign posts shall be Southern Yellow 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 $\frac{1}{4}$ inch wide in its maximum dimension. Sign posts shall have a creosote oil or a pentachlorophenol treatment of not less than 8 pounds per cubic foot, as required by Item 492, "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 forms, falsework, and 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 above 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 (Creosote Oil or Pentachlorophenol)

492.1. Description. This item shall govern for the preservative, and for the seasoning, preparation, and treatment

of lumber, timber, and posts where either creosote or pentachlorophenol treatment is specified on the plans or called for in the specifications, and for the preservative, and for the seasoning, preparation, and treatment of timber piling where creosote treatment is specified on the plans or called for in the specifications. The amounts of treatment to be used are shown on the plans or in the specifications and are based on the use of either Southern Yellow Pine or Douglas Fir, except that where Douglas Fir is permitted by the specifications for use with creosote treatment, the amount of treatment shall be as follows:

Where 12 pound treatment is specified, 8 pound treatment shall be used for Douglas Fir.

Where 16 pound or heavier treatment is specified, 12 pound treatment shall be used for Douglas Fir.

Except as otherwise provided herein, Federal Specification TT-W-571 or current revision thereof shall govern for materials and methods of treatment.

492.2. Seasoning. Timber, piling, and posts may be seasoned by air or steam. 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. Pretreated stock will not be accepted by the Inspector except in emergencies, and even then, special permission must be obtained from the Engineer. Retreatment of a portion in a charge may be permitted for Southern Yellow Pine only subject to provisions of Federal Specification TT-W-571 which allows 10 percent of a charge to be retreated material under limitations contained therein. This provision is not to be construed as permitting the use of pretreated stock, but it is intended to conform only to the usual practice of securing proper penetration where the plant procedure has failed to produce required results in a specific charge.

492.3. Incising. No incising will be required on any Southern Yellow Pine material, nor on sawn Douglas Fir material where the least nominal dimension is less than 2 inches. Unless otherwise specified on the plans, all sawn Douglas Fir material with least nominal dimension 2 inches or over, shall be incised in a suitable power driven machine. When material has a nominal thickness of 3 inches or more, it shall be incised on all four sides. Material of nominal thickness from 2 inches up to 3 inches shall be incised on the wide faces only. The spacing and shape of the cutting

492.4 to .5

teeth and the method of incising shall be such as to produce a uniform penetration. The depth of the incision shall be in accordance with the following schedule with intermediate sizes in proportion:

Nominal Thickness	Minimum Depth of Incision
2"	$\frac{3}{8}$ "
3"	$\frac{7}{16}$ "
4"	$\frac{1}{2}$ "
8"	$\frac{9}{16}$ "
10"	$\frac{5}{8}$ "
12"	$\frac{3}{4}$ "

Douglas Fir will not require incising.

492.4. Preservatives. The preservatives used for the creosote treatment of timbers, piling, and posts shall be Standard Grade I Creosote Oil.

The preservatives used for pentachlorophenol treatment shall consist of a five per cent solution of pentachlorophenol in a suitable petroleum solvent. Pentachlorophenol shall comply with the requirements of Federal Specification TT-W-571 and current revisions thereto. Where the treated timber is required to be paintable the petroleum solvent shall comply with the following requirements:

(1) Specific gravity at 60 F shall be not less than 0.825 (not greater than 40 A P I).

(2) Water and sediment content (B S & W) shall not exceed 0.5 percent (Current ASTM Standard D 98).

(3) Flash point shall be not less than 145 F as determined by the Pensky-Martens closed tester (Current ASTM Standard D 93).

(4) The total volume of the fractions distilling below 500 F shall not exceed 60 percent and the total distilling below 625 F shall be not less than 90 percent.

(5) Pentachlorophenol solvency shall be not less than 10 percent by weight at 75 F.

(6) Solvent shall be of such character as will prevent staining the wood to a darker color than light brown and the discoloration of paints of suitable type when applied to the timber.

492.5. Retention of Preservative. Unless otherwise shown on the plans or in special provision the amount of pentachlorophenol preservative retained shall be as follows:

Guard Fence Posts:	Not less than 8 lbs./cu. ft.
Bridge Timbers:	Not less than 12 lbs./cu. ft.
Lumber other than Bridge Timbers:	Not less than 8 lbs./cu. ft.

492.6. 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.

492.7. Loading and Treatment. Piling to be creosoted shall be loaded on trams so that a minimum of distortion will result during the conditioning process. Requirements for straightness before treatment will apply after treatment. If there is any question regarding the conformity after treatment, the piling shall be placed on skids so it can be checked properly. The bottom piling in a charge that is to be steam conditioned shall be protected from the metal trams if necessary to prevent serious tram marking.

492.8. Cubic Volume. The average volume used for each size and length of piling shall be determined by measuring each piling in order to arrive at the average butt and tip of each group.

492.9. Treatment Results. In addition to the penetration requirements under Federal Specification TT-W-571, if less than 16 of the first 20 borings taken from a charge of creosote treated piling meet the requirements of the specifications, the entire charge may be rejected for non-compliance.

492.10. Increment Boring Holes. All test holes in creosoted piling shall be circled with aluminum keel. The holes then shall be plugged tightly with creosoted plugs.

492.11. Treatment of Cuts. When it is necessary to bore holes or cut the timbers after pentachlorophenol treatment, or when any pentachlorophenol treated surface has been badly scarred, the hole, cut or scarred surfaces must be given a three-coat treatment of the concentrated solution as specified, applied with a brush; and this solution must be between 135 F and 165 F when applied.

492.12. Inspection. Inspectors representing the purchaser shall have access to all parts and facilities of plants used in the conditioning and treating of forest products and shall be present during the treating procedure to ascertain whether the process meets specifications.

492.13 to 496.2

492.13. Measurement and Payment. Payment for all work prescribed herein will be included in the unit prices bid for "Timber for Structures", "Timber Piling", or "Timber Post Guard Fence", 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 re-use 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 slogging the concrete into sizes not larger than one cubic foot.

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 two 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 slogging the masonry into sizes not larger than 1 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 two 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.

496.3 to .4

Materials 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 and 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 Item 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 a plant inspection laboratory, equipped by the Contractor as specified herein, for the use of the Engineer at a prestressed concrete fabricating plant.

498.2. General Requirements. The laboratory shall be provided prior to the beginning of casting prestressed concrete units for use on Department contracts.

The building and equipment shall be maintained in such manner that it will continue to function properly for its intended use.

Department personnel and the Contractor's personnel will not be housed in the same office or laboratory space.

498.3. Laboratory Building. The building furnished shall be not less than 10 feet by 20 feet by 8 feet high with a dividing partition wall separating two rooms, the smallest of which shall not be less than 8 feet by 10 feet. One entrance door, one door between rooms, and two glass windows in each room shall be provided. The building shall be water tight.

Each room shall be provided with adequate overhead lighting with wall switches and a minimum of two 110 volt base plugs.

The building shall be adequately heated.

498.4. Equipment. The larger room shall be equipped with a sink, running water, a 3 foot by 6 foot work table, and equipped with permanent facilities listed below.

(1) **Compression Testing Machine.** A compression testing machine shall be furnished meeting the following requirements: This equipment shall be hydraulically operated by a constant flow electric or gasoline powered pump and shall have a minimum load range of 200,000 pounds. The pump shall be set to apply loads between 20 and 50 psi per second on the cylinder without pulsation. The testing

machine shall be equipped with a pressure gauge of the Bourdon tube type, and shall have a gauge calibrated in pounds, with sub-graduations of 500 pounds or smaller, with a range of at least 200,000 pounds. The gauge shall have a maximum loading pointer.

(2) **Torsion Balance and Metric Weights.** The torsion balance shall be furnished and shall be equipped with a beam graduated to at least 100 grams in one gram divisions and shall have a sliding tare weight. The capacity of the balance shall be not less than 4 kilograms. The following metric weights shall be provided:

1—2,000 gram	2—200 gram
1—1,000 gram	1—100 gram
1— 500 gram	

(3) **Moisture and Specific Gravity Determination Equipment.** A supply of 1 and 2 quart Mason jars, pycnometer tops, wide spout funnel, and siphon bulb shall be furnished.

(4) **Set of Sieves.** A complete set of sieves, as required for sieve analysis of both fine and coarse aggregates as set forth under the specifications for Class F and Class G concrete, shall be furnished. These sieves shall be U.S. Bureau of Standards Series and shall bear the identifying permanently attached name plate showing manufacturer's name, size of opening in inches, mesh, U.S. sieve series numbers, and micron designation.

(5) **Cylinder Molds.** A minimum of 12 permanent cylinder molds for each line to be produced for each day's run shall be furnished. 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 shall also be furnished. The assembled mold and base plate shall be water tight. Cylinder shall conform in every respect to ASTM Designation: C 31 and C 192.

(6) **Shovel and Trowel.** One small shovel and a trowel shall be furnished for purposes of making concrete cylinders.

(7) **Aggregate Pans.** Three round aggregate pans shall be furnished.

(8) **Cylinder Capping Equipment.** Equipment shall be

urnished for capping specimen for compression tests and shall meet all requirements of ASTM Designation: C 192.

(9) **Curing Tank.** A thermostatically controlled curing tank, which is capable of maintaining water temperature between 70 F and 90 F, and large enough to accommodate a minimum of six cylinders for each pour for at least 14 days of consecutive run, shall be provided.

(10) **Unit Weight Equipment.** A quartering cloth, sand sleeve, hand scoop, calibrated and tared 0.5 cubic foot measure, calibrated and tared 0.1 cubic foot measure and one 80 pound aggregate scale with hook for weighing tared containers shall be provided.

(11) **Slump Mold and Tamping Rod.** A slump mold and tamping rod shall be provided as required for Test Method Tex-415-A.

The equipment shall be subject to the approval of the Engineer.

If elevated temperature curing is used, one remote reading thermometer and one recording thermometer shall be furnished for each 100 foot length of casting bed in simultaneous use. The same equipment shall be provided for use from November 1 through March 31 for any kind of curing method.

All equipment shall be calibrated properly and housed in a weatherproof enclosure. Recalibrations of any equipment shall be done at the expense of the Contractor when directed by the Engineer.

498.5. Measurement and Payment. No direct compensation will be made to the Contractor for the work, materials, or equipment involved in providing the "Plant Inspection Laboratory (Equipped)", but this item will be considered subsidiary to the several items of work for which unit prices are provided in the contract.

PART II, CONSTRUCTION DETAILS
DIVISION V,
INCIDENTAL CONSTRUCTION

ITEM 500

WEIGHING 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 "Specifications, Tolerances and Regulations for Commercial Weighing and Measuring Devices for Use in the State of Texas", published by the Texas Department of Agriculture, Austin, Texas, except that accuracy to within 0.4 percent of the total 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 as deemed necessary.

For use of State inspection forces in checking the scales during operation, the Contractor shall furnish four certified 50 pound weights, checked and certified at least once each year. In addition, the Contractor shall furnish four certified 5 pound weights and four certified 2 pound weights, checked and certified at least once a year, to be used in checking cement, asphalt and small platform scales. All scales shall be satisfactorily insulated against shock, vibrations or movement of other operating equipment in the plant.

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

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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

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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.

(6) **Automatic Proportioning Devices.** When required by the plans or special provisions, batching plants shall be equipped to proportion by weight, aggregates, bulk cement or asphalt 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 proportioning 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 or asphaltic material bucket have been filled with the correct charge. The discharge gate on the cement hopper or the asphaltic material bucket 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 Section (1) of this specification.

(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

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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 502

READY-MIX PLANTS

502.1. Description. This item shall govern for the plant facilities, equipment, and operation of a Ready-Mix Plant.

502.2. Material. All materials for concrete placed in structures shall conform to the requirements of Item 421, "Concrete for Structures", or Item 423, "Lightweight Concrete for Structures".

All materials for concrete placed in pavements shall conform to the requirements of the governing items of "Concrete Pavement".

502.3. General. All plant facilities and equipment used in the manufacture and delivery of Ready-Mix Concrete under this item shall be in first-class operating condition, and together with the method of operation and the materials used, shall be subject to inspection and approval by the En-

gineer to assure that all concrete for use in the Department's work is produced and delivered as specified herein.

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 agitating speed. (Central Mix Concrete)

(2) Mixed partially in a stationary mixer with the mixing completed in a truck mixer and transported to the point of delivery at mixing and agitating speed. (Shrink Mix Concrete)

(3) Mixed completely in a truck mixer and transported to the point of delivery at mixing and agitating speed. (Transit Mix Concrete)

Concrete which does not meet the slump, workability, and consistency requirements of the governing items for which the concrete is being produced, shall not be placed in the structure or pavement.

502.4. Storage of Materials. Adequate storage facilities shall be provided for all Department approved materials. The intermixing of nonapproved materials with Department approved materials either in stock piles or in bins will not be permitted. Aggregates from different sources shall be stored in different stockpiles.

Separate storage and use of materials will not be required except when:

- (1) Materials do not meet the Department requirements.
- (2) Adequate provisions are not provided for the checking and testing of materials.
- (3) Combined use causes delay to the production and placement of concrete for the Department's project.

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.

502.5. Measuring Devices for Materials.

- (1) **General.** All materials shall be measured by ap-

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proved devices. Weighing and measuring equipment shall be in accordance with Item 500, "Weighing and Measuring Equipment".

(2) **Admixtures.** Admixtures shall be measured and dispensed in accordance with Item 437, "Concrete Admixtures".

502.6. Equipment.

(1) **Batching Plant.** The batching plant shall be provided with adequate bins for batching the fine and coarse aggregates required under these 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 the hopper used for weighing the aggregates.

(2) **Mixers and Agitators.** Mixers may be stationary mixers or truck mixers. All mixers shall be of an approved type and shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity. Agitators shall be truck agitators.

(a) Stationary mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed and shall be in accordance with the requirements of Item 421, "Concrete for Structures".

(b) The drum of truck mixers shall be actuated by an engine mounted as an integral part of the mixing unit for the purpose of rotating the drum. 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 mixer is equipped with a transmission that will govern the speed of the drum within the specified rpm, no separate engine for rotating the drum will be required.

Truck mixers shall be equipped with facilities to readily permit access to the inside of the drum for inspection, cleaning, and repair of blades.

Truck mixers shall be examined daily for changes in condition due to accumulation of hardened concrete or mortar, or to wear of blades. The blades shall be replaced when any part or section is worn as much as 10 percent below the original height of the manufacturer's design. Any accumulation of hardened concrete shall be removed and any excessively worn blades shall be replaced before the mixer will be permitted to be used under these specifications.

A copy of the manufacturer's design, showing dimensions and arrangement of blades, shall be available at the plant at all times. Worn blades shall be replaced with new blades in accordance with the manufacturer's design and arrangement for that particular unit.

Each truck mixer 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 the speed of rotation of the mixing drum for both the mixing speed and the agitating speed, the capacity of the unit for complete mixing, for partial mixing, and for use as an agitating unit only.

Truck mixers shall be equipped with actuated counters by which the number of revolutions of the drum may be readily verified. The counters shall be actuated at the time of starting mixing at mixing speeds.

Truck mixers shall have adequate water supply and metering devices. No water shall be added to the concrete after the initial mixing water without the permission of the Engineer.

Truck mixers in addition to the requirements herein shall be in accordance with the requirements of the Truck Mixer Manufacturer's Bureau of the National Ready-Mix Concrete Association.

(c) Truck agitators shall comply with all of the requirements for truck mixers except for the actual mixing requirements.

502.7. Operation of Plant and Equipment. When a stationary mixer is used for the entire mixing of the concrete, the mixing time for one cubic yard of concrete shall be one minute with an increased mixing time of 15 seconds for each additional cubic yard or portion thereof.

When a stationary mixer is used for partial mixing, the mixing time shall be a minimum of 30 seconds. Mixing shall be completed by truck mixer at mixing speed.

Mixing time shall be measured from the time all cement, water, and aggregates have been entered into the drum. The batch shall be so charged into the mixer that one-third of the water will enter the drum in advance of cement and aggregates, and all 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.

Truck mixers shall not be loaded to exceed the capacity of the unit as rated by the Truck Mixer Manufacturer's Bureau of the National Ready-Mix Association.

Mixing at mixing speed shall begin immediately after all ingredients are in the mixer. For complete mixing in the truck each batch shall be mixed not less than 70 nor more than 100 revolutions of the drum. For partial mixing in the truck each batch shall be mixed not less than 50 nor more than 100 revolutions of the drum. 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 four revolutions per minute. The drum shall be kept in continuous motion from the time mixing is started until the discharge is completed.

The production and delivery of ready-mixed concrete shall be such that will provide a *continuous* finishing operation and in *no* case more than 20 minutes shall elapse between the depositing of successive batches of concrete in any monolithic unit. The Contractor shall satisfy the Engineer that adequate stand-by trucks can be made available. Each batch of concrete shall be delivered to the work and discharged completed within the time specified in Section 13 of Item 420, "Concrete Structures".

The Contractor shall provide and use a ticket system for recording the transportation of batches from the proportioning plant to the site of the work. The tickets shall be issued to the truck operator at the Ready-Mix Plant for each load and shall be signed by the Department's plant inspector, which will signify that the concrete in the truck has been inspected prior to departure. Each ticket shall bear the reading of the revolution counter and the time the truck was charged. The tickets shall be delivered to the inspector at the site of the work. Loads for which tickets are not provided and which do not arrive in satisfactory condition within the time limits specified shall not be used in the work.

502.8. Certification of Plant. Before mixing and hauling concrete to Department projects, the plant will be thoroughly inspected and approved by the Engineer.

All scales shall be checked, prior to beginning operations,

as required under Item 500, "Weighing and Measuring Equipment".

Adequate inspection of the plant will be made by the Engineer during the operation of the job to insure that all requirements are being met.

If at any time after approval of a plant the equipment and/or facilities provided fail to meet the requirements, approval of the plant will be withdrawn.

502.9. Measurement and Payment. No direct compensation will be made for concrete produced under the requirements of this item. Payment for concrete 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. 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 unreinforced 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 66.

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 drain pipe shall be constructed of a mixture of Portland cement, water, and aggregates conforming to the provisions of the Item, "Concrete for Structures (Natural Aggregate)". The mixture of cement and aggregate shall contain no adulterants. All joints shall be of the tongue and groove type with not less than 1 inch at each end constructed of dense concrete to assure maximum strength. The strength requirements shall conform to those of AASHO Designation: M 86, Table 1, for the same diameter of pipe. With each end sealed the rate of infiltration shall be not less than 1.75 gallons per minute, per inch of diameter, per foot of pipe, when submerged horizontally in water to a depth of 1 inch above the pipe.

Type 5. Perforated Asbestos-Cement Pipe.

Asbestos-Cement pipe and fittings shall consist of a mixture of Portland cement, Portland blast furnace slag cement or Portland pozzolan cement and asbestos fiber with or without the addition of curing agents. Pipe shall be free from organic substances and shall be formed under pressure and thoroughly cured.

The strength of the pipe after perforating shall be not less than that shown in the following table when tested by the Three-Edge Bearing method in accordance with the test method of AASHO Designation: T 33:

Pipe Size	Minimum Strength
4"	1000 Lbs. Per Lin. Ft.
6"	1000 Lbs. Per Lin. Ft.
8"	1000 Lbs. Per Lin. Ft.
10"	1100 Lbs. Per Lin. Ft.
12"	1200 Lbs. Per Lin. Ft.

Pipe shall be shop perforated. Perforations shall be circular and clean cut $\frac{1}{4}$ inch ($\pm 1/16$ inch) in diameter, arranged in rows parallel to the axis of the pipe. Perforations shall be approximately three inches center to center along the rows. Rows shall be arranged in two groups on either side of the vertical centerline of the pipe and the total number of rows shall be as shown in the following table. The lower imperforated segment shall have a width corresponding to an arc of 90 degrees (± 5 degrees). The

centerlines of the top or outer rows of perforations shall be a distance from the centerline of the lower imperforated segment corresponding to an arc of 80 degrees ($\pm 2\frac{1}{2}$ degrees). With each group, the spacing of the rows shall be uniform. Spacing of rows between these limits shall be uniform.

Pipe Size—(Inch)	Rows of Perforations
4	4
6	4
8	4
10	6
12	6

Couplings shall be the sleeve type suitable for holding the pipe in alignment without the use of sealing compound 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 AASHTO 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 AASHTO Designation: M 136 except as modified by AASHTO Designation: M 36, and with the following additional modifications: The pipe may conform to any one of the types specified in said Designation: M 136, and perforations may be either drilled or punched.

In lieu of the requirements of AASHTO Designation: M 36, 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: MIL-P-15145. The paint shall be furnished by the Contractor at his expense.

Damaged areas caused by end finishing shall be thoroughly cleaned and painted as specified above.

Type 8. Perforated Corrugated Metal Pipe (Bituminous Coated).

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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 coating shall meet the requirements of Test Method Tex-522-C.

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.

510.3. Filter Material. Filter material for use in back-filling 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.

The percentage composition by weight of the filter material in place shall conform to one of the gradings in the following table:

Sieve Size	Percentage Retained on Sieve		
	Type A	Type B	Type C
2"	—	—	—
1½"	—	—	0-10
¾"	—	0-10	20-40
⅜"	—	15-35	—
No. 4	0-10	35-55	40-60

That portion of the filter material of any type that is finer than No. 4 sieve shall be graded as follows:

Sieve Size	Percentage Retained on Sieve
4	—
20	35- 65
50	75-100

The material shall conform to the requirements of materials for the Item, "Concrete for Structures (Natural Aggregate)". Unless otherwise specified on the plans, Type B or Type C filter material, at the option of the Contractor, shall be used around underdrains. If Type A filter material is specified, it shall not be placed within 6 inches of any

perforation. The perforated pipe shall be embedded in Type B or C filter material before any Type A material is placed.

510.4. 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 up, 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 $\frac{3}{8}$ 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 $\frac{1}{2}$ 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 (Natural Aggregate)".

510.5. 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 (Ft.)	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 ground 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”.

510.6. 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 “Pipe Underdrains” of the type and size specified, which price shall be full compensation for furnishing and placing all materials, for all plugs, 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 include all excavating, bracing and removal of same, backfilling of trench, disposal of excess materials, 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 (Natural Aggregate)”.

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

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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. 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. 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.

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. Materials shall conform to the requirements for Class “C” Concrete of the Item, “Concrete for Structures (Natural Aggregate)”, 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 $\frac{1}{2}$ " sieve	0%
Retained on $\frac{3}{8}$ " sieve	0 to 5%
Retained on No. 4 sieve	35 to 60%
Retained on No. 10 sieve	90 to 100%
Loss by decantation	0 to 1%

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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

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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 grade line. To provide a continual check on the curb grade, a pointer or gage 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".

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. 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.

The reinforcing steel, if required, shall be placed in posi-

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tion 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. 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. 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.

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 sub-grade; 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 (Natural Aggregate)", 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

524.4 to 530.2

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 3 days.

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, normal Portland cement and water. Cement and water

shall conform to the requirements of the Item, "Concrete for Structures (Natural Aggregate)". 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 $\frac{1}{2}$ 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. Handmixing will be permitted on small quantities; otherwise mixing shall be done in a batch mixer of approved type and size which will 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 by the impervious membrane method; 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.

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 "Tagliabue Open 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 $\frac{1}{2}$ 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 Methods. 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 pro-

542.1 to .3

vided 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 workman-like appearance, with no pieces 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 (Natural Aggregate)", 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 materials 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.

544.4 to 550.1

The excavated area for retards shall be moist when the concrete is placed.

The concrete for this item shall not be classified but shall be mixed in the proportions of one part cement, three parts of fine aggregate, and eight parts of coarse aggregate, mixed in a manner acceptable to the Engineer with sufficient water to give the desired consistency. 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 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 (Natural Aggregate)".

Reinforcing steel shall conform to the requirements of the Item, "Reinforcing Steel".

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 in-

560.1 to .2

stallation 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 supported on timber or steel posts. Metal beam guard fence (barrier) shall consist of two or more lines of beam 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.

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 12½ foot sectional length of beam, the maximum deviation of the beam edges from the

straight edge shall not exceed $\frac{1}{2}$ 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 Gage (Steel)	Minimum Tensile Strength of Rail Element and Joint Pound
A	0.156	10	100,000
B	0.105	12	60,000

Where aluminum 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 steel rail is used, the plate or sheet shall be the United States Standard Gage designated for that class.

The rail elements may be either aluminum, painted steel or galvanized steel, unless one or the other 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 or electric-furnace steel and shop painted with one coat of primer and two field coats of paint. A test specimen of the rail material shall elongate not less than 12 percent in a 2-inch gage length.

Paint and painting shall conform to the requirements for bridge rail painting as set out in the Item, "Railing".

Galvanized Steel Rail. The rail element and terminal section shall be formed from open-hearth or electric-furnace steel and a test specimen of the rail material shall elongate not less than 12 percent in a 2-inch gage length.

The rail element may be galvanized before or after fabrication and shall have a minimum coating class of $2\frac{1}{2}$ ounces

per square foot of double exposed surface in accordance with the requirements of ASTM Designation: A 123, or ASTM Designation: A 93, whichever is applicable.

(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 shall be Southern Yellow Pine. All posts shall be round. End posts shall not be less, in any place, than 8 inches in diameter, and intermediate posts shall not be less, in any place, than 7 inches in diameter. They shall be of the length shown on the plans; the bottom shall be sawed off square, and the top shall be dome shaped. The posts shall be peeled and trimmed of all knots and knobs and shall be straight and smooth. The posts 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 dimension. 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 $1\frac{1}{4}$ inches.

All timber posts shall have a creosote oil or pentachlorophenol treatment of not less than 8 pounds per cubic foot, as required in the Item, "Timber Preservative and Treatment".

Steel Posts. Steel posts shall be of the rolled I-beam section as shown on the plans. The post section shall be of structural steel conforming to the requirements of ASTM Designation: A 7. The top of all posts shall be bevelled as required by details, and drilled or punched for bolts for rail attachment.

Steel posts used with painted steel rail shall be coated at the factory with one coat of the specified primer and two field coats of paint conforming to the requirements of bridge rail painting in the Item, "Railing".

Steel posts 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 desig-

nated 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 have proper strength for the purpose intended. They shall be hot-dip galvanized to conform to ASTM Designation: A 153.

The post connection shall withstand a 5,000 pound pull in either direction.

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 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

560.5 to .6

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.

Steel posts may be driven to the established line and grade where approved caps or driving devices are provided to avoid distortion of the metal. 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 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.

After erection, all parts of painted steel posts and rail elements on which the primer coat has become scratched or chipped shall be thoroughly cleaned and spot painted with the paint specified for the first field coat. The spot coat shall be allowed to dry for at least 12 hours, after which the beam and metal posts shall be painted with Number One Field Coat. After the first field coat has dried for at least 48 hours, the second field coat shall be applied.

After erection, all parts of galvanized steel posts 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: MIL-P-15145. The paint shall be furnished by the Contractor at his expense.

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 shall be made upon the face of the rail in place, from center of end posts.

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)" of the class specified, or for "Aluminum Beam Guard Fence", "Aluminum Beam Guard Fence (Barrier)", "Painted Steel Beam Guard Fence", "Painted Steel Beam Guard Fence (Barrier)", "Galvanized Steel Beam Guard

Fence”, or “Galvanized Steel Beam Guard Fence (Barrier)” of the class specified, which price shall each be full compensation for furnishing all materials, for all preparation, hauling and erection and painting of same, for setting post in concrete when specified, and for all labor, tools, equipment and incidentals necessary to complete the work, including excavation, backfilling and disposal of surplus material.

When a bid is requested for “Metal Beam Guard Fence” or “Metal Beam Guard Fence (Barrier)”, the contractor shall furnish the same type of rail material throughout the project.

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 metal beams 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

561.4 to 562.2

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 metal beams 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 lo-

cation. 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.

562.4. 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 Metal Beam 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 563

TIMBER POST GUARD FENCE

563.1. Description. "Timber Post Guard Fence" shall consist of posts only. All guard fence 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 designated plan and typical details shown.

563.2. Materials. The posts shall be Treated Southern Yellow Pine, and shall be not less than 6 inches in diameter at any point. The bottom shall be sawed off square and the top shall be dome shaped.

Posts shall be round and shall be peeled and trimmed of all knots and knobs and shall be straight and smooth. The posts shall be sound and free from defects such as injurious ring shakes, large 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 dimension. 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

563.3 to 564.1

post at any point more than $1\frac{1}{4}$ inches. Posts shall be bored and cut to dimensions shown on plans before treatment.

Posts shall be inspected at time of treatment. Unless otherwise shown on the plans all posts shall have either a creosote oil or a pentachlorophenol treatment of not less than 8 pounds per cubic foot, as required in the Item, "Timber Preservative and Treatment".

563.3. Construction Methods. The posts shall be placed as shown on Guard Fence Standard in the plans or as directed by the Engineer. 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.

When a bid is requested for "Timber Post Guard Fence (Painted)", all timber posts shall be painted with two coats of aluminum paint after erection 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 of paint that will produce a neat and workmanlike job, satisfactory to the Engineer.

When a bid is requested for "Timber Post Guard Fence" no painting will be required.

563.4. Measurement. Timber Post Guard Fence will be measured as each post, complete in place.

563.5. 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 "Timber Post Guard Fence (Painted)" or "Timber Post Guard Fence", which price shall be full compensation for furnishing all materials, for all preparation, hauling and installation of same, and for all labor, tools, equipment and incidentals necessary to complete the work, including furnishing and applying all paint, if required, excavation, backfilling and disposal of surplus material.

ITEM 564

PLACING TIMBER POST GUARD FENCE

564.1. Description. "Placing Timber Post Guard Fence" shall consist of installing timber post guard fence and painting the posts. The posts will be furnished to the Contractor in stockpiles along the right of way.

564.2. Construction Methods. Posts shall be secured from stockpiles along the right of way, and shall be placed as shown on the plans or as directed by the Engineer. Posts shall be placed according to Guard Fence Standard shown in 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. Any posts scarred, battered or broken by the Contractor shall be replaced at his own expense.

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.

564.3. Measurement. Placing Timber Post Guard Fence will be measured as each post, complete in place.

564.4. Payment. Work and accepted materials, performed and measured as provided under "Measurement", will be paid for at the unit price bid for "Placing Timber Post Guard Fence", which price shall be full compensation for setting all posts, cleaning, furnishing and applying all paint, all necessary excavation, backfilling and for all labor, tools, equipment, hauling and incidentals necessary to complete the work.

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 to 566.3

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. Construction 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 post 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 fence to the posts in a manner that will not damage the post or 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 post 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 $\frac{1}{2}$ 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 $1\frac{1}{2}$ 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 $12\frac{1}{2}$ -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 $12\frac{1}{2}$ -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 $1\frac{1}{2}$ inches long and the wire from which they are made shall be galvanized as specified in section 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 inter-

567.5 to .6

vals 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-gage 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; 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 and height 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 gage specified on the plans.

(b) Between posts, the fabric shall be fastened to a top and bottom tension wire by ties of the gage and spacing shown on the plans. The tension wire shall be at least 7 gage 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 wire ties shall conform to the gage and spacing as shown on the plans and shall be of suitable design to fasten fabric to the posts. Wire ties of the gage 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 MIL-P-15145. 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 (Natural Aggregate)". Hand mixing of concrete will be permitted on batches under $\frac{1}{2}$ 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

568.6 to .7

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 $\frac{5}{8}$ 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. These specifications shall provide for furnishing and installing two reflectionized railroad crossbuck signs which together shall comprise the standard "Metal Series Railroad Crossing Signs".

570.2. Materials.

(1) **Sheet Steel for Signs.** Sheet steel shall be corrosion resisting. The total amount of carbon, manganese, phosphorus, sulphur and silicon shall not exceed 0.70 percent. If the total amount of these five elements equals or exceeds 0.20 percent, the metal shall contain not less than 0.17 percent copper and not more than 0.06 percent sulphur. If the total of these five elements is less than 0.20 percent and sulphur is not greater than 0.04 percent, the presence of copper is optional with the Contractor. The metal shall, after fabrication, be uniformly coated with a good quality of zinc and the surface of the coated metal shall be of such nature that the primer will adhere firmly. Zinc coating shall be applied by the hot dip method and heat treated after coating in such manner as to give a tight dull coat which will not peel or flake on the outside of a flat reverse bend and which shall have the characteristics of a matte and shall be free from bright or flossy spangle, or shall be applied by electrochemical deposition in a manner which will give equivalent results.

(2) **Sheet Steel Crossbuck Signs.** Sheet steel crossbuck signs shall conform to these specifications and to the details shown on the plans. The front, back and intermediate plates shall be No. 16 U. S. Standard Gage. Reinforcing plates used in the back of signs shall be $\frac{1}{4}$ inch in thickness. The front and back plates of the sign shall be flanged to a depth of not less than $\frac{1}{2}$ inch. Flanges shall be welded at the corners. The front plate shall be slightly larger than the back plate so that it will freely telescope over the flanges of the back plate. The front plate shall have the legend of the sign embossed upon it. The embossed legend shall be raised not less than 0.085 inches nor more than 0.125 inches. The dimensions inside, between the front and back plates, shall be such as is necessary to meet the requirements of this specification and the particular reflector units assembled in the sign. The front plate shall be attached to the back plate

by bronze screws of special design which cannot be removed with an ordinary screw driver. If nuts are used, they shall be of such design that they cannot be removed with ordinary pliers, wrench or screw driver. The opening for reflector buttons in the front plate shall be approximately $\frac{3}{4}$ inches in diameter and shall be such that any metal rim of the reflector buttons will not be visible when the buttons are assembled in the sign. The reflector buttons shall be securely held by the intermediate plate with their axes perpendicular to the face of the sign in such manner that the buttons may not be removed except by first dismantling the sign. The intermediate plate shall be readily removable without the use of tools and when removed shall release the reflector buttons. Reflector buttons shall project not more than $\frac{1}{4}$ inch outside the aperture in the face of the sign. A durable waterproof gasket of non-corrosive material shall be used between the reflector buttons and the front plate.

(3) Paint and Painting of Metal Signs. Metal to which the prime coat is applied shall be free of all rust, mill scale, oil, dirt and other foreign substances which would be deleterious to the procurement of firm adhering durable paint coating with a pleasing appearance. All surfaces shall be uniformly coated to a minimum dry film thickness of 4 mils. The completed sign, after 200 hours exposure to salt spray resistance testing in accordance with Federal Method 6061, shall show no blistering and no rusting beyond $\frac{1}{8}$ inch from the score line.

Paint shall be applied in accordance with the patterns and dimensions shown on the plans. The legend of the crossbuck sign shall be black and all other exterior surfaces shall be white. Sixty degree specular gloss of all finish coats shall be between 45 and 65 degrees.

(4) Reflecting Materials.

(a) Reflector Buttons. Reflector buttons shall be incorporated into the signs in accordance with the details and patterns shown on the plans. The lenses shall be made of clear, practically colorless glass or acrylic plastic of uniform reflecting power. Each lens shall be accurately formed and free from all defects which adversely affect optical or physical properties. It shall be practically free from chromatic aberration when viewed within an angle of 30 degrees from its axis. The specific intensity (candle power returned at

he chosen divergence angle by a reflector per square foot of reflective surface for each foot-candle of illumination at the reflector) of the reflector shall equal or exceed the following minimum values:

Entrance Angle Degrees	Divergence Angle Degrees	Specific Intensity Cp./Sp. Foot/ Foot-Candle
0	1/10	2000
20	1/10	800
0	1/3	1000
20	1/3	400

The reflecting surface, if made of glass, shall be silvered and hermetically sealed in a protective metal housing. Reflector buttons shall withstand being immersed in ice water at 2 C for 30 minutes, then transferred to hot water at 90 C for 10 minutes, cooled under tap water, and the operation repeated for three cycles of cooling and heating, and then placed in a damp room with a temperature of 70 F and left for 3 days without affecting its luminosity or reflecting ability a sufficient amount to be detected when tested buttons are compared with untested buttons.

The reflectors, if made of acrylic plastic, shall withstand without visible damage the following tests:

Seal Test. The following test shall be used to determine if a reflector is adequately sealed against dust and water. Submerge 50 samples in water bath at room temperature. Subject the submerged samples to a vacuum of five inch gauge for five minutes. Restore atmospheric pressure and leave samples submerged for five minutes, then examine the samples for water intake. Failure of 2 or more buttons per 50 tested shall be cause for rejection.

Heat Resistance Test. Three reflectors shall be tested for four hours in a circulating air oven at 175 degrees plus or minus five degrees F. The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples after exposure to heat shall show no significant change in shape and general appearance when compared with corresponding unexposed control standards.

Corrosion Test. Where applicable the reflectors shall withstand the combined corrosion test set forth in ASTM Specification: B 117.

Reflector buttons shall be equipped with bases of suitable design to permit mounting in accordance with the plan details and these specifications.

(b) Reflex-Reflecting Sheet Material. Reflex-reflecting sheet material may be used in lieu of reflector buttons, and shall conform to the requirements governing the material and its application as outlined in the Association of American Railroad Signal Specification 255 Manual Part 276.

(5) Masts, Adapter Clamps, Pinnacles and Split Type Bases for Crossbuck Signs. Four inch standard weight steel pipe masts shall be provided and installed as indicated on the plans. Steel shall be manufactured by the open hearth process. Castings of adapter clamps, pinnacles and split type base shall be in accordance with the details shown on the plans and shall be gray iron conforming to the requirements of the Standard Specifications for Gray Iron Castings, ASTM Designation: A 48, ASTM Class 20. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. Iron castings shall be true to pattern, form and dimensions, free from pouring faults, sponginess, cracks, blowholes and other defects in positions affecting their strength and value for the service intended. Anchor bolts, "U" bolts and bolts used in attaching the crossbuck to the adapter clamp shall be of steel that has been manufactured by the open hearth process and shall be suitably protected against corrosion. Masts, pinnacles, adapter clamps, split type bases and all of their accessories shall be thoroughly cleaned and then given one prime coat of red lead chromate or a suitable iron oxide primer of the long oil type on all surfaces, and then shall be painted with two evenly and smoothly applied coats of aluminum paint of high quality acceptable to the Engineer. Stripes on masts shall consist of synthetic enamel, being of black eggshell finish, applied in three top coats, each being smoothly and evenly applied. All paint shall be applied in accordance with the pattern and dimensions shown on the plans.

(6) Concrete Bases for Crossbuck Signs. Concrete for concrete bases of crossbuck signs shall be constructed in accordance with the plans. All concrete shall be Class "A". Materials, methods of construction and workmanship shall

be in accordance with the Item, "Concrete for Structures (Natural Aggregate)". All exposed surfaces shall receive a Type 1 finish in accordance with the Item, "Concrete Structures". Conduit shall be installed in bases as indicated on the plans. Each end of the conduit shall be capped to prevent the entrance of foreign materials.

570.3. Construction Methods. Crossbuck signs shall be assembled and installed complete in place in accordance with these specifications and the plan details, at the locations shown on the plans or as altered by the Engineer. Concrete bases for crossbuck signs shall be poured in excavated holes. After the concrete bases are completed the removed material shall be backfilled and securely tamped. Excess material shall be disposed of as directed by the Engineer. Following the installation of the signs, any existing railroad or highway crossing signs in place at or near the crossing prior to installation of the new signs shall then be removed and delivered to the State Highway Department on the adjacent highway right of way.

570.4. Measurement. Measurement will be made of each complete unit of "Metal Series Railroad Crossing Signs", each unit consisting of two crossbuck signs. Each crossbuck sign shall be complete with pinnacle, adapter clamp, split type base, anchor bolts, conduit, concrete base, reflector buttons, all bolts, nuts, screws, paint and painting and incidentals necessary for the complete sign, 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 580

STRUCTURE FOR FIELD OFFICE AND LABORATORY

580.1. Description. This specification shall govern for the erection of a building to be used by the Engineer during

580.2 to .3

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 one of the types hereinafter described. The type to be furnished will be designated on the List of Governing Specifications included in the proposal and contract.

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 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 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.

The Contractor will not be required to furnish a stove or fuel for the heating of the building.

580.3. Type of Structure.

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.

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.

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.

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.

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.

580.4. Payment. No direct compensation will be made to the Contractor for the work and materials involved in providing the Field Office, Field Laboratory or Field Office and Laboratory as the case may be. Such work and materials shall be considered subsidiary to the several items of work for which unit prices are requested in the proposal.

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 (Natural Aggregate)". 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 (Natural Aggregate)".

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.

PART II, CONSTRUCTION DETAILS**DIVISION VI, LIGHTING****ITEM 610****ROADWAY ILLUMINATION ASSEMBLIES
(Aluminum)**

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.

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

610.4 to 611.3

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 materials 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 611

ROADWAY ILLUMINATION ASSEMBLIES (Steel)

611.1. 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.

611.2. 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.

611.3. 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.

611.4. Measurement. Roadway Illumination Assemblies will be measured as each of the several types of assemblies, complete in place.

611.5. 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 "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 612

ROADWAY ILLUMINATION ASSEMBLIES (Concrete)

612.1. 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.

612.2 to .5

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.

612.2. 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.

612.3. 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.

612.4. Measurement. Roadway Illumination Assemblies will be measured as each of the several types of assemblies, complete in place.

612.5. 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 "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 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. Material. 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,

640.1 to .3

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 ferrous, non-ferrous and polyvinyl chloride conduit shall bear evidence of approval by Underwriters' Laboratories.

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 incasement. Joints shall be of the tapered coupling type.

640.3. Construction Methods. The conduits, 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; 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

350.5 to 660.2

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 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 POLE

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

680.1 to .5

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 STATION

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 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 State of Texas 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.

**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 are
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, and approved by the U. S. Bureau of Public Roads.

Item.....

Item.....

Required Provisions: Required Provisions—Federal-Aid

Contracts

Special Provisions: Special Provisions shall govern and take precedence over the specifications enumerated hereon wherever in conflict therewith.

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.

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 of the State of Texas payable to the order of the Texas State Highway Commission for.....
Dollars (\$.....).

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

Address

my
Please return our bidders check to

Name

Address

Address

*NOTE: Signatures to comply with paragraph 2.5 of the standard specifications.

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 30665-45452.

RECOMMENDED FOR EXECUTION:

Engineer of Aid Projects

Construction Engineer

CONTRACTOR
Party of the Second Part

(Print Firm Name)

By:-----
(Title)

By:-----
(Title)

By:-----
(Title)

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.

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.

CONSTRUCTION ESTIMATE

Highway No. District No.
 County No.
 Project
 Control No. Sec. Job

Estimate Period
 From 19... to 19...
 On first estimate and final estimate use actual work dates
 For
 Contractor

ESTIMATE NO.

Item	Unit of Measure	Project Estimate Quantities	Total Work Done on Contract	Contract Price	Amount

<p>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:</p>	<p>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:</p>
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APPROVED:
 Resident Engineer Date
 District Engineer or Engineer-Manager Date
 Construction Engineer Date
 Bridge Engineer Date

Total Amount of Work Done. \$
 Less Retainage. \$
 Difference. \$
 Less Special Deductions. \$
 Less Liquidated Damage. \$
 Less Previous Payments. \$
 Amount Due This Estimate. \$

PART IV, INDEX

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
104	REMOVING OLD CONCRETE	
	Remov Old Conc (of type specified)	SY
	Remov Old Conc (of type specified)	CY
	Remov 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	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
130	BORROW	
	Uncl Borrow (Ord Comp)	CY
	Rock Borrow (Ord Comp)	CY
	Com Borrow (Ord Comp)	CY
	Uncl Borrow (Dens Cont)	CY
	Rock Borrow (Dens Cont)	CY
	Com Borrow (Dens Cont)	CY
	Refers to Items 132 and 140	
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 and Placing Topsoil	Sta
	Salv and Placing Topsoil	CY
	Refers to Items 100, 102, 204, 210, 211, 212, 213, 214, 215 and 216	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
162	SODDING FOR EROSION CONTROL	
	Spot Sodding	SY
	Block Sodding	SY
	Grass Retards	SY
	Broadcast Sprigging	CY
	Mulch Sodding	CY
	Refers to Items 166 and 204	
164	SEEDING FOR EROSION CONTROL	
	Broadcast seeding (of type specified)	SY or Ac
	Disked Seeding (of type specified)	SY or Ac
	Straw Mulch Seeding (of type specified)	SY or Ac
	Asph Mulch 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 Rdwy	Sta
190	ROADSIDE PLANTING	
	Vine	Ea
	Shrub	Ea
	Tree	Ea
200	STRIPPING	
	Stripping	CY
204	SPRINKLING	
	Sprinkling	MG
210	ROLLING (FLAT WHEEL)	
	Rolling (Flat Wheel)	Hr
	Refers to Item 204	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
211	ROLLING (TAMPING) Rolling (Tamping) Refers to Items 204 and 212	Hr
212	ROLLING (HEAVY TAMPING) Rolling (Hvy Tamping) Refers to Item 204	Hr
213	ROLLING (PNEUMATIC TIRE) Rolling (Light Pneum Tire) Rolling (Medium Pneum Tire) (of the type specified) Refers to Item 204	Hr Hr
214	ROLLING (HEAVY PNEUMATIC) Rolling (Hvy Pneum) Refers to Item 204	Hr
215	ROLLING (GRID) Rolling (Grid) Refers to Item 204	Hr
216	ROLLING (PROOF) Rolling (Proof) Refers to Item 204	Hr
230	ROADBED TREATMENT Rdbed Treat (Ord Comp) (of the type specified) Rdbed Treat (Ord Comp) (of the type specified) Rdbed Treat (Dens Cont) (of the type specified) Rdbed Treat (Dens Cont) (of the type specified) Addl Qtr Mi Haul Addl Qtr Mi Haul Refers to Items 204, 210, 211, 212, 213, 214, 215, 216 and 500	CY Ton CY Ton CY Ton

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
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 Cont) (of the type and grade specified)	CY
	Flex Base (Dens Cont) (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, 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

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
236	FLEXIBLE BASE (BANK RUN GRAVEL)—Continued	
	Flex Base (Dens Cont) (of the grade specified)	Ton
	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
	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
	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		

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
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
	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	
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	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
248	FLEXIBLE BASE	
	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 (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
	Sand Admix	CY
	Caliche Admix	CY
	Addl Qtr Mi Haul	CY
	Addl Qtr Mi Haul	Ton
	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	
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, 212, 213, 214, 215 and 216	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
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	
270	PORTLAND CEMENT TREATMENT FOR MATERIALS IN PLACE	
	Portland Cement	Bbl
	Cement Treat (Exist Matl)	SY
	Refers to Item 500	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
272	PORTLAND CEMENT TREATMENT FOR BASE COURSES	
	Portland Cement	Bbl
	Refers to Item 500	
280	SOIL ASPHALT BASE (ROAD MIX)	
	Soil Asph Base	SY
	Addl Soil	CY
	Addl Soil	Ton
	Asph Matl	Gal
	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	
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	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
316	SEAL COAT	
	Aggr (of the type and grade specified)	CY
	Aggr (Stkpl) (of the type and grade specified)	CY
	Asph (of the type and grade specified)	Gal
	Refers to Items 210, 213, 300, 302 and 304	
320	ONE COURSE SURFACE TREATMENT	
	Aggr (of the type and grade specified)	CY
	Aggr (Stkpl) (of the type and grade specified)	CY
	Asph (of the type and grade specified)	Gal
	Refers to Items 210, 213, 300, 302 and 304	
322	TWO COURSE SURFACE TREATMENT	
	Aggr (of the 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, 302 and 304	
324	THREE COURSE SURFACE TREATMENT	
	Aggr (of the 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, 302 and 304	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
330	COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT (CLASS A)	
	Cold Mix LRA Pvt (of the types specified)	Ton
	Tack Coat	Gal
	Refers to Items 213, 300, 310 and 500	
332	COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT	
	Cold Mix LRA Pvt (of the types specified)	Ton
	Tack Coat	Gal
	Refers to Items 213, 300, 310 and 500	
340	HOT MIX ASPHALTIC CONCRETE PAVEMENT (CLASS A)	
	Asph	Ton
	Aggr (of the types specified)	Ton
	Tack Coat	Gal
	Refers to Items 213, 300, 310 and 500	
346	HOT MIX ASPHALTIC CONCRETE PAVEMENT (CLASS AA)	
	Asph	Ton
	Aggr (of the types specified)	Ton
	Tack Coat	Gal
	Refers to Items 213, 300, 310 and 500	
350	HOT MIX-COLD LAID ASPHALTIC CONCRETE PAVEMENT (CLASS A)	
	Hot Mix-Cold Laid ACP (of the types specified)	Ton
	Tack Coat	Gal
	Refers to Items 213, 300, 310 and 500	
352	HOT MIX-COLD LAID ASPHALTIC CONCRETE PAVEMENT	
	Hot Mix-Cold Laid ACP (of the types specified)	Ton
	Tack Coat	Gal
	Refers to Items 213, 300, 310 and 500	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
360	CONCRETE PAVEMENT (WATER CEMENT RATIO)	
	Conc Pvt	SY
	Conc Pvt	CY
	Conc Pvt (HS)	SY
	Conc Pvt (HS)	CY
	Mono Curb	LF
	Refers to Items 110, 130, 150, 204, 210, 211, 212, 213, 214, 215, 216, 300, 420, 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 HG Stl)	SY
	Conc Pvt (Contin Reinf HG Stl)	CY
	Conc Pvt (Contin Reinf HY Stl)	SY
	Conc Pvt (Contin Reinf HY Stl)	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	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
372	ASPHALT SUBGRADE MEMBRANE	
	Asph (of the type and grade specified)	Gal
	Sand	CY
	Refers to Item 300	
400	STRUCTURAL EXCAVATION	
	Uncl Struct Excav	CY
	Rock Struct Excav	CY
	Com Struct Excav	CY
	Uncl Struct Excav (of the class specified)	CY
401	EXCAVATION AND BACKFILL FOR SEWERS	
	Sew Excav	CY
	Cement Stab Backfill	CY
	Refers to Items 421 and 464	
405	TEST LOAD PILING	
	Test Load	Ea
	Refers to Item 404	
406	TIMBER PILING	
	Treat Tim Piling (Treatment)	LF
	Treat Tim Test Piling (Treatment)	EA
	Untreat Tim Piling	LF
	Untreat Tim Test Piling	EA
	Refers to Items 404, 405 and 492	
407	STEEL PILING	
	Stl H Piling (of the specified size and weight)	LF
	Stl H Test Piling (of the specified size and weight)	LF
	Sheet Piling	SF
	Refers to Items 404, 405, 420, 421, 441, 442, 446 and 448	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
408	METAL SHELL PILING	
	Metal Shell Piling (of the size specified)	LF
	Metal Shell Test Piling (of the size specified)	LF
	Refers to Items 404, 405, 420, 421, 440, 442, 446 and 448	
409	CONCRETE PILING	
	Conc Piling (of the size specified)	LF
	Conc Test Piling (of the size specified)	LF
	Refers to Items 404, 405, 412, 420, 421, 426, 440 and 448	
410	DISPLACEMENT PILING	
	Displ Piling (of the size specified)	LF
	Displ Test Piling (of the size specified)	LF
	Refers to Items 404, 405, 408, 409 and 412	
412	PRESTRESSED CONCRETE PILING	
	Prestr Conc Piling (of the size specified)	LF
	Prestr Conc Test Piling (of the size specified)	LF
	Refers to Items 404, 405, 409, 420, 421, 423, 425, 426 and 440	
416	DRILLED SHAFT FOUNDATIONS	
	Drilled Shaft (of the specified diameter)	LF
	Test Hole (of the specified diameter)	LF
	Bell Footings	CY
	Test Bell (of the specified diameter)	Ea
	Refers to Items 420, 421 and 440	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
421	CONCRETE FOR STRUCTURES (NATURAL AGGREGATE)	
	Class (Various Classes) Conc (Various Classifications)	CY
	Class (Various Classes) Conc	CY
	Refers to Items 420, 425, 426, 437, 442, 498, 500 and 502	
423	LIGHTWEIGHT CONCRETE FOR STRUCTURES	
	Class X Conc (Various Classifications)	CY
	Class Y Conc (Various Classifications)	CY
	Class X Conc	CY
	Class Y Conc	CY
	Refers to Items 420, 421, 425, 437, 442, 498, 500 and 502	
425	PRESTRESSED CONCRETE STRUCTURES	
	Prestr Conc Beams (of the type specified)	LF
	Prestr Conc Span	Ea
	Prestr Conc Member (specify name and type)	LF
	Prestr Conc Member (specify name and type)	Ea
	Refers to Items 409, 420, 426 and 498	
426	PRESTRESSING	
	Prestressing	LS
	Refers to Items 409, 412, 421, 423, 425, 440, 441 and 442	
430	EXTENDING CONCRETE STRUCTURES	
	Class (Various Classes) Conc for Ext Str (of various classifications)	CY
	Class (Various Classes) Conc for Ext Str	CY
	Refers to Items 400, 420, 421, 423, 440 and 448	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
431	PNEUMATICALLY PLACED CONCRETE Pneum Placed Conc (of type specified) SF Refers to Items 420, 421 and 440	
432	RIPRAP Riprap (of various classifications shown) Refers to Items 400, 420, 421, 431 and 440	CY
440	REINFORCING STEEL Reinf Stl Refers to Item 448	Lb
442	METAL FOR STRUCTURES Struct Stl Struct Stl (I Beam) Struct Stl (Pl Girder) Struct Stl (of other classifications shown on plans) Refers to Items 441, 446 and 448	Lb Lb Lb Lb
446	PAINT AND PAINTING Clean and Paint Exist Str	LS
450	RAILING Rail (of classification and type shown on plans) Refers to Items 420, 421, 423, 425, 426, 435, 440, 441, 442, 446 and 448	LF
451	REMOVING AND REPLACING RAILING Remov and Repl Rail (of the type specified) Refers to Item 446	LF
452	REMOVING RAILING Remov Rail (of the type specified) Refers to Item 430	LF

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
453	TEMPORARY RAILING	
	Temp Rail	LF
	Refers to Items 446 and 450	
458	WATERPROOFING	
	Memb Waterproofing (of the type specified)	SY
	Waterproofing (of the type specified)	SY
459	DAMPPROOFING	
	Dampproofing	SY
	Refers to Item 458	
460	CORRUGATED GALVANIZED METAL PIPE	
	CGM Pipe (of the size specified)	LF
	CGM Pipe (Perf) (of the size specified)	LF
	CGM Pipe (Bit Ctd) (of the size specified)	LF
	CGM Pipe (Asph Bnd) (of the size specified)	LF
	CGM Pipe Arch (of the design specified)	LF
	CGM Pipe Arch (Bit Ctd) (of the design specified)	LF
	CGM Pipe Arch (Bit Ctd Pvd Inv) (of the design specified)	LF
	CGM Pipe Arch (Asph Bnd) (of the design specified)	LF
	CGM Pipe Arch (Asph Bnd Pvd Inv) (of the design specified)	LF
	CGM Pipe (Bit Ctd Inv) (of the size specified)	LF
	CGM Pipe (Asph Bnd Pvd Inv) (of the size specified)	LF
	Refers to Item 400	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
461	STRUCTURAL PLATE PIPES, PIPE ARCHES, AND ARCHES	
	Struct Pl Pipe (of the size specified)	LF
	Struct Pl Pipe Arch (of the size specified)	LF
	Struct Pl Arch (of the size specified)	LF
	Refers to Items 400, 420, 421 and 440	
464	REINFORCED CONCRETE PIPE CULVERTS	
	Reinf Conc Pipe (of the class and size specified)	LF
	Refers to Items 400 and 421	
465	PIPE SEWERS	
	Pipe Sew (of the class and size specified)	LF
	Refers to Items 401, 420, 421, 440 and 464	
470	MANHOLES AND INLETS	
	Manhole (Complete) (of the type specified)	Ea
	Manhole (Stage I) (of the type specified)	Ea
	Manhole (Stage II) (of the type specified)	Ea
	Inlet (Complete) (of the type specified)	Ea
	Inlet (Stage I) (of the type specified)	Ea
	Inlet (Stage II) (of the type specified)	Ea
	Inlet Ext	Ea
	Refers to Items 400, 420, 421, 440, 441, 442 and 471	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
471	FRAMES, GRATES, RINGS, AND COVERS	
	Grate	Ea
	Frame	Ea
	Grate and Frame	Ea
	Frame and Cover	Ea
	Ring and Cover	Ea
	Refers to Items 446 and 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, 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 specified)	LF
	Jack, Bor or Tunnel Pipe (of type, size and class specified)	LF
	Refers to Items 460 and 464	
479	ADJUSTING MANHOLES AND INLETS	
	Adj Manholes	Ea
	Adj Inlets	Ea
	Adj Manholes and Inlets	Ea
	Refers to Items 401 and 470	
491	TIMBER FOR STRUCTURES (DOUGLAS FIR AND SOUTHERN YELLOW PINE)	
	Treat Tim (of the treatment specified)	MFBM
	Untreat Tim	MFBM
	Refers to Items 490 and 492	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
496	REMOVING OLD STRUCTURES	
	Remov Old Str (Large)	Ea
	Remov Old Str (Small)	Ea
	Remov Old Str (Pipe)	LF
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 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	

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
530	CEMENT STABILIZED RIPRAP Cement Stab Riprap Refers to Items 360, 420, 421 and 531	CY
540	ROCK RETARDS Rock Retards	CY
542	GROUTED ROCK RETARDS Grouted Rock Retards Refers to the Item 531	CY
544	CONCRETE RETARDS Conc Retards Refers to Items 421 and 531	CY
550	RIGHT OF WAY MARKERS Right of Way Markers (of the type specified) Instal Right of Way Markers Remov and Repl Right of Way Markers Refers to Items 420, 421 and 440	Ea Ea Ea
560	METAL BEAM GUARD FENCE Metal Beam Gd Fence (of the class specified) Metal Beam Gd Fence (Bar) (of the class specified) Al Beam Gd Fence (of the class specified) Al Beam Gd Fence (Bar) (of the class specified) Painted Stl Beam Gd Fence (of the class specified) Painted Stl Beam Gd Fence (Bar) (of the class specified) Galv Stl Beam Gd Fence (of the class specified) Galv Stl Beam Gd Fence (Bar) (of the class specified) Refers to Items 450 and 492	LF LF LF LF LF LF LF LF

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
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 Refers to Item 560	LF
563	TIMBER POST GUARD FENCE Timber Post Gd Fence (Painted) Timber Post Gd Fence Refers to Item 492	Ea Ea
564	PLACING TIMBER POST GUARD FENCE Plac Timber Post Gd Fence	Ea
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) Gate (of the type, height and opening shown on the plans) Refers to Item 492	LF Ea
568	CHAIN LINK BARRIER FENCE Chain Link Barrier Fence (of the height specified) Pedestrian Gate (of the type, height and opening specified) Vehicular Gate (of the type, height and opening specified) Refers to Item 421	LF Ea Ea

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
570	METAL SERIES RAILROAD CROSSING SIGNS Met Ser RR Xing Signs Refers to Items 420 and 421	Ea
590	CONCRETE MEDIANS AND DIRECTIONAL ISLANDS Conc Med Conc Med Conc Directional Isl Conc Directional Isl Refers to Items 360, 420, 421, 440, 521 and 531	LF SY LF SY
610	ROADWAY ILLUMINATION ASSEMBLIES (ALUMINUM) Rdwy Illum Assem (of the types specified)	Ea
611	ROADWAY ILLUMINATION ASSEMBLIES (STEEL) Rdwy Illum Assem (of the types specified)	Ea
612	ROADWAY ILLUMINATION ASSEMBLIES (CONCRETE) Rdwy Illum Assem (of the types specified)	Ea
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 specified size and type)	LF

INDEX TO PAY QUANTITIES—Continued

Item	Description	Unit of Measurement
660	CIRCUIT PROTECTOR ASSEMBLY Circuit Protector Assem	Ea
670	SERVICE POLE Service Pole (of the types specified)	Ea
680	TRANSFORMER STATION Transformer Sta (of the types specified)	Ea

