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STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION

Edition 1925

THE STATE OF TEXAS

TEXAS DEPARTMENT OF TRANSPORTATION

STATE OF TEXAS
STATE HIGHWAY DEPARTMENT

STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION

Edition 1925

STATE HIGHWAY COMMISSION
STATE HIGHWAY ENGINEERING DEPARTMENT

TEXAS STANDARD SPECIFICATIONS - MARCH 1925.

E R R A T A

P. 1-1615-2 - Last line - Strike out "are," insert "not."

P. 10-25-1616-5 - Fifth paragraph - Strike out "trench" before "drains."

P. 10-25-1616-7 - Paragraph "Description" under item 18, first line insert "shall" after "item;" second line after "pits" strike out "on," insert "or."

P. 10-25-1616-12 - Last paragraph - Strike out "per square yard."

P. 31-44-1617-6 - Paragraph "Materials" - Strike out "formed," insert "found."

P. 31-44-1617-13 - First paragraph, second line - Strike out "of" before "broken," insert "or."

P. 31-44-1617-14 - Last paragraph, fifth line after "delivering on the road" insert "and rolling."

P. 31-44-1617-18 - Paragraph "Joints," first line - Strike out "Surface," insert "Base."

P. 50-71-1618-1 - Paragraph "Material," third line - Strike out "designed," insert "designated."

P. 50-71-1618-2 - Last paragraph, seventh line - Strike out "furnishing," insert "finishing."

P. 50-71-1618-5 - First paragraph, second line - Strike out "furnishing," insert "finishing."

P. 50-71-1618-6 - Paragraph "Materials," second line - Strike out "formed," insert "found."

P. 50-71-1618-18 - Tabulation under "Cover Stone," second line - Strike out "Passing 1/4 inch screen," insert "Passing 1/2 inch screen."

P. 50-71-1618-25 - Tabulation under "Coarse Aggregate," - Strike out "Total passing 3/4 inch screen 15 to 75 per cent," insert "Total passing 3/4 inch screen 45 to 75 per cent."

P. 50-71-1618-25 - Paragraph captioned "Fine Aggregate" - Strike out "or a combination of one or more sands or stone screenings," insert "or a combination of one or more sands and stone screenings."

P. 50-71-1618-25 - Tabulation bottom page requirement for material passing 80 mesh, retained on 200 mesh - Strike out "10 to 40 per cent," insert "18 to 40 per cent."

P. 50-71-1618-25 - After tabulation at bottom of page prescribing grading for material passing the 10 mesh sieve add "Of the material passing the 200 mesh sieve as above prescribed, at least one half shall be Mineral Filler."

P. 50-71-1618-39 - Second paragraph, next to last line - Strike out "bags of cement," insert "bags of cement of 94 pounds each."

P. 50-71-1618-41 - Fourth paragraph, next to last line - Strike out "building or pedestals," insert "building of pedestals."

P. 50-71-1618-43 - Fifth paragraph - Insert "Joints" after "expansion;" same paragraph, next line - Strike out "expansion," insert "Center."

P. 50-71-1618-25 - Paragraph captioned "Fine Aggregate" - Strike out "or a combination of one or more sands or stone screenings," insert "or a combination of one or more sands and stone screenings."

P. 50-71-1618-43 - Sixth paragraph, second line - Strike out "at the joints," insert "at the points."

P. 50-71-1618-45 - Third paragraph, fourth line - Strike out "not less than eighteen guage," insert "not more than eighteen guage." Same page, fourth paragraph - Strike out "Joints or other materials," insert "Joints of other materials."

P. 50-71-1618-45 - Last paragraph - Strike out "Unless otherwise specified or permitted by the State Highway Engineer."

P. 50-71-1618-46 - Third paragraph, after first sentence, - Insert this sentence, "The belt used shall be a flexible canvas or rubber belt, not less than 8 inches wide and not less than 2 feet longer than the width of the pavement."

P. 50-71-1618-46 - Fifth paragraph, third line - Strike out "strike board," insert "strike boards."

P. 50-71-1618-49 - First paragraph, third line - Strike out "structures," insert "pavements."

P. 80-81-1619-1 - Third paragraph - Strike out "If it is possible to proceed," insert "if it is impossible to proceed."

P. 80-81-1619-3 - Next to last paragraph - Strike out "French."

P. 83-94-1622-2 - Strike out "7" before caption "Untreated Timber," insert "6."

P. 83-94-1622-4 - Fifth paragraph - Strike out caption "K Pins."

P. 83-94-1622-5 - First paragraph, fourth line - Strike out "Heads of piles," insert "Heads of struts and piles." Next to last paragraph, last sentence - Strike out "Any concrete masonry," insert "Any piling, concrete masonry."

P. 83-94-1622-6 - Tabulation - Strike out "Vitrified clay," insert "Vitrified clay and corrugated galvanized metal."

P. 83-94-1622-8 - First paragraph - Strike out "bags of cement," insert "bags of cement of 94 pounds each."

P. 83-94-1622-10 - Paragraph "Hydrated Lime," fifth line - Strike out "correct specifications," insert "current specifications."

P. 100-120-1623-6 - Fourth paragraph - Strike out "except that the heads of piles need not be coated with protective paint."

P. 100-120-1623-6 - After fifth paragraph insert "After the necessary cutting has been done to receive the cap, the heads of piles shall be given three coats of hot creosote oil. They shall then be covered with a coat of hot tar pitch over which shall be placed a sheet of 3-ply roofing felt or galvanized iron, or a covering may be built up of alternate layers of hot tar pitch and loose woven fabric similar to membrane water-proofing, using four layers of pitch and three of the fabric. The cover shall measure at least six inches more in each dimension than the diameter of the pile, and shall be bent down over the pile and the edges fastened with large headed nails, or secured by binding with galvanized wire. After the cover is in place the cap shall be placed and drift-bolted as prescribed."

P. 1624-2 - Top line - Insert "quarter" before "mile."

P. 1624-4 - Strike out "Relaying Pipe per linear foot for the sizes prescribed,"

Insert "Relaying Culvert Pipe 18" diameter and under per linear foot."

"Relaying Culvert Pipe over 18" diameter per linear foot."

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GENERAL REQUIREMENTS AND COVENANTS

1. DEFINITION OF TERMS.

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

State. The State of Texas.

Commission. The State Highway Commission of Texas.

Department. The State Highway Department of Texas.

State Highway Engineer. State Highway Engineer of Texas.

County. The party of the first part in the accompanying contract.

Engineer. County or Resident Engineer of a County, duly authorized by the State Highway Engineer, acting directly or through an assistant.

Inspector. The authorized representative of the Engineer assigned to make detailed inspection of any or all portions of the work, and materials involved in this contract.

Bidder. Any individual, firm or corporation submitting a proposal.

Contractor. The Party of the Second Part; the individual, firm, or corporation acting for or in behalf of the Contractor in the execution of all or of any part of the work.

Superintendent. Authorized representative for the contractor on the work at all times, authorized to receive and fulfill instructions from the Engineer and capable of superintending the work efficiently.

Surety. The corporate body which is bound with and for the Contractor, who is primarily liable, and which engages to be responsible for his payment of all debts pertaining to and for his acceptable performance of the Work for which he has contracted.

Laboratory. The testing laboratories of the University of Texas and of A. & M. College or any other testing laboratory that might be designated or approved by the State Highway Engineer.

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

Proposal Guaranty. The security designated in the proposal, to be furnished by the Bidder as a Guaranty of good faith to enter into a Contract if the work is awarded to him.

Plans. The official approved plans, profiles, typical cross section, general cross section, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions, and details of the work to be done, and which are to be considered as a part of the contract supplementary to these specifications.

Specifications. The directions, provisions, and requirements contained herein as supplemented by such "Special Provisions" and "Supplemental Agreements" as may be necessary, pertaining to the method and manner of performing the work or to quantities and qualities of materials to be furnished under the contract. "Special Provisions" are intended to cover work appertaining to a particular project and proposed in the estimate, but not satiscaftorily covered by these general specifications. Special Provisions will govern the work and take precedence over the general specifications wherever in conflict therewith. "Supplemental Apreegments" are written agreements executed by the Contractor and Engineer, approved by the State Highway Engineer, covering alterations and unforeseen work incidental and necessary to the project.

Contract. The agreement between the Parties of the First and Second Part covering the performance of the work and the furnishing of materials in the construction of same. The Contract shall include the "Proposal", "Plan", "Specifications", "Special Provisions", and "Contract Bond", also any and all supplemental Agreements which are required to complete the construction of the work.

Contract Bond. The approved form of security furnished by the Contractor and his Surety as a guaranty of good faith on the part of the Contractor to execute the work in accordance with the terms of the Contract.

Highway. The whole right-of-way which is reserved for and secured for use in constructing the roadway and its appurtenances.

Roadway. That portion of the highway included between the outside lines of slopes, gutters, or side ditches, including also the appertaining structures, and all slopes, ditches, channels, waterways, etc., necessary to proper drainage.

Roadbed. That portion of the roadway between the inside edges of slopes of ditches and tops of fill slopes; the "subgrade" plus the "Shoulders".

Subgrade. That portion of the roadbed upon which the surface Course or Pavement is to be placed.

Bridges. Structures of over 20-foot span measured under the copings along the center line of the road, and mutiple span structures where the individual spans are in excess of 10 feet.

Culverts. All waterway structures not defined as bridges.

Temporary Structures. Any temporary structure or stream crossing, required to maintain traffic while constructing or reconstructing structures or parts of structures covered by the contract. The temporary structure shall include the earth approaches thereto.

Bridge Complete. Th entire structure, including both substructure and superstructure.

Substructure. All of that part of the structure below the bridge seats or below the spring lines of concrete arches. Parapets, backwalls and wingwalls of abutments shall be considered as parts of the substructure.

Superstructure. All of that part of the structure above the bridge seats or above the spring lines of concrete arches.

The Work. All the work specified herein or indicated on the plans as the contemplated improvement.

2. PROPOSAL REQUIREMENTS AND CONDITIONS.

Contents of Proposal Forms: Bidder will be furnished with Proposal Forms which will state the location and description of the contemplated construction and will show the approximate estimate of the various quantities of work to be performed or materials to be furnished, with a schedule of items for which unit bid prices are asked, and the date and time and place of the opening of the Proposals. The "Notice of Contractor" and the "Special Provisions" will be attached to the Proposal Form.

Interpretation of Estimates: The quantities listed in the "Proposal Form" are to be considered as approximate and are to be used only for the comparison of bids. Payment to the Contractor will be made only for the actual quantities of work performed in accordance with the plans and specifications and if, upon completion of the Construction, the actual quantities shall either increase or decrease from the quantities given in the approximate estimate, the unit bid prices mentioned in the proposal will still prevail, except as otherwise herein provided for. The right is reserved to increase or decrease any or all of the amounts given in the estimate of approximate quantities as shown in the "Proposal Form", and it is understood that the length of the improvement, the quantities of work to be done, and materials to be furnished may be increased or diminished not exceeding 20 per cent of the total length of the improvement or of the total amount of work or materials of any one item, without in any way invalidating the bid prices.

Examination of Plans, Specifications, Special Provisions, and Site of Work: The bidder is required to examine carefully the site of, and the proposal, plans, specifications and contract form for the work contemplated, and it will be assumed that he has judged for and satisfied himself as to the conditions to be encountered, as to the character quality and quantities of work to be performed and materials to be furnished, and as to the requirements of these specifications, special provisions, and contract.

Preparation of Proposal: The bidder must submit his proposal on the form above described. The blank spaces in the proposal must be filled in correctly, where indicated, for each and every item for which a quantity is given, and the bidder must state the prices (written in ink, both in words and numerals) for which he proposes to do each item of the work contemplated. The bidder shall sign his proposal correctly. If the proposal is made by an individual, his name and post-office address must be shown. If made by a firm or partnership, the name and post-office address of each member of the firm or partnership must be shown. If made by a corporation, the person signing the proposal must show the name of the State under the laws of which the corporation was chartered and the names, titles and business address of the President, Secretary and Treasurer.

Rejection of Proposals Containing Alterations, Erasures or Irregularities. Proposals may be rejected if they show any alteration of form, additions not called for, conditional or alternate bids, incomplete bids, erasures, or irregularities of any kind.

Proposal Guaranty: No proposal will be considered unless accompanied by a "Proposal Guaranty", of the character and amount indicated in the proposal form.

Delivery of Proposals: Each proposal shall be placed, together with the proposed guaranty, in a sealed envelope so marked as to indicate its contents without being opened. This envelope shall then be placed in another which shall be sealed and addressed as indicated in the "Notice to Contractors". Proposals will be received on the hour and date set for the opening thereof and must be in the hands of the official indicated by that time.

Withdrawal of Proposals: A bidder may withdraw his proposal provided the request in writing is in the hands of the official indicated in the "Notice to Contractors" by the time set for opening proposals. When such proposal is reached, it will be returned to the bidder unread.

Public Opening of Proposals: Proposals will be opened and read publicly at the time and place indicated in the "Notice to Contractors". Bidders or their authorized agents are invited to be present.

Disqualification of Bidders: More than one proposal from an individual, a firm or partnership, a corporation or an association under the same or different names will not be considered. Reasonable ground for believing that any bidder is interested in more than one proposal for the work contemplated will cause 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 obviously are unbalanced may be rejected. No contract will be awarded except to responsible bidders capable of performing the class of work contemplated.

Competency of Bidders: Bidders must be capable of performing the various items of work bid upon. They may be required to furnish a statement covering experience on similar work, a list of machinery, plant and other equipment available for the proposed work, and such statements of their financial resources as may be deemed necessary

Material Guaranty: Before any contract is awarded the Bidder may be required to furnish a complete statement of the origin, composition and manufacture of any or all materials to be used in the construction of the work, together with samples, which samples may be subjected to the tests provided for in these specifications to determine their quality and fitness for the work.

3. AWARD AND EXECUTION OF CONTRACT.

Consideration of Bids: For the purpose of award, after the Proposals are opened and read, the correct summation of the products of the approximate quantities shown in the Proposal, by the unit bid prices will be considered the amount of the bid. The amounts will then be compared and the results of such comparison will be immediately made public. Until the final award of the contract, however, the right will be reserved to reject any and all proposals and to waive technical errors as may be deemed best for the interests of the State.

Award of Contract: The Award of the contract, if it be awarded, will be to the lowest responsible bidder whose proposal shall comply with all the requirements necessary to render it formal. The award, if made, will be within 30 days after the opening of the proposals, but in no case will an award be made until all necessary investigations are made into the responsibility of the bidder to whom it is proposed to award the contract.

Return of Proposal Guaranties: Certified checks or Cashier's checks will be returned to the unsuccessful bidders within ten (10) days after contracts have been awarded.

Execution of Contract and Bond: The Contractor must execute and file a contract and a good and sufficient bond in full amount of the contract price executed by some Surety Company authorized to do business in the State of Texas, in compliance with Chapter 99 General Laws of the Regular Session of the 33rd Legislature, 1913, and Chapter 127, Acts Regular Session 38th Leg. S. B. 406, as a guaranty of his faithful performance of said contract, and the payment of all obligations incurred for material and labor in the performance of this work, both executed on the forms hereto attached, with the party of the first part within fifteen (15) days after written notification of award of contract.

Approval of Contract. All contracts require the approval of the State Highway Engineer before any construction work is started. Any materials delivered before such approval is given is entirely at the contractor's risk.

Failure to Execute Contract. It is hereby expressly understood and agreed upon, that, should the successful bidder refuse or neglect to execute the contract and bond within fifteen (15) days after being notified to do so, the amount of the certified check or cashier's check shall become the property of the party of the first part, not as a penalty, but as liquidated damages for such neglect or refusal.

4. SCOPE OF WORK.

Intent of Plans and Specifications: The intent is to prescribe a complete work or improvement which the Contractor undertakes to do, in full compliance with the Plans, these Specifications, the Special Provisions, Proposal and Contract. The Contractor shall perform all Earth Work, construct all Surface Courses, build all Structures and Incidental Construction, and perform Extra Work, all in accordance with the lines, grades, typical cross section and dimensions shown on the Plans. He shall furnish, unless otherwise provided in the Special Provisions or in the Contract, all materials, implements, machinery, equipment, tools, materials, supplies and labor necessary to the prosecution and completion of the work.

Special Work: Proposed construction or requirements not covered by these specifications will be covered by "Special Provisions" and performed or complied with by the Contractor.

Alteration of Plans or of Character of Work: The Engineer reserves the right to make such alterations in the plans or in the quantity of the work as may be considered necessary or desirable during the progress of the work to complete fully and perfectly the proposed construction provided such alterations do not change materially the original Plans and Specifications, or alter the length of the improvement, the quantities of work or materials to be done or furnished more than (20) per cent of the total. Such alterations shall not be considered as a waiver of any conditions of the Contract nor invalidate any of the provisions thereof. The Contractor shall perform the work as increased or decreased and no allowance will be made for anticipated profits.

Extra Work: Unforeseen work made necessary by alteration of plans or of work, or by other reasons, involving increased or decreased unit cost to Contractor, or work necessary to complete the proposed improvement, for which no price is provided in the contract, shall be deemed "Extra Work" and shall be performed by the contractor in accordance with the specifications and as directed; provided, however, that before any "Extra Work" is started a "Supplemental Agreement" shall be signed by both contracting parties or a written order from the Engineer to do the work on a Force Account Basis given the Contractor.

Maintenance of Detours: The designation and maintenance of detours and temporary structures necessary for public travel, which are not adjacent or contiguous to the project will be at the charge of the County or State unless otherwise provided in the Special Provisions. Other detours and temporary structures will be constructed and maintained by the Contractor and no allowance will be made therefor.

Removal and Disposal of Structures and Obstructions: All fences, buildings, structures of any character not necessary to the construction of the roadway, or other encumbrances upon or within the limits of the right of way shall be removed by the Contractor and carefully placed on the abutting property or otherwise disposed of, if and as required. This work will be paid for as "Extra Work", except as otherwise provided in these specifications.

Rights in and Use of Materials Found on the Work: The Contractor, with the approval of the Engineer, may use in the proposed construction suitable stone, gravel or sand found in the "Excavation", and will be paid for the excavation of such materials at the contract unit price therefor, but he shall replace at his own expense with other suitable material all of that portion of the material so removed and used as was contemplated for use in the embankments, back-fills, approaches, or otherwise. No charge for materials so used will be made against the Contractor except the replacement herein provided for. The Contractor shall not excavate or remove any material from within the highway location which is not within the excavation, as indicated by the slope and grade lines, without written authorization from the Engineer.

Final Clearing Up: Upon completion of the work and before acceptance and final payment shall be made, the Contractor shall clean and remove from the highway, footways and adjacent property all surplus and discarded materials, weeds, bushes, rubbish and temporary structures, restore in an acceptable manner all property, both public and private, which has been damaged during the prosecution of the work, and shall leave the site of the work in a neat and presentable condition throughout.

Upon the completion of any structure, all superfluous material, cofferdams, construction buildings and other temporary structures and debris resulting from construction shall be removed. Falsework Timbers and piles are to be removed to the ground level. Where work is in the stream, such debris shall generally be removed to the bed of the stream, or as may be specially directed. All materials shall be disposed of as directed by the Engineer and the stream channel, structure and roadway left in a neat and presentable condition. No special payment will be made for this work, its cost being included in the prices paid for the construction work.

4-1615-2

5. CONTROL OF THE WORK.

Authority of Engineer: The work shall be done under the direct supervision of the Engineer and to his satisfaction. The Engineer shall decide any and all questions which may arise as to the quality or acceptability of materials furnished and work performed and as to the manner of performance and rate of progress of the work and shall decide all questions which may arise as to the interpretation of the plans and specifications, and all questions as to the acceptable fulfillment of the contract on the part of the Contractor, as to disputes and mutual rights between the Contractor and Subcontractors under these Specifications affecting the integrity of the work, and as to compensation. His decisions shall be final and he shall have executive authority to enforce and make effective such decisions and orders as the Contractor fails promptly to carry out.

Engineer as Referee: It is mutually agreed by both parties to this Contract that the Engineer shall act as referee in all questions arising under the terms of this contract between the parties hereto and that the decision of the Engineer in such cases shall be final and binding upon both alike.

Plans. Plans will show in detail structures up to and including 20-foot spans, lines, grades, typical cross section of improvement, and general cross sections; plans also will show general features of bridges (over 20-foot span). Such Supplementary bridge plans, shop details, working drawings, etc., as are necessary shall be furnished by the Contractor, but shall not be used prior to approval. Authorized alterations will be endorsed on approved plans or shown on supplementary sheets.

Working drawings for steel structures shall consist of shop detail, erection and other working plans showing details, dimensions, sizes of material and other information necessary for the complete fabrication and erection of the metal work.

Working drawings for concrete structures shall consist of such detailed plans as may reasonably be required for the successful prosecution of the work and which are not included in the plans furnished by the Engineer. These may include plans for falsework, bracing, centering and form work, masonry layout diagrams and diagrams for bent reinforcement.

It is expressly understood that the approval by the Engineer of the Contractor's working drawings is general and such approval will not relieve the Contractor from any responsibility whatsoever.

The Contractor shall furnish the Engineer with such blue print copies of the working drawings as may be required for approval and for construction purposes and upon completion of the work the original tracings, if so required, shall be surrendered to the Engineer.

The contract price shall include the cost of furnishing all working drawings and the Contractor will be allowed no extra compensation for such drawings.

Conformity with Plans and Allowable Deviations: Finished surfaces in all cases shall conform with lines, grades, cross sections and dimensions shown on the approved plans. The crown, or rise of the finished surface of the roadway from the curb or side lines to the center line, shall be as shown on the typical cross section of the plans except at intersecting highways or wherever, to insure correct drainage or for other reasons, changes may be directed. On curves or at other places where deemed necessary the Contractor may be required to superelevate the roadway. Such other deviations from the plans, approved working drawings and specifications as may be required by the exigencies of construction, will in all cases be determined by the Engineer and authorized in writing.

Co-ordination of Plans, Specifications and Special Provisions: These specifications, the accompanying plans, special provisions and all supplementary documents 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 cooperative, to describe and provide for a complete work. In case of discrepancy, figured dimensions shall govern over scaled dimensions, plans shall govern over specifications, and special provisions shall govern over both specifications and plans.

Cooperation of Contractor: The Contractor will be supplied with two copies of the Plans, Specifications and Special Provisions, and he shall have available on the work at all times one copy each of said Plans and Specifications and Special Provisions. He shall give the work his constant attention to facilitate the progress thereof and shall cooperate with the Engineer in every way possible. He shall have at all times a competent and reliable English-speaking Superintendent on the work authorized to receive orders and to act for him. Such Superintendent shall be furnished by the Contractor regardless of how much of the Work may be Sub-let.

Construction Stakes. The Engineer will furnish and set construction stakes establishing lines and continuous profile grade in road work, and center line and benchmark for bridge work, and will furnish the Contractor with all necessary information relating to lines and grades. The Contractor shall furnish, free of charge, all additional stakes, all templates and other materials necessary for making and maintaining points and lines given. The Contractor shall be held responsible for the preservation of all stakes and marks and if, in the opinion of the Engineer, any of the Construction stakes or marks have been carelessly or willfully destroyed or disturbed by the Contractor, the cost of replacing them shall be charged against him and shall be deducted from the payment for the work.

Authority and Duties of Inspectors: Inspectors, approved by the State Highway Department shall be authorized to inspect all work done and all material furnished. Such inspection may extend to all or any part of the work and to the preparation or manufacture of the materials to be used. An Inspector shall be stationed on the construction 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 to the attention of the Contractor any such failure or other infringement; but such inspection shall not relieve the Contractor from any obligation to perform all of 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 shall have the authority to reject materials or suspend work until the question at issue can be referred to and decided by the Engineer. The Inspector shall not, however, be authorized to revoke, alter, enlarge, relax or release any requirements of these specifications, nor to approve or accept any portion of work, nor to issue instructions contrary to the plans and specifications. He shall in no case act as foreman or perform other duties for the Contractor, nor interfere with the management of the work. Any advice which the Inspector may give the Contractor shall in no wise be construed as binding the Engineer in any way, or as releasing the Contractor from the fulfillment of the terms of the contract.

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 specifications and contract. If the Engineer requests it, the Contractor shall, at any time before acceptance of the work, remove or uncover such portions of the finished work as may be directed. After examination the Contractor shall restore said portions of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the 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 by the Engineer or his representative.

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

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, and no compensation shall be allowed him for such removal or replacement. Work done beyond the lines and grades shown on the plans or as given, except as herein provided, or any extra work done without written authority will be considered as unauthorized and at the expense of the Contractor, and will not be measured or paid for. Work so done may be ordered removed at the Contractor's expense. Upon failure on the part of the Contractor to forthwith comply with any order of the Engineer made under the provisions of this article, the Engineer shall have authority to cause Defective Work to be remedied, or removed and replaced, and unauthorized work to be removed and such costs to be deducted from any moneys due or to become due the Contractor.

Final Inspection: Whenever the work provided and contemplated by the contract shall have been satisfactorily completed and the final cleaning up performed the Engineer shall, within ten days unless otherwise provided, make the "Final Inspection".

6. CONTROL OF MATERIAL.

Source of Supply and Quality of Materials: The source of supply of each of the materials shall be approved by the Engineer before the delivery is started. Representative preliminary samples of the character and quantity prescribed shall be submitted by the Contractor or producer for examination and tested in accordance with the methods referred to under tests of samples of materials. Only materials conforming to the requirements of these specifications and approved by the Engineer shall be used in the work. All materials proposed to be used may be inspected or tested at any time during their preparation and use. If, after trial, it is found that sources of supply which have been approved do not furnish a uniform product, or if the product from any source proves unacceptable at any time, the Contractor shall furnish approved material from other approved sources. No material which, after approval, has in any way become unfit for use shall be used in the work.

Samples and Tests. Tests of all materials specified will be made by the Engineer in accordance with the official approved methods described in United States Department of Agriculture Bulletin No. 1216, in so far as they apply and in any case only standard methods shall be used. When tests are made at places other than the Laboratory, the Contractor shall furnish every facility for the verification of all scales, measures and other devices which he operates.

Storage of Materials: Materials shall be stored so as to insure the preservation of their quality and fitness for the work.

Defective Materials: All materials not conforming to the requirements of these specffications shall be considered as defective, and all such materials, whether in place or not, shall be rejected and shall be removed immediately from the site of the work, unless otherwise permitted by the Engineer. No rejected material, the defects of which have been subsequently corrected, shall be used until approval has been given. Upon failure on the part of the Contractor to forthwith comply with any order of the Engineer made under the provisions of this article, the Engineer shall have authority to remove and replace defective material and to deduct the cost of removal and replacement from any moneys due or to become due the Contractor.

7. LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC.

Laws to be Observed: The Contractor is assumed to have made himself familiar with and at all times shall observe and comply with all Federal and State laws and local by-laws, ordinances and regulations in any manner affecting the conduct of the work, and shall indemnify and save harmless the party of the first part and its representatives against any claim arising from the violation of any such law, by-law, ordinance or regulations, whether by himself or by his employees.

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

Patented Devices, Materials and Processes: If the Contractor is required or desires to use any design, device, material, or process covered by letters patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or owner and a copy of this agreement shall be filed with the Party of the First Part; if no such agreement is made or filed as noted, the Contractor and the Surety shall indemnify and save harmless the County and State from any and all claims for infringement by reason of the use of any patented design, device, material or process, or any trade mark or copyright in connection with the work agreed to be performed under the contract, and shall indemnify the County and State for any costs, expenses and damages which it may be obliged to pay, by reason of any such infringement, at any time during the prosecution or after the completion of the work; provided, however, that the State hereby assumes the responsibility to defend any and all suits brought for the infringement of any patent claimed to be infringed by the design, type of construction or material provided for in plans furnished the Contractor by the State, and to hold the Contractor harmless on account of such suits.

Federal Participation: On Federal Aid Projects, the U. S. Government participates under the provisions of the Federal Highway Act. This act provides that the Construction work shall be done under the direct supervision of the State Highway Department; it does not subject the Contractor to compliance with the Federal laws relative to hours of labor etc. on Government contracts.

State Participation: The attention of the bidder is invited to the fact that if the proposed work is a State aid Project in which the State of Texas participates in the improvement through the State Highway Department in accordance with the provisions of the State Highway Act -- Chapter 190 -- Acts 1917, and subsequent amendments by the Legislature of the State of Texas, that the acceptance of this contract and of the completed work under this contract requires the approval of the State Highway Commission, but such approval will in no sense make the State of Texas a party to this contract.

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 is presented. Until the Acceptance of the work to be performed under the contract, the Contractor shall make all necessary repairs in an acceptable manner, at any point in the Roadway where any opening has been made by due authority. Such repair work will be paid for by the party to whom the permit is issued on the basis of "Extra Work" as provided for in these specifications, and said work shall be subject to the same conditions as the original work performed.

Sanitary Provisions: The Contractor shall 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. He shall commit no public nuisance.

Public Convenience and Safety: The safety of the general public along or near the road and the convenience of traffic are to be regarded as of prime importance. If the contractor constructs temporary bridges and provided temporary stream crossings, his responsibility for accidents shall include the roadway approaches as well as the structures of such crossings. Materials stored upon the highway shall be placed so as to cause as little obstruction to the traveling public as is considered necessary. No section of road shall be closed to the public except by express permission of the Engineer. When the road under construction is being used by the traveling public, special attention shall be paid to keeping both the subgrade and newly laid surfacing in sudh condition that the public can travel over same in comfort and safety. The Contractor shall, at his own expense, "road machine" the subgrade and all courses adapted to such treatment when and as directed by the Engineer. When so provided on the typical cross section, and directed by the Engineer, Concrete Base, Concrete Pavement, and other suitable pavements shall be constructed one-half at a time, opened and maintained for traffic. The Contractor shall cooperate with the Engineer in the regulation of traffic.

Barricades, Danger, Warning and Detour Signs: The Contractor shall provide, erect and maintain all necessary barricades, suitable and sufficient red lights, danger signals, and signs, provide a sufficient number of watchmen and take all necessary precautions for the protection of the work and safety of the public. Highways closed to traffic shall be protected by effective barricades on which shall be placed acceptable warning signs. All barricades and obstructions shall be illuminated at night and all lights for this purpose shall be kept burning from sunset to sunrise.

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 such storage places shall be marked clearly "DANGEROUS - EXPLOSIVES" and shall be in care of competent watchmen at all times.

Preservation and Restoration of Property, Trees, Monuments, Etc.: The Contractor shall be responsible for the preservation of all public and private property, trees, monuments, etc., along and adjacent to the roadway and shall use every precaution necessary to prevent damage or injury thereto. He shall use suitable precaution necessary to prevent damage to pipes, conduits and other underground structures and shall protect carefully from disturbance or damage all land monuments and property marks until an authorized agent has witnessed or otherwise referenced their location and shall not remove them until directed. The Contractor shall not injure or destroy tress or shrubs nor remove or cut them without proper authority. When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work, or in consequence of the non-execution thereof on the part of the Contractor, he shall restore at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring same, or he shall make good such damage or injury in an acceptable manner.

Responsibility for Damage Claims, Etc: The Contractor shall save harmless the Party of the First Part and all of its representative from all suits, actions or claims of any character brought on account of any injuries or damages sustained by any person or property in consequence of any neglect in safeguarding the work, or through the use of unacceptable materials in the construction of the improvement or on account of any act of omission, by the said Contractor, or on account of any claims or amounts recovered for any infringement of patent, trade mark or copyright, except as herein elsewhere specifically provided, or from any claims or amounts arising or recovered under the "Workmen's Compensation Laws", or any other law, by-law, ordinance, order or decree. He shall be responsible for all damage or injury to property of any character during the prosecution of the work resulting from any act, omission, neglect or misconduct in his manner or method of executing said work satisfactorily, or due to his non-execution of said work or at any time due to defective work or materials. He shall not be released from said responsibility until the roadway shall have been completed and accepted and so much of the money due the said contractor under and by virtue of his contract as shall be considered necessary by the State Highway Department may be retained for the use of the State or surety may be held until such aforesaid claims have been settled and suitable evidence to that effect furnished to the State Highway Department.

Contractor's Responsibility for Work: Until the acceptance of the work by the Engineer as evidenced in writing, it shall be under the charge and care of the Contractor. He shall take every necessary precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the non-execution of the work. The Contractor shall rebuild, repair, restore and make good, at his own expense, all injuries or damages to any portion of the work occasioned by any of the above causes before its completion and acceptance. In case of suspension of work from any cause whatever the Contractor shall be responsible for all materials, and shall properly store them if necessary; he shall provide suitable drainage of the roadway and erect temporary structures where necessary.

The Contractor will be required to maintain the road in first-class condition until final acceptance. Whenever, in the opinion of the Engineer, any roadway, or portion thereof, is in acceptable condition for travel, it shall be opened to traffic as may be directed and such opening shall not be held to be in any way an acceptance of the roadway or any part of it, or as a waiver of any of the provisions of these specifications and contract. Necessary repairs or renewals made on any section of the roadway, due to its being opened to travel under instructions from the Engineer, to defective materials or work, natural causes, to ordinary wear and tear or otherwise, pending completion and acceptance of the roadway, shall be performed at the expense of the Contractor. The Contractor shall harrow, drag or otherwise maintain the completed sections of the road, until final acceptance of such section, in a manner approved by the Engineer. Work on this contract will be accepted in sections as shown on plans, but the retained percentage amount will not be paid on any section until completion and acceptance of the entire project.

Personal Liability of Public Officials: In carrying out any of the above provisions or in exercising any power or authority granted to him by this contract there shall be no liability upon said Engineer or his authorized assistants, either personally or as an official of the County or State, it being understood that in such matters he acts as the agent and representative of the County or State.

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8. PROSECUTION AND PROGRESS.

Subletting or Assigning of Contract: Before any work is sublet or assigned by the Contractor, he shall advise the Engineer in writing, giving a description of the work to be sublet, the name of the subcontractor, the number of teams and the amount of equipment owned by the subcontractor and the time required for completing the work. He shall also furnish the Engineer a statement from the subcontractor advising that he understands the plans and specifications and is properly qualified to perform such work. No subcontract shall be valid until approved by the Engineer.

Prosecution of Work: The Contractor shall begin the work to be performed under the contract on such date as will enable him to complete it within the time agreed upon. The Contractor shall notify the Engineer at least twenty-four hours before beginning work. He shall start the work at the part of the road designated by the Engineer and shall prosecute the work at as many different points as the Engineer shall direct.

Limitations of Operations: The Contractor shall at all times conduct the work in such manner and in such sequence as will insure the least practicable interference with traffic and he shall have due regard to convenient detours. He shall not open up work to the prejudice of work already started and in this feature of the prosecution of the work shall be governed by the orders of the Engineer.

Character of Workmen and Equipment: Any foreman or workman employed by the Contractor or by any sub-contractor who, in the opinion of the Engineer or his authorized representative, does not perform his work in a proper and skillful manner or is disrespectful, intemperate, disorderly or otherwise objectionable, shall at the written request of the Engineer be forthwith discharged by the Contractor or sub-contractor employing such foreman or workman, and shall not be employed again on any portion of the work without the written consent of the Engineer. Should the Contractor fail to remove such person or persons or fail to furnish suitable and sufficient machinery, equipment, or force for the proper prosecution of the work, the Engineer may with-hold all estimates, which are or may become due or may suspend the work until such orders are complied with. No item of equipment or machinery after once being placed on the work, shall be removed without the consent of the Engineer.

All workmen must have sufficient skill and experience to properly perform the work assigned them. All workmen engaged on special work or skilled work, such as Bituminous courses or mixtures, Concrete bases, pavements or structures, or in any trade, shall have had sufficient experience in such work to properly and satisfactorily perform it and operate the equipment involved, and shall make due and proper effort to execute the work in the manner prescribed in these specifications. Otherwise the Engineer may take action as above prescribed.

Temporary Suspension of Work: The Engineer shall have the authority to suspend the work wholly or in part, for such period as he may deem necessary, due to unsuitable weather, or to such other conditions as are considered unfavorable for the suitable prosecution of the work, or for such time as he may deem necessary due to the failure on the part of the Contractor to carry out orders given, or to perform any provision of the contract. The Contractor shall not suspend the work without authority.

Computation of Contract time for Completion: The Contractor shall perform the work in an acceptable manner and within the time stated in the contract. For the purpose of computation the consecutive working days shall be considered as beginning 15 days after the date of written authorization by the State Highway Engineer to begin work. In adjusting the contract time for the completion of the roadway the length of time, expressed in days during which the prosecution of the work has been delayed or suspended in consequence of the unsuitable condition of the weather or other unfavorable conditions not by any fault of the Contractor, or in consequence of any act or omission of the State Highway Department, shall be allowed the Contractor in working days in making the adjustment. The adjustment shall be made and certified to in writing by the Engineer. Sundays and legal holidays shall not be computed as working days. Requests for extension of time shall be in writing. If the satisfactory completion of the contract shall require work and material in greater amounts or quantities than those set forth in the contract, then the contract time shall be increased in the same ratio as the additional work bears to the original work contracted for. No allowance shall be made for delay or suspension of the work due to fault of the Contractor.

Failure to Complete the Work on Time: It is further agreed by the parties hereto that in case all work required under this contract is not completed within the time specified in the Proposal and Contract, damage will be sustained by the party of the first part and that it is and will be difficult or impossible to determine the actual damage which the party of the first part will sustain in the event of and by reason of such delay, and it is therefore agreed that said Contractor, party of the second part, will pay to the party of the first part as liquidated damages as provided in the following schedule:

For Amount of Contract	Amount of Liquidated damages per day.
$5,000 or less	$ 5.00
More than $5,000 and less than $10,000	10.00
$10,000 or less than $20,000	15.00
$20,000 or less than $50,000	20.00
$50,000 or more	25.00

Unless otherwise specified the amount of liquidated damages mentioned above shall be deducted from money due the Contractor.

Annulment of Contract: If the Contractor fails to begin the work under contract within the time specified, or fails to perform the work with sufficient workmen and equipment or with sufficient materials to insure the prompt completion of said work, or shall perform the work unsuitably or shall neglect or refuse to remove materials or perform anew such work as shall be rejected as defective or unsuitable, or shall discontinue the prosecution of the work, or if the Contractor shall become insolvent or be declared bankrupt, or commit any act of bankruptcy or insolvency, or allow any final judgment to stand against him unsatisfied for a period of 48 hours, or shall make an assignment for the benefit of creditors, or from any other cause whatsoever shall not carry on the work in an acceptable manner, the Engineer shall give notice in writing to the Contractor and his Surety, of such delay, neglect or default, specifying the same, and 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, to appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable and may enter into an agreement for the completion of said contract according to the terms and provisions thereof, or use such other methods as in his opinion shall be required for the completion of said 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 said Contractor. In case the expense so incurred by the Party of the first part shall be less than the sum which would have been payable under the contract, if it had been completed by said Contractor, then the said Contractor shall be entitled to receive the difference, and in case such expense shall exceed the sum 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 said excess.

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9. MEASUREMENT AND PAYMENT.

Measurement of Quantities: All work completed under the contract shall be measured by the Engineer according to United States Standard Measures, unless otherwise agreed upon in writing. All longitudinal measurements for area will be made along the actual surface of the roadway and not horizontally, and no deduction will be made for fixtures in the roadway having an area of 9 square feet or less. Then for all transverse measurements for area of Base Courses, Surface Courses and Pavements, the dimension to be used in calculating the pay area shall be the neat dimension shown on Plans or ordered in writing by the Engineer. All materials which are specified for measurement by the Cunic yard loose measurement shall be hauled in approved standard vehicles and measured therein at the point of delivery on the road. Standard vehicles for this purpose may be of any type or size satisfactory to the Engineer, provided that the body is of such a type that the actual contents may be readily and accurately determined. Each approved vehicle must bear an identification mark indicating specific approval by the Engineer or his representative, and also a permanent plainly legible number. The Inspector may reject all loads not hauled in such approved vehicles.

Scope of Payment. The Contractor shall accept the compensation, as herein provided, in full payment for furnishing all materials, labor, tools and equipment necessary to the completed work and for performing all work contemplated and embraced under the contract; also for loss or damage arising from the nature of the work, or 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 theEngineer, and for all risks of every description connected with the prosecution of the work, also for all expenses incurred in consequence of the suspension or discontinuance of the work as herein specified, and for any infringement of patent, trade mark, or copyright; and for completing the work according to the plans and specifications. The payment of any current or final estimate or of any retained percentage 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 under the contract and to be responsible for all damages due to such defects, if such defects or damages are discovered on or before the final inspection and acceptance of the work. No moneys payable under the contract, except the estimate for the first month or period, shall become due if the Engineer so elects, until the Contractor shall satisfy the Engineer that he has fully settled for materials and equipment used in or upon the work and labor done in connection therewith.

Payment and Compensation for Altered Quantities: When Alterations in plans or quantities of work as hereinbefore provided for are ordered and performed and when such alterations result in increase or decrease of the quantity of work to be performed, the Contractor shall accept payment in full at the contract unit price for the actual quantities of work done and no allowance will be made for anticipated profits.

Extra and Force Account Work: Extra Work ordered and accepted shall be paid for under a "Supplemental Agreement" or as Force Account as agreed upon, as herein provided and, in all cases, before the work is started. When alterations in the plans or the work are productive of increased unit cost or decreased unit cost to the contractor, a fair and equitable sum to be fixed and shown in a "Supplemental Agreement" signed by both Contracting Parties before such work is started, shall be added to or deducted from the contract unit price as the case may be. When the Engineer deems it impracticable to handle any Extra Work ordered on the unit price basis the Supplemental Agreement may be made up in any practical form desired, or the work may be ordered done and paid for on a Force Account basis as follows:

(a) For all labor, teams, and foremen in direct charge of the specific operation, the Contractor shall receive the current local rate of wage, to be agreed upon in writing before starting such work, for each and every hour that said labor, teams and foremen are actually engaged in such work, to which shall be added an amount equal to fifteen per centum (15%) of the sum thereof. No charge shall be made by the contractor for organization, overhead expense, nor shall any charge for superintendence be made except when there shall be necessarily employed on the proposed extra work at any time and in one place six (6) laborers or more in which case a foreman may be employed and his actual expense to the Contractor charged to the Extra Work for the actual time employed.

(b) For all materials used, the Contractor shall receive the actual cost of such materials including freight charges, as shown by original receipted bills, to which cost shall be added a sum equal to fifteen per centum (15%) thereof.

(c) For any machine power tools or equipment, including fuel and lubricants, which it may be deemed necessary or desirable to use, the Engineer shall allow the Contractor a reasonable rental price, to be agreed upon in writing before such work is begun, for each and every hour that said tools or equipment are in use on such work and to which sum no percentage shall be added.

The compensation as herein provided shall be received by the Contractor as payment in full for extra work done on a force account basis, and shall include superintendence, use of tools and equipment for which no rental is allowed, and profit. The Contractor's representative and the Inspector shall compare records of extra work done on a force account basis at the end of each day. Copies of these records shall be made upon suitable forms provided for this purpose, by the Inspector and signed by both the Inspector and the Contractor's representative, one copy being forwarded, respectively, to the Engineer and one to the Contractor. All claims for extra work done on a force account basis shall be submitted to the Engineer, by the Contractor upon certified statements to which shall be attached original receipted bills covering the cost of and the freight charges on all materials used in such work, and said statements shall be filed not later than the tenth day of the month following that in which the work was actually performed, and shall include all labor charges, etc., and material charges in so far as they can be verified.

Freight Rates: In the event that during construction the freight rates on materials entering into the completed work should be increased, the County will compensate the Contractor the amount of such increase, but should the freight rates be decreased the County shall deduct the amount of such decrease from the amount due the Contractor.

Partial Payments: At the earliest possible date after the first day of each month, the Engineer will make current estimate in writing of the materials in place complete and the amount of work performed during the preceding month or period and the value thereof at the unit prices contracted for, as shown in Proposal and Contract. In addition to the above, an estimate may be made for payment of seventy-five per cent of the value of the reinforcing steel, structural steel, crushed stone, gravel asphalt, paving brick, or creosoted timber, if same has been insured against fire, delivered on the work and not used at the time of such estimate. From the total of the amounts so ascertained, shall be deducted ten per cent to be retained until after the completion of the entire work to the satisfaction of the Engineer, and ninety (90) per cent of the amount so ascertained shall be paid the Contractor.

No estimate other than a final estimate, shall be made where the value of the work performed since the last preceding payment, is less than one-fourth of the amount of the average monthly estimate to be expected as computed by dividing the amount of the contract by the contract time in months.

Acceptance and Final Payment:

(a) The Engineer shall, as soon as practicable after the completion of this contract, make a final estimate of the amount of work done thereunder, and the value of such work, and the party of the first part shall, at such time, within thirty days from and after the date of said estimate, as the county may elect pay the entire sum so found to be due hereunder, after deducting therefrom all previous payments and all amounts to be kept and all amounts to be retained under the provisions of this contract. All prior partial estimates and payments shall be subject to correction in the final estimate and payment.

(b) It is mutually agreed between the parties hereto, that no estimate or payment made under this contract, except the final payment shall be conclusive evidence of the performance of this contract, either wholly or in part, against any claim of the party of the first part, and then not until the lapse of thirty days after the acceptance of the work by the party of the first part; and no payments shall be construed to be an acceptance of any defective work or improper materials, nor a release from any claim for damages.

(c) And the said Contractor hereby further agrees that the payment of the final amount due under this contract, and the adjustment and payment of the bill rendered for any work done in accordance with any alterations of the same, shall release the party of the first part and the State of Texas, the Engineer from any and all claims or liability on account of work performed under this contract, or alerations thereof.

Work Limited to Amount of Money Available: Before starting the work there shall be appropriated by the Commissioners' Court out of the proper funds, an amount which will in the judgment of the Engineer and Contractor pay the Cost of the proposed work at the unit prices listed in the contract. This appropriated money will in no case be reduced or increased unless said reduction or increase shall be agreed to in writing by the State Highway Engineer and the Commissioners' Court, and a copy of such agreement shall be furnished the Contractor. Provided, however, the increase or reduction in quantities as provided herein in Sections "Alteration of Plans or of Character of Work" and "Extra Work", may be made whenever the total cost of the work is not increased beyond the amoney appropriated for the work without such written agreement. If a reduction of appropriation is made in a manner other than hereinabove mentioned the Contractor shall have cause for court proceedings against the Commissioners for misappropriation of funds, and the said Commissioners shall be subject to penalties covering misappropriation of funds. The Contractor is hereby cautioned and warned and agrees that he will receive no greater amount for the work done than the amount appropriated therefor and all work done beyond that quantity which cannot be paid for from appropriated money, shall be done at the Contractor's expense. Should the Engineer fail to keep the Contractor acquainted with the amount of money available then the Contractor should request such information whenever it is thought that the work done has nearly utilized the money available so that he may have sufficient time to stop the work before the appropriated money has been utilized. In case such information is not furnished the Contractor, he will be permitted to stop the work until the required information is obtained.

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CONSTRUCTION DETAILS.

10. EARTHWORK.

Description. Earthwork shall consist of all clearing and grubbing, roadway excavation, channel excavation, excavation for structures, embankment, disposal of surplus material, borrow, stripping material pits, overhaul, sub-base, completion of subgrade and shoulders and subsidiary work, all of which shall be done and paid for in accordance with the specifications.

11. CLEARING AND GRUBBING.

Description. This item shall consist of clearing the ground of all trees, brush, rubbish and other objectionable materials within the lines for clearing designated on the ground by the Engineer, and of grubbing the roadway within the limits designated by the Engineer for grubbing.

Clearing: All merchantable timber required to be cut, which is not to be used in the work, shall be trimmed, and cut such lengths, and neatly piled along the right of way, as the Engineer may direct, all other tress, not reserved by the Engineer within the clearing limits together with logs, brush and "Duff" shall he cut, removed and disposed of as required by the Engineer. All stumps shall be so cut that the tops shall be at least 18 inches below the finished surface of the subgrade, and shoulders. All trees not required to be removed shall be carefully protected.

Grubbing: Except in areas which are to be covered with embankment more than 2 feet in height, all stumps, roots, wood and vegetable matter embedded in the ground within the roadway as designated by the Engineer shall be grubbed or blasted out of the ground and removed.

Methods of Measurement: Clearing will be classified as "Light Clearing" and "Clearing". Sections of the highway where the trees are scattered and isolated and the work of Clearing unusually light will be designated on the plans as "Light Clearing" and measured by the 100-foot station. All other areas within the lines of Clearing established by the Engineer shall be measured by the acre as "Clearing".

Grubbing will be classified as "Light Grubbing" and "Grubbing". Sections of the Roadway where the stumps are scattered and isolated and grubbing is of a very light nature, will be designated on the Plans as "Light Grubbing" and measured by the 100-foot station. All other areas within the limits designated for grubbing will be measured by the acre as "Grubbing".

Basis of Payment: All work performed as required under this item measured as provided above will be paid for at the contract unit prices bid for "Light Clearing" per 100-station, "Clearing" per acre, "Light Grubbing" per 100-foot station and "Grubbing" per acre, as the case may be, which prices shall be full compensation for furnishing all labor, materials, equipment, tools and incidentals necessary to complete the work.

12. ROADWAY EXCAVATION.

Description. This work shall consist of excavating the roadway, removing and satisfactorily disposing of all materials taken from within the limits of the work, and shall include all excavation, shaping and sloping necessary for the construction, preparation and completion of all embankments, subgrades, shoulders, slopes, gutters, intersections, approaches and private entrances, as directed, strictly to the required alignment, grade and typical cross section shown on the Plans. All material excavated hereunder of whatever material shall be considered "Unclassified" unless in the Proposal, prices are requested and tendered for "Solid Rock" and "Common" excavation, in which case all materials shall be classified as follows:

"Solid Rock" shall include all rock masses which cannot be removed without blasting, also all detached rock or boulders measuring not less than one-half cubic yard each.

"Common" excavation shall include all other materials encountered.

Construction-Methods: All suitable materials removed from the excavation shall be used as far as practicable in the formation of the embankment, subgrade, shoulders, and at such other places as directed. No excavated material shall be wasted without permission, and when such material is to be wasted it shall be disposed of as directed by the Engineer. No payment will be made for any excavated material which is used for purposes other than those designated, except as hereinbefore provided under "Rights in and Use of Materials Found on the Work". During the construction of the roadway the roadbed shall be maintained in such condition that it will be well drained at all times. Side ditches or gutters emptying from cuts to embankment shall be so constructed as to avoid damage to embankment by erosion. Solid rock excavation shall be carried 6 inches below subgrade, and shoulder surface and "backfilled" as "Embankment", as directed by the Engineer. All slopes, except in solid rock or other material which in the judgment of the Engineer requires a modified slope, shall be trimmed accurately to the slopes shown in the cross-section drawings, and care should be exercised that no material shall be loosened below the required slopes. All breakage and Slides shall be removed by the Contractor and disposed of as directed by the Engineer. All roots, stumps, and other foreign matter in the sides and bottom of the gutters shall be cut to conform to the slope, grade and shape of the section shown.

Method of Measurement: All accepted roadway excavation shall be measured in its original position by the method of average end areas, which measurements will include overbreakage or slides in Common Excavation, not attributable to carelessness of the Contractor, and authorized excavation of solid rock below grade, also of soft and spongy spots below grade. The measurement shall include unavoidable overbreakage in "Solid Rock Excavation" to an amount not to exceed in any half station of 50 feet, 10 per cent of the actual quantity required for the same half station within the lines shown on the plans.

Basis of Payment: The yardage of Roadway Excavation, measured as provided above, shall be paid for at the contract unit price per cubic yard bid for "Unclassified", "Solid Rock" or "Common" Excavation, as the case may be, which price shall be full compensation for formation and compaction of embankments, trimming of slopes, disposal of surplus materials, preparation and completion of subgrade and shoulders and roadway, and the furnishing of all equipment, tools, labor and incidentals necessary to complete the work.

13. CHANNEL EXCAVATION.

Description. This work shall consist of excavating and completing all Channels, Channel Changes and Ditches as shown on Plans and to the lines and grades established by the Engineer, and satisfactorily disposing of all materials taken therefrom. "Ditches" shall include inlet and outlet ditches to structures, and all ditches without the confines of the "Roadway" Slopes. The material encountered will not be classified unless specifically so provided in the "Special Provisions", the yardage of excavation, however, shall be classified as "Wet" and "Dry".

Yardage, in the excavation of which the use of pumps is necessary to unwater the site of same shall be classified as "Wet".

All other yardage shall be classified as "Dry".

Construction Methods. All suitable materials removed from the excavation shall be used as far as practicable in the formation of the Embankment, and at such other places as directed. No payment will be made for any excavated material which is used for purposes other than those designated. During construction the work shall be kept drained so far as practicable, and prosecuted in a neat and workmanlike manner, so that it may be accurately measured.

Method of Measurement: All accepted Channel Excavation shall be measured in its original position by the method of average end areas.

Basis of Payment. The yardage of Channel Excavation measured as provided above, shall be paid for at the unit contract price per cubic yard bid for "Dry Channel Excavation" or "Wet Channel Excavation" as the case may be, which prices shall be full compensation for furnishing all labor, material, equipment, tools and incidentals necessary to complete the work. Overhaul will be allowed on the same basis as for Roadway Excavation.

The excavated material described in this item will not be paid for as "Borrow".

14. EXCAVATION FOR STRUCTURES.

Description. This work shall consist of all excavation for foundations for culverts, bridges and all other structures unless hereinafter otherwise provided. This work shall include disposal of all material obtained from such excavation and back-filling to the level of the original ground. It shall also include all necessary bailing, draining, sheeting and the construction of cofferdams or cribs, if found necessary, and their subsequent removal. The Material shall be disposed of as directed by the Engineer and 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. The excavation shall be done in accordance with the lines and depths indicated on the Plans and established by the Engineer, or as altered by him in matters of depth, elevation or dimensions to secure adequate bearing and foundation.

Classification; Unless otherwise provided on Plans or Special Provisions, Excavation for Structures shall only be classified as follows:

"Excavation for Bridges" shall include all "Excavation for structures" directly incident to the construction of "Bridges" as herein elsewhere defined.

"Excavation for Culverts" shall include all other "Excavation for Structures".

Construction Methods. When a structure is to rest on an excavated surface other than rock, especial 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 made until just before the masonry is to be placed.

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 mortar or grout.

Coffer dams or cribs: The Contractor shall submit upon request, drawings showing his proposed method of cofferdam construction and other details left open to his choice or not fully shown on the Engineer's drawings. The type and clearance of cofferdams in so far as such details affect the character of the finished work, will be subject to the approval of the Engineer, but other details of design will be left to the Contractor who will be responsible for the successful construction of the work.

In general Cofferdams or cribs shall be carried well below the bottom of the footings and shall be well braced and as water tight as practicable. The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams which are tilted or moved laterally during the process of sinking shall be righted or enlarged, as necessary at the sole expense of the Contractor.

When conditions are encountered which, in the opinion of the Engineer, render it impracticable to otherwise unwater the foundation he may require the construction of a concrete foundation seal of such dimensions as may be necessary. The foundation shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed and the weight utilized to practically overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal.

Cofferdams shall be constructed so as to protect green concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. Where cofferdams are affected by high-water or tides they shall be properly vented.

Pumping from the interior of any foundation enclosure shall be done in such manner as to preclude the possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete, or for a period of at least 24 hours thereafter, unless it be done from a suitable sump separated from the concrete work by a water-tight wall.

Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

Unless otherwise provided in the Special Provisions, cofferdams or cribs with all sheeting and bracing 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 finished masonry. In lieu of the entire removal of the cofferdam or cribs the Engineer may require the Contractor to remove any portion of them or to leave them entirely in place.

Back-filling: All spaces excavated and not occupied by abutments, piers, or other permanent work shall be refilled with material satisfactory to the Engineer up to the surface of the surrounding ground with a sufficient allowance for settlement. The material shall be free from large or frozen lumps, wood, or other extraneous material. For foundation through a hard material exposed to erosion, the back-fill 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 unless otherwise provided such back-fill shall be paid for as Extra Work.

No backfilling shall be placed against any abutment, wingwall or culvert until permission shall have been given by the Engineer, In the case of masonry such permission will preferably not be given until the masonry has been in place 21 days. Adequate provision shall be made for thorough drainage and ~~trench~~ drains shall be placed at weep holes.

Fill placed around culverts and piers shall be deposited on both sides to approximately the same elevation at the same time. All filling adjacent to structures shall be deposited in horizontal layers and well compacted. Especial care shall be taken to prevent any wedging action against the structure, and the slopes bounding the excavation shall be stepped or serrated to prevent such wedge action.

Method of Measurement. The yardage of excavation to be paid for will be that actually removed except that no measurement will be made of material removed outside of a volume bounded by vertical planes, one foot outside of the footings and parallel thereto.

Basis of Payment. Payment for all work prescribed under this item and measured as provided above shall be made at the contract unit prices bid per cubic yard for "Excavation for Culverts" or "Excavation for Bridges" as the case may be which prices shall be full compensation for furnishing all material for all labor, equipment, tools and incidentals necessary to complete ~~with~~ work; provided that in the case of Bridges when it is found necessary to carry footings deeper than the elevation shown on the Plans, such excavation shall be paid for as "Extra Work" unless a Special Provision and Proposal Price for such work is included in the Contract.

15. EMBANKMENT.

Construction Method. Embankments shall be formed of suitable material placed in successive horizontal layers, not more than two feet in depth, for the full width of the cross-section, and shall be compacted by distributing the necessary hauling uniformly over each succeeding layer. Stumps, trees, rubbish, sod or any other unsuitable material or substance shall not be placed in the embankment. When embankments are to be made on a hill side, the slope of the hill side on which the embankment is to be placed, shall be plowed or cut into steps before the filling is commenced. All such embankment so made shall be thoroughly compacted as stated herein. The Contractor shall be responsible for the stability of all constructed embankments and shall replace any portions, which in the opinion of the Engineer, may become displaced due to carelessness or negligence on his part.

Excavated rock shall be used in forming embankments wherever the depth of the fill is sufficient to properly contain it. When so used it shall be carefully distributed so that interstices between the larger particles are filled with smaller particles of earth to form a dense compact mass, as directed by the Engineer.

Embankments shall be made slightly higher than called for on the Plans, in order that after shrinkage and settlement are complete the embankment may have the required cross-section at all points. The Engineer will co-operate in determining the necessary amounts of such allowance, but such co-operation shall not relieve the Contractor from any responsibility.

Compensation. The work prescribed under this item shall not be paid for directly, but shall be considered as subsidiary work pertaining to the several classes of Excavation or to "Borrow".

16. DISPOSAL OF SURPLUS MATERIAL.

All surplus excavated and waste material shall be used to uniformly widen embankments or flatten slopes, or deposited in such other places and for such surposes as the Engineer may direct. In no case shall material be deposited above the grade of the adjacent roadway unless directed in writing by the Engineer. The work prescribed in this item shall not be paid for directly but shall be considered as subsidiary work pertaining to the several classes of Excavation or to "Borrow".

17. BORROW.

Description. Borrow shall consist of the excavation and disposal, as directed of suitable and satisfactory material obtained from borrow pits designated and measured by the Engineer. Borrow shall only be resorted to when sufficient quantities of suitable materials are not available as herein prescribed, from the Roadway and Channel Excavation to properly construct the embankments subgrade and shoulders, and to complete the back-filling of structures. In no case shall material be borrowed until so ordered by the Engineer and then only from designated pits. The widening of roadway cuts or the increasing of slopes will not be considered as Borrow. The right of way of all borrow pits will be furnished by the County.

Construction Methods. The Contractor shall notify the Engineer sufficiently in advance of the opening of any borrow pit, so that the cross-sectional elevations and measurements of the existing ground surface may be staked and recorded. Materials shall be so excavated as to leave the pit in a neat and suitable condition to facilitate the accurate measurement of the material used, and so that, where practicable, no water will collect and stand therein.

Method of Measurement. Borrowshall be measured in its original position by the method of average end areas.

Basis of Payment. The yardage so measured shall be paid for at the contract unit price per cubic yard bid for "Borrow" which price shall be full compensation for all labor equipment, tools, and incidentals necessary to complete the work, provided, however, that no payment whatever will be allowed the Contractor for any material excavated prior to the staking out and cross-sectioning of the work by the Engineer.

or 18. STRIPPING MATERIAL PITS.

Description. This item shall consist of the removal of unsuitable material from pits on quarries where surfacing material is obtained from local sources. This stripping shall be removed from the limits of the pit or quarry and placed in spoil banks located as directed by the Engineer, and it shall be so placed as to permit the Engineer to measure the amount of stripping removed. This measurement shall be made as soon as possible after the satisfactory completion of the stripping of the pit or quarry staked out by the Engineer.

Basis of Payment. This item shall be paid for at the contract unit price bid per cubic yard for"Stripping Material Pits" which price shall be full compensation for all labor,equipment,tools and incidentals necessary to complete the work.

19. OVERHAUL.

Overhaul Excavation. When the distance between the center of gravity of any cut or borrow pit, and the center of gravity of the corresponding embankment exceeds 200 feet, all of the material obtained from the cut and used in the embankment shall be known as overhaul excavation, and the length of overhaul shall be measured as the distance between the center of gravity of the cut and center of gravity of the fill minus 200 feet.

Basis of Payment. "Overhaul Excavation" shall be paid for at the unit price bid per cubic yard per station of 100 feet of "Overhaul".

20. ROAD GRADER WORK.

Description. Where the material is suitable and the natural ground surface is fairly even and practically parallel to the subgrade line, the excavation may be classed as "Road Grader Work". The portions of the road on which this class of work is anticipated are shown on the Plans, and no portion will be less that five consecutive stations.

Construction Methods. All weeds, grass or rubbish will first be removed from within the limits of the section to be graded, and disposed of as directed by the Engibeer, Road Grader Work will include all necessary scarifying, plowing, moving and shaping of the earth to bring the surface or subgrades accurately to the line, continuous grade and typical cross-section shown on the Plans. All objectionable material shall be removed from the traveled way.

Basis of Payment. This Item shall be paid for at the contract unit price per 100-foot station bid for "Road Grader Work", which price shall be full compensation for all Labor Equipment, tools and incidentals necessary to complete the work.

21. SUBGRADE.

Description. When the road is to be surfaced or paved and after the earth work has been substantially completed and after all drains have been laid, the subgrade shall be brought to the lines, grades and typical cross section shown on the plans, in accordance with these specifications.

Construction Methods: All soft and unstable material, muck, quicksand and any portions of the subgrade which will not compact readily, shall be removed as directed. All loose rock or boulders appearing in the earth excavations or embankments shall be removed or broken off to a depth of not less than 6 inches below the subgrade. All holes or depressions shall be filled with approved material and the subgrade brought to line and grade and compacted; this material shall be obtained as "Excavation" or "Borrow" and paid for as such unless otherwise directed in writing.

After the roadbed has thus been prepared it shall be allowed to stand or "cure" under traffic until, in the opinion of the Engineer, it is in a satisfactory condition to receive a surface course. During this "curing" the roadbed shall be maintained by the Contractor, unless otherwise agreed, free from ruts and all weak spots that develop under traffic shall be picked up and repaired with suitable material as they develop. Such rolling as the Engineer may require shall be done.

Highway Intersections: All intersecting public highways shall be graded as shown on the plans or as directed by the Engineer, and acceptable material used on the surface so that a commodious smooth-riding, and satisfactory Intersection shall be produced.

Railway Intersections: At all grade crossing of intersecting railways the Contractor shall construct the roadway so that a commodious, smooth-riding, and satisfactory intersection is obtained, meeting the requirements of the railway company. Four-inch planking for the full width of the roadway shall be securely spiked to the ties between the rails and on the extension of the ties outside the rails in such manner that the surface of the planking will coincide with the grade of the tops of rails.

When in the opinion of the Engineer, the roadbed is in proper condition to receive a surface, and upon written permission of the State Highway Engineer or his representative, the subgrade shall be finally prepared as below:

Trench Method: The subgrade shall be prepared by trenching to the full width as shown on Plans to receive the base course or surface course. The material excavated in trenching the subgrade shall be deposited upon the shoulders just outside the trench. When, in the opinion of the Engineer, it is necessary or when specified under the various types of pavement, the subgrade after trenching shall be rolled until firm, and unyielding.

Feather Edge Method: When so shown on the Plans the surfacing material will be spread on the flat subgrade without trenching. In such cases care shall be taken not to disturb the soil of the sub grade, which should be hard and smooth.

If the surface of an old stone or gravel roadbed conforms approximately to the surface of the finished subgrade at sections where reconstructed base course is not proposed, such sections shall be scarified superficially as directed to a uniform depth below and for the full width of the subgrade, to a depth just sufficient to eliminate all depressions and to permit of uniform reshaping. The loosened material shall then be spread and compacted so as to bring all the material to uniform density, and rolled if so directed by the Engineer. The essential purpose of the roller is to eliminate or reveal soft and hard spots or areas, and to produce uniformity of bearing strength throughout the width of the subgrade.

Protection of Subgrade: At all times ditches and drains along the subgrade shall be so maintained as to drain it effectively. When ruts of 2 inches or more in depth are formed, the subgrade shall be brought to grade if necessary, reshaped and rerolled. In no case shall any surface course or pavement be placed on a frozen or muddy subgrade. In handling tools, equipment, etc., the Contractor shall protect the subgrade by laying planks or otherwise as directed. Until the subgrade has been checked and approved, no surface course or pavement shall be laid thereon.

Special Subgrade Finish for Concrete Base or Pavements: After the subgrade has been prepared, as specified, and has been properly consolidated, the forms set and accepted, and immediately before the base or surfacing material is to be placed on the subgrade, it shall be tested as to crown and elevation by the use of a templet, furnished by the contractor. In the lower edge of the templet there shall be driven nails six inches apart and to such depths that the heads will just come to the true position of the subgrade, when the templet is riding on the forms. Testing the elevation of the subgrade shall be done by moving the templet back and forth on the forms. If the subgrade, when tested by means of the templet, as hereinbefore specified, is found to be as much as one-fourth of an inch high, additional excavation shall be made until the required depth is obtained, and the excavated material shall be deposited on the shoulders. Unless otherwise provided in the specifications, those areas below the true elevation shall be filled with concrete, making an integral part of the slab proper, all expenses for this extra material being borne by the Contractor. Before placing the concrete the subgrade shall be clean of all materials that may have fallen upon it and if dry it shall be thoroughly wetted, but not to the extent of forming mud or pools of water.

Compensation. The work prescribed under this item except rolling shall not be paid for directly, but shall be considered as subsidiary work pertaining to the several items of "Excavation" or "Borrow" or "Pavement".

22. SHOULDERS.

Description; After the earth work, including the slopes, has been substantially completed and after all drains have been laid, the shoulders shall be constructed of approved material to the elevation, width and shape shown on the plans, and dressed as directed after surface course or pavement is completed.

Construction Methods. Before any subgrade shall be approved the adjacent shoulders shall be constructed to the full width and at least to the level of the finished subgrade, but not necessarily to the final height and shape. When the surface course or pavement is completed the shoulders shall be shaped and dressed as directed to the lines, elevations, and cross section shown on the Plans. This work shall be done in proper sequence with the surface course or pavement construction as directed.

Compensation. The work prescribed under this item, except rolling, shall not be paid for directly, but shall be considered as subsidiary work pertaining to the several classes of Excavation and Borrow.

23. SUB-BASE.

Description. This item shall consist of special approved material placed and compacted in excavation made by the removal of soft, unstable or other unsuitable subgrade materials, and shall be constructed only where specifically directed and in accordance with these specifications.

Material. The material to be used shall consist of sound, tough, durable, "Telford" stone, napped field or quarry stone, crushed rock, slag, or gravel, and necessary filler. The "Telford" stone shall be approximately rectangular in section from 2 to 6 inches in width, 6 to 12 inches in length, and 8 inches in depth; the field or quarry stones shall be not more than 5 inches in their largest dimension after napping; and the crushed rock, slag or gravel shall consist of pieces varying from 1 inch to $3\frac{1}{2}$ inches in diameter. When a finer material is necessary for the filler, quarry chips, gravel or sand may be used to an amount not over 15 per cent of the total. All material shall be approved before being used.

Construction Methods. Unsuitable subgrade materials shall be removed and the bottom of the excavation shaped uniformly and compacted firmly and provision made for drainage. The material shall then be placed in the prepared excavation. If "Telford" stones are used, they shall be laid at right angles to the center line of the roadway and rammed in layers of not more than 8 inches in depth; or if napped field or quarry stone, crushed rock, slag, or gravel is used, it shall be spread and rammed in layers of not more than 5 inches. When delivered the material shall be dumped along the sides of the roadway and not directly into the excavation, but shall be placed carefully therein by hand or with shovels. After the material has been placed in layers until level with the surrounding subgrade surface the voids shall be filled with the finer material and the work rolled or tamped if inaccessible to the roller; and the filling and rolling shall be continued until the entire mass is compacted thoroughly and satisfactorily. The surface shall be finished to conform accurately to the grade and cross section of the surrounding subgrade.

Basis of Payment. This work will be paid for at the contract unit price per cubic yard bid for "Sub-Base" complete in place, which prices shall be full compensation for furnishing, hauling and placing all materials, and for all equipment, tools, labor and incidentals necessary to complete the work, except rolling.

24. FINE GRADING SUBGRADE AND SHOULDERS.

Description. This work shall consist of preparing Previously graded road for immediate placement of base courses, surface courses or pavements. No work will be done or paid for under this item unless prices for same are requested and tendered in the Proposal; otherwise, all work prescribed under this item shall not be paid for directly, but shall be considered as subsidiary work pertaining to the several classes of Excavation, or to Borrow.

Construction Methods. The existing roadway shall be scarified, if directed, bladed and shaped to conform accurately to the line, grade and cross section shown on the plans. Should there develop any depressions or narrow embankments, sufficient approved earth material shall be obtained and placed, as "Common Excavation" or "Borrow", to bring the surface of the roadway, including the shoulders, to the exact lines, grades and cross section shown on the plans. When so shown on the typical cross-sections, in addition to the above requirements, a trench or pit shall be cut to receive the surfacing material so that its cross-section shall have the crown as shown on the plans, and the material thus excavated used in building up the shoulders, to retain the surfacing material within the limits of the specified subgrade.

Existing gravel road-beds shall be treated as provided under "Subgrade".

When required, the subgrade shall be thoroughly rolled until it is brought to a firm, unyielding surface, and all work done necessary to produce a completed and acceptable foundation for the placement of the surface course or pavement as provided under "Subgrade".

Basis of Payment. Furnishing and hauling the additional earth material mentioned above shall be paid for by the cubic yard at the unit prices bid for "Unclassified Excavation", "Common Excavation" or "Borrow". All other work covered by the specifications for this item shall be included in the price bid per square yard for "Fine Grading , Subgrade and Shoulders", when such price is requested in the Proposal, which price shall be full compensation, for shaping, dressing, and compacting the subgrade and shoulders, except rolling, all as prescribed in the specifications therefor, and for all equipment, tools, labor and incidentals necessary to complete the work,

25. EXTRA ROLLING EARTHWORK.

Description. This work shall be done only upon written order of the Engineer. The Contractor shall furnish and operate as directed, an approved roller weighing not less than 200 pounds per linear inch of width of roller.

Construction Methods. On the work as ordered the rolling shall commence at either side, and, rolling parallel with the road, progress gradually toward the center, uniformly lapping each preceding track and covering thoroughly the entire surface with the rear wheels; the operation shall then be repeated from the opposite side.

The rolling shall be done under the supervision of the engineer or his authorized representative.

Method of Measurement. The hours of rolling to be paid for will be actual time roller is working as ordered.

Basis of Payment. Rolling, performed as provided above, shall be paid for at the contract unit price per hour bid ~~per square yard~~ for "Extra Rolling Earthwork", which price shall be full compensation for furnishing the roller and Operator, all Equipment, Labor, tools, fuel (if any), and incidentals involved in the work.

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31. EXTRA ROLLING AND SPRINKLING FOR BASE AND SURFACE COURSES

Description. This work shall be done only upon written order of the Engineer. The Contractor shall furnish and operate as directed a self propelled roller weighing not less than 300 pounds per linear inch of width of roller. He shall also secure water and furnish and operate an approved sprinkler, as directed.

Construction Methods. On the work as ordered the rolling shall commence at either side overlapping the shoulders not less than 6 inches and, rolling parallel with the road, progress gradually toward the center uniformly lapping each preceding track and covering thoroughly the entire surface with the rear wheels; the operation shall then be repeated from the opposite side.

The rolling shall be done only after the course has been wetted by rains or by sprinkling. The sprinkling shall be performed where directed, and in the amount required.

Method of Measurement. The hours of rolling to be paid for will be actual time roller is working as ordered. Sprinkling will be measured by the number of thousand gallons sprinkled on the work as ordered.

Basis of Payment. Rolling, performed as provided above, shall be paid for at the contract unit price per hour bid for "Extra Rolling Base and Surface Courses," which price shall be full compensation for furnishing the Roller and Operator, all equipment, labor, tools, fuel and incidentals involved in the work.

Sprinkling, performed as provided above, will be paid for at the contract unit price per 1000 gallons bid for "Sprinkling," which price shall be full compensation for the cost of the water, hauling one mile, furnishing all equipment, tools, labor and incidentals involved in the work. Hauling the water into each mile beyond the first mile shall be paid for at the contract unit price bid per 1000 gallons for "Water Hauled Additional Mile."

32. SUBGRADE TREATMENT

Description. This item shall consist of treating a Gumbo, Adobe or other faulty subgrade with a stabilizing course of granular material to perfect a foundation for base courses, surface courses or pavements. It shall be constructed in accordance with the Specifications and in conformity with the line, grade and typical cross-section shown on Plans.

Materials. The materials for this course will be noted on the Plans. In general they will be coarse sand, fine gravel, cinders or other local material of a granular nature, of such quality and properties as the Engineer may approve in writing. Unless otherwise prescribed the material shall be such that all will pass the $\frac{1}{2}$-inch screen, and 40% will be retained on the 10 mesh screen.

Construction Methods. The subgrade to be treated shall have been completed to line, grade and typical cross-section. The granular material shall then be delivered and evenly spread on the subgrade in such quantity that when the work is completed the requirements of the typical cross-section will have been fulfilled. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station and uniformly distributed throughout each station.

The material shall then be incorporated with the material of the subgrade as required on the Plans and rolled and sprinkled as directed. The Contractor shall work and dress the surface as directed until the treated subgrade is set up hard and smooth in accordance with the grade and typical cross-section required, and so maintained until the proposed base course or Surface Course or pavement is in place.

Method of Measurement. Work and acceptable material furnished shall be measured by the cubic yard of material, loose measurement.

Basis of Payment. The material furnished as prescribed by this item shall be paid for at the contract unit price per cubic yard for "Subgrade Treatment Material." The work performed as prescribed for this item, measured as provided above, shall be paid for at the contract unit price bid per cubic yard for "Subgrade Treatment," which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road, spreading and finishing, all labor, equipment, tools and incidentals necessary to complete the work except screening material, rolling and sprinkling. Hauling material into each quarter mile beyong the first quarter mile shall be paid for at the contract unit price per cubic yard bid for "Material Hauled Additional Quarter Mile." Screening will be paid for at the contract unit price bid per cubic yard for "Screening."

33. RECONSTRUCTED BASE COURSE

Description. This item shall consist of the reshaping of the existing surface and the addition of the required amount of new material, all of which shall be compacted to form a foundation course for other base courses or for surface courses or pavements. The additional material shall conform to the requirements for material of the type of the original course as prescribed in these specifications, and the item shall be constructed in accordance with these specifications and in conformity with the lines, grades and typical cross-section shown on the Plans. The item name corresponding to the original course shall be given on the Plans.

Construction Methods. The existing surface shall be scarified for the full width of the proposed base-course and to such uniform depth below the proposed finished surface as will eliminate all existing depressions and irregularities and permit of uniform reshaping. Any existing bituminous mat of more than $\frac{1}{2}$ inch thickness shall be removed from the work.

After scarifying, the material shall be shaped to conform to the required section, the required material added in a uniform course of such depth that when compacted the finished surface will conform to the line, grade and typical cross section. The course shall then be rolled and sprinkled if directed, and finished and maintained as required in the specifications for the base course corresponding to the original construction as noted on the Plans.

Methods of Measurement and Basis of Payment. The work of scarifying, loosening and shaping the original construction shall be Measured by the square yard and paid for at the contract unit price per square yard bid for "Reconstructed Base Course."

All other work performed as prescribed, and all accepted material shall be measured by the cubic yard loose measurement. The material furnished as prescribed shall be paid for at the contract unit price per cubic yard for the base course material corresponding to the original construction as noted on the Plans when such price is requested and tendered in the Proposal. When such price is not so requested, right-of-way and royalty charges on the material in the pit will be borne by the county.

The work performed as prescribed shall be paid for at the contract price per cubic yard bid for the item named on the Plans as the type of original construction, which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road, spreading and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyong the first quarter mile shall be paid for at the contract unit price per cubic yard bid for "Material Hauled Additional Quarter Mile."

34. SHELL BASE COURSE

Description. This item shall consist of a foundation course for surface courses, or other base courses, shall be composed of shell, and shall be constructed on the prepared subgrade in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Material. The shell shall consist of sound particles of oyster, clay, or other shells equally acceptable to the Engineer, and shall not contain more than fifteen per cent of mud, clay marl or loam.

Construction Methods. The material shall be delivered, and spread by hand on the prepared subgrade or completed course to such depth that when compacted the thickness shown on the Plans will be secured and shaped to conform to the typical cross-section. Side forms and either cubical blocks or center guide forms of proper size shall be used to fix the depth of the loose material. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station and uniformly distributed throughout each station.

The work shall be rolled and sprinkled or opened to traffic as directed. The Contractor, as often as directed, shall work and dress the surface so that the cross-section shall continue uniform and true to line and grade until accepted. When the typical cross-section requires that this item be constructed in more than one course, each additional course shall be constructed independently after the previous one has been completed and accepted, all as prescribed above.

Method of Measurement. Work and accepted material hauled to the road shall be measured by the cubic yard of material loose measurement as delivered on the road.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

WASHINGTON, D. C.

IN YOUR REPLY PLEASE

REFER TO FILE No. J-1

March 14, 1925

State Highway Engineer
Austin, Texas
MAR 21
Referred to

Texas State Highway Commission
Austin,
Texas

Gentlemen:

Reply is made to your letter of February 25, 1925, File B-5, wherewith you submitted direct to this office mimeographed copies of standard road and bridge specifications revised in accordance with our suggestions made by correspondence and by conference in Austin during January of this year.

In view of the urgent need of a working standard specification for current Texas work, it has been deemed expedient in this case, in place of further correspondence, to insert in the mimeographed specification "Errata Sheets" covering such minor typographical and accidental errors as would render the intent and meaning obscure.

As supplemented by the errata sheets, the enclosed specification is hereby tentatively approved as the standard specification for Texas, to be used with the errata sheets attached pending formal action when the corrected and printed copies are received.

In connection with the clauses relative to partial payment, Page 9-1615-3, we would call attention to the fact that the Bureau can not allow Federal aid on materials before incorporation in the permanent wotk.

On Page 10-25-1616-11, the last paragraph, we believe that the context requires the retention of the word "progress," as mimeographed.

Very truly yours,

E. H. James

Acting Chief Engineer

Basis of Payment. The material furnished as prescribed by this item shall be paid for at the contract unit price per cubic yard bid for "Shell". The work performed as prescribed by this item and measured as provided above, shall be paid for at the contract unit price per cubic yard bid for "Shell Base Course," which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile."

35. Caliche Base Course

Description. This item shall consist of a foundation course for surface courses or other base courses, shall be composed of Caliche, and shall be constructed on the prepared subgrade in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of component courses and typical cross-section shown on Plans.

Material. Caliche shall consist of a natural mixture of approximately equal proportions of calcareous dust and quartz sand with or without the presence of gravel or small stones, all of which, when tested, shall pass a $3\frac{1}{2}$ inch screen, and shall not contain more than 10 per cent clay.

Construction Methods. The material shall be delivered and spread by hand on the prepared subgrade to such depth that when compacted the thickness shown on the Plans will be secured and shaped to conform to the typical cross-section. Side forms and either cubical blocks or center guide forms of proper size shall be used. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100-foot station and uniformly distributed throughout each station.

If, in the opinion of the Engineer, it be practicable to do so, the caliche shall be puddled with water before being finally shaped and compacted. This puddling may be done either in the pit before the material is hauled on to the road or it may be done by sprinkling with water after the material has been spread upon the subgrade. In case puddling is done in the material pit, the caliche shall at once be hauled on to the road, spread by means of hoes, rakes or shovels, shaped and rolled before it has dried out. In case puddling is to be done after it has been spread upon the subgrade, the surface shall be thoroughly harrowed, plowed or otherwise opened up, during the process of sprinkling, in order to insure the proper puddling of the caliche. After being thoroughly puddled, to the satisfaction of the Engineer, the surface shall be shaped to a uniform thickness and cross section and the succeeding course of material shall be added and puddled in the same manner. Each succeeding course shall be placed and puddled as soon after the preceding one as practicable.

The work shall be rolled or opened to trafficeas directed. The Contractor, as often as directed, shall work and dress the surface so that the cross section shall continue uniform and true to line and grade until accepted.

Method of Measurement. Work and accepted material shall be measured by the cubic yard of material loose measurement as delivered on the road.

Basis of Payment. When a unit price for "Caliche" is requested and tendered in the Proposal, the material furnished as prescribed by this item shall be paid for at the contract unit price so bid per cubic yard. When such price is not so requested, right of way charges and royalties on the material in the pit will be borne by the County. The work performed as prescribed for this item, measured as provided above, shall be paid for at the contract unit price bid per cubic yard for "Caliche Base Course," which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road, puddling and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling, and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price per cubic yard bid for "Material hauled additional quarter mile."

36. DISINTEGRATED LIMESTONE BASE COURSE

Description. This item shall consist of a foundation course for surface courses or other base courses, shall be composed of Disintegrated limestone, and shall be constructed on the prepared subgrade in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of component courses and typical cross-section shown on Plans.

Materials. The material shall consist of a good quality of disintegrated limestone, reasonably free from soil and clay, and when loaded from the material pit shall not contain more than 25 per cent of material which will pass a $\frac{1}{4}$-inch mesh screen. The disintegrated limestone shall be such as can be loosened up in the pit by the use of plows or picks and without the use of explosives. Material containing gravel or hard flint pebbles, will be admitted, although all hard stones over $3\frac{1}{2}$ inches in their largest dimension, which will not be broken up by traffic or rolling, must be thrown out at the pit by the Contractor at his own expense.

Construction Methods. The material shall be delivered and spread by hand on the prepared subgrade to such depth that when compacted the thickness shown on the Plans will be secured, and shaped to conform to the typical cross-section. Side forms and either cubical blocks or center guide forms of proper size shall be used to fix the depth of the loose material. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100-foot station and uniformly distributed throughout each station.

After the material has been spread and shaped, the surface shall be thoroughly sprinkled with water and rolled as soon as sufficiently dried off. The Contractor, as often as directed, shall work and dress the surface so that the cross-section shall continue uniform and true to line and grade until accepted. When the typical cross-section requires that this item be constructed in more than one course, each additional course shall be constructed independently after the previous one has been completed and accepted, all as prescribed above.

Method of Measurement. Work and accepted material hauled to the road shall be measured by the cubic yard of material loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Disintegrated Limestone" is requested and tendered in the Proposal, the material furnished as prescribed by this item shall be paid for at the contract unit price so bid per cubic yard. When such price is not so requested, right of way charges and royalties on the material in the pit will be borne by the County. The work performed as prescribed for this item, measured as provided above, shall be paid for at the contract unit price bid per cubic yard for "Disintegrated Base Course," which price shall be full compensation for loosening and loading all material at the pit, hauling not over one quarter mile, delivering on the road, puddling and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile."

37. IRON ORE TOP SOIL BASE COURSE

Description. This item shall consist of a foundation course for surface courses or other base courses, shall be composed of Iron Ore Top Soil, and shall be constructed on the prepared subgrade in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of component courses and typical cross-section shown on Plans.

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Materials. Iron Ore Top Soil shall consist of hematite, hydrated hematite, or limonite ore as formed at the surface but of a quality free from vegetable matter which when loaded from the material pit shall not contain more than 15 per cent of clay. The material shall be such as can be loosened up in the pit by the use of plows or picks and without the use ofexplosives. Material containing gravel or hard pieces of ore will be admitted although all pieces over 3½ inches in their largest dimension, which will not be broken up during construction, must be thrown out at the pit by the Contractor at his own expense. The material shall have a cementing value of not less than 50 and be so graded that 40 to 75 per cent is retained on a 10-mesh screen when tested by laboratory methods.

Construction Methods. The material shall be delivered and spread by hand on the prepared subgrade to such depth that when compacted the thickness shown on the Plans will be secured and shaped to conform to the typical cross-section, and rolled if required. Side forms and either cubical blocks or center guide forms of proper size shall be used to fix the depth of the loose material. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station and uniformly distributed throughout each station.

After the material has been spread and shaped, the work shall be rolled or opened to traffic as directed. If the material is of such a quality that it adheres to the wheels of the roller after sprinkling, the surface shall be sanded, the necessary material being measured as Surfacing material. The Contractor, as often as directed shall work and dress the surface so that the cross-section shall continue uniform and true to line and grade until accepted. When the typical cross-section requires that this item be constructed in more than one course, each additional course shall be constructed independently after the previous one has been completed and accepted, all as prescribed above.

Method of Measurement. Work and accepted material hauled to the road shall be measured by the cubic yard loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Iron Ore Top Soil" is requested and tendered in the Proposal, the material furnished as prescribed by this item shall be paid for at the contract unit price so bid per cubic yard. When such price is not so requested, right of way charges and royalties on the material in the pit will be borne by the County. The work performed as prescribed for this item, measured as provided above, shall be paid for at the contract unit price bid per cubic yard for "Iron Ore Top Soil Base Course", which price shall be full compensation for loosening and loading all material at the pit, hauling not over one quarter mile, delivering on the road, finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile."

38. Gravel Base Course

Description. This item shall consist of a foundation course for surface courses or for other base courses, shall be composed of gravel, and shall be constructed on the prepared subgrade in accordance with these specifications, and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Material. The gravel shall consist of hard durable particles of stone mixed with sand or clay or other similar binding material and when tested by laboratory methods shall fulfill the following requirements:

Retained on $3\frac{1}{2}$ inch screen 0 - 5%
Retained on $\frac{1}{4}$-inch screen 50 - 75%

Of the material retained on the $\frac{1}{4}$-inch screen 50 to 75% shall be retained on the 3/4 -inch screen.

The material passing the $\frac{1}{4}$ inch screen shall be known as "Binder," and of this material 15 to 35% shall pass the 200 mesh sieve. The cementing value of the binder shall be not less than 50.

The gravel may be crushed or uncrushed, and may be bank run, or the Binder may be added and incorporated by approved methods as hereinafter specified.

Construction Methods. The material shall be delivered in slat-bottom wagons or approved trucks and uniformly dumped on the subgrade or completed course, spread to such depth that when compacted, the thickness shown on the Plans will be secured, harrowed if necessary and shaped to conform to the typical cross-section. Each day's hauling shall be spread the same day. When the width of the course is more than 12 feet the material shall be dumped in two equal rows. The thickness of the course as well as the material shall be strictly uniform. Side forms, and either center forms or cubical blocks, shall be used to fix the depth of loose material. All areas and "nests" of segregated coarse or fine material shall be removed and replaced with well graded material and compacted.

If the gravel is deficient in Binder as prescribed under "materials" above, after it is spread and shaped, additional Binder shall be furnished and applied in the amount directed by the Engineer so as to comply with the grading requirements. Such Binder shall be measured and paid for as provided for the normal gravel, and shall be carefully and evenly incorporated with the material in place as directed by the Engineer.

The work shall be rolled and sprinkled, or opened to traffic as directed. Ruts shall be kept filled twice a day or more as directed. When irregularities, depressions or weak spots develop during the process of shaping and setting up, the affected areas shall be corrected immediately by scarifying, adding material as needed, reshaping and compacting. Thisprocess shall be continued, and the course maintained with grading machines or other equipment as required, to the required line, grade and typical cross-section until the surface is smooth and hard, free from ruts and undulations, well bonded to the width shown on Plans, and the work is accepted.

When the typical cross-section requires that this item be constructed in more than one course, each course shall be constructed independently after the previous one is completed and accepted, all as prescribed above.

Method of Measurement. Work and accepted material shall be measured by the cubic yard of material loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Gravel for Base Course" is requested and tendered in the Proposal, the material furnished as prescribed for this item shall be paid for at the contract unit price so bid; which price shall include all pit charges, crushing screening, and freight F. O. B. delivery points. When such price is not requested the material will be furnished by the County free of royalty and right of way charges, and the Contractor will be paid for all "Crushing and Screening" or "Screening" as ordered, at the prices bid per cubic yard for "Crushing and Screening" or for "Screening."

The work performed as prescribed for this item, measured as provided under "Measurement," shall be paid for at the contract unit price bid per cubic yard for "Gravel Base Course," which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road, spreading and finishing, all labor, equipment, tools and incidentals necessary to complete the work except crushing, screening, rolling and sprinkling. Hauling into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile."

39. SOFT LIMESTONE BASE COURSE

Description. This item shall consist of a foundation course for surface courses, or for other base courses, shall be composed of large fragments of soft local limestone wedged in place with small stones and spalls and leveled up with smaller stone and binder, and shall be constructed on the prepared subgrade in accordance with these specifications, and in conformity with the lines, grades and typical cross sectionsshown on the Plans.

Material. The limestone shall be the best obtainable in the local pits, free from soapstone or similar material and with a per cent of wear of not more than 12. The stones shall be no larger than 12 inches in their largest dimension. The broken stone shall be of a size to pass the $3\frac{1}{2}$ inch screen. The binder shall be screenings, gravel, caliche or other approved material which shall pass the 3/4 inch screen.

Construction Methods. The large stone shall be dumped and spread upon the prepared subgrade, and broken with sledges until there are no stones near the top of the course larger than 6 inches. When the sledging has been finished, the surface shall be re-arranged to insure uniform distribution of the material, the larger voids filled with spalls and the course rolled. The surface shall then be bonded with sufficient crushed stone and binder to fill the superficial voids, and the course finished to conform to the line, grade and typical cross-section.

The rolling shall be as prescribed under "Extra Rolling and Sprinkling for Base Courses", and the surface shall be sprinkled if ordered by the Engineer. Any irregularities that develop during or after rolling shall be remedied by loosening, adding or removing material and rebonding. The surface shall be maintained in its finished condition until accepted.

Method of Measurement. Work and accepted material shall be measured by the cubic yard of material loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Local Base Course Limestone" is requested and tendered in the Proposal, the material furnished as prescribed for this item shall be paid for at the contract unit price so bid. When such price is not so requested, right-of-way charges and royalties on the material in the pit will be borneby the County.

The work performed as prescribed for this item, measured as provided under "Measurement", shall be paid for at the contract unit price bid per cubic yard for "Soft Limestone Base Course", which price shall be full compensation for Loading all material, hauling not over one quarter mile, delivering on the road, spreading and finishing, all labor, equipment, tools and incidentals necessary to complete the work, except rolling and sprinkling. Hauling into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile".

40. SLEDGED STONE BASE COURSE

Description. This item shall consist of a foundation course for surface courses, or for other base courses, shall be composed of large stones wedged in place by small stones and spalls and leveled up with broken stone and binder, and shall be constructed on the prepared subgrade in accordance with these specifications, and in conformity with the lines, grades and typical cross-section shown on Plans.

Material. The Stone shall be a good grade of limestone or sandstone, free from excess of shell, soapstone or other similar material with a per cent of wear of not over 5. Thin stones which break into slabs shall not be used. The stones shall not be over 12 inches in their largest dimension. The Broken Stone shall be of a size to pass the 3½ inch screen. The Binder shall be screenings, gravel, caliche or other approved material which shall pass the 3/4 inch screen.

Construction Methods. The large stone shall be dumped and spread upon the prepared subgrade, and broken with sledges until there are no stones near the top of the course larger than 6 inches. When the sledging has been finished, the surface shall be re-arranged to insure uniform distribution of the material, the larger voids filled with the spalls and the course rolled. The surface shall then be bonded with sufficient crushed stone and binder to fill the superficial voids, and the course finished to conform to the line, grade and typical cross-section.

The rolling shall be as prescribed under "Extra Rolling and Sprinkling for Base Courses," and the surface shall be sprinkled if ordered by the Engineer. Any irregularities that develop during or after rolling shall be remedied by loosening, adding or removing material and rebonding. The surface shall be maintained in its finished condition until accepted.

Method of Measurement. Work and accepted material shall be measured by the cubic yard of material loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Sledging Stone" is requested and tendered in the Proposal, the material furnished as prescribed for this item shall be paid for at the contract unit price so bid. When such price is not so requested right of way charges and royalties on the material in the pit will be borne by the County.

The work performed as prescribed for this item, measured as provided under "Measurement," shall be paid for at the contract unit price bid per cubic yard for "Sledged Stone Base Course," which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road, spreading and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile."

31-44-1617-10

41. CRUSHER RUN BROKEN STONE BASE COURSE

Description. This item shall consist of a foundation course for surface courses, or other base courses, shall be composed of crushed stone and screenings as the material comes from the crusher, and shall be constructed on the prepared subgrade, or other completed base course, in accordance with these specifications, and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Material. The stone shall not contain more than 5 per cent of partially decomposed particles, and not more than 5 per cent of flat or elongated pieces, the width of which is less than half the length. The material may be unscreened or partially screened, but when tested by laboratory methods, the stone shall meet the following requirements:

Retained on the $3\frac{1}{2}$ inch screen 0 to 5%
Retained on the 2 inch screen 25 to 60%
Retained on the $\frac{1}{4}$-inch screen, 95 to 100

Screenings for additional binder shall be the product from similar stone which shall meet the following requirements.

Retained on the 1 inch screen 0 to 5%
Retained on the $\frac{1}{4}$-inch screen 20 to 60%

Construction Methods. The subgrade shall be rolled. The stone shall be delivered in slat-bottom wagons or approved trucks, and uniformly dumped on the subgrade, spread to such a depth that when compacted the thickness shown on the Plans will be secured, shaped to conform to the typical cross-section, and rolled. The subgrade shall be thoroughly dry when the material is delivered; each day's hauling shall be spread the same day. When the width of base course is more than 12 feet the material shall be dumped in two equal rows. The thickness of the course as well as the material shall be strictly uniform. Side forms, and either center forms or cubical blocks, shall be used to fix the depth of loose material. All areas and "nests" of segregated coarse or fine material shall be removed and replaced with well graded material and rerolled if necessary.

The rolling shall be as prescribed under "Extra Rolling and Sprinkling Base and Surface Courses." After thorough rolling, and if found necessary screenings shall be spread with shovels in a uniform layer. The screenings shall not be dumped directly on the surface of the coarse stone. The course shall be further rolled and sprinkled if ordered by the Engineer, the surface shall be thoroughly bonded to his satisfaction, and finished to conform to the line, grade and typical cross-section.

If any irregularities develop in the surface during or after rolling, they shall be remedied by loosening, adding or removing material and rebonding. The surface shall be maintained in its finished condition until accepted.

If at any time the subgrade material shall become churned up or mixed with the base course, the Contractor without additional compensation, dig out and remove such mixture, reshape and compact the subgrade and reconstruct the base course with new material.

When the typical cross-section requires that this item be built in more than one course, each course shall be constructed independently after the previous one is completed and accepted, all as prescribed above.

Method of Measurement. Work and accepted material shall be measured by the cubic yard of material loose measurement, as delivered on the road.

Basis of Payment. The material furnished as prescribed by this item shall be paid for at the contract unit price per cubic yard ofor "Crusher Run Broken Stone," which price shall also be full compensation for quarrying, crushing and screening, and freight involved. The work performed as prescribed for this item, measured as provided above, shall be paid for at the contract unit price per cubic yard bid for "Crusher Run Broken Stone Base Course," which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road, spreading and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling, and sprinkling. Hauling material into each additional quarter mile beyond the first quarter mile shall be paid for at the contract unit price per cubic yard bid for "Material Hauled Additional Quarter Mile."

31-44-1617-12

42. WATER BOUND GRAVEL OR BROKEN STONE MACADAM BASE COURSE

Description. This item shall consist of a foundation course for surface courses or pavements, shall be composed of washed gravel of broken stone and binder, and shall be constructed on the prepared subgrade or other completed base course in accordance with these specifications, and in conformity with the lines, grades, compacted thickness and typical cross-section shown on the Plans.

Material. The Broken Stone shall consist of angular fragments of rock (Excluding schist shale or slate) of uniform quality throughout, with not more than 5 per cent of soft friable material, not more than 5 per cent of flat or elongated pieces the width of which is less than half the length, and with a per cent of wear of not more than 8. When tested by laboratory methods the stone shall meet the following requirements:

Retained on $3\frac{1}{2}$ inch screen 0 - 5%
Retained on 2 inch screen, 25 - 60%
Retained on 3/4 inch screen, 100 %

The Washed Gravel shall consist of rounded or angular fragments of rock with not more than 5% of slate, shale or soft sand stone particles, and shall be free from organic matter, clay, loam or pebbles coated therewith. It may be crushed or uncrushed, and shall have a per cent of wear (abrasion test for gravel) of not more than 18. When tested by laboratory methods it shall meet the following requirements:

Retained on $3\frac{1}{2}$ inch screen 0 - 5%
Retained on $1\frac{1}{2}$ inch screen 25 - 60%
Retained on $\frac{1}{2}$-inch screen 95 - 100 %

Screenings shall consist of material equal in quality to that specified for "Broken Stone" above, and shall be that product of the crusher including the dust of fracture, which will meet the following requirements:

Retained on 3/4 inch screen 0 - 5%
Retained on $\frac{1}{4}$-inch screen 20 - 60%
Passing 200 mesh sieve 5 - 20%

Construction Methods. The subgrade shall be rolled and shall be dry and clean of all foreign substances. The stone or gravel shall be furnished, spread upon it to such loose depth that when completed the compacted depth shown on Plans will be obtained, harrowed if necessary, sloped to the typical cross-section, and dry rolled. The stone shall be spread with shovels from storage piles along the side of the roadway or from dumping boards or may be spread directly from approved vehicles. The gravel may be dumped in two equal rows and shaped by grading machine or road drag, provided it is shaped the same day it is dumped. The thickness of the course, as well as the material shall be strictly uniform. Side forms, and either center forms or cubical blocks shall be used to fix the depth of loose material. The shoulders shall be built up to support the edges of the course as directed. All areas and "nests" of segregated coarse or fine material shall be removed and replaced with well graded material.

The dry rolling shall be done with a self-propelled roller weighing not less than 8 tons. The rolling shall be longitudinal, shall begin at the sides, overlapping the earth shoulders at least six inches, and progress gradually to the center. At any low places that develop the material shall be loosened and the necessary additional material placed, and re-rolled. The entire surface shall be thoroughly rolled until all settlement has ceased.

Screenings shall be applied gradually over the surface during the dry rolling in such an amount as will completely fill the interstices. The screenings shall not be dumped on the surface of the stone or gravel, but shall be cast thinly with a spreading motion of the shovel and broomed into the voids. The rolling shall continue while the screenings are being spread, so as to aid by jarring the fine material into the interstices. The screenings shall not be allowed to cake or "bridge" on the surface so as to prevent the filling of the voids or the direct bearing of the roller on the surface of the stone or gravel. The spreading and rolling shall continue until no more screenings will go in dry and the whole surface conforms to the line, grade and typical cross-section. No excess screenings shall be used.

Dumping of ashes and cinders from the fire box on the course must ~~bota~~ be allowed and any letter must be removed from the Stone or gravel before the roller passes over it.

After the dry rolling and filling is complete, the surface of the course shall be sprinkled with water until thoroughly saturated and more screenings added and rolled. The sprinkling and rolling shall continue until a grout forms in front of the roller that will fill all voids. The work shall then be permitted to partially dry out, and the rolling shall be continued on successive days until the bond is complete and the surface does not creep, or wave under the roller. The surface of the course shall be maintained in its finished condition until accepted.

Method of Measurement. The work completed and accepted shall be measured by the square yard.

Basis of Payment. All work performed under this item and measured as provided above shall be paid for at the contract unit price per square yard bid for "Water Bound Gravel of Broken Stone Macadam Base Course," which price shall be full compensation for purchasing, furnishing, quarrying, screening, hauling and delivering on the road and rolling all materials, for all labor, equipment, tools and incidentals necessary to complete the work. No overhaul will be allowed.

31-44-1617-14

43. BITUMINOUS CONCRETE BASE COURSE

Description. This item shall consist of a bituminous concrete foundation course for bituminous surface courses or pavements, shall be composed of coarse and fine mineral aggregate and bituminous cement, and shall be constructed on the prepared subgrade or completed base course in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross section shown on the Plans.

Materials. The Mineral Aggregate for the mixture shall consist of a coarse Aggregate of crushed stone or gravel, and a Fine Aggregate. Samples of the Coarse and Fine Aggregate shall be submitted in accordance with standard prescribed methods, and approval both of the material and of the source of supply shall be obtained from the Engineer, prior to delivery of material. Material shipped in dirty cars or vehicles will be rejected. The Coarse Aggregate shall consist of clean tough durable fragments of rock (excluding schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, and free from soft or disintegrated stone, dirt, organic or other injurious matter occurring either free or as a coating on the stone. All Limestone shall meet the requirements of the Soundness Test. The Aggregate shall have a per cent of wear of not more than 7 for stone and not more than 15 for gravel (abrasion test for gravel) and when tested by laboratory methods shall meet the following requirements:

Passing $2\frac{1}{2}$ inch screen 100%
Passing $1\frac{1}{4}$ inch screen 25 to 75%

The Fine Aggregate shall consist of sand or a combination of sand and screenings, composed of hard durable grains free from clay organic matter or any soft or injurious material. When tested by laboratory methods, it shall meet the following requirements:

Passing	Retained on	Per Cent
$\frac{1}{4}$ inch screen		100
$\frac{1}{4}$ inch screen	10 mesh sieve	0 to 20
10	40	15 to 50
40	80	25 to 65
80	200	7 to 40
200		9 to 6

The Bituminous Material shall meet the requirements given below for OA-7, NA-7 or NA-9. The material shall be homogeneous, free from water and the asphalt material shall not foam when heated to 175°C (347°F.) Oil Asphalt for any one contract shall not vary more than 0020 in specific gravity nor more than 10°C in melting point within the test limits above specified.

OA-7, Oil Asphalt

Specific gravity 25°/25°C. (77°/77°F.)---------- not less than 1.020
Flash point ---------- ----not less than 175°C. (347°C.)
Melting point ----------45°C. (113°F.) to 65°C. (149°F.)
Penetration at 25°C. (77°F.), 100 g., 5 sec ---------- 40 to 50
Loss at 163°C. (325°F.) 5 hours ---------- not more than 1.0%

a. Penetration of residue at 25° C. (77°F.), 100 g., 5 sec ---------- not less than 25
Total bitumen (soluble in carbon disulphide), not less than 99.5%
a. Organic matter insoluble ---------- not more than 0.2%.

NA-7. Fluxed Bermudez Asphalt.

Specific gravity 25°/25° C. (77°/77°C.) ---------- 1.055 to 1.075
Flash point ---------- not less than 175°C. (347°F.)
Melting point ---------- 45°C. (113°F.) to 55°C. (131°F.)
Penetration at 25°C. (77°F.), 100 g., 5 sec ---------- 40 to 50
Loss at 163°C. (325°F.), 5 hours ---------- not more than 3.0%

a. Penetration of residue at 25°C. (77°F.), 100 g., 5 sec ---------- not less than 20
Total bitumen (soluble in carbon disulphide), not less than 94.0%
b. Inorganic matter insoluble ---------- 2.5% to 4.0%

NA-9 Fluxed Trinidad Asphalt

Specific gravity, 25°/25°C. (77°/77°F.) ---------- 1.210 to 1.270
Flash point ---------- not less than 175°C. (347°F.)
Melting point ---------- 50°C. (122°F.) to 60°C. (140°F.)
Penetration at 25°C. (77°F.), 100 g., 5 sec ---------- 4- to 50
Loss at 163°C. (325° F.), 5 hours ---------- not more than 3.0%

a. Penetration of residue at 25°C. (77°F.), 100 g., 5 sec ---------- not less than 20
Total bitumen (soluble in carbon disulphide), ---- not less than 65.0%
b. Inorganic matter insoluble ---------- 22.0% to 32.0%

Proportions of materials in total mixture: in addition to the previous requirements, the Coarse Aggregate, Fine Aggregate and Bituminous Material shall be so graded and proportioned by weight that when combined a total mixture of the following proportions will be secured:

Passing	Retained on	Per cent by weight	
$2\frac{1}{2}$ inch screen	$1\frac{1}{4}$ inch screen	20 to 45%)	50% to 65%
$1\frac{1}{2}$ inch screen	$\frac{1}{4}$ inch screen	15 to 45%)	
$\frac{1}{4}$ inch screen	10 mesh sieve	10 to 25%	
10 mesh		15 to 35%	
200		3 to 5%	

Bitumen (soluble in carbon disulphide) 4 to 7%

The proportions shall be varied within the limits designated as directed by the Engineer, but neither the type or proportions of material shall be varied without the consent of the Engineer. The percentage of bitumen in the finished base course shall not vary more than $\frac{1}{2}$% from the proportion established by the Engineer. Unvarying uniformity is of prime importance and both the proportioning and treatment of all materials must be maintained consistently satisfactory to the Engineer throughout the construction period, and whenever required by him, samples of the hot mixture may be taken several times daily, and the mixture to be acceptable, must invariably conform to all requirements.

Preparation of Mineral Aggregate: The Coarse and Fine Aggregate shall be heated as directed to between 250 to 350 degrees F. in suitable apparatus in which the aggregate shall be continuously agitated during the heating and in which the temperature can be efficiently and positively controlled.

The Bituminous Material shall be separately heated, with effective control of the temperature at all times, to between 250 and 350deg. F. All material heated above 350 deg. F. either before or during the mixing with the Mineral Aggregate shall be rejected.

Mixing: The constituent proportions of the Mineral Aggregate shall be measured separately and accurately by wieght or volume by accurate plant methods which meet the Engineer's specific written approval. The required quantity of hot bituminous material for each batch shall be measured by actual weighing with accurate scales attached to the bucket. The measuring and proportioning shall be such as to accurately and consistently secure the graded mixture prescribed by these specifications. Batches shall be uniform and shall not be varied except by direction of the Engineer. The mixing shall be done in an approved batch mixer, which shall be designed and operated as to produce and discharge a uniform mixture of thoroughly coated Mineral Aggregate and Bituminous Material as prescribed. The heated Bituminous Material shall be introduced in the mixing chamber after the Mineral Aggregate has been previously mixed therein. The mixture as discharged shall be at a temperature between 250 and 350 deg. F., and shall not vary more than 30° from the temperature set by the Engineer within those limits. The plant must be provided with separate heating and mixing chambers, no direct heat except steam shall be applied to the exterior surface of the mixing chamber and no flame shall be allowed to pass through the mixing chamber.

Placing: The prepared mixture shall be transported from the mixing plant to the road in tight vehicles previously cleaned of all foreign materials, and shall be delivered on the road at a temperature between 250 and 350 deg. F. If required by Engineer the loads shall be protected from the weather by canvas, or other suitable material. No loads shall be sent out so late in the day as to prevent spreading and rolling the mixture during daylight, unless artificial light satisfactory to the Engineer is provided. The work shall be done only when weather conditions in the opinion of the Engineer are suitable.

Prior to the arrival of the hot mixture upon the work, the subgrade have been rolled, shall be thoroughly bonded with no loose or foreign particles on its surface, and shall be dry or in any case free from standing water. Contract surfaces of curbs, gutters, manholes,etc., shall be painted with a thin uniform coat of hot asphaltic cement, or asphaltic cement disolved in naptha, just before the surface mixture is placed against them. Upon arrival at the work, the hot mixture shall be dumped on approved steel "dump boards" outside of the area upon which it is to be spread, and immediately distributed into place by means of hot shovels and spread with hot rakes in a uniformly loose layer of such depth that when compacted the compacted depth shown on the typical cross-section will be obtained. Adjacent to flush curbs, gutters etc., the mixture shall be raked uniformly high so that it will be slightly above the edge of the curb or flush structure. The mixture shall be rolled at once while it is still warm and pliable, beginning at the edges and working toward the center. The rolling shall be done by tandem rollers weighing not less than 8 tons, or by a similar tandem roller and a 3 wheeled roller weighing not less than 10 tons. Means for preventing the bituminous material from adhering to the roller shall be provided as directed by the Engineer. The rolling shall progress continously at the rate of not more than 200 square yards per hourper roller and shall include longitudinal rolling and two diagonal rollings approximately at right

angles to each other. The motion of the rollers shall be at all times slow enough to avoid displacement of the hot mixture or any tendency to the creation of "Waves", and shall be continued until all roller marks disappear and the course has a density of not less than 95% of its maximum calculated density. For a radial distance of 8 inches around all structures and all places inaccessible to the rollers, compression shall be effected by hot iron tampers of bearing area of 48 square inches or more, and weight or not less than 25 pounds.

Joints: Placing of the ~~surface~~ Base course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is discontinued for such length of time as to permit the mixture to become chilled. In all such cases when the work is resumed the material laid shall be cut back so as to produce a slightly beveled edge for the full thickness of the course. The old material which has been cut away shall be removed from the work and new mix laid against the fresh cut. If desired, a stout rope may be stretched across the pavement where the joint is to be made. When the work is resumed, the material laid shall be cut back to the rope which will be removed together with the surplus material and the fresh mix laid against the joint thus formed. Hot smoothing irons may be used for sealing joints, but in such case extreme care shall be exercised to avoid burning the surface.

Surface Finish and Tests: The surface of the mixture after rolling shall be smooth, dense, and true to the established crown and grade. Before the completion of the rolling the surface shall be tested as follows, and corrected as necessary by properly adding or removing hot mixture, retesting, and rerolling until the finished surface complies with the test requirements.

Surface Tests: The finished course shall show no deviation from the general surface in excess of $\frac{1}{4}$ inch as shown by deviation from a 10 foot straight edge laid parallel to the center line of the road so as to bridge any depressions and touch all high spots.

Such portions of the course as are defective in finish, density or composition, or become loose, broken or mixed with dirt prior to the application of the wearing surface shall be removed and replaced with fresh hot mixture and rebuilt in accordance with these specifications at the expense of the Contractor. The base course shall be protected from traffic until cold.

The surface shall be maintained in its finished condition until accepted.

Method of Measurement: This item shall be measured by the square yard complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price bid per square yard, for "Bituminous Concrete Base Course," which price shall be full compensation for quarrying, furnishing, hauling and placing all material, for preparation of all material, for all labor, equipment, tools and incidentals necessary to complete the work.

44. CONCRETE BASE COURSE AND CURB

Description. This item shall consist of a foundation course composed of Portland Cement concrete, and shall be constructed on the prepared subgrade or other completed base course, in accordance with these specifications and in conformity with the lines, grades and typical cross-section shown on the Plans. The curb or edging shall be constructed integrally as shown on Plans.

The composition of the base course shall be $7\frac{1}{2}$ parts of coarse and fine aggregate to 1 part of Portland cement, and of the curb or edging, $5\frac{1}{2}$ parts of coarse and fine aggregate to 1 part of Portland Cement. The Engineer shall regulate the proportion of fine to coarse aggregate to secure the maximum density, and the proportions in terms of the 3 ingredients shall approximate 1-$2\frac{1}{2}$-5 and 1-2-$3\frac{1}{2}$ respectively. In no event shall the number of bags of cement used per cubic yard of concrete in place be less than 5 for the base and $6\frac{1}{2}$ for the integral curb.

Materials. The coarse Aggregate shall consist of Broken Stone or gravel conforming to the following requirements.

Broken Stone shall consist of clean, tough, durable, fragments or rock (excluging schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, soft or disintegrated stone, dirt, organic or other injurious matter occuring either free or as a coating on the Stone. All stone shall have a per cent of wear of not more than 6. All limestone shall meet the requirements of the Soundness Test.

Gravel shall consist of clean hard durable uncoated pebbles having a per cent of wear of not more than 15 (abrasion test for gravel) and shall be free from an excess of soft, thin or laminated pieces, disintegrated Stone, dirt, organic or other injurious matter occurring either free or as a coating on the Stone; where reinforcing steel is to be used gravel shall be free from salt and alkali.

Grading: Coarse Aggregate, when tested by laboratory methods shall meet the following requirements:

Passing $2\frac{1}{2}$ inch screen 95 to 100%
Retained on $1\frac{1}{4}$ inch screen 25 to 60%
Retained on 3/4 inch screen 40 to 75%
Retained on $\frac{1}{4}$ inch screen 95 to 100%

Alternate Grading. (Special written approval required)

Passing 3 inch screen 100
Retained on $1\frac{1}{2}$ inch screen 25 to 60
Retained on 1 inch screen 40 to 75
Retained on $\frac{1}{4}$ inch screen 95 to 100

Coarse Aggregate conforming in all respects to the above requirements except grading may be used, provided that concrete made from such material meets the requirements of the Strength Test hereinafter specified.

Fine aggregate shall consist of sand, or a combination of sand and not more than 50% of stone screenings, conforming to the following requirements:

Sand shall be composed of clean, hard durable uncoated grains, free from lumps, soft or flaky particles, loam, organic or other injurious matter. Where reinforcing steel is to be used sand shall be free from salt and alkali.

Stone screenings shall consist of the clean dustless product resulting from the crushing of stone, meeting all the requirements for Coarse Aggregate except for grading, and free from lumps.

Fine Aggregate shall be well graded from coarse to fine and shall meet the following requirements:

Passing the $\frac{1}{4}$ inch screen	95% to 100%
Passing 20 mesh sieve	50 to 80
Passing 50 mesh sieve	5 to 30
Passing 100 mesh sieve	0 to 5

Weight removed by elutriation test not more than 3%

When subjected to the color test for organic impurities, the Fine Aggregate shall not show a color darker than the standard color.

Fine Aggregate conforming to all requirements except grading and color, and mortar strength hereinafter specified, may be used provided that concrete made from such material shall meet the requirements of the Concrete Strength Test hereinafter specified.

Cement shall conform to the requirements for Portland Cement prescirbed in U. S. Department of Agriculture Bulletin 1216.

Water shall be clean, clear, free from oil, acid, alkali or vegetable matter and shall not be used until the source of supply has been approved. If at any time the water from this source shall be come of unsatisfactory quality or insufficient quantity the Contractor may be required to provide satisfactory water from some other source. Water of doubtful quality shall be tested in briquets as provided under "Mortar Strength" of this specification and the test results shall be equal to those made from water of known satisfactory quality.

Mortar Strength: When the Fine Aggregate is mixed with Portland Cement in the proportion of 1:3, the tensile or compressive strength ratio compared to Ottawa sand mortar briquettes of the same proportions and consistency shall be not less than 100% at 7 and 28 days.

Concrete Strength Test: Concrete materials may be submitted to the following test and shall be considered to pass the Concrete Strength Test when the following strength requirements are fulfilled. In no case, however, shall aggregate be used which contain more than 3% material removable by the Eluctriation test, nor shall the coarse aggregate contain more than $1\frac{1}{2}$% of clay or dust.

The Coarse Aggregate, Fine Aggregate and Cement and Water proposed for use, shall be mixed in the same proportions and to the same consis tency that they are to be used in the work, and tested as prescribed in U. S. Department of Agriculture Bulletin, No. 1216, and at least the following compression strengths shall be obtained.

Proportions	7 day test	28 day test
1 to $5\frac{1}{2}$	2000	3000
1 to $7\frac{1}{2}$	1000	1700

The 7 day requirements may be waived. The exact proportions may be varied with the approval of the Engineer to obtain the strength desired and the new proportions used in the work, but the proportions of cement to total aggregate shall not be less than hereinbefore prescribed, only such proportions shall be used as will produce a workable mixture, and no allowance shall be made the Contractor for altered or additional work or material involved in the reproportioning.

All sampling of materials shall be as required in U. S. Department of Agriculture Bulletin No. 1216. Cement shall be packed, shipped, stored and inspected as prescribed in Bulletin 1216. Aggregate shipped in dirty cars or containers, or that becomes mixed with weeds, dirt or foreign material or that is not uniform, or the component parts of which have become segregated will be rejected. No aggregate shall be stored or dumped on the road bed.

Construction Methods. The subgrade shall have been rolled and finished as prescribed for Concrete Bases or Pavements. It shall be tested with the subgrade templet just before placing the concrete mixture and shall be in a moist condition. The subgrade templet shall be furnished and used by the Contractor and shall be so designed and constructed that when the templet is reding on the side forms, the testing edge shall exactly conform to the grade and crown prescribed on the typical cross-section. This templet shall be kept in place at all times on the forms at the discharge end of the mixer.

All equipment, tools, and machinery used for handling materials and performing any part of the work must be approved by the Engineer and must be maintained in satisfactory working condition.

Forms: Outside forms for this work shall be of metal, of depth equivalent to the edge thickness of the work prescribed, straight and free from warp. They shall be of approved section, shall have a flat top of not less than 1 3/4 inches width, and such base width that the maximum load on the subgrade under any method of finish shall not be more than 7 pounds per square inch.

. The forms shall be joined neatly and tightly and securely pinned and staked to line and grade, at least 200 feet in advance of placing concrete. The forms shall be of such strength and shall be so secured as to resist the pressure of the concrete and the mechanical tamper without springing or settlement. Bearing stakes driven flush with the bottom of the form may be required for additional stability. The entire length of the forms shall be in contact with the subgrade. The Engineer may require additional bearing area, secured by planks fastened to the forms and to the subgrade. The building of pedestalsof earth or other material upon which to rest the forms in order to bring them up to grade will not be permitted.

The inside forms for the integral curb shall be of approved material and of such design as to provide the curb required, and rigidly attached to the outside forms. Sufficient forms shall be provided so that they may remain in place 12 hours or more after the concrete has been placed before it is necessary to remove and re-use them. Forms shall be cleaned and oiled before concrete is placed against them. The alignment and grade of forms shall be checked and approved immediately before placing concrete. Forms which show a variation exceeding the surface test required shall be reset or removed as directed.

Measuring Materials: All materials shall be separately and accurately measured by volume unless otherwise specified, and each batch shall be uniform. Coarse and Fine Aggregate shall be measured loose and separately. No computed change in volume for moisture content shall be considered. A bag of cement, American as packed by the manufacturer and weighing 94 pounds shall be considered 1 cubic foot. The Contractor shall furnish and use approved measuring boxes, pans or mechanical devices, which in operation will give the exact volumes of coarse and fine aggregate required and so designed and plainly marked that the Inspector can accurately and conveniently check the quantities of each aggregate actually being used.

Consistency: Sufficient water shall be used in mixing to produce a workable mixture which will flatten out and quake when deposited in place, but not enough to cause it to flow, and which can be conveyed from the mixer to the work without segregation of coarse aggregate from mortar.

When a "Central Mixing Plant" is used, especial care shall be taken that the consistency is such as will not result in segregation of the aggregate during transportation of the mixture to the work. In no case shall the quantity of water used be sufficient to cause the collection of a surplus on the surface. The quantity of water shall be determined by the Engineer, and not varied without his consent. The Contractor shall furnish and use with the mixer an approved adjustable water measuring device which will prevent excess water flowing into the mixer.

Mixing Conditions: The concrete shall be mixed in the quantities required for immediate use and any which has developed initial set, or which is not in place within 30 minutes after the water has been added, shall not be used. No concrete shall be mixed while the air temperature is at or below 35 degrees F. without the approval of the Engineer. No materials containing frost or lumps of hardened materials shall be used. If the Contractor intends using a "Central Mixing Plant" he must so state beforehand, and must obtain permission for its use from the State Highway Engineer.

Mixing: The mixing shall be done in a batch-mixer of approved type which will insure the uniform distribution of the materials throughout the mass so that the mixture is uniform in color and smooth in appearance. The mixing shall continue for a minimum time of 1 minute after all the ingredients are assembled in the drum, during which time the drum shall revolve at the speed for which it was designed but shall make not less than 14 nor more than 20 revolutions per minute. The mixer shall be equipped with an attachment for satisfactorily locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch. The mixer shall be equipped with bucket and broom delivery unless otherwise permitted by the engineer, have a capacity of not less than 3 bags of cement per batch of concrete of the composition herein specified: and a speed regulator to hold the mixer to its normal speed of revolution.

Hand Mixing: Hand mixing will only be allowed when yardage of concrete base is too small to warrant the use of a paver. When hand mixing is permitted it shall be done on a watertight platform. The fine aggregate and cement shall first be mixed until a uniform color is attained and then spread over the mixing board in a thin layer.

The coarse aggregate, which shall have been previously drenched, shall then bespread over the fine aggregate and cement in a uniform layer and the whole mass turned as the water is added.

After the water has been added, the mass shall be turned at least six times, and more if necessary, to make the mixture uniform in color and smooth in appearance. Hand-mixed batches shall not exceed one-half cubic yard in volume.

Checking Quantities of Cement Used: The Engineer shall ascertain by calculation and tests, the amount of cement required for each section between transverse joints, according to these specifications, and as the work progresses, the Engineer shall compare the amount so ascertained with the amounts actually used in each section of concrete between successive transverse joints, as determined by actual count of the number of bags of cement used in each section. If the amount of cement used in any three adjacent sections (between transverse joints) is less by more than four per cent, or if the amount of cement used in any one section is less by more than five per cent of the amount herein required, the Contractor shall remove all such sections and replace the same with new material, according to these specifications, and at his own expense.

Placing Concrete: Concrete shall be placed only on a moist subgrade. If the subgrade is dry it shall be sprinkled with as much water as will be absorbed readily. The concrete shall be deposited on the subgrade rapidly in successive batches, by means of a discharging device which does not cause separation of the mortar and the coarse aggregate and shall be distributed to the required depth and for the entire width of the pavement by shoveling or other approved methods. Rakes shall not be used in handling concrete. This operation shall be continuous. At the end of the day, or in case of an unavoidable interruption of more than 30 minutes, a transverse joint shall be placed at the point of stopping work, provided that the section on which the work has been suspended shall be not less than 10 feet in length. Sections less than 10 feet in length shall be removed.

Placing Reinforcing Steel: When reinforcement is required it shall be placed as shown on Plans, and provided in these specifications under "Reinforcing Steel."

Placing Curb: The concrete for the integral curb as required shall be placed immediately and in no case more than 30 minutes after the base course has been placed. The base course concrete shall extend the full width to the outside forms and the curb placed on top, tamped and spaded.

Joints: Transverse or Longitudinal joints if required on Plans, or when the work is interrupted shall be constructed as provided for Concrete Pavement.

Finishing Concrete shall be as provided for Concrete Pavement, except that when hand finish is employed only one belting is necessary.

The surface for bituminous pavements may be left moderately rough with the aggregate well embedded, but not covered with mortar. The top surface of the curb shall be floated to a smooth even surface and the outside edge rounded as shown on Plans.

Curing: Newly laid concrete shall be cured by covering with burlap covers which shall be wet for twenty-four hours and may then be removed, but the concrete shall be kept soaked with water for at least 7 days following the placing of the concrete. This watering shall be done during daylight. At no time shall more concrete be laid than can be properly cured. For each one thousand feet of concrete base laid less than seven days, there shall be at least one man who shall devote his entire time to watering the base.

All honey combs in the edges shall be properly pointed up with mortar, and earth thrown up to the sides of the pavement to a width of twelve inches outside the edges.

When it is expected that the temperature may fall below 32 degrees Fahrenheit, a sufficient supply of straw, hay, grass, or other suitable material must be on hand along the roadway being concreted, to cover the pavement and to sufficiently protect its surface and sides against freezing , but care shall be taken not to mar the surface of the concrete base. Lanterns hung within frames enclosed by canvas or other approved material , or fires built in containers or on the ground and maintained at close intervals along the roadside may be used. The period of time over which this protection shall be maintained will be determined by the Engineer, but in general will not exceed four days.

It is understood that the Contractor accepts all responsibility for the quality and strength of concrete laid. All classes of traffic and hauling shall be excluded from the base course by the erection of suitable barricades as directed, until in the opinion of the Engineer the concrete has hardened sufficiently. In no case shall traffic or hauling or the laying of surface course be permitted until the concrete base is at least ten days old. All cracks in the base course shall be sealed with an approved bituminous material in the event the base course is not covered with bituminous material before November first.

Surface Test: The surface of the base course shall be tested with an approved template shaped in accordance with the typical cross-section and with a 10 foot straight edge to secure a uniform surface free from all depressions or other irregularities that are more than $\frac{1}{2}$ inch above or below the general surface as checked by the template and the straight edge.

Method of Measurement. This item shall be measured by the square yard complete in place. The width for measurement will be the total width from out to out of integral curb as shown on the typical cross-section.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price bid per square yard for "Concrete Base Course and Curb," which price shall be full compensation for furnishing, quarrying, preparing, transporting, delivering and placing all material, for all labor, equipment, tools and incidentals necessary to complete the work.

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50. SURFACE COURSES AND PAVEMENTS.

51. SAND CLAY SURFACE COURSE.

Description. This item shall consist of a wearing course composed by an intimate mixture, either natural or artificial, of properly proportioned sand and clay, and shall be constructed on the prepared subgrade in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of competent courses, and typical cross-section, shown on the Plans.

designated

Material. Natural Sand-Clay shall consist of sand and clay or topsoil, occuring properly proportioned, and obtained from pits ~~designed~~ by the Engineer. After the pit has been stripped the Engineer shall inspect and approve the material before it is placed on the subgrade. All material used shall be free from weeds, vegetable or other injurious matter, and all stones of more than 1 inch diameter shall be removed by the Contractor at the pit.

Sand for an artificial mixture or to supplement a natural mixture shall be sharp, clean, free from dirt or loam and not too fine. It shall not be used until approved by the Engineer.

Clay for an artificial mixture or to supplement a natural mixture shall show resistance to slaking and shrinking satisfactory to the Engineer, shall have good binding qualities and shall not be used until approved by the Engineer.

Construction Methods. Where it is necessary to bring the sand and clay on the subgrade separately, and mix them in place, a trench shall be formed in the subgrade with the grading machine to receive the bottom layer, which may be either the sand or clay. No trenching of the subgrade will be required where the subsoil is of sand or clay that is to be mixed with the clay or sand, as the case may be.

a. Clay on Sand Subgrade: The clay shall be spread over the prepared subgrade in such quantities and to such depth that when mixed with the sand a compacted surfacing of the width and depth shown on the plans, will be obtained. After the clay has been spread the Contractor shall plow up sand from beneath and add sand from the sides, but only in such amount that the net proportion of sand and clay is about two to one, or in sufficient quantity so that the clay will slightly more than fill the voids of the sand.

b. Sand on Clay Subgrade: This process is exactly similar to that in Paragraph above, except that the subgrade shall be plowed to a depth of four inches, after which, it shall be harrowed until completely pulverized; the sand shall be spread over the subgrade in such quantities and to such a depth that when mixed with clay, a compacted surfacing of the width and depth, shown on Plans will be obtained. The depth to which the sand should be spread will depend upon the amount of sand contained originally in the clay of the roadbed. As near as practicable only enough clay shall be plowed up from beneath to just fill the voids of the sand, and no surplus of clay will be allowed. Where the subgrade material consists of clay which, in the opinion of the Engineer, is not considered suitable for use in the surface, the sand layer shall be spread first, and of a depth more than is sufficient for use in surfacing, and as directed by the Engineer. The surplus sand shall remain

under the completed surface to serve to improve the drainage of the road. The proper proportion of suitable clay shall then be hauled and spread on the sand as in case "C" following.

c. Sand and Clay on a Different Subgrade Soil: Where it is necessary to bring the sand and clay on the road separately, the trench should be filled with the bottom layer of material (which may be either sand or clay) to such a depth, and then have the top layer spread upon it to such a depth, that when mixed together the sand and clay will show a properly proportioned and uniformly mixed compacted surfacing of the width and depth shown on Plans.

d. Natural Sand-Clay: The surfacing material shall be spread on the prepared subgrade to such a depth, that when compacted, it will be of the width and depth shown on the Plans.

In all cases, only sufficient clay to fill the voids of the sand shall be used, the clay serving as a binder for the sand. On sections of road that are not exposed to the sun and wind, as in dense woods, deep cuts, or on low boggy sections, a smaller percentage of clay will be required, in proportion to the smaller percentage of voids in the sand. On heavy grades, especially when exposed to the sand and wind, a greater percentage of clay will be required. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station and uniformly distributed throughout each station.

After the material has been spread as prescribed in the several cases above, the material shall be thoroughly mixed with a disk harrow. The operations of plowing and harrowing shall be repeated until the sand and clay are mixed thoroughly and uniformly in the proper proportions. After the mixing is completed, the Contractor shall shape the roadway with a road machine or road drag and permit traffic upon it. After the first soaking rain the Contractor shall plow and harrow the surfacing material until it practically becomes mud, after which he shall shape the surface and keep it in shape by repeated dragging until it has dried out and is thoroughly compacted.

When the typical cross-section requires that this item be constructed in more than one course the additional courses shall be constructed independently on the previously completed course in accordance with clauses "c" or "d" of these specifications, and maintained and finished as provided above.

Method of Measurement. Work and accepted material hauled from prescribed pits to the road shall be measured by the cubic yard of material loose measurement, as delivered on the road.

Basis of Payment. The material will be furnished by the County unless otherwise provided in Special Provisions. The work performed as prescribed by this item and measured as provided above, shall be paid for at the contract unit price per cubic yard bid for "Sand-Clay Surface Course", which price shall be full compensation for loading all material, hauling not over one quarter mile, delivering on the road and furnishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price per cubic yard bid for "Material Hauled Additional Quarter Mile".

52. SHELL SURFACE COURSE.

Description. This item shall consist of a wearing course composed of shell, and shall be constructed on the prepared subgrade, or completed base course, in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Materials. The shell shall consist of sound particiles of oyster, clay or other shells equally acceptable to the Engineer, and shall not contain more than fifteen per cent of mud, clay marl or loam. No shells which will not be broken up during construction to pieces not larger than 2 inches shall be allowed in the material delivered, and all such oversize shell shall be removed at the Contractor's expense.

Construction Methods. The material shall be delivered, and spread by hand on the prepared subgrade, or completed course, to such depth that when compacted the thickness shown on the Plans will be secured and shaped to conform to the typical cross-section. Side forms and either cubical blocks or center guide forms of proper size shall be used to fix the depth of the loose material. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station and uniformly distributed throughout each station.

The work shall be rolled and sprinkled or opened to traffic as directed. The Contractor, as often as directed, shall work and dress the surface so that the cross-section shall continue uniform and true to line and grade, and until the surface is smooth, hard, free from ruts and undulations and well bonded to the width shown on Plans, and the work is accepted, When the typical cross-section requires that this item be constructed in more than one course, each additional course shall be constructed independently after the previous one has been completed and accepted, all as prescribed above.

Methods of Measurement. Work and accepted material hauled to the road shall be measured by the cubic yard of material loose measurement as delivered on the road.

Basis of Payment. When a unit price for "Shell" is requested and tendered in the Proposal, the material furnished as prescribed by this item shall be paid for at the contract unit price so bid per cubic yard. The work performed as prescribed by this item and measured as provided above, shall be paid for at the contract unit price bid per cubic yard for "Shell Surface Course", which price shall be full compensation for loading all materials, hauling not over one quarter mile, delivering on the road and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile".

53. CALICHE SURFACE COURSE.

Description. This item shall consist of a wearing course composed of Caliche, and shall be constructed on the prepared subgrade or completed base course in accordance with these specifications, and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Materials. Caliche shall consist of a natural mixture of approximately equal proportions of calcareous dust and quartz sand with or without the presence of gravel or small stones, all of which, when tested, shall pass a 2 inch screen, and shall not contain more than 10 per cent of clay. Oversize material shall be removed at the Contractor's expense.

Construction Methods. The material shall be delivered and spread by hand on the prepared subgrade to such depth that when compacted the thickness shown on the Plans will be secured, and shaped to conform to the typical cross-section. Side forms and either cubical blocks or center guide forms of proper size shall be used. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100-foot station and uniformly distributed throughout each station.

If, in the opinion of the Engineer, it be practicable to do so, the caliche shall be puddled with water before being finally shaped and compacted. This puddling may be done either in the pit before the material is hauled on the road, or it may be done by sprinkling with water after the material has been spread upon the subgrade. In case puddling is done in the material pit, the caliche shall at once be hauled on to the road, spread by means of hoes, rakes or shovels, shaped and rolled before it has dried out. In case puddling is to be done after it has been spread upon the subgrade, the surface shall be thoroughly harrowed, plowed or otherwise opened up, during the process of sprinkling, in order to insure the proper puddling of the caliche. After thoroughly puddled, to the satisfaction of the Engineer, the surface shall be shaped to a uniform thickness and cross-section and the succeeding course of material shall be added and puddled in the same manner. Each succeeding course shall be placed and puddled as soon after the proceeding one as practicable.

The work shall be rolled or opened to traffic as directed. The Contractor, as often as directed, shall work and dress the surface so that the cross-section shall continue uniform and true to line and grade, and until the surface is smooth, hard, free from ruts and undulations and well bonded to the width shown on Plans, and the work is accepted.

Methods of Measurement. Work and accepted material hauled to the road shall be measured by the cubic yard loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Caliche" is requested and tendered in the Proposal, the material furnished as prescribed by this item shall be paid for at the contract unit price so bid per cubic yard. When such price is not so requested, right of way charges and royalties on the material in the pit will be borne by the County. The work performed as prescribed for this item, measured as provided above, shall be paid for at the contract unit price bid per cubic yard for "Caliche Surface Course", which price shall be full compensation for

loosening and loading all material at the pit, hauling not over one quarter mile, delivering on the road, puddling and furnishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling, and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile".

54. DISINTEGRATED LIMESTONE SURFACE COURSE.

Description. This item shall consist of a wearing course composed of Disintegrated Limestone, and shall be constructed on the prepared subgrade or completed base course in accordance with these specifications, and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Materials. The material shall consist of a good quality of disintegrated limestone, reasonably free from soil and clay, and when loaded from the material pit shall not contain more than 25 per cent of material which will pass a $\frac{1}{4}$ inch mesh screen. The disintegrated limestone shall be such as can be loosened up in the pit by the use of plows or picks and without the use of explosives. Material containing gravel or hard flint pebbles, will be admitted, although all hard stones over $1\frac{1}{2}$ inches in their largest dimension, which will not be broken up during construction, must be thrown out at the pit by the Contractor at his own expense.

Construction Methods. The material shall be delivered, and spread by hand on the prepared subgrade, or completed course, to such depth that when compacted the thickness shown on the Plans will be secured and shaped to conform to the typical cross-section. Side forms and either cubical blocks or center guide forms of proper size shall be used to fix the depth of the loose material. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station and uniformly distributed throughout each station.

After the material has been spread and shaped, the surface shall be thoroughly sprinkled with water and rolled as soon as sufficiently dried off. The Contractor, as often as directed, shall work and dress the surface so that the cross-section shall continue uniform and true to line and grade, and until the surface is smooth, hard, free from ruts and undulations and well bonded to the width shown on Plans, and the work is accepted. When the typical cross-section requires that this item be constructed in more than one course, each additional course shall be constructed independently after the previous one has been completed and accepted, all as prescribed above.

Method of Measurement. Work and accepted material hauled to the road shall be measured by the cubic yard of material loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Disintegrated Limestone" is requested and tendered in the Proposal, the material furnished as prescribed by this item shall be paid for at the contract unit price so bid per cubic yard, when such price is not so requested, right of way charges and royalties on the material in the pit will be borne by the County. The work performed as prescribed for this item, measured as

provided above, shall be paid for at the contract unit price bid per cubic yard for "Disintegrated Limestone Surface Course", which price shall be full compensation for loosening and loading all material at thepit, hauling not over one quarter mile, delivering on the road, puddling and finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile".

55. IRON ORE TOP SOIL SURFACE COURSE.

Description. This item shall consist of a wearing course composed of Iron Ore Top Soil, and shall be constructed on the prepared subgrade in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of component courses and typical cross-section shown on Plans.

Materials. Iron Ore Top Soil shall consist of hematite, hydrated hematite, or limonite ore as formed at the surface but of a quality free from vegetable matter which when loaded from the material pit shall not contain more than 15 per cent of clay. The material shall be such as can be loosened up in the pit by the use of plows or picks and without the use of explosives. Material containing gravel or hard pieces of ore will be admitted although all pieces over $1\frac{1}{2}$ inches in their largest dimensions, which will not be broken up during construction, must be thrown out at the pit by the Contractor at his own expense. The material shall have a cementing value of not less than 50 and be so graded that 40 to 75 per cent is retained on a 10-mesh screen when tested by laboratory methods.

Construction Methods. The material shall be delivered and spread by hand on the prepared subgrade to such depth that when compacted the thickness shown on the Plans will be secured and shaped to conform to the typical cross-section, and rolled if required. Side forms and either cubical blocks or center guide forms of proper size shall be used to fix the depth of the loose material. It shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station and uniformly distributed throughout each station.

After the material has been spread and shaped, the work shall be rolled or opened to traffic as directed. If the material is of such a quality that it adheres to the wheels of the roller after sprinkling, the surface shall be sanded, the necessary material being measured as Surfacing material. The Contractor, as often as directed shall work and dress the surface so that the cross-section shall continue uniform and true to line and grade and until the surface is smooth, hard, free from ruts and undulations and well bonded to the width shown on Plans, and the work is accepted. When the typical cross-section requires that this item be constructed in more than one course, each additional course shall be constructed independently after the previous one has been completed and accepted, all as prescribed above.

Method of Measurement. Work and accepted material hauled to the road shall be measured by the cubic yard loose measurement, as delivered on the road.

Basis of Payment. When a unit price for "Iron Ore Top Soil" is requested and tendered in the Proposal, the material furnished as prescribed by this item shall be paid for at the contract unit price so bid per cubic yard. When such price is not so requested, right of way charges and royalties on the material in the pit will be borne by the County. The work performed as prescribed for this item, measured as provided above, shall be paid for at the contract unit price bid per cubic yard for "Iron Ore Top Soil Surface Course", which price shall be full compensation for loosening and loading all material at the pit, hauling not over one quarter mile, delivering on the road, finishing, all labor, equipment, tools and incidentals necessary to complete the work except rolling and sprinkling. Hauling material into each quarter mile beyond the first quarter mile shall be paid for at the contract unit price bid per cubic yard for "Material Hauled Additional Quarter Mile".

56. PEA GRAVEL SURFACE COURSE.

Description. This item shall consist of a wearing course composed of fine or pea gravel, and shall be constructed on the prepared subgrade, or completed base course, in accordance with these specifications and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Materials. The gravel shall consist of hard, durable particles of stone mixed with sand or clay or similar binding material and when tested by laboratory methods shall fulfill the following requirements

Passing the 1 inch screen 95 to 100%
Retained on $\frac{1}{4}$ inch screen 10 to 35%
Retained on 10 mesh sieve 35 to 70%

Of the material passing the 10 mesh sieve 25 to 40 shall pass the 200 mesh sieve. The cementing value of the material passing the 10 mesh sieve shall not be less than 50.

Construction Methods. The material shall be delivered in slat-bottom wagons or approved trucks and uniformly dumped on the subgrade or completed course, spread to such depth that when compacted, the thickness shown on the Plans will be secured, harrowed if necessary and shaped to conform to the typical cross-section. Each day's hauling shall be spread the same day. When the width of the base-course is more than 12 feet the material shall be dumped in two equal rows. The thickness of the course as well as the material shall be strictly uniform. Side forms, and either center forms or cubical blocks, shall be used to fix the depth of loose material. All areas and "nests" of segregated coarse or fine material shall be removed and replaced with well graded material and compacted.

The work shall be rolled and sprinkled, or opened to traffic as directed. Ruts shall be kept filled twice a day or more as directed. When irregularities, depressions or weak spots develop during the process of shaping and setting up, the affected areas shall be corrected immedaitely by scarifying, adding material as needed, reshaping and compacting. This process shall be continued, and the course maintained with grading machines or other equipment as required, to the required line, grade and typical cross-section until the surface is smooth and hard, free from ruts and undulations, well bonded to the width shown on Plans, and the work is accepted.

58. WATER BOUND MACADAM SURRACE COURSE.

Description. This item shall consist of a wearing course composed of broken stone and screenings and shall be constructed on the prepared subgrade or completed base-course in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the Plans.

Material. The Broken Stone shall consist of angular fragments of rock, excluding schist, shale or slate, of uniform quality throughout, with not more than 5% of soft friable material, not more than 5% of flat or elongated pieces the width of which is less than half the length, and with a percent of wear of not more than 7. When tested by laboratory methods the stone shall fulfill the following requirements:

Passing 2 inch screen	95 to 100%
Retained on 1 inch screen	25 to 60%
Retained on $\frac{3}{4}$ inch screen	100%

Screenings shall consist of material equal in quality to that specified for Broken Stone above, and shall be that product of the crusher including the dust of fracture, which will fulfill the following requirements:

Passing the $\frac{3}{4}$ inch screen	95 to 100%
Retained on $\frac{1}{4}$ inch screen	20 to 60%
Passing 200 mesh sieve	5 to 20%

Construction Methods. The subgrade shall be rolled and shall be dry and clean of all foreign substances. The Stone shall be furnished, spread upon it to such loose depth that when completed the compacted depth shown on Plans will be obtained, harrowed if necessary, shaped to the typical cross-section, and dry rolled. The Stone shall be spread with shovels from storage piles along the side of the roadway or from dumping boards or may be spread directly from approved vehicles. The thickness of the course, as well as the material shall be strictly uniform. Side forms, and either center forms or cubical blocks shall be used to fix the depth of loose material. The shoulders shall be built up to support the edges of the course as directed. All areas and "nests" of segregated coarse or fine material shall be removed and replaced with well graded material.

The dry rolling shall be done with a self-propelled roller weighing not less than 8 tons. The rolling shall be longitudinal, shall begin at the sides, overlapping the earth shoulders at least six inches, and progress gradually to the center. At any low or irregular places that develop the material shall be loosened and the necessary additional material placed, and rerolled. The entire surface shall be thoroughly rolled until all settlement has ceased.

Screenings shall be applied gradually over the surface during the dry rolling in such an amount as will completely fill the voids.

The screenings shall not be dumped on the surface of the stone or gravel, but shall be cast thinly with a spreading motion of the shovel and broomed into the voids. The rolling shall continue while the screenings are being spread, so as to aid by jarring the fine material into the voids. The screenings shall not be allowed to cake of "bridge" on the surface so as to prevent the filling of the voids or the direct bearing of the roller on the surface of the stone or gravel. The spreading and rolling shall continue until no more screenings will go in dry and the whole surface conforms to the line, grade and typical cross-section. No excess screenings shall be used.

Dumping of ashed and cinders from the fire box on the course must not be allowed and any litter must be removed from the stone or gravel before the roller passes over it.

After the dry rolling and filling is complete, the surface of the course shall be sprinkled with water until thoroughly saturated and more screenings added and rolled. The sprinkling and rolling shall continue until a grout forms in front of the roller that will fill all voids. The work shall then be permitted to partially dry out, and the rolling shall be continued on successive days until the bond is complete and the surface does not creep or wave under the roller.

Surface Finish: The surface of the completed course shall be smooth, dense, and true to the established crown and grade. Before the completion of the rolling the surface shall be tested as follows, and corrected as necessary by properly adding or removing material, retesting, and rerolling until the finished surface complies with the test requirements.

Surface Test: The finished course shall show no deviation from the general surface in excess of $\frac{1}{4}$ inch as shown by deviation from a 10 foot straight edge laid parallel to the center line of the road so as to bridge any depressions and touch all high spots.

Method of Measurement. This item shall be measured by the square yard complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price bid per square yard for "Water Bound Macadam Surface Course", which price shall be full compensation for furnishing, hauling and placing all material, for preparation of all material, for all labor, rolling, equipment, tools and incidentals necessary to complete the work.

59. SINGLE BITUMINOUS SURFACE TREATMENT.

Description. This item shall consist of a wearing surface composed of a single application of $\frac{1}{2}$ gallon of bituminous material per square yard, covered with fine gravel or broken stone, and shall be constructed on the completed and approved base course or surface course in accordance with these specifications.

Material. The cover material shall be Gravel or Broken Stone, The Gravel shall consist of rounded or angular fragments of rock with not more than 5% of slate, shale or soft sand stone particles and shall be free from organic matter, clay, loam or pebbles coated therewith. It shall have a per cent of wear (abrasion test for gravel) of not more than 15. When tested by laboratory method it shall fulfill the following requiremenst:

Passing $\frac{3}{4}$ inch screen	100%
Retained on $\frac{1}{4}$ inch screen	85 to 100%

The Broken Stone shall consist of angular fragments of rock (excluding schist, shale or slate) of uniform quality throughout, with not more than 5% of soft friable material, not more than 5% of flat or elongated pieces the width of which is less than half the length, and with a per cent of wear of not more than 6. When tested by laboratory methods the material shall fulfill the following requirements:

Passing $\frac{3}{4}$ inch screen	100%
Passing $\frac{1}{2}$ inch screen	25 to 75%
Retained on $\frac{1}{4}$ inch screen	85 to 100%

The Bituminous material shall fulfill the requirements prescribed in the Special Provisions for "Bituminous Material for Surface Treatment".

Construction Methods. All holes, ruts, depressions, or other defects in the surface shall be repaired by cleaning out defective areas by scarifying, acceptable hand method, and after being filled with new material of the same character as contained in the road surface, or other materials approved by the Engineer, shall be compacted by rolling or tamping so that a smooth, hard, well cemented surface, conforming to line, grade and typical cross-section shown on Plans, is secured. After the repairs required have been made in an acceptable manner and the patches allowed to set up under traffic and are properly bonded, the surface of the roadway shall be swept clean and free from dirt, dust, detritus, or other deleterious matter by means of a mechanical rotary street sweeper, hand brooms, compressed air. All cakes of dust or clay and all other foreign matter shall be removed and the surface thoroughly cleaned, before any bituminous material is applied, until the top embedded aggregate is cleaned, but not dislodged or loosened. If found necessary by the Engineer the surface may be lightly sprinkled just prior to application of Bituminous Material. No bitumen shall be applied when temperature is at 50 degrees F. or below.

Application; The Bituminous Material shall be applied on the clean surface at the uniform rate of $\frac{1}{2}$ gallon per square yard. The application shall be made by some approved type of self propelled pressure distributor so designed as not to produce ruts in the surface during application and so operated as to distribute the material in the quantity specified evenly and smoothly under a pressure of not less than 20 nor more than 75 pounds per square inch. In order to insure uniformly at the junction of two distributor loads when the last of the load starts to thin the distributor shall be shut off, and upon starting the next load building paper shall be spread over the latter portion of the previous application, and the distributor shall lap back over this paper sufficiently to start the sprayers full force when the uncovered surface is reached. This building paper shall then be removed and destroyed.

Immediately following the application of bituminous material there shall be evenly spread over the bituminous surface cover material to the amount of one cubic yard loose measurement per 40 square yards of surface. The entire surface shall then be thoroughly rolled with a suitable roller, self-propelled, giving a compression of not less than 200 pounds per inch of roller width, which will not "pick up" the surface. Should any depressions or unevenness or irregular spots develop in the surface, they shall be remedied and the surface brought to true grade and cross-section as shown on Plans.

Traffic should not be allowed to use the road until the course of cover material has been placed and thoroughly rolled. The cover material must be evenly and accurately distributed by a mechanical spreader; if hand spreading is permitted, the work must be done by experienced workmen, to the end that an even and smooth surface be obtained.

After the work has been completed as specified above, there should be a slight excess of cover material over the surface. The Contractor shall be responsible for the maintainance of the surface until the work is accepted by the Engineer. He shall repair all fatty spots with additional cover material and all lean mixtures by additional asphalt, to the extent that a uniform dense treatment is finally obtained.

Method of Measurement. This item shall be measured by the square yard complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price per square yard, bid for "Single Bituminous Surface Treatment", which price shall be full compensation for furnishing, hauling and placing all material, for preparation of all material, for all labor, rolling, equipment, tools and incidentals necessary to complete the work.

60. DOUBLE BITUMINOUS SURFACE TREATMENT.

Description. This item shall consist of a wearing surface composed of two applications of Bituminous Material of the amounts per square yard hereinafter prescribed, covered with gravel or broken stone, in the same amounts per square yard prescribed, and shall be constructed on the completed and approved base course or surface course in accordance with these specifications.

Material. The aggregate shall be gravel or broken stone. The gravel shall consist of rounded or angular fragments of rock with not more than 5% of slate, shale, or soft sand stone particles, and shall be free from organic matter clay, loam, or pebbles coated therewith. It shall have a per cent of wear (abrasion test for gravel) of not more than 15. The broken stone shall consist of angular fragments of rock (excluding schist, shale or slate) of uniform quality throughout, with not more than 5% of soft friable material, not more than 5% of flat or elongated pieces the width of which is less than half the length, and with a per cent of wear of not more than 6. When tested by laboratory methods, the aggregate shall fulfill the following requirements:

No. 1. Passing $1\frac{1}{4}$ inch screen, retained on 5/8 inch screen 100%
No. 2. Passing 5/8 inch screen, retained on $\frac{1}{4}$ inch screen 85 to 100%.

The bituminous material shall fulfill the requirements presecribed in the Special Provision for "Bituminous Material for Surface Treatment".

Construction Methods. All holes, ruts, depressions, or other defects in the surface shall be repaired by cleaning out defective areas by scarifying, or acceptable hand method, and after being filled with new material of the same character as contained in the road surface, or other materials approved by the Engineer, shall be compacted by rolling or tamping so that a smooth, hard, well cemented surface, conforming to line, grade and typical cross-section shown on Plans, is secured. After the repairs required have been made in an acceptable manner and the patches allowed to set up under traffic and are properly bonded, the surface of the roadway shall be swept clean and free from dirt, dust, detritus, or other deleterious matter by means of a mechanical rotary street sweeper, hand brooms, compressed air. All cakes of dust or clay and all other foreign matter shall be removed and the surface thoroughly cleaned, before any bituminous material is applied, until the top embedded aggregate is cleaned, but not dislodged or loosened.

If found necessary by the Engineer the surface may be lightly sprinkled just prior to application of Bituminous Material. No bitumen shall be applied when temperature is at 50 degrees F. or below.

Application. Bituminous Material shall be applied on the clean surface at the rate of 0.35 gallons per square yard in the manner and with the equipment prescribed for Single Bituminous Surface Treatment, and covered with No. 1 aggregate at the rate of one cubic yard (loose measurement) to each 40 square yards of first application. The work shall then be lightly rolled and the second application of 0.45 gallons per square yard applied in the manner prescribed for the first and covered with No. 2 aggregate at the rate of 1 cubic yard (loose measurement) to each 80 square yards of second application. The entire surface shall be thoroughly rolled with a suitable roller, self-propelled, giving a compression of not less than 200 pounds per inch of roller width, which will not "pick up" the surface.

The aggregate must be evenly and accurately distributed by a mechanical spreader; if hand-spreading is permitted, the work must be done by experience workmen, to the end that an even and smooth surface be obtained. After the work has been completed as specified above, there should be a slight excess of No. 2 stone over the surface. The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer. He shall repair all fatty spots with additional cover material and all lean mixtures by additional asphalt, to the extent that a uniform dense treatment is finally obtained. Should any depressions or unevenness or irregular spots develop in the surface, they shall be remedied and the surface brought to true grade and cross-section as shown on the plans.

Method of Measurement. This item shall be measured by the square yard of two course work complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price per square yard, bid for "Double Bituminous Surface Treatment", which price shall be full compensation for furnishing, hauling, and placing all material, for preparation of all material, for all labor, rolling, equipment, tools and incidentals necessary to complete the work.

61. TRIPLE BITUMINOUS SURFACE TREATMENT.

Description. This item shall consist of a wearing surface composed of three applications of Bituminous Material of the amounts per square yard hereinafter prescribed, covered with gravel or broken stone in the amount per square yard prescribed and shall be constructed on the completed and approved base-course or surface course in accordance with these specifications.

Material. The aggregate shall be gravel or broken stone. The gravel shall consist of rounded or angular fragments of rock with not more than 5% of slate, shale, or soft sand stone particles and shall be free from organic matter, clay, loam, or pebbles coated therewith. It shall have a per cent of wear (abrasion test for gravel) of not more than 15. The broken stone shall consist of angular fragments of rock (excluding schist, shale, or slate) of uniform quality throughout, with not more than 5% of soft friable material, not more than 5% of flat or elongated pieces the width of which is less than half the length, and with a per cent of wear of not more than 6. When tested by laboratory methods, the aggregate shall fulfill the following requirements:

No. 1. Passing $1\frac{1}{2}$ inch screen, retained on 1-inch screen 100%
No. 2. Passing 1 inch screen, retained on $\frac{1}{2}$-inch screen 100%
No. 3. Passing $\frac{1}{2}$-inch screen, (with dust removed) 100%

The Bituminous material shall fulfill the requirements prescribed in the Special Provisions for "Bituminous Material for Surface Treatment".

Construction Methods. Construction methods shall be as prescribed for Double Bituminous Surface Treatment with the addition of a third application and cover. The amounts required to be used per square yard for each successive application shall be as follows:

Application.	Bituminous Mat'l.	Coverage.
1st	0.4 gallon	1 cubic yard No.1 aggregate to 24 sq.yds
2nd	0.6 gallon	1 cubic yard No.2 aggregate to 48 sq.yds
3rd	0.3 gallon	1 cubic yard No.3 aggregate to 72 Sq.yds

After the third application has been covered as provided above, the entire surface shall be thoroughly rolled with a suitable roller, self-propelled, giving a compression of not less than 200 pounds per inch of roller width, which will not "pick up" the surface.

The aggregate must be evenly and accurately distributed by a mechanical spreader; if hand-spreading is permitted, the work must be done by experienced workmen, to the end that an even and smooth surface be obtained. After the work has been completed as specified above, there should be a slight excess of No. 3 aggregate over the surface. The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer. He shall repair all fatty spots with additional cover material and all lean mixtures by additional asphalt, to the extent that a uniform dense treatment is finally obtained. Should any depressions, unevenness, or irregular spots develop in the surface, they shall be remedied and the surface brought to true grade and cross section as shown on the plans.

Method of Measurement. This item shall be measured by the square yard of three course work complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price bid per square yard for "Triple Bituminous Surface Treatment", which price shall be full compensation for furnishing, hauling, and placing all material, for preparation of all materials, for all labor, rolling, equipment, tools, and incidentals necessary to complete the work.

62. LIMESTONE ROCK ASPHALT SURFACE TREATMENT.

Description. This item shall consist of a wearing surface composed of a compacted layer containing the required weight per square yard of prepared natural limestone rock and shall be constructed on the approved and completed base course or surface, in accordance with these specifications and in conformity with the typical cross section shown on the Plans.

The required thickness of the completed work shall not be secured by measurement, but the completed work shall be considered to be of the thickness required when the amount by weight of prepared rock asphalt, including the flux, but excluding the rock asphalt dust for the seal coat, put down per square yard of completed work is in the proportion of 100 pounds per inch of depth shown on Plans.

Materials. The rock asphalt shall be uniform, well graded, natural limestone rock asphalt, consisting of 9 to 12 per cent of asphalt and 88 to 91 per cent of limestone preactically free from Sulphates, iron pyrites and alumina. No material shall be used before it has been sampled and tested in the laboratory and approved by the State Highway Engineer.

The flux shall be an asphaltic base oil fulfilling the following requirements:

The oil shall be free from water;
Specific Gravity at 25°C - not less than 0.95;
Asphaltic Content @ 100 Penetration, not less than 50% by weight, (Open evaporation 480°- 500° F - Bul. 1216).

Construction Methods. The existing surface shall be thoroughly cleaned of all dust, dirt, and foreign matter to the satisfaction of the Engineer, by sweeping with a rotary street-sweeper of approved type, or with hand brooms or by such other means as the Engineer may deem necessary. Then the surface of the roadway shall be treated with from .20 to .25 gallons per square yard, of hot asphaltic oil, not lighter than that used for flux, put on in 2 applications. The first application consisting of .10 to .15 gallons per square yard, shall be made not less than twenty four hours in advance of placing the rock asphalt, and the ~~second~~ application, consisting of approximately .10 gallons per square yard, shall be made immediately before the rock asphalt is placed. If the rock asphalt is to be laid on a concrete base, one application of asphaltic oil, not exceeding .10 gallons per square yard, shall be made not less than twenty four hours in advance of laying the rock asphalt surface. Great care shall be taken that the asphaltic oil be regularly and evenly distributed.

The surface of the roadway shall be brought to the cross-section as shown on plans, by filling all holes and depressions with pulvarized rock asphalt immediately following the first application of asphaltic oil. The extra material and work needed for patching depressions in the existing surface shall not be paid for directly but shall be considered incidental work and material pertaining to the item.

Preparation Fluxing and Mixing of Materials. The natural limestone rock asphalt shall be reduced by pulverizing, until the maximum size particle shall not exceed $\frac{1}{4}$ inch in any dimension. A sufficient amount of the dust shall be removed from the pulverized rock asphalt to make the seal coat for the pavement after it has been laid and properly rolled.

After pulverizing the rock asphalt, there should be added to it from 1 to 2% of the flux specified above and the whole thoroughly mixed in a pug or other approved type of mixer, until a homogeneous mixture is produced which shall contain from 9 to 12 per cent of asphaltic cement soluble in carbon disulphide. In order that the mixture shall be uniform, each batch of pulverized rock asphalt and the asphaltic oil flux shall be weighed or measured before being incorporated in the mixture.

During the process of preparation of the limestone rock asphalt, if so desired, and in a manner approved by the Engineer, the rock may be heated to a temperature not exceeding 340°F.

Applications. The Prepared Rock Asphalt shall be placed upon the prepared surface and immediately spread, shoveling and raking to such uniform depth that when thoroughly compacted by rolling, the depth shown on the Plans will be secured. The material shall not be dumped on the place it is to occupy, but sufficiently in advance of the finished pavement, so that in placing it will be necessary to handle all of the material with shovels. The rock asphalt shall be thoroughly raked so that all clusters of coarse materials and lumps shall be separated, and then rolled with a self-propelled roller giving compression of not less than 200 pounds per inch of roller width. After rolling all low or uneven places which have been developed shall be filled with the mixture and rerolled. After the surface has been satisfactorily rolled and brought to the required cross section, a thin coat of the limestone asphalt dust, free from flux shall be spread over the entire surface, the surface shall be again rolled until the surface is thoroughly compacted and in conformity with the typical cross section, and so maintained until acceptance.

No traffic shall be allowed on the roadway while the pavement is being laid nor for such time thereafter, as in the judgment of the Engineer, may be necessary for the proper setting of the material.

Method of Measurement. This item shall be measured by the square yard complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price per square yard, bid for "Limestone Rock Asphalt Surface Treatment", which price shall be full compensation for furnishing, hauling and placing all material, for preparation of all material, for all labor, rolling, equipment, tools and incidentals necessary to complete the work.

63. BITUMINOUS MACADAM SURFACE COURSE.

Description. This item shall consist of a wearing surface course composed of coarse broken stone and bituminous binder applied hot by penetration methods, with a bituminous seal coat and mineral cover, and shall be constructed on the completed and approved base course in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the Plans.

Materials. The Broken Stone shall consist of clean tough durable fragments of rock (excluding schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, and free from soft or disintegrated stone, dirt, organic or other injurious matter covering either free or as a coating on the stone. All stone shall have a per cent of wear of not more than 6. All limestone shall meet the requirements of the Soundness Test.

Three types of this broken stone shall be provided and used as hereinafter prescribed. Coarse Stone, Intermediate Stone and Cover Stone, when tested by Laboratory methods shall fulfill the following requirements:

Coarse Stone.

Passing $2\frac{1}{2}$ inch screen.....95 to 100%
Retained on $1\frac{1}{4}$ inch screen.....85 to 100%

Intermediate Stone.

Passing $1\frac{1}{4}$ inch screen.....95 to 100%
Passing 1 inch screen.....25 to 75%
Retained on $\frac{3}{4}$ inch screen.....85 to 100%

Cover Stone.

Passing $\frac{3}{4}$ inch screen.....95 to 100%
Passing ~~$\frac{1}{2}$~~ inch screen.....25 to 75%
Retained on $\frac{1}{2}$ inch screen.....85 to 100%

The Bituminous Material shall meet the requirements given below for OA-3, or NA-3. The material shall be homogeneous, free from water and the asphalt material shall not foam when heated to 175° C (347° F). Oil asphalt for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C in melting point within the test limits specified.

OA-3. Oil Asphalt.

Specific gravity 25°/ 25° C. (77°/ 77° F.).....not less than 1.010
Flash point .....not less than 175°C.(347°F).
Melting Point.....40°C. (104°F) to 60° C. (140° F).
Penetration at 25° C. (77° F.) 100g., 5 sec.....80 to 90.
Loss at 163° C. (325° F) 5 hours..... not more than 1.0%

a. Penetration of residue at 25° C. (77° F) 100g., 5 sec----------not less than 50
Total bitumen (soluble in carbon disulphide), not less than 99.5%
a. Organic matter insoluble..... not more than 0.2%

NA-3. Fluxed Bermudez Asphalt.

Specific gravity, 25°/ 25° C. (77°/77° F.)....1.050 to 1.070
Flash point..... not less than 175°C. (347° F.)
Melting point.....40° C. (104° F) to 50° C. (122° F.)
Penetration at 25° C. (77° F.), 100 G., 5 sec.....80 to 90.
Loss at 163° C. (325° F.) 5 hours.....not more than 3.0%

a. Penetration of residue at 25° C. (77° F.) 100g., 5 sec.....not less than 40
Total bitumen (soluble in carbon disulphide), not less than 95.0%
b. Inorganic matter insoluble..... 1.5% to 3.0%

Construction Methods. In the absence of curbs, planks approximately 3" x 8" shall be placed as temporary curbs to support the edges of the Bituminous Macadam.

The Coarse Stone shall be spread upon the prepared base course with shovels from piles along the side of the roadway or from dump boards or by means of approved spreading vehicles, to such uniform depth that when compacted and completed the compacted thickness shown on the Plans will be secured. The stone shall then be dry rolled with a self-propelled roller weighing not less than 8 tons until the fragments are interlocked (but not crushed) and a stable, uniform, but open, surface is secured. Any depressions or irregularities that develop shall be immediately loosened and corrected by the addition of coarse stone as necessary. All stone which becomes coated or mixed with dirt shall be removed, replaced and recompacted. No traffic shall be allowed to pass over the stone before the application of the bituminous binder. The rolling shall be longitudinal beginning at the sides and progressing gradually toward the center from each side.

Application of Bituminous Binder: The Bituminous material shall be heated in tanks designed to secure uniform heating of the entire contents. Asphalt Binder shall be heated to and applied at a temperature between 275 and 350 degress F. Materials heated beyond the above limits shall be rejected. The Contractor shall provide all necessary facilities for determining the temperature of the Bituminous Materials. Upon the thoroughly dry and clean coarse stone, rolled as provided above, there shall be applied by means of an approved pressure distributor from $1\frac{1}{2}$ to $1\frac{3}{4}$ gallons of hot Bituminous Material per square yard of surface. This work shall be done only when weather conditions, in the opinion of the Engineer, are suitable. The pressure distributor shall be so designed and operated as to distribute the Bituminous Material uniformly and in the amount required under a pressure of from 20 to 75 pounds per square inch. It shall be equipped with an accurate stationary thermometer in the tank containing the asphalt cement, and with an accurate gauge so located as to be easily observed by the Inspector, while walking beside the distributor. In order to prevent lapping at the end junction of two loads, the distributor shall be promptly shut off when the application begins to thin just before the tank is emptied. Before continuing the application with a new load of Bituminous cement, building paper shall be spread over the treated surface for a sufficient distance back so that the sprayers are operating at full force when the uncovered surface is reached. The building paper shall then be removed and destroyed. A narrow spout pouring pot or hose attachment to the distributor shall be used to apply the bituminous cement necessary to touch up all spots unavoidably missed by the distributor. The distributor shall be equipped with wide solid or pneumatice rubber tires, and in case the tractive action of the driving wheels tends to loosen or disturb the interlocked coarse aggregate, the distributor shall be pulled by the roller during the application of the bituminous cement.

Filling Surface Vpids with Intermediate Aggregate: After the first application of the bituminous cement and while it is still warm, a thin layer of dry intermediate stone shall be broad-casted over the treated surface in such quantity as to fill voids and just cover the treatment. It shall then be broomed if necessary, to break up all lumps and produce a uniform covering, after which the pavement shall be rolled until thoroughly compacted and bonded.

Suitable precautions shall be taken to prevent the distribution of the intermediate aggregate over any portion of the coarse aggregate which has not received the first application of bituminous cement and in no case shall it be dumped directly upon either the treated or untreated coarse aggregate

Bituminous Seal Coat: After the intermediate aggregate has been rolled the pavement shall be swept clean of all loose material and treated with a second application of bituminous cement under the same conditions and in the same manner as specified for in the first paragraph, except that the rate of application shall be from $\frac{1}{2}$ to $\frac{3}{4}$ gallons per square yard, as directed by the Engineer. After the second application of bituminous cement, and while it is still warm, dry cover stone shall be cast thinly over the surface and rolled until thoroughly bonded to the road. As required, additional fine aggregate shall be spread and broomed over the surface during rolling in sufficient quantity to take up all excess bituminous cement. Upon completion of the pavement, a light uniform covering of loose fine aggregate shall be allowed to remain on the road. The finished surface shall be uniform, free from ruts or irregularities and true to the established grade.

Protection of Pavement: During the period between the initial placing of the coarse aggregate and the completion of the seal coat, the road shall be closed to all traffic other than that absolutely necessary to its construction.

Surface Test: The finished course shall be true to line, grade and typical cross-section, free from undulations and irregularities. When tested by a 10 foot straight edge laid parallel to the center line of the road so as to bridge any depressions and touch the high spots, the surface shall show no deviation from the straight edge of more than $\frac{1}{4}$ inch.

Method of Measurement. This item shall be measured by the square yard complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price bid per square yard for "Bituminous Macadam Surface Course", which price shall be full compensation for furnishing, hauling and placing all material, for preparation of all material, for all labor, rolling, equipment, tools and incidentals necessary to complete the work,

64. TWO COURSE LIMESTONE ROCK ASPHALT SURFACE COURSE.

Description. This item shall consist of a pavement composed of two courses containing the required weight per square yard of prepared limestone rock asphalt and shall be constructed on the completed and accepted concrete, broken stone, or gravel base course, or approved and prepared surface course of the same types, as the case may be, in accordance with these specifications, and in conformity with the lines, grades, and typical cross section shown on the Plans.

The required thickness of the completed work shall not be secured by measurement, but the completed work shall be considered to be of the thickness required when the amount by weight of prepared rock asphalt, including the flux, but excluding the rock asphalt dust for the seal coat, put down per square yard of completed work is in the proportion of 100 pounds per inch of depth shown on Plans

Materials. The rock asphalt shall be uniform, well graded, natural limestone rock asphalt, consisting of 9 to 12 per cent of asphalt and 91 to 88 per cent of limestone practically free from sulphates, iron pyrites, and alumina. No material shall be used before it has been sampled and tested in the laboratory and approved by the State Highway Engineer.

The flux shall be an asphaltic baseoil fulfilling the following requirements:

The oil shall be free from water;
Specific Gravity at 25° C - not less that 0.95;
Asphaltic Content @ 100 Penetration, not less than 50% by weight.
(Over evaporation 480°- 500° F - Bul. 1216)

Construction Methods. The existing surface shall be thoroughly cleaned of all dust, dirt, and foreign matter to the satisfaction of the Engineer, by sweeping with a rotary street-sweeper of approved type, or with hand brooms or by such other means as the Engineer may deem necessary. Then the surface of the roadway shall be treated with from .20 to .25 gallons per square yard, of hot asphaltic oil, not lighter than that used for flux, put on in 2 applications. The first application consisting of .10 to .15 gallons per square yard, shall be made not less than twenty-four hours in advance of placing the rock asphalt, and the second application, consisting of approximately .10 gallons per square yard, shall be made immediately before the

rock asphalt is placed. If the rock asphalt is to be paid on a concrete base, one application of asphaltic oil, not exceeding .10 gallons per square yard, shall be made not less than twenty-four hours in advance of laying the rock asphalt surface. Great care shall be taken that the asphaltic oil be regularly and evenly distributed.

The surface of the roadway shall be brought to the cross-section as shown on Plans, by filling all holes and depressions with pulverized rock asphalt immediately following the first application of asphaltic oil. The extra material and work needed for patching depressions in the existing surface shall not be paid for directly but shall be considered incidental work and material pertaining to the item.

Preparation Fluxing and Mixing of Materials: The natural limestone rock asphalt shall be reduced by pulverizing, until the maximum size particle shall not exceed $\frac{1}{2}$ inch in any dimension. A sufficient amount of the dust shall be removed from the pulverized rock asphalt to make the seal coat for the pavement after it has been laid and properly rolled.

After pulverizing the rock asphalt, there should be added to it from 1 to 2% of the flux specified above and the whole thoroughly mixed in a pug or other approved type of mixer, until a homogeneous mixture is produced which shall contain from 9 to 12 per cent of asphaltic cement soluble in carbon disulphide. In order that the mixture shall be uniform, each batch of pulverized rock asphalt and the asphaltic oil flux shall be weighted or measured before being incorporated in the mixture.

During the process of preparation of the limestone rock asphalt, if so desired, and in a manner approved by the Engineer, the rock may be heated to a temperature not exceeding 340° F.

Application. The Prepared Rock Asphalt shall be placed upon the prepared surface and immediately spread, shoveled and raked to such uniform depth that when thoroughly compacted by rolling, the depth shown on the Plans will be secured. The material shall not be dumped on the place it is to occupy, but sufficiently in advance of the finished pavement, so that in placing it will be necessary to handle all of the material with shovels. The rock asphalt shall be thoroughly raked so that all clusters of coarse materials and lumps shall be separated, and then rolled with a self-propelled roller giving compression of not less than 200 pounds per inch of roller width. After rolling, all low or uneven places which have been developed shall be filled with the mixture and rerolled.

The first course shall be thoroughly cleaned of all dust, dirt and foreign matter. The second course shall then be placed, spread, raked and compacted as specified for the first course. The thickness of the second course shall not be less than $\frac{1}{2}$ that of the first. After the surface has been satisfactorily rolled and brought to the required cross section, a thin coat of the limestone asphalt dust, free from flux shall be spread over the entire surface, the surface shall be again rolled until the surface is thoroughly compacted free from undulations and in conformity with the typical cross section, and so maintained until acceptance.

The laying of the second course may follow immediately the laying of the first, or if preferred and so directed by the Engineer, the laying of the second course may be delayed until a section or all of the first course is completed. When the laying of the second course is delayed until the completion of a section, or all of the first course, the road should be opened to traffic until the second course is laid.

No traffic shall be allowed on the roadway while the pavement is being laid nor for such time thereafter, as in the judgment of the Engineer, may be necessary for the proper setting of the material.

Method of Measurement. This item shall be measured by the square yard of two course pavement complete in place.

Basis of Payment. The yardage of completed and accepted pavement measured as provided above shall be paid for at the contract unit price bid per square yard for "Two Course Limestone Rock Asphalt Surface Course", which price shall be full compensation for furnishing, pulverizing, hauling, and placing all material, for preparing all material, for all labor, rolling, equipment, tools and incidentals necessary to complete the work.

65. HOT MIXED LIMESTONE ROCK ASPHALT PAVEMENT.

Description. This item shall consist of a wearing course composed of a compacted layer of natural limestone rock asphalt, pulverized, graded and hot mixed with a prescribed flux and shall be constructed on the completed and accepted concrete, broken stone, or gravel base course, or approved and prepared surface course of the same types as the case may be, in accordance with these specifications, and in conformity with the lines, grades, compacted thickness, and typical cross section shown on the Plans.

Materials. The rock asphalt shall be uniform, well graded natural limestone rock asphalt, consisting of 9 to 12 per cent of asphalt and 88 to 91 per cent of limestone practically free from sulphates, iron pyrites, and alumina. No material shall be used before it has been sampled and tested in the laboratory and approved by the State Highway Engineer.

The flux shall be an asphaltic base oil fulfilling the following requirements for material "a" below or a parafine base oil meeting the requirements for material "b" below:

(a)

The oil shall be free from water.
Specific Gravity at 25° C - not less than 0.95.
Asphaltic Content @ 100 Penetration, not less than 50% by weight. (Open evaporation 480°- 500° F -Bul. 1216)

(b)

The oil shall be free from water;
Specific Gravity at 25° C. .92 to 98;
Baume equivalent 10° to 22° C.
Flash Point (closed cup) not less than 350° F.
Loss after 5 hrs. at 325° F. not more than 5%.

Construction Methods. The existing surface shall be thoroughly cleaned of all dust, dirt, and foreign matter to the satisfaction of the Engineer, by sweeping with a rotary street-sweeper of approved type, or with hand brooms or by such other means as the Engineer may deem necessary. After the surface of the roadway has been thoroughly cleaned, the surface of the roadway shall be treated with from .20 to .25 gallons per square yard, of hot asphaltic oil, not lighter than that used for flux, put on in 2 applications, the first application consisting of .10 to .15 gallons per square yard, shall be made not less than twenty-four hours in advance of placing the rock asphalt, and the second application, consisting of approximately .10 gallons per square yard, shall be made immediately before the rock asphalt is placed. If the rock asphalt is to be laid on a concrete base, one application of asphaltic oil, not exceeding .10 gallons per square yard, shall be made not less than twenty-four hours in advance of laying the rock asphalt surface. Great care shall be taken that the asphaltic oil be regularly and evenly distributed.

The surface of the roadway shall be brought to the cross-section as shown on plans, by filling all holes and depressions with pulverized rock asphalt immediately following the first application of asphaltic oil. The extra material and work needed for patching depressions in the existing surface shall not be paid for directly but shall be considered incidental work and material pertaining to the item.

Preparation and Mixing of Materials: The natural limestone rock asphalt shall be reduced by pulverizing until the maximum size particles shall not exceed one-fourth inch in any direction, and not more than 50% of the particles shall be retained on a ten mesh sieve. The pulverized rock asphalt shall be passed into revolving cylinder and heated to a temperature ranging from 280° to 340° F depending upon the distance the material is to be hauled and the temperature of the air. Care shall be taken in the heating that the flame does not come in contact with the materials

After the pulverized rock asphalt has been heated to the required torperature, there shall be added from 1% to 2% of a asphaltic base oil meeting the specifications "a" or of a parafine base oil meeting the specifications "b".

The amount of flux shall be sufficient to raise the penetration of the asphalt to between 25 and 30.

After the fluxing oil has been added to the pulverized rock asphalt as specified above, the materials shall be thoroughly mixed until homogenous mixture is produced which shall contain from 9% to 12% of the asphaltic cement soluble in carbon disulphide. In order that the treated mixture shall be uniform, each batch of pulverized rock asphalt and the fluxing oil shall be accurately weighed, or measured by some approved measuring devices, before being incorporated in the mixture.

The prepared hot rock asphalt mixture shall be delivered in covered trucks or wagons direct from the mixer to the road, placed on the prepared surface at a temperature of from 280° to 340° F., and immediately spread into place with hot shovels and rakes by experienced laborers to such uniform thickness that when thoroughly rolled and compacted, the thickness shown on the Plans will be secured. The material shall not be dumped on the place it is to occupy, but sufficiently in advance of the finished pavement so that in placing it will be necessary to handle all of the material with shovels.

The Contractor shall provide a sufficient number of accurate, efficient field thermometers for determining the temperature of the mixture in the mixer and at point of delivery on the road.

Immediately after being spread, the rock asphalt shall be rolled with a self-propelled tandem roller, weighing not less than 8 tons, and the rolling shall be continued until the surface of the pavement shall be free of all waves and depressions, and until the surface is thoroughly compacted and ceases to creep under the action of the roller. At points and places where the roller cannot reach, the surface shall be hand tamped and hot smoothing irons shall be used where necessary.

As soon as the surface has been thoroughly rolled and brought to the required cross-section, a thin coat of hydraulic cement or natural limestone rock asphalt dust, free from any flux, shall be spread evenly over the entire surface, and the surface shall be again rolled until the hydraulic cement, or rock asphalt dust has been thoroughly incorporated into the surface.

Care shall be exercised in making a bond between the new surface and that which has already been laid. The edges of the surface already laid shall be cut smooth with an axe and the edge well coated with asphaltic cement, or heated with a gasoline heater. The hot mixture shall then be brought up agsinst this edge and properly tamped and rolled. Hot smoothing irons shall be run over the joint until all traces of the joint shall, as far as practicable, have been removed.

Surface Tests: Before the completion of the rolling, the surface shall be tested as follows, and corrected as necessary by properly adding orremoving material, retesting, and rerolling until the finish surface complies with the test requirements.

The finished payment shall show no deviation from the general surface in excess of 1/16 inch per foot as measured in the following manner: A 10 foot straight edge shall be placed parallel to the center line of the roadway so as to bridge any depressions, and touch all high spots. Ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed 1/16 inch for each foot in distance from the nearer point of contact.

Such portions of the completed pavement as are defective in finish, compression, density, or composition, or that do not comply in all respects with the requirements of the specifications, shall be taken up, removed, and replaced with suitable material, properly laid in accordance with these specifications, and at the expense of the Contractor.

No traffic shall be allowed on roadway while pavement is being laid or for such time thereafter as in the judgment of the Engineer may be necessary for the proper setting of the pavement.

Method of Measurement. This item shall be measured by the square yard of payement complete in place.

Basis of Payment. The yardage of completed and accepted pavement measured as provided above shall be paid for at the contract unit price bid per square yard for "Hot Mixed Limestone Rock Asphalt Pavement", which price shall be full compensation for furnishing, pulverizing, hauling, and placing all material, for heating and preparing all material, for all labor, rolling, equipment, tools, and incidentals necessary to complete the work.

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66. COARSE AGGREGATE BITUMINOUS CONCRETE PAVEMENT

Description. This item shall consist of a wearing course composed of a compacted mixture of Coarse and Fine Mineral Aggregate and Bituminous Material, and shall be constructed on the completed and approved base course in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on Plans.

Material. The Mineral Aggregate for the mixture shall consist of a Coarse Aggregate, a Fine Aggregate, a Mineral Filler. Samples of each shall be submitted. Approval of both the material and of the course of supply shall be obtained from the Engineer prior to delivery of material. Materials shipped in dirty cars or vehicles will be rejected.

The Coarse Aggregate shall consist of clean tough durable fragments of rock (excluding schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, and free from soft or disintegrated stone, dirt, organic or other injurious matter occuring either free or as a coating on the stone. All limestone shall meet the requirements of the Soundness Test. All stone shall have a per cent of wear of not more than 6, and when tested by laboratory methods shall fulfill the following requirements:

Passing $1\frac{1}{4}$ inch screen not less than 100%
Total passing $\frac{3}{4}$ inch screen 45 ~~75~~ to 75%
Retained on $\frac{1}{2}$ inch screen not less than 80%

The Fine Aggregate shall consist of sand, or a combination of one or more sands ~~or~~ and stone screenings. The sand shall be composed of sound, durable stone particles, free from a coating of clay or loam. The screenings shall be of the same or similar material as specified for Coarse Aggregate. The Fine Aggregate shall be of such grading that it will all pass a $\frac{1}{4}$ inch screen, and produce combination mixtures meeting the requirements hereinafter give.

The Mineral Filler shall consist of thoroughly dry limestone dust, dolomite dust, Portland Cement, or other approved material which, when tested, shall meet the following requirements:

Passing 30-mesh sieve	100 per cent.
Passing 200-mesh sieve	65 per cent.

The grading of that portion of the Fine Aggregate which passes the 10-mesh sieve, and the proportion of Mineral Filler used shall be such that, when tested in combination, the mixture shall meet the following requirements:

Passing 10-mesh sieve	100%
Passing 10-mesh, retained on 40-mesh	10 to 36%
Passing 40-mesh, retained on 80-mesh	20 to 55%
Passing 80-mesh, retained on 200-mesh	10 to 40%
Passing 200-mesh sieve	11 to 20%

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Of the material

The Bituminous Material shall meet the requirements given below for OA-6, NA-5 or NA-6 as elected by the Contractor, who shall notify the Engineer of his choice before the construction starts and shall not thereafter change the material without written permission by the Engineer. The material shall be homogenous, free from water and shall not foam when heated to 175° C (347° F.) Oil asphalt for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C in melting point within the test limits above specified.

OA-6 Oil Asphalt.

Specific gravity 25°/ 25° C. (77°/ 77° F.), not less than 1.020
Flash Point..... not less than 175°C. (347° F.)
Melting Point..... 40°C. (104° F.) to 60°C. (140° F.)
Penetration at 25° C. (77° F.), 100 g., 5 sec..... 50 to 60.
Loss at 163° C. (325° F.) 5 hours..... not more than 1.0%

a. Penetration of residue at 25° C. (77° F.) 100g., 5 sec. not less than 30.
Total bitumen (soluble in carbon disulphide), not less than 99.5%

b. Organic master insoluble.....not more than 0.2%

NA-5 Fluxed Bermudez Asphalt.

Specific gravity 25°/ 25° C. (77°/ 77° F.).....1.050 to 1.070
Flash point..... not less than 175° C. (347° F.)
Melting point ..... 45° C. (113° F. to 55° C. (131° F.)
Penetration at 25° C (77° F.), 100g., 5 sec..... 60 to 70
Loss at 163° C. (325° F.), 5 hours ..... not more than 3.0%

a. Penetration of residue at 25° C. (77° F.), 100 g. 5 sec..... not less than 30
Total bitumen (soluble in carbon disulphide) not less than 95. 5%

b. Inorganic matter insoluble..... 2.0% to 3.5%

NA-6. Fluxed Bermudez Asphalt.

Specific gravity 25° / 25°C. (77°/ 77° F.).....1.050 to 1.070
FTlash Point .....not less than 175° C.(347° F.)
Melting point..... 45° C. (113°F) to 55° C. (131° F.)
Penetration at 25° C. (77° F.) 100g., 5 sec..... 50 to 60
Loss at 163° C. (325° F.), 5 hours.....not more than 3.0%

a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec ..... not less than 25
Total bitumen (soluble in carbon disulphide), not less than 94.0%

b. Inorganic matter insoluble..... 2.5 % to 4.0 %

Proportioning Materials: The Mineral Aggregate and Bituminous material shall be so proportioned as to produce a combination mixture conforming to the following composition by weight:

Mineral Aggregate retained on the 10-mesh sieve	50 to 70%
Combined Fine Aggregate and Filler all passing 10-mesh sieve	25 to 50%
Bitumen soluble in carbon disulphide	5 to 8 %

The proportions of the materials between those limits shall be as directed by the Engineer, and shall not be varied without the consent of the Engineer.

The percentage of bitumen in the finished course shall not vary more than $\frac{1}{2}$% from the proportion established by the Engineer. All materials, and sources of materials shall be satisfactory to the Engineer and whenever required by him, samples of the hot mixture may be taken several times daily, and the mixture, to be acceptable must invariably conform to all requirements.

Construction Methods. For the verification of weights or proportions and character of materials and determinations of temperatures secured, the Engineer, or his authorized representative, shall have access at any time to all parts of the paving plant. Suitable and accurate thermometers, weighing scales, and other necessary appratus shall be furnished and kept in order by the Contractor and installed as directed by the Engineer.

The Coarse and Fine Aggregate shall be heated as directed to between 250 and 350 degrees F. in suitable apparatus in which the aggregate shall be continuously agitated during the heating and in which the temperature can be efficiently and positively controlled.

The Bituminous Material shall be separately heated, with effective and positive control of the temperature at all times, to between 250 and 350 degrees F. All material heated above 350 degrees F. either before, or during the mixing with the Mineral Aggregate shall be rejected.

Mixing: The prepared Aggregates, the Mineral Filler and the Bituminous Material shall be proportioned by weighing, and mixed as directed in the order mentioned, and in adequate and suitable apparatus, so that the resulting mixture shall be thoroughly homogeneous and shall meet all the requirements herein specified. When discharged the mixture shall have a temperature of between 250 and 350 degress F.

The Mineral Aggregate shall in all cases be measured by weighing unless specific methods of guaging, approved in writing by the Engineer, are used.

Laying: The bituminous concrete mixture, heated and prepared as specified, shall be hauled to the work in tight vehicles previously cleaned of all foreign materials, and, if necessary, covered with canvas of sufficient size to protect the entire load. The dispatching of the vehicles shall be arranged so that all material, delivered may be placed and shall have received initial rolling in daylight. The mixture shall be laid only on a base course which is dry, or in any case free from standing water, and free from loose or foreign materials and only when weather conditions, in the opinion of the Engineer, are suitable. Contact surfaces of curbs and structures and all joints when so required by the Engineer, shall be painted with a thin, uniform coating of asphaltic cement before the course is spread. The mixture shall be at a temperautre of 250 to 350 degrees F. when laid. The mixture shall be dumped on a "Dumping Board" outside of the area on which it is to be spread, the entire load distributed into place and raked to grade in a uniformly loose layer of such depth that after receiving ultimate compression by rolling it shall have the compacted depth shown on the Plans. Adjacent to flush curbs, gutters, liners, and structures, the mixture shall be raked uniformly high so that when compacted it will be slightly above the edge of the curb or flush structure.

Rolling: Rollers used on the bituminous concrete shall be well balanced, self-propelled, tandem rollers, weighing between 7 and 8 tons each. Each shall have a compression under the rear roller of between 200 and 300 pounds per linear inch of roll and shall be provided with an ash pan, which shall prevent ashes from dropping upon the bituminous concrete.

The bituminous concrete wearing course, laid as specified, shall be rolled at once while the mixture is warm and pliable, beginning at the edges and working toward the center, followed immediately by cross rolling or diagonal rolling. Means for preventing the bituminous material from adhering to the roller shall be provided as directed by the Engineer. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacements occurring as a result of reversing the direction of the roller or by any other cause, shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall proceed at an average rate of not to exceed 200 square yards per hour per roller. Rolling shall continue without interruption until all roller marks disappear and the surface shows no further compressibility. After the pavement has had its initial compression limestone dust or Portland Cement as directed by the Engineer shall be swept thinly over the entire surface. A sufficient number of rollers must be employed to obtain the maximum compression, and in all cases at least 96% of the calculated density shall be obtained. Places which the roller cannot effectively reach shall be compressed with hot iron tampers.

Joints: Placing of the surface course shall be nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is discontinued for such length of time as to permit the mixture to become chilled. In all such cases when the work is resumed, the material laid shall be cut back so as to produce a slightly beveled edge for the full thickness of the course. The old material which has been cut away shall be removed from the work and new mix laid against the fresh cut. If desired a stout rope may be stretched across the pavement where the joint is to be made. When the work is resumed, the material laid shall be cut back to the rope which will be removed together with the surplus material and the fresh mix laid against the joint thus formed. Hot smoothing irons may be used for sealing joints, but in such case extreme care shall be exercised to avoid burning the surface.

Surface Tests: Before the completion of the rolling, the surface shall be tested as follows; and corrected as necessary by properly adding or removing material, retesting, and rerolling until the finished surface complies with the test requirements.

The finished pavement shall show no deviation from the general surface in excess of 1/16 inch per foot as measured in the following manner: A 10-foot straightedge shall be placed parallel to the center line of the ro roadway so as to bridge any depressions and touch all high spots. Ordinates measured from the face of the straightedge to the surface of the pavement shall not exceed 1/16 inch for each foot in distance from the nearer points of contact.

Such portions of the completed pavement as are defective in finish, compression, density, or composition, or that do not comply in all respects with the requirements of the specifications, shall be taken up, removed, and replaced with suitable material, properly laid in accordance with these specifications, and at the expense of the Contractor.

Method of Measurement. The yardage to be paid for shall be the number of square yards of wearing course in place, completed and accepted

Basis of Payment. This item shall be paid for by the yardage measured as provided above at the price bid per square yard for "Coarse Aggregate Bituminous Concrete Pavement" which price shall be full compensation for quarrying, furnishing all materials, for all heating, mixing, hauling, placing, rolling and finishing, and for all labor, tools, equipment and incidentals necessary to complete the work.

67. BITUMINOUS CONCRETE PAVEMENT. (Modified Topeka Type)

Description. This item shall consist of a wearing course composed of a compacted mixture of Mineral Aggregate and Bituminous Material, and shall be constructed on the completed and approved base course, or, in the case of a bridge, on the prepared floor slab, in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the Plans.

Materials. The Mineral Aggregate shall be composed of a Coarse Aggregate of crushed stone, a Fine Aggregate, and Mineral Filler. Samples of the Coarse Aggregate, Fine Aggregate, and Mineral Filler shall be submitted in accordance with prescribed methods. Approval both of the material and of the source of supply must be obtained from the Engineer prior to delivery of material.

The Course Aggregate shall consist of clean tough durable fragments of rock (excluding schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, and free from soft or disintegrated stone, dirt, organic or other injurious matter occurring either free or as a coating on the stone. All Limestone shall meet the requirements of the Soundness Test. All stone shall have a per cent of wear of not more than 6, and when tested by laboratory methods shall fulfill the following requirements:

Passing $\frac{1}{2}$ inch screen, not less than 95 per cent
Passing $\frac{1}{4}$ inch screen, not more than 80 per cent

The Fine Aggregate shall consist of sand or a combination of sand and stone screenings. Sand shall be composed of sound durable stone particles free from loam or other injurious foreign matter. Screenings shall be of the same or similar material as specified for coarse aggregate. The sand or combination of sand and screenings shall meet the following requirements:

Passing 10-mesh sieve, not less than	95%
Total retained on 40-mesh sieve	12-40%
Passing 40 mesh sieve, retained on 80-mesh sieve	25-60%
Passing 80-mesh sieve, retained on 200-mesh sieve	25-45%
Passing 200 mesh sieve not over	6

The mineral filler shall consist of limestone dust, dolomite dust, or Portland cement. It shall be free from foreign or other injurious matter. When tested by means of laboratory sieves it shall meet the following requirements:

Passing 30-mesh sieve 100%
Total passing 200-mesh sieve, not less than 65%

The Bituminous Material shall meet the requirements given below for OA-6, NA-5 or NA-6, as elected by the Contractor, who shall notify the Engineer of this choise before the construction starts and shall not there after change the material without written permission by the Engineer. The material shall be homogenous, free from water and shall not foam when heated to 175° C (347° F) Oil asphalt for any one contract shall not vary more than 0-020 in specific gravity nor more than 10° C in melting point within the test limits above specified.

OA-6 Oil Asphalt.

Specific gravity 25°/ 25° C. (77°/77° F.), not less than 1.020
Flash point..... not less than 175° C. (347° F)
Melting point..... 40° C. (104° F) to 60° C. (140°F)
Penetration at 25° C. (77° F.), 100 g. 5 sec..... 50 to 60
Loss at 163° C (325° F.) 5 hours..... not more than 1.0%

a. Penetration of residue at 25° C (77° F.) 100g. 5 sec..... not less than 30.
Total bitumen (soluble in carbon disulphide),..... not less than 99,5%
a. Organic matter insoluble..... not more than 0.2%

NA-5 Fluxed Bermudez Asphalt.

Specific gravity 25° / 25° C. (77° / 77° F.).....1.050 to 1.070
Flash point..... not less than 175° C. (347° F.)
Melting point..... 45° C. (113° F.) to 55° C. (131° F.)
Penetration at 25° C. (77° F.), 100 g., 5 sec.....60 to 70
Loss at 163° C. (325° F.), 5 hours..... not more than 3.0%
a. Penetration of residue at 25° C. (77° F.) 100 g., 5 sec..... not less than 30
Total bitumen (soluble in carbon disulphide) ..... not less than 94.5%
b. Inorganic matter insoluble..... 2.0 % to 3.5%

NA-6 Fluxed Bermudez Asphalt.

Specific gravity 25° / 25° C. (77° / 77° F.).....1.050, to 1.070
Flash point..... not less than 175° C. (347° F.)
Penetration at 25° C, (77° F.), 100 g., 5 sec..... 50 to 60
Loss at 163° C (325° F.), 5 hours..... not more than 3.0%
a. Penetration of residue at 25° C. (77° F.) 100 g. 5 sec..... not less than 25
Total bitumen (soluble in carbon disulphide).. not less than 94.0%
b. Inorganic matter insoluble..... 2.5% to 4.0%

The paving mixture shall consist of a uniform mixture of coarse aggregate, fine aggregate, mineral filler and bituminous meterial to be proprtioned by weight; the grading of each constituent shall be such as to produce, when properly proportioned, a mixture conforming to the following limitations for grading. The exact proportion of each constituent producing the total aggregate within these limits, shall be as directed by the Engineer. When tested by means of laboratory sieves, the paving mixture shall meet the following requirements:

Passing $\frac{1}{2}$ inch screen and retained on $\frac{1}{4}$ inch screen	5-10%
Passing $\frac{1}{4}$ inch screen and retained on 10 mesh sieve	15-22%
Total retained on 10 mesh sieve	25-32%
Passing 10 mesh sieve, retained on 40 mesh sieve	7-22%
Passing 40 mesh sieve, retained on 80 mesh sieve	14-34%
Passing 80 mesh sieve, retained on 200 mesh sieve	11-25%
Passing 200 mesh sieve	7-12%
Bitumen soluble in carbon disulphide	$7\frac{1}{2}$-11%

The percentage of bitumen in the finished course shall not vary more than $\frac{1}{2}$% from the proportion established by the Engineer, All materials, and sources of materials shall be satisfactory to the Engineer and whenever required by him, samples of the hot mixture may be taken several times, daily, and the mixture, to be acceptable must invariably conform to all requirements.

Construction Methods. When the Bituminous Concrete Pavement is to be laid on a concrete base course, or in case of a bridge, on the concrete slab floor, the surface of the slab shall be finished moderately rough with the coarse aggregate well embedded, but not covered with a coating mortar, and with the entire surface free from all depressions or other irregularities.

For the verification of weights or proportions and character of materials and determinations of temperatures secured, the Engineer, or his authorized representative, shall have access at any time to all parts of the paving plant. Suitable and accurate thermometers, weighing scales, and other necessary apparatus shall be furnished and kept in order by the Contractor and installed as directed by the Engineer.

The Coarse and Fine Aggregate shall be heated as directed to between 250 and 350 degrees F. in suitable apparatus in which the aggregate shall be continuously agitated during the heating, and in which the temperature can be efficiently and positively controlled.

The Bituminous Material shall be separately heated in kettles so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed by the Engineer to a temperature between 250 degrees F. and 350 degrees F. All bituminous material heated beyond 350 degress F. either before or during mixing with the mineral aggregate shall be rejected.

Mixing: The prepared Aggregates, the Mineral Filler and the Bituminous Material shall be proportioned by weighing, and mixed as directed in the order mentioned, and in adequate and suitable apparatus, so that the resulting mixture shall be thoroughly homogeneous and shall meet all the requirements herein specified. When discharged the mixture shall have a temperature of between 250 and 350 degrees F.

The Mineral Aggregate shall in all cases be measured by weighing, unless specific methods of gauging, approved in writing by the Engineer, are used.

Laying: The bituminous concrete mixture, heated and prepared as specified, shall be hauled to the work in tight vehicles previously cleaned of all foreign materials, and , if necessary, covered with canvas of sufficient size to protect the entire load. The dispatching of the vehicles shall be arranged so that all material delivered may be placed and shall have received initial rolling in daylight. The mixture shall be laid only on a base course which is dry, or in any case free from standing water, and free from loose or foreign materials, and only when weather conditions, in the opinion of the Engineer are suitable, Contact surfaces of curbs and structures and all joints, when so required by the Engineer, shall be painted with a thin, uniform coating of asphaltic cement before the course is spread.

The mixture shall be at a temperature of 250 to 350 degrees F. when laid. The mixture shall be dumped on a "Dumping Board" outside of the area on which it is to be spread, the entire load distributed into place and raked to grade in a uniformly loose layer of such depth that after receiving ultimate compression by rolling it shall have the compacted depth shown on the Plans. Adjacent to flush curbs, gutters, liners, and structures, the mixture shall be raked uniformly high so that when compacted it will be slightly above the edge of the curb or flush structure.

Rolling: Rollers used on the bituminous concrete shall be well-balanced, self-propelled, tandem rollers, weighing between 7 and 8 tons each. Each shall have a compression under the rear roller of between 200 and 300 pounds per linear inch of roll and shall be provided with an ash pan, which shall prevent ashes from dropping upon the bituminous concrete.

The bituminous concrete wearing course, laid as specified, shall be rolled at once while the mixture is warm and pliable, beginning at the edges and working toward the center, followed immediately by cross rolling or diagonal rolling. Means for preventing the bituminous material from adhering to the roller shall be provided as directed by the Engineer.

The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacements occurring as a result of reversing the direction of the roller or by any other cause, shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall continue without interruption until all roller marks disappear and the surface shows no further compressibility. After the pavement has had its initial compression limestone dust or Portland cement as directed by the Engineer shall be swept thinly over the entire surface. A sufficient number of rollers must be employed to obtain the maximum compression, and in no case shall less than 96% of the calculated density be obtained. Places which the roller cannot effectively reach shall be compressed with hot iron tampers.

Joints: Placing of the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is discontinued for such length of time as to permit the mixture to become chilled. In all such cases when the work is resumed the material laid shall be cut back so as to produce a slightly beveled edge for the full thickness of the course. The old material which has been cut away shall be removed from the work and new mix laid against the fresh cut. If desired, a stout rope may be stretched across the pavement where the joint is to be made. When the work is resumed, the material laid shall be cut back to the rope which will be removed together with the surplus material and the fresh mix laid against the joint thus formed. Hot smoothing irons may be used for sealing joints, but in such case extreme care shall be exercised to avoid burning the surface.

Surface Tests: Before the completion of the rolling, the surface shall be tested as follows, and corrected as necessary by properly adding or removing material, retesting, and rerolling until the finish surface complies with the test requirements.

The finished pavement shall show no deviation from the general surface in excess of 1/16 inch per foot as measured in the following manner: A 10 foot straight edge shall be placed parallel to the center line of the roadway so as to bridge any depressions, and touch all high spots. Ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed 1/16 inch for each foot in distance from the nearer point of contact.

Such portions of the completed pavement as are defective in finish, compression, density, or composition, or that do not comply in all respects with the requirements of the specifications, shall be taken up, removed, and replaced with suitable material, properly laid in accordance with these specifications, and at the expense of the Contractor.

Method of Measurement. The yardage to be paid for shall be the number of square yards of wearing course in place, completed and accepted.

Basis of Payment. This item shall be paid for by the yardage measured as provided above at the price bid per square yard for "Bituminous Concrete Pavement" (Modified Topeka Type) which price shall be full compensation for quarrying, furnishing all materials, for all heating, mixing, hauling, placing, rolling and finishing, and all labor, tools, equipment and incidentals necessary to complete the work.

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68. SHEET ASPHALT PAVEMENT.

Description. This item shall consist of a pavement composed of an asphaltic binder course and a sheet asphalt wearing course, each of $1\frac{1}{2}$ inches compacted thickness, and shall be constructed on the completed and approved base course in accordance with these specifications and in conformity with the lines, grades and typical cross-section shown on Plans.

The Binder Course shall be composed of a compacted mixture of Coarse and Fine Mineral Aggregate and Bituminous Material, and shall be laid on the base course. The wearing Course shall be composed of compacted mixture of Sheet Asphalt Sand, Mineral Filler and Bituminous Material.

Materials. Samples of the Mineral Aggregates and Bituminous Material to be used shall be submitted and tested. Approval both of the material and of the source of supply must be obtained prior to delivery of material.

The Coarse Aggegate shall consist of clean tough durable fragments of rock (excluding schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, and free from soft or disintegrated stone, dirt, organic or other injurious matter occurring either free or as a coating on the stone. All Limestone shall meet the requirements of the Soundness Test. All stone shall have a per cent of wear of not more than 6, and when tested by laboratory methods shall fulfill the following requirements:

Passing $1\frac{1}{4}$ inch screen	100%
Retained on $\frac{1}{4}$ inch screen	80 to 100%

Fine Aggregate shall consist of clean sound durable stone particles free from loam or injurious foreign matter, and when tested by laboratory methods shall fulfill the following requirements:

Passing the $\frac{1}{4}$ inch screen.....	95 to 100%
Passing the 200 mesh sieve.....	6%

The Sheet Asphalt Sand shall consist of clean sound durable stone particles free from loam or injurious foreign matter, and when tested by laboratory sieves shall fulfill the following requirements:

Passing 10 mesh retained on 40 mesh sieve	12 to 40%
Passing 40 mesh retained on 80 mesh sieve	25 to 60%
Passing 80 mesh retained on 200 mesh sieve	20 to 45%
Passing 200 mesh sieve	0 to 6%

Mineral filler: The mineral filler shall consist of limestone dust, dolomite dust or Portland cement. It shall be free from foreign or other injurious matter. When tested by means of standard Laboratory sieves, it shall meet the following requirements:

Passing Standard No. 30 sieve	100%
Total passing Standard 200 sieve not less than....	65%

Bituminous Material for the mixtures shall fulfill the requirements of NA-7, NA-7 or NA-9 as elected by the Contractor, who shall notify the Engineer before construction starts, and shall not thereafter change the material without written permission by the Engineer. The material shall be homogeneous, free from water and the asphalt material shall not foam when heated to 175° C (347° F.) Oil Asphalt for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C, in melting point within the limits specified.

OA-7 Asphalt.

Specific gravity 25° / 25° C. (77° / 77° F.) ..... not less than 1.020
Flash point..... not less than 175° C. (347° F.)
Melting point..... ..... 45° C. (113° F.) to 65° C. (149° F.)
Penetration at 25° C. (77° F.). 100 g. 5 sec..... 40 to 50
Loss at 163° C. (325° F.) 5 hours..... not more than 1.0%
a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec..... not less than 25
Total bitumen (soluble in carbon disulphide), not less than 99.5%
b. Organic matter insoluble..... not more than 0.2%

NA-7 Fluxed Bermudez Asphalt.

Specific gravity 25° / 25° C. (77° / 77° F.) ..... 1.055 to 1.075
Flash point..... not less than 175°C. (347°F)
Melting point..... 45 ° C. (113° F.) to 55° C. (131° F.)
Penetration at 25° C. (77° F.), 100 g., 5 sec..... 40 to 50
Loss at 163° C. (325° F.), 5 hours..... not more than 3.0%
a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec..... not less than 20
Total bitumen (soluble in carbon disulphide), not less than 94.0%
b. Inorganic matter insoluble..... 2.5% to 4.0%

NA-9. Fluxed Trinidad Asphalt.

Specific gravity 25°/ 25° C. (77°/ 77° F.)..... 1.210 to 1.270
Flash point..... not less than 175° C. (347°F.)
Melting point..... 50° C. (122° F.) to 60° C. (140° F)
Penetration at 25° C. (77° F.), 100 g., 5 sec..... 40 to 50
Loss at 163° C. (325° F.), 5 hours..... not more than 3.0%
a. Penetration of residue at 25° C. (77° F.), 100 g., 5 sec..... not less than 20
Total bitumen (soluble in carbon disulphide), not less than 65.0%
b. Organic matter insoluble..... 22.0% to 32.0%

Proportioning and grading Binder Mixture: The Coarse and Fine Aggregate shall be measured separately, by weight, and then mixed with Bituminous Material in such proportions that the resulting mixture, when tested by laboratory methods shall fulfill the following requirements by weight:

Total retained on ½ inch screen	15 to 65%
Passing ½ inch retained on 10 mesh sieve	20 to 50%
Passing 10 mesh sieve	15 to 35%
Bitumen (soluble in carbon disulphide)	4 to 7%

Proportioning and grading Wearing Course Mixture: The proportions and grading of each constituent shall be such as will produce a mixture fulfilling the following requirements by weight when tested by laboratory methods:

Sand passing 10 mesh retained on 40 mesh sieve	10-32%
Sand passing 40 mesh retained on 80 mesh sieve	20-48%
Sand passing 80 mesh retained on 200 mesh sieve	16-36%
Filler passing 200 mesh sieve.....	10-18%
Bitumen (Sol. in carbon disulphide).....	9½-12½%

The item designated as "Filler" within the designated limits includes, in addition to stone dust or cement, sand passing the 200 mesh sieve not exceeding four and one-half per cent of the entire mixture and the mineral dust naturally contained on the asphaltic cement.

The proportions of the material between these limits shall be as directed by the Engineer, and shall not be varied without the consent of the Engineer.

The percentage of bitumen both in the Binder and in the Wearing course shall not vary more than ½% from the proportion established by the Engineer. Unvarying uniformity is of prime importance and both the proportioning and treatment of all materials must be maintained consistly satisfactory to the Engineer throughout the construction period, and whenever required by him, samples of the hot mixture may be taken several times daily, and the mixture to be acceptable, must invariably conform to all requirements.

Construction Methods. For the verification of weights or proportions and character of materials and determinations of temperatures secured, the Engineer, or his authorized representative, shall have access at any time to all parts of the paving plant. Suitable and accurate thermometers, weighing scales and other necessary apparatus shall be furnished and kept in order by the Contractor and installed as directed by the Engineer.

Binder Course Mixture: The Coarse and Fine Aggregate shall be heated as directed to between 250 and 350 degrees F. in suitable apparatus in which the aggregate shall be continuously agitated during the heating and in which the temperature can be efficiently and positively controlled.

The Bituminous Material shall be separately heated, with effective and positive control of the temperature at all times, to between 250 and 350 degrees F. All material heated above 350 degrees F. either before, or during the mixing with the Mineral Aggregate shall be rejected.

Mixing Binder Course: The Coarse and Fine Aggregates and the Bituminous Material shall be proportioned by weighing, and mixed as directed in the order mentioned, and in adequate and suitable apparatus, so that the resulting mixture shall be thoroughly homogeneous and shall meet all the requirements herein specified. When discharged the mixture shall have a temperature of between 250 and 350 degrees F. The Mineral Aggregate shall in all cases be measured by weighing unless specific methods of gauging, approved in writing by the Engineer, are used.

Wearing Surface Mixture: The asphalt Sand shall be separately heated as directed in revolving driers in which the material shall be continuously agitated during the heating to between 250 and 350 degrees F. When a mixture of 2 or more materials is required to produce a graded material conforming to the requirements prescribed for "Asphalt Sand", such combinations shall be made either before the sand is fed into driers or be simultaneously feeding the individual sands into the drier in proper proportion. A registering pyrometer shall be installed at a suitable point at the discharge end of the drier with the registering device so located as to clearly indicate to the drum fireman the temperature of the mineral aggregate when discharged.

The Bituminous Material shall be separately heated in apparatus designed to assure uniform heating of the entire mass with an efficient and positive control of the heat at all times. It shall be heated as directed be between 250° and 350° F. and all material heated beyond 350°F shall be rejected.

Mixing Wearing Course: When thoroughly heated to the temperature specified the hot sand shall be thoroughly mixed with the cold filler. The Bituminous Material shall then be added and thoroughly mixed at least 1 minute with the hot sand and filler at the specified temperature and in the specified proportions until a homogeneous mixture is produced. The sand, filler and Bituminous Material for each batch shall be proportioned by weight and shall be weighed separately by scales attached to the receptable or bucket used for such proportioning or weighing. The weighing apparatus shall be of approved design and shall be kept in working order.

The mixer used shall have revolving blades, and shall be so designed and operated as to produce and discharge a thoroughly coated and uniform mixture of non-segregated sand, filler and Bituminous Material. When discharged the mixture shall have a temperature of not less than 250 and not more than 350° F.

Laying Binder Course: The surface of the base course shall be clean, free from loose and foreign particles. The prepared mixture shall be transported from the Plant, placed and rolled and joints constructed as provided for the Wearing Course. The surface of the mixture after rolling shall be smooth dense and true to the established crown grade and cross-section for the Binder Course. Such portions of the course as are defective in finish, density or composition, or become loose shall be removed and replaced with fresh material and rebuilt in accordance with the specifications at the expense of the Contractor.

Laying Sheet Asphalt Wearing Course: The surface mixture, heated and prepared as specified, shall be delivered direct from the mixer to the point of deposit in tight vehicles previously cleaned of all foreign materials and provided with canvas covers of retaining the heat. As delivered, the surface mixture shall have a temperature for between 250 degrees and 350 degrees F. The temperature shall be regulated to the character of materials employed. The dispatching of the vehicles shall be arranged so that all material, delivered may be placed and shall have received initial rolling in daylight. The mixture shall be laid only on a base course which is dry, or in any case free from standing water, and free from loose or foreign materials and only when weather conditions, in the opinion of the Engineer, are suitable. Before the surface mixture is placed all contact surfaces of curbs, edgings, manholes, etc., shall be thinly and evenly painted with hot asphaltic cement. The hot surface mixture shall be dumped on a "Dumping Board" clear of the space to be occupied by the mixture and shall be shoveled with hot shovels into position on the binder course. The surface mixture shall be immediately raked with hot iron rakes, as directed by the Engineer, by men experienced in such work to a uniform consistency and in such a manner that when rolled it shall have a thickness as hereinbefore prescribed, and shall be free from surface depressions and irregularities.

Rolling: The rollers shall be well balanced, self-propelled, tandem rollers, weighing between 7 and 8 tons each. Each shall have a compression under the rear roller of between 200 and 300 pounds per linear inch of roll, and shall be provided with an ash pan, which shall prevent ashes from dropping on the pavement.

The Wearing course, laid as specified, shall be rolled at once while the mixture is warm and pliable, beginning at the edges and working toward the center, immediately followed by cross or diagonal rolling. Means for preventing the bituminous material from adhering to the roller shall be provided as directed by the Engineer. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacements occurring as a result of reversing the direction of the roller or by any other cause, shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall continue without interruption until all roller marks disappear and the surface shows no further compressibility. A sufficient number of rollers must be employed to obtain the maximum compression, and in no case shall less than 96% of the calculated density be obtained. Before final compression shall have been obtained, limestone dust or Portland cement, as directed by the Engineer, shall be thinly swept over the surface and the rolling continued. Places which the roller cannot reach effectively shall be compressed with hot iron tampers.

Joints: Placing of the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is discontinued for such length of time as to permit the mixture to become chilled. In all such cases when the work is resumed the material laid shall be cut back so as to produce a slightly beveled edge for the full thickness of the course. The old material which has been cut away shall be removed from the work and new mix laid against the fresh cut. If desired, a stout rope may be stretched across the pavement where thejoint is to be made. When the work is resumed, the material laid shall be cut back to the rope which will be removed together with the surplus material and the fresh mix laid against the joint thus formed. Hot smoothing irons may be used for sealing joints, but in such case extreme care shall be exercised to avoid burning the surface.

Surface Tests: Before the completion of the rolling, the surface shall be tested as follows, and corrected as necessary by properly adding or removing material, retesting, and rerolling until the finished surface complied with the test requirements.

The finished pavement shall show no deviation from the general surface in excess of 1/16 inch per foot as measured in the following manner:

A 10 foot straight edge shall be placed parallel to the center line of the roadway so as to bridge any depressions and touch all high spots. Ordinates measured from the face of the straightedge to the surface of the pavement shall not exceed 1/16 inch for each foot in distance from the nearer point of contact.

Such portions of the completed pavement as are defective in finish, compression, density, or composition, or that do not comply inall respects with the requirements of the specifications, shall be taken up, removed, and replaced with suitable material, properly laid in accordance with these specifications, and at the expense of the Contractor.

Method of Measurement. The yardage to be paid for shall be the number of square yards of Sheet Asphalt Pavement completed and accepted.

Basis of Payment. This item shall be paid for by the yardage measured as provided above at the price bid per square yard for "Sheet Asphalt Pavement" complete in place, which price shall be full compensation for both Binder Course and Wearing Course for furnishing all materials, for all heating, mixing, hauling, placing, rolling and finishing, and for all labor, tools, equipment and incidentals necessary to complete the work.

69. CONCRETE PAVEMENT.

Description. This item shall consist of a wearing course composed of Portland Cement Concrete with or without reinforcing steel as required and shall be constructed on the prepared subgrade or completed and accepted base course in accordance with these specifications and in conformity with the lines, grades, thickness and typical cross-section shown on Plans.

The concrete shall be composed of $5\frac{1}{2}$ parts of Coarse and Fine Aggregate to 1 part of Portland Cement. The Engineer shall regulate the proportion of fine to coarse aggregate to secure the maximum density, and the proportions in terms of the 3 ingredients shall approximate 1-2-$3\frac{1}{2}$. In no event shall the number of bags of cement, used per cubic yard of concrete in place be less than $6\frac{1}{2}$ of 94 pounds each

Materials. The Coarse Aggregate shall consist of Broken Stone or gravel conforming to the following requirements.

Broken Stone shall consist of clean tough durable fragments of rock (excluding schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, soft or disintegrated stone, dirt, organic or other injurious matter occurring either free or as a coating on the stone. All stone shall have a per cent of wear of not more than 6. All limestone shall meet the requirements of the Soundness Test.

Gravel shall consist of clean hard durable uncoated pebbles having a per cent of wear of not more than 15 (abrasion test for gravel) and shall be free from an excess of soft, thin or laminated pieces, disintegrated Stone, dirt, organic or other injurious matter occurring either free or as a coating on the Stone; where reinforcing steel is to be used gravel shall be free from salt and alkali.

Grading: Coarse Aggregate shall be well graded and when tested by laboratory methods shall fulfill the following requirements:

Passing $2\frac{1}{2}$ inch screen	95 to 100%
Retained on $1\frac{1}{4}$ inch screen	25 to 60%
Retained on $\frac{3}{4}$ inch screen	50 to 75%
Retained on $\frac{1}{4}$ inch screen	95 to 100%

Coarse Aggregate conforming in all respects to the above requirements except grading may be used, provided that concrete made from such material meets the requirements of the Strength Test hereinafter specified.

Fine aggregate shall consist of sand, or a combination of sand and not more than 50% of stone screenings, conforming to the following requirements:

Sand shall be composed of clean, hard, durable uncoated grains, free from lumps, soft or flaky particles, loam, organic or other injurious matter. Where reinforcing steel is to be used sand shall be free from salt and alkali.

Stone screenings shall consist of the clean dustless product resulting from the crushing of stone, meeting all the requirements for Coarse Aggregate except for grading, and free from lumps.

Fine Aggregate shall be well graded from coarse to fine and shall meet the following requirements:

Passing the $\frac{1}{4}$ inch screen	95 to 100%
Passing 20 mesh sieve	50 to 80%
Passing 50 mesh sieve	5 to 30%
Passing 100 mesh sieve	0 to 5%

Construction Methods. The subgrade shall have been rolled and finished as prescribed for Concrete Bases or Pavements. It shall be tested with the subgrade templet just before placing the concrete mixture and shall be in a moist condition. The subgrade templet shall be furnished and used by the Contractor and shall be so designed and constructed that when the templet is riding on the side forms, the testing edge shall exactly conform to the grade and crown prescribed on the typical cross-section. This templet shall be kept in place at all times on the forms at the discharge end of the mixer.

All equipment, tools, and machinery used for handling materials and performing any part of the work must be approved by the Engineer and must be maintained in satisfactory working condition.

Forms: Ouside forms for this work shall be of metal, of depth equivalent to the edge thickness of the work prescribed, straight and free from warp. They shall be of approved section, shall have a flat top of not less than $1\frac{3}{4}$ inches width, and such base width that the maximum load of the subgrade under any method of finish shall not be more than 7 pounds per square inch.

The forms shall be joined neatly and tightly and securely to pinned and staked to line and grade, at least 200 feet in advance of placing concrete. The forms shall be of such strength and shall be so secured as to resist the pressure of the concrete and the mechanical tamper without springing or settlement. Bearing stakes driven flush with the bottom of the forms may be required for additional stability. The entire length of the forms shall be in contact with the subgrade. The Engineer may require additional bearing areas, secured by planks fastened to the forms and to the subgrade. The building or pedestals of earth or other material upon which to rest the forms in order to bring them up to grade will not be permitted.

Sufficient forms shall be provided so that they may remain in place 12 hours or more after the concrete has been placed before it is necessary to remove and re-use them. Forms shall be cleaned and oiled before concrete is placed against them. The alignment and grade of forms shall be checked and approved immediately before placing concrete. Forms which show a variation exceeding the surface test required shall be reset or removed as directed.

Measuring Materials: All materials shall be separately and accurately measured by volume unless otherwise specified, and each batch shall be uniform. The Coarse and Fine Aggregates shall be measured loose and separately. No computed change in volume for moisture content shall be considered. A bag of cement (American) as packed by the manufacturers and weighing 94 pounds shall be considered 1 cubic foot. The Contractor shall furnish and use approved measuring boxes, pans, or mechanical devices, which in operation will give the exact volumes of coarse and fine aggregate required and so designed and plainly marked that the Inspector can accurately and conveniently check the quantities of each aggregate actually being used.

Consistency: Sufficient water shall be used in mixing to produce a workable mixture which will flatten out and quake when deposited in place, but not enough to cause it to flow, and which can be conveyed from the mixer to the work without segregation of coarse aggregate from mortar. When a "Central Mixing Plant" is used, especial care shall be taken that the consistency is such as will not result in segregation of the aggregate during transportation of the mixture to the work. In no case shall the quantity of water used be sufficient to cause the collection of a surplus on the surface. The quantity of water shall be determined by the Engineer, and not varied without his consent. The Contractor shall furnish and use with the mixer an approved adjustable water measuring device which will prevent excess water flowing into

Mixing Conditions: The concrete shall be mixed in the quantities required for immediate use and any which has developed initial set, or which is not in place within 30 minutes after the water has been added, shall not be used. No concrete shall be mixed while the air temperature is at or below 35 degrees F. without the approval of the Engineer. No materials containing frost or lumps of hardened materials shall be used. If the contractor intends using a "Central Mixing Plant" he must so state beforehand, and must obtain permission for its use from the State Highway Engineer.

Mixing: The mixing shall be done in a batch-mixer of approved type which will insure the uniform distribution of the material throughout the mass so that the mixture is uniform in color and smooth in appearance. The mixing shall continue for a minimum time of 1 minute after all the ingredients are assembled in the drum, during which time the drum shall revolve at the speed for which it was designed but shall make not less than 14 nor more than 20 revolutions per minute. The mixer shall be equipped with an attachment for satisfactorily locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch. The mixer shall be equipped with bucket and boom delivery unless otherwise permitted by the Engineer, have a capacity of not less than 3 bags of cement per batch of concrete of the composition herein specified; and a speed regulator to hold the mixer to its normal speed of revolution.

Hand Mixing: Hand mixing will only be allowed when yardage to concrete surface is too small to warrant the use of a paver. When hand mixing is permitted it shall be done on a watertight platform. The fine aggregate and cement shall first be mixed until a uniform color is attained and then spread over the mixing board in a thin layer.

The coarse aggregate, which shall have been previously drenched, shall then be spread over the fine aggregate and cement in a uniform layer and the whole mass turned as the water is added.

After the water has been added, the mass shall be turned at least six times, and more if necessary, to make the mixture uniform in color and smooth in appearance. Hand mixed batches shall not exceed one-half cubic yard in volume.

Checking Quantities of Cement Used: The Engineer shall ascertain by calculation and tests, the amount of cement required for each section between transverse joints, according to these specifications, and as the work progresses, the Engineer shall compare the amount so ascertained with the amounts actually used in each section of concrete between successive transverse joints, as determined by actual count of the number of bags of cement used in each section. If the amount of cement used in any three adjacent sections (between transverse joints) is less by more than four per cent, or if the amount of cement used in any one section is less by more than five per cent of the amount therein required, the Contractor shall remove all such sections and replace the same with new materials, according to these specifications, and at his own Expense.

Placing Concrete: Concrete shall be placed only on a moist subgrade. If the subgrade is dry it shall be sprinkled with as much water as will be absorbed readily. The concrete shall be deposited on the subgrade rapidly in successive batches, by means of a discharging device which does not cause separation of the mortar and the coarse aggregate and shall be distributed to the required depth and for the entire width of the pavement by shoveling or other approved methods. Rakes shall not be used in handling concrete. This operation shall be continuous. At the end of the day, or in case of an unavoidable interruption of more than 30 minutes, a transverse joint shall be placed at the point of stopping work, provided that the section on which the work has been suspended shall be not less than 10 feet in length. Sections less than 10 feet in length shall be removed.

Placing Reinforcing Steel: When reinforcement is required it shall be placed as shown on Plans, and provided in these specifications under "Reinforcing Steel".

No concrete shall be placed when the minimum air temperature is less than 35° F. unless permission to do so is granted in writing by the Engineer. When such permission is given the Contractor shall furnish sufficient canvas and framework or other type of housing to enclose and protect fresh concrete in such a way that the temperature of the air surrounding the concrete is maintained at not less than 45° F. for a period of 5 days or more. It is understood that the Contractor is responsible for the quality and strength of concrete placed under any weather conditions.

Joints: Transverse expansion and construction joints shall be either of the poured or premoulded type as designed on Plans or in Special Provisions. Expansion joints shall also be formed around all objects that project through the pavement, such as manholes, catch basins, etc., also between curbs and pavements. The edges of all transverse and longitudinal, expansion and construction joints shall be rounded as shown on detailed plans. The bitumen used to form poured joints and in the manufacture of premoulded joints shall comply with the requirements for Bituminous filler of brick pavement hereinafter given.

Transverse expansion shall be straight and shall be perpendicular to the surface and to the axis of the pavement. Longitudinal ~~expansion~~ joints shall be perpendicular to the surface and shall follow the axis of the pavement. All joints shall be constructed true to line and in a workmanlike manner.

Transverse Expansion Joints: Transverse expansion joints shall be constructed at the joints designated on Plans or in special Provisions. In all cases they shall be made at the close of each day's work or whenever the mixer is stopped for over 30 minutes. In no case shall the length of slab be less than 10 feet.

When the pavement is being constructed one-half at a time, in the construction of the last half of the pavement, transverse expansion joints shall be placed directly opposite the joints in the completed half, except in case of break down or delay due to unforeseen conditions. In such an emergency, if in the opinion of the Engineer a joint cannot be constructed as required above, it may be placed ataa distance of not less than 10 feet from the nearest joint in the compacted half of the pavement.

The form used to cast a poured joint must be so designed and used that the concrete will not be injured by its removal, and the opening will have the specified dimensions, be perpendicular to pavement surface and axis and must be approved by the Engineer. It shall be so set that the edge is at the same elevation as the surface of the concrete and firmly held in place by iron rods or pins driven into the subgrade.

The filler used in a poured joint shall be a bituminous mastic composed of from 50 to 75 per cent of approved sand, 25 to 50 per cent of approved bituminous cement. The quantity of bitumen used shall be sufficient to form a mastic having sufficient fluidity at the temperature it is applied to permit the joint opening to be completely filled. The sand shall have a temperature of from 350° F. to 400° F. when mixed with the bitumen. The Bitumen shall be heated sufficiently to be in a fluid condition when mixed with the sand and at no time shall be heated above 400° F.

The mastic must be so prepared as to be uniform in composition, and have a temperature not under 325° F. when poured into the joint. As the filler cools and subsides, additional material shall be added so that the joint will be flushed full when the bituminous mastic has cooled to normal temperature. The joint opening must be free from all foreign material, open to the full depth and the faces clean and dry when the hot mastic is applied.

When sheets of bituminized felt or prepared semi-solid bitumen are specified as the joint filler, they shall be inserted during construction, perpendicular to the axis of the pavement and the surface of the concrete, firmly anchored in position and left in place. They shall be from $\frac{1}{4}$ to $\frac{1}{2}$ inches in thickness, equal in length to the width of the pavement, have the same width as the pavement's thickness, and so set that the top edge is flush with the finished pavement surface, and parallel thereto, and kept in this position when the supporting device is removed. All sheets of bituminous felt or prepared semi-solid bitumen shall have the top edge cut to the required crown of the surface before installation. When two sheets are used for one joint, the abutting ends must be cut square and held firmly together during installation, placing, and finishing of the concrete. After side forms are removed, the ends of the joints shall be cleaned of all concrete to the full depth of the pavement so that the joint opening at this point will have the width specified.

The ends of the different slabs shall be held in the same relative position by plain round iron rods. 6 rods shall be used in each joint, spaced one foot from each outside edge, and from each other unless otherwise shown on Plans. They shall be $\frac{3}{4}$ inch in diameter, 60 inches long, $\frac{1}{2}$ of each rod shall be wrapped in one layer of one-ply tarred paper or else covered with a paper tube. When tarred paper is used, it shall extend about 2 inches beyond the end of the rod, doubled over and must be firmly tied or fastened on. When paper tubes are used, they shall be from 17 to 18 inches in length, $\frac{3}{4}$ inch inside diameter and have one end closed. These paper coverings must be kept intact until the rods are properly placed. The rods shall be installed during construction of all transverse joints. They shall extend about equal distances into each slab, be from 3 to 4 inches from the finished surface, parallel thereto, also to the axis of the pavement.

The plates used to hold joint fillers in position must be so constructed that these rods can be easily inserted into the concrete and not disturbed when said plates are removed.

Longitudinal Expansion Joints: When the pavement extends to paved gutters, curbs or adjacent to or around structures etc., expansion joints shall be constructed adjacent thereto. The type of joint specified shall be constructed of the same material and in a similar manner to that required for the same type of transverse expansion joints.

Sealing Expansion Joints and Filling Cracks: Transverse joints shall be sealed by ironing down the prepared filler with a hot iron, then pouring the tar or asphalt into and over the joints when they are dry. Care shall be observed to prevent the sealing material from spreading over the surface of the pavement for a width of more than one inch on either side of the joint.

Longitudinal Center Joints and Circumferential Reinforcement: When shown on plans or specified by the Engineer, on concrete pavements sixteen feet or over in width, a metal joint shall be placed in the center of the pavement. The metal used in this joint shall be not less than eighteen gauge and may be either painted or galvanized similar to the detail drawing shown on Plans. Adjoining metal strips shall be lapped two inches and securely fastened together by means of three-eights inch pins driven through matched holes in the splices.

The metal joint shall be accurately staked to line and grade by means of pins left in place driven vertically through holes provided for that purpose in the metal at not to exceed 3 feet 4 inches centers. The pins used shall be of mild steel 3/8 inch in diameter and not less than 15 inches in length. The metal used in the joints may be of any length provided it is staked in place at intervals of not to exceed 3 feet 4 inches in the manner as specified above. Punched or cut holes shall be provided in the joints at not to exceed 5 foot centers to receive the $\frac{1}{2}$ inch round, deformed tie bars. A templet approved by the Engineer shall be used to place the metal joint in horizontal and vertical alignment prior to the depositing and finishing of the concrete and care must be exercised not to displace the joint during the finishing operation. If especially permitted by the State Highway Engineer, the use of Longitudinal Joints or other materials will be allowed.

The $\frac{1}{2}$ inch round deformed bars extending across the center joint shall be placed through the center joint as shown on Plans. These bars shall be 4 feet in length and spaced not to exceed 5 foot centers. The use of any deformed rough surfaced bar, having a cross sectioned area equal to or greater than the $\frac{1}{2}$ inch round bar, will be permitted.

When so indicated on the Plans, a $\frac{3}{4}$ inch round, smooth bar shall be placed in the edge of the concrete pavement as shown on Plans. These bars may be of any length.

The bars shall be held in the position shown on the Plans by means of wire staples driven into the ground, by notched wooden blocks, or by other methods approved by the Engineer, during the operation of depositing the concrete.

Finishing: ~~unless otherwise specified or permitted by the State Highway Engineer,~~ the concrete shall be tamped and finished by one of the methods specified below.

Machine Finishing: After the concrete has been deposited it shall be leveled off to approximately one inch above the grade specified and tamped mechanically with a machine approved by the Engineer until all voids are removed and the concrete is thoroughly compacted. The mechanical tamper shall go over each area of the pavement until the concrete is thoroughly compacted and all voids removed.

Immediately after final tamping with the machine, the surface shall be floated longitudinally, from bridges, with a long wooden float ten to fourteen feet in length, properly stiffened to prevent flexibility and with handles at each end. This float shall be reasonably light in order to prevent working or sinking into the surface. It shall be worked longitudinally along and across the pavement in the same motion, the men handling it standing on the bridges. Bridges shall be so constructed as to be entirely clear of any portion of the pavement.

After the water glaze or sheen disappears and just before the concrete attains its initial set, the surface shall be given the final belting in order to produce a uniform surface of gritty texture. This belting shall be of short rapid transverse strokes having a sweeping longitudinal motion.

The concrete adjacent to the transverse joint shall be finished with a split wood float which will insure finishing both sides to the same grade, after which the edges of the concrete at the joint shall be rounded with an approved edging tool to a radius of three-sixteenths of an inch. The finishing of the joint shall be done from a bridge which shall not rest on the concrete at any point.

Hand finishing: After being properly placed, the concrete shall be struck off sufficiently above the surface grade specified so that it will not be compressed below this grade during tamping. The strike-boards shall be moved forward with a combined longitudinal and transverse motion, so manipulated that neither end will be raised off the side forms. A slight excess of material must be kept in front of the cutting edge at all times. The whole surface of the concrete shall then be tamped until thoroughly consolidated. The tamping shall be so executed that all voids in the body of the concrete are closed and porous places on the surface of the concrete eliminated. Additional concrete shall be added to all remaining low places and porous spots, and the concrete retamped and restruck. The striking and tamping shall continue until the whole pavement has a uniform, even surface that is free from porous or rough spots, waves or depressions, has the required crown, and is at the specified grade. The concrete in general must be uniform in appearance, composition, density and strength.

All strike-boards used must be straight, free from warp, shod on the striking surface with a strip of steel, and have the required curvature and crown, be not less than two feet longer than the pavement is wide, and equipped with handles so constructed that the workmen can easily manipulate them in the manner required. The heavier one used for the initial striking shall weigh not less than eight nor more than ten pounds per lineal foot. The lighter one used for subsequent striking and tamping shall weigh not less than four nor more than five pounds per lineal foot. The heavier one shall be so constructed as to leave about one-half inch surplus mortar above the specified grade; the lighter one shall be constructed to tamp and strike the concrete to grade. A light unshod template shall also be provided, which is at least six inches longer than the pavement is wide, cut to the required curvature and made from well-seasoned lumber. All strike-boards must be kept well oiled and protected so that they will not warp or twist out of shape.

After tamping, the pavement shall be tested with the straight edge, and the light template, and any depressions discovered shall be filled with fresh concrete, struck off with the lighter strike-board, and tamped again. Projections shall be removed and the testing, striking off, and tamping shall continue until the pavement has the required surface contour.

After the final tamping has been completed, the pavement shall be finished by 2 applications of a soft, flexible belt made of canvas or rubber belting, not less than eight inches wide and not less than two feet longer than the width of the pavement. The belt shall be drawn with a combined crosswise and longitudinal motion. For the first application, vigorous strokes at least twelve inches long shall be used and the longitudinal movement of belt along the pavement shall be very slight. The second application of the belt shall be immediately after the water glaze or sheen disappears and the stroke of the belt shall be not more than four inches, and the longitudinal movement shall be much greater than for the first application. The belt shall be removed from the pavement surface between applications. If required by the Engineer, instead of the beltings as above described, the longitudinal float previously prescribed under Machine Finishing shall be used. The final belting and joint finish shall be prescribed under Machine Finishing.

Surface Test: Before initial set and the final belting the entire surface shall be tested and all irregularities or undulations, not within the tolerance of the following test, shall be corrected with fresh concrete, brought within the requirements of the test and refinished as necessary.

A 10 foot straight edge shall be placed parallel to the centerline of the road so as to bridge any depressions and touch all high spots. Ordinates measured from the face of the straightedge to the surface of the pavement shall at no place exceed 1/16 inch per foot, from the nearer point of contact.

Protection and Curing of Concrete Pavement: As soon as the concrete pavement has been finished as described above, it shall be protected from the sun and wind by means of a canvas covering, suspended not less than 12 inches nor more than 24 inches above the surface and if directed, the surface of the pavement shall be sprinkled with water. Or if preferred 10 to 12 ounce burlap, thoroughly wetted may be laid directly upon the surface of the pavement as soon as in the judgment of the Engineer, the concrete has sufficiently set to prevent marring the surface. The burlap shall be kept thoroughly wet in order to protect and properly cure the pavement.

As soon as practical, after the concrete has taken its final set, and not later than 10 o'clock A.M. of the day following the placing of the concrete, the canvas covering or burlap shall be removed and the entire pavement shall be immediately covered with water held in place by means of dykes, or with earth thoroughly saturated with water. Either of these methods will be equally acceptable under these specifications.

When the "ponding" method is used, the surface of the pavement shall be kept covered with water for a period of two weeks.

If an earth covering is used, the edges of the pavement shall be banked with earth and the surface of the pavement shall be covered with at least 2 inches of earth. The earth covering shall be thoroughly saturated with water twice each day at intervals of about 12 hours for two weeks, and the covering shall remain upon the road for at least 14 days from the time of its application and for a longer period of time if weather conditions in the opinion of the Engineer make this desirable.

Before final acceptance of the work, and at least 6 days before traffic is permitted on the pavement, the earth covering shall be scraped off by the contractor and spread over the earth shoulders, as directed by the Engineer, on either side of the concrete, in a thin uniform layer.

The pavement shall be kept closed to traffic for 20 days, or if, in the opinion of the Engineer the weather conditions make it advisable, the pavement shall be kept closed to traffic a longer period of time. In no event, however, shall there be any hauling on the concrete surface or shoulders until the pavement has been cleaned of all earth and foreign material.

Method of Measurement. This item shall be measured by the square yard complete in place.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price per square yard, bid for "Concrete Pavement", which price shall be full compensation for quarrying, furnishing, hauling and placing all material for preparation of all material, for all labor, equipment, tools and incidentals necessary to complete the work.

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70. REINFORCING STEEL FOR PAVEMENTS.

Description. Under this item, reinforcing steel of the type, size, and quantity designated shall be furnished and placed in concrete ~~structures~~ pavements as required by these specifications and shown on the plans.

Materials. Reinforcing steel shall meet the requirements of the American Society for Testing Materials, Standard Specifications for Billet Steel Concrete Reinforcement bars, Serial Designation A15-14, with subsequent amendments. Unless otherwise designated upon the plans, all bar or fabric reinforcement shall be made from open hearth steel of the structural grade. Intermediate grade may be used if authorized by the Engineer.

When deformed bars are specified, the form of the bar must be such as to provide a net section at all points equivalent to that of a plain square or round bar of equal nominal size. Twisted bars will be used only by permission of the Engineer.

Steel fabric for this style of reinforcement shall be cold drawn from rods hot rolled from billets. The wire, after fabrication, shall have a minimum tensile strength of seventy thousand pounds per square inch, and shall withstand being bent cold, around its own diameter, through one hundred and eighty degrees, without cracking on the outside of the bent portion.

Construction Methods. All reinforcing metal must be kept clean and free from foreign material that will prevent the proper bond with the concrete. Sheet fabric shall be handled carefully during placing and kept straight until installed.

Placing: The reinforcement shall be placed 2 inches below and parallel to the finished surface, unless otherwise indicated on the plans or directed, with the main members laid at right angles to the center line of the pavement or at such an angle as is considered most advantageous for the kind of fabric used. The reinforcement shall extend to within 2 inches of both the ends and sides of the slabs, or sections. Adjacent sheets of fabric shall be lapped not less than 4 inches when the lap is made at right angles to the center line of the pavement. When sheets are permitted to be lapped parallel to the center line, the lap shall be not less than 12 inches.

To install sheet fabric, or mats of reinforcing bars, a layer of concrete shall be placed upon the subgrade as provided under concrete base course or pavement to such a depth that when struck off its surface will be at the elevation specified for the reinforcing metal to be installed. When the reinforcing metal is properly placed, it shall be covered at once, before the bottom course has taken any initial set, with a layer of concrete so deposited and distributed thereover that when finished the pavement shall have the required thickness and crown.

Basis of Payment. This item shall be paid for at the contract unit price bid per pound for "Reinforcing Steel for Pavements" which price shall be full compensation for furnishing and placing all material, for all labor, equipment, tools, and incidentals necessary to complete the work.

71. BITUMINOUS FILLED BRICK PAVEMENT.

Description. This item shall consist of a wearing course composed of vitrified brick pavement with a bituminous filler and sand bed, laid on a Portland cement concrete base-course or other type of base-course specifically approved for this pavement, and shall be constructed in accordance with these specifications and in conformity with the lines, grades and typical cross-section shown on the Plans.

Material. All brick shall conform to the recognized sizes in accordance with the recommendations now in force of the Permanent Committee on Simplification of Variety and standards for Vitrified Paving Brick of the Department of Commerce of the United States.

Sizes in Inches.

3 x $3\frac{1}{2}$ x $8\frac{1}{2}$	$3\frac{1}{2}$ x $3\frac{1}{2}$ x $8\frac{1}{2}$
3 x 4 x $8\frac{1}{2}$	$3\frac{1}{2}$ x 4 x $8\frac{1}{2}$

Variations among bricks from a single plant shall not exceed the following limits:

Variation in length, $\frac{1}{2}$ inch. Variation in width 1/8 inch, Variation in depth, 1/8 inch.

If the edges of the brick are rounded, the radius shall not exceed three-sixteenths of an inch. They shall be thoroughly annealed, tough, and durable, regular in size and shape and evenly burned. When broken, the brick shall show a dense stonelike body, free from lime, air pockets, cracks, or marked laminations. Kiln marks shall not exceed three sixteenths of an inch, and the wearing surface shall show only slight kiln marks. Only one kind of brick shall be used on a continuous section of roadway. Representative samples of the brick shall meet the following requirements when tested in the standard rattler test for paving brick as prescribed in U. S. D. A. Bulletin 1216.

Rattler Test	Average Loss Per Cent	
Nominal Sizes	Repressed	Wirecut
3 x $3\frac{1}{2}$ x $8\frac{1}{2}$	26	27
3 x 4 x $8\frac{1}{2}$	25	26
$3\frac{1}{2}$ x $3\frac{1}{2}$ x $8\frac{1}{2}$	25	26
$3\frac{1}{2}$ x 4 x $8\frac{1}{2}$	24	25

Basis of rejection to be an average of five tests, with maximum variation not exceeding eight per cent. No sample to show more than two per cent more than the average above specified for the size and type under consideration.

If the brick have lugs or projections they shall be on one side and raised not less than one-eighth inch nor more than one-quarter inch. The ends of the brick may have either a semi-circular groove with a radius of not less than one-eighth of an inch nor more than one-quarter of an inch, or a bulge of at least one-sixteenth of an inch. If lettering appears on the brick the letter shall be depressed, not raised. Shipments in excess of 100,000 bricks to one or more projects under the jurisdiction of the Engineer, shall be inspected and tested at the place of manufacture. Shipments of less than 100,000 brick may at the option of the Engineer, be tested at the plant or on the cars or road after delivery.

The bricks shall be subjected to visual inspection subsequent to delivery at the place of use, prior to and during laying. The Inspector shall cull out and reject all bricks not meeting requirements upon the following grounds:

All bricks not meeting general and dimension clauses herein given.

All bricks which are broken through, or chipped in such manner that neither wearing surface remains substantially intact, or in such manner that the lower or bearing surface is reduced in area by more than one-eighth.

All bricks which are cracked to a depth greater than 3/8 inch on any surface, or which are cracked on the wearing surface.

All bricks which are so off-size or so misshaped, bent, twisted or kiln-marked that they will not form a proper surface or align properly with other bricks.

All bricks which are obviously too soft and too poorly vitrified to endure street wear.

Material for sand bed: This sand shall consist of hard, durable grains, free from vegetable and other deleterious substances. When dry it shall pass a one-quarter inch laboratory screen and shall be well graded from coarse to fine. The material removed by the elutriation test shall not exceed five per cent by weight. Granulated slag, slag screenings, or limestone screenings meeting the above specifications may be used in place of sand.

Bituminous Filler shall fulfill all the requirements of one of the two following materials:

a. Asphalt Filler: Asphalt filler shall be homogeneous, free from water, and shall not foam when heated to 200° C. (392° F.). It shall meet the following requirements;

1. Flash point.....not less than 200° C. (392° F.)
2. Softening point.....not less than 65° C.(149°F.) nor more than 110° C. (230° F.)
3. Penetration at 25° C. (77° F.), 100 g., 5 sec..... 30 to 50
   Penetration at 0° C. (32° F.), 200 g. 1 min..... not less than 10
   Penetration at 26.1° C. (115° F.), 50 g., 5 sec..... not more than 110.
4. Ductility at 25° C. (77° F.)..... not less than 2 CM.
5. Loss at 163° C. (325° F.) 5 hours..... not more than 1.0%
   Penetration of residue at 25° C. (77° F.), 100 g., 5 sec. as compared to penetration before meeting not less than 60%
6. Bitumen (soluble in carbon disulphide), not less than 99.0%.
7. Proportion of bitumen soluble in carbon tetrachloride, not less than 99.0%

b. Coal Tar Pitch Filler shall be free from water, shall contain not more than 0.5 per cent of inorganic matter, and shall meet the following test requirements:

Specific gravity at 60° F.....1.23 to 1.33
Free carbon by weight..... 20% to 35%

Melting point between 130 and 180° F. as directed, with permissible variation of 5° F. from figure designated by Engineer. This determination shall be made by the cube method in water.

Construction Methods. The prescribed curbing or edging shall have been completed and accepted.

Placing Sand Bed: Upon the prepared base course which shall be cleaned of all loose and foreign materials shall be spread a sand bed of the thickness shown on the Plans.

Bedding shall be shaped to a true surface parallel with the proposed surface of the finished roadway by means of a template extending the entire width of the roadway, drawn forward upon the curbs or other guide rails as provided. When the width of the roadway precludes the use of a template spanning the entire distance, the bedding shall be shaped in sections, using scantling laid upon the base as guide-rails. The bedding course shall be struck off at least twice with the template. Any depressions which develop shall be filled in and the bed again struck off with the template. This operation shall be continued until a perfect surface is secured.

If directed by the Engineer, in addition to shaping with a template, the bedding course shall also be compacted with a hand roller. The roller shall be not less than thirty-six inches in diameter, twenty-four inches in width and weigh not less than ten pounds per inch of width. In such case the bedding course shall be rolled after striking off. All depressions which develop shall be filled in, struck off with the template and again rolled. This operation shall be repeated until a perfect surface is secured.

When the use of the template and guide is impracticable in finishing the bedding surface, it shall be shaped to the surface required by hand lutes.

The bedding shall not be disturbed after final shaping prior to laying the brick. Sand bed which is injured or displaced by the flow of water, rain, or by any other cause shall be satisfactorily replaced. The sand bed shall be prepared at least 50 feet ahead of the brick laying.

Laying Brick. Brick shall be handled carefully. When piled by the roadside, they shall be so protected that they will not become spattered with earth or mud. All brick shall be kept scrupulously clean until the pavement is finished. No wheeling in barrows will be allowed on the brick surface. Brick shall be carried on pallets, in brick clamps, or on mechanical conveyors in such order that when delivered to the dropper they will lie so that in the regular operation of placing them on the sand bed the better face or side will be upward.

Upon the sand bed as approved the bricks shall be laid immediately with the best face up, lugs, if any, in the same direction, from one side of the pavement to the other, in parallel straight courses at right angles to the center line, except at intersections and on curves where they shall be laid as directed by the Engineer. The bricks shall be laid with both ends and sides

in contact, breaking joints not less than three inches. The courses shall be straightened by striking lightly with a sledge on a four by four inch timber three feet long, placed against every fourth course, all thick bricks being removed. At the ends of courses, and where necessary between courses, closures shall be made by carefully placing bricks cut accurately to give close joint. Cut or broken bricks shall be used only at the ends of courses, placed with the cut end turned toward the adjacent whole brick and shall be not less than three inches in length. While laying bricks the pavers shall not walk or stand on the bed. The spaces between the bricks shall be kept clean and open to the bottom until the filler is applied. After laying the bricks shall be inspected, culled and approved before rolling, and if any section contains more than 10 per cent of culls, the bricks shall be removed and the bed replaced.

Hillside bricks shall be laid as above specified with the grooves across the line of traffic and the square edge upgrade. Suitable nose brick of quality approved by the Engineer shall be used on the gauge side of trolley rails, as shown on Plans.

Rolling Brick: Before rolling, the surface of the bricks shall be swept free of spalls. The pavement shall then be rolled with a tandem roller weighing not less than 3 nor more than 5 tons, commencing at the sides and proceeding slowly back and forth, parallel to the sides, until the center of the pavement is reached; then passing to the opposite side the rolling shall be repeated in the same manner until the center is again reached, after which the speed may be increased and the rolling continued until the bricks are bedded firmly. The rolling shall then be done obliquely from one side of the pavement to the other side, repeating this operation in the opposite direction. All bricks which are broken or injured during rolling shall be removed and replaced with perfect ones, which likewise shall be brought to the true surface. The brick adjacent to curbing and other areas inaccessible to the roller shall be tamped to grade by the use of a hand tamper, applied upon a two-inch board. If the bed is forced up between the bricks more than $\frac{1}{2}$ inch, the bricks shall be removed and the bed reshaped.

After final rolling the pavement shall be tested with a template laid transversely and a 10-foot straight edge, laid parallel with the side of the pavement, and any depressions exceeding the allowance of the surface test hereinafter prescribed shall be corrected and, if necessary, the entire surrounding surface again rolled.

Applying bituminous filler: After the bricks have been rolled thoroughly, inspected and approved, the spaces between them shall be filled with the hot asphalt filler.

The filler shall be heated in kettles so designed as to admit of an even heating of the entire mass, with an efficient and positive control of the heat at all times. The Asphalt Filler shall be heated as directed to a temperature between 300 and 400 degrees F. and Tar Filler between 250 degrees and 325 degrees F. Material heated beyond these temperatures shall be rejected.

The Contractor shall provide a sufficient number of accurate efficient thermometers for determining the temperature of the filler in kettles.

Brick shall be clean and dry when the filler is applied. Immediately before filling the joints, the surface of the brick shall be swept clean. All brick shall be filled and the surface dressing applied on the day of laying. Filler shall not be applied if the bricks are wet nor if air temperatures are such that the filler will not flow freely into the joints.

Filler shall be removed from the heater and applied promptly to the pavement before cooling. Filler shall be worked into the joints by means of squeegees operated slowly backward and forward at an angle with the joints. Squeegeeing shall continue until the joints appear full and a thin coating of asphalt remains upon the surface of the brick.

While the filler is still soft and pliable the pavement shall be covered with a thin layer of dry stone screenings, or sand. Top dressing shall be of such sizes that all will pass a $\frac{1}{4}$ inch screen. As soon as the dressing is spread, the surface of the pavement shall be rolled thoroughly to bed the dressing into the asphalt coating.

Surface Test: The finished pavement surface shall show no deviation from the general surface in excess of 1/16 inch per foot, as measured in the following manner: A 10-foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depression, and touch all high spots, and ordinates measured from the face of the straight edge to the surface of the pavement shall at no place exceed 1/16 inch for each foot in distance from the nearer point of contact.

Traffic shall not be permitted on the pavement until the filler has cooled to the air temperature.

Method of Measurement. The yardage to be paid for shall be the number of square yards of wearing course in place, completed and accepted.

Basis of Payment. The yardage of this item measured, as provided above, shall be paid for at the contract unit price per square yard bid for "Bituminous Filled Brick Pavement", which price shall be full compensation for furnishing, delivering, and placing all material, for all labor, equipment, tools and incidentals necessary to complete the work.

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80. STRUCTURES

81. CONCRETE BRIDGES

Description. All concrete bridges shall be built as indicated on the plans, conforming to lines, grades, dimensions, and designs shown, and in accordance with the specifications for Piling, Concrete, Reinforcing Steel, and other pay items which are to constitute the complete structure.

Materials. Materials used shall be those prescribed for the general items which constitute the structure.

General Construction Methods. All foundations shall be inspected and approved by the Engineer previous to placing any concrete. All excavation shall be carried to depth of foundation materials satisfactory to the Engineer, regardless of the elevations shown on the plans, and unsuitable material shall be replaced with approved material if required. If rock bottom is secured, the excavation shall be done in such a manner as to allow the solid rock to be exposed and prepared in horizontal beds for receiving the masonry. All loose and disintegrated rock or thin strata shall be removed. In general, all footings except those on solid rock, shall be carried to a depth of at least four feet and preferably from five to six feet below the permanent bed of the stream and to such additional depth as will eliminate the danger of undermining. All foundations, where practicable, shall be constructed by open excavation and the foundation openings shall be shored, braced, or protected by cofferdams. Wherever possible, all foundation excavation shall be pumped dry and concrete deposited in the open. If it is impossible to proceed as above outlined, a seal of concrete of sufficient thickness to resist any possible uplift shall be deposited under water as herein elsewhere required.

When footings can be placed in the dry without the use of cribs or cofferdams, backforms may be omitted at the discretion of the Engineer and the entire excavation filled with concrete to the required elevation of the top of the footing.

Piling shall, be used when footings cannot, in general and at a reasonable expense, be carried to rock or other solid material.

Concrete Bridge Floors

Class of Concrete: The concrete used for bridge floors shall be Class D. as indicated under Concrete, unless otherwise specified.

Swinging the Span: Before concrete floors are placed on steel spans, the centering under the bridge shall be released and the span swung free on its supports.

Placing Reinforcement: Reinforcement shall be rigidly wired at all intersections and suitable provision shall be made for supporting it in position during the placing of concrete. No concrete shall be deposited until the reinforcement is in place and has been inspected and approved by the Engineer. The placing of any reinforcement during the process of placing the concrete will not be permitted. Splices, when permitted, shall be made at points of least tension in the steel.

Placing Concrete: The operation of placing the concrete in any floor slab shall be continuous between expansion joints.

On steel truss spans the concrete shall be placed symmetrically about the center line of the span, beginning at the center and working simultaneously toward each end, or beginning at the ends and working simultaneously toward the center. Care shall be taken to prevent the displacement of reinforcement during the placing of concrete.

If for any reason it becomes necessary to introduce a construction joint, this shall be formed by means of a vertical bulkhead so constructed as to produce a keyed or dove-tailed joint. In concrete floors not supported by longitudinal joints, any necessary construction joints shall be located at the center of the slab span.

In placing concrete around steel shapes it shall be placed only on one side of the shape until it flushes up over the bottom flange of the shape on the opposite side, after which it shall be placed on both sides to completion.

Expansion Joints: Expansion joints may be of the following types:

Friction joints.
Open joints.
Filled compression joints.
Mortise joints.
Special expansion joints.

Friction joints, when of metal, shall be composed of cast iron or bronze plates as noted on the Plans. Sliding surfaces shall be planed true and smooth, the marks of the planes paralleling the movement of the joints. Expansion plates shall be well anchored as shown on the plans. All sliding surfaces of expansion plates must be thoroughly coated with graphite and grease just before being placed in position and special care taken to avoid placing concrete in such manner as to interfere with their free action.

Open joints shall be placed at locations designated on the Plans and shall be formed by the insertion and subsequent removal of a templet of timber, metal or other suitable material. The method of insertion and removal of joint templets shall be such as to avoid the possibility of chipping or breaking down at the edges and the templets shall be so constructed that their removal may be readily accomplished without injury to the work.

Filled compression joints shall be made with an asphalt filler or premolded filler, the materials for which shall conform to the requirements of Bituminous Materials.

Mortise joints shall be as shown on the Plans and in general shall consist of a tenon of concrete or metal sliding in a suitable concrete or metal socket or mortise. Concrete tenons in concrete mortise sockets, brass or bronze tenons sliding in concrete sockets or metal tenons sliding in galvanized pipe sockets may be used as desired. In any case, the construction shall be such as to permit freedom of movement and such as to be as far as possible, watertight and rust proof.

Special types of expansion joints may be used when so specified on the Plans or ordered in writing by the Engineer.

Expansion joints through bridge floors shall preferably be constructed with a waterproof flashing of copper or Zinc to prevent the entrance of water into the joint. Such flashing shall be so arranged as to lead all drainage water to a point of discharge such as will avoid any staining of the exposed concrete surfaces.

Drainage: Transverse drainage of the roadway shall be secured by means of a suitable crown in the floor slab. Longitudinal drainage shall be secured by means of scuppers or weep holes constructed in the gutter or curbs in accordance with the details, and at the location, indicated on the Plans. Floor drains shall be constructed so as to prevent the discharge of drainage water against any portion of the structure. They shall be placed and securely fastened in position before the concrete is placed.

Surface Finish: After the concrete is placed it shall be struck off with a templet to provide the proper crown. Unless otherwise specified, all concrete floors shall be hand finished to a smooth even surface by means of wood floats, rollers, or hose. Before the concrete has taken its initial set, the surface shall be tested for irregularities or waves by means of a 10 foot straight edge laid parallel to the center line of roadway. Should there appear any unevenness of $\frac{1}{4}$ inch or more, either above or below the general contour of the surface, such defect shall be immediately remedied.

Curing: The finished floor shall be cured and protected from traffic in accordance with the requirements specified for "Concrete".

Substructure Design

For streams where erosion is possible, piling should preferably be used (if possible to drive) as a protection against scour, even though the safe bearing resistence of the natural soil is sufficient to support the substructure without piling.

Preservation of Channel: Unless otherwise specified, no excavations shall be made outside of caissons, cribs, cofferdams, steel piling, or sheeting, and the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs, or cofferdams are sunk or in place, the Contractor shall, without extra charge, after the foundation base is in place back fill all such excavations to the original ground surface or river bed with material satisfactory to the Engineer. Material deposited within the stream area from foundation or other excavations or from the filling of cofferdams shall be removed and the stream area freed from obstruction thereby.

Construction Joints: Concrete in substructures shall be placed in such manner that all construction joints will be truly horizontal, and, if possible, in such location as not to be exposed to view in the finished structure. Special care shall be taken to avoid construction joints through parallel wing walls or other large surfaces which are to be treated architecturally.

Drainage of Substructures: The filling material back of abutments and wingwalls shall be thoroughly and effectively drained by means of a system of tiling, ~~French~~ drains, or other adequate construction.

Design Details.

a. Forces: Abutments and piers shall be designed to resist the superimposed dead, wind, live, and impact loads, their own weights, the overturning action of wind, earth fills, floods with their accompanying jams of debris or ice, tractive and temperature forces without exceeding the foregoing unit stresses or the following foundation pressures, unless the bearing capacity of the material is determined by actual test:

Materials	Tons per sq. ft.
Alluvial earth and loam confined	0 to 0.5
Soft clay, dry earth and loam confined	0.5 to 1.5
Ordinary clay and sand clay, confined	1.5 to 2.0
Dry clay and fine sand, firm confined	2.0 to 3.0
Hard Clay, coarse sand, and uncemented Gravel compacted	3.0 to 5.0
Gravel and coarse sand, cemented	5.0 to 7.0
Soft rock, cleaned to solid bed	7.0 to10.0
Ordinary rock, cleaned to solid rock	10.0 to15.0
Hard bed rock	15.0 to25.0

These pressures are based on the assumption that the materials are in mass and not simply in thin layers. Generally foundation pressures for culverts shall not exceed 1.5 and for small bridges shall not exceed 2.0 tons per square foot.

If tests are made, the test load shall be $1\frac{1}{2}$ times the proposed pressure. The test load shall remain for 48 hours during which time it shall show no settlement.

The most unfavorable conditions of buoyancy shall be assumed in all calculations, generally; in determining foundation pressures use the buoyancy due to extreme low water, and for stability against lateral forces use the buoyancy effect of extreme high water.

b. Weep holes not less than 3 inches in diameter and not more than 10 feet apart shall be placed in all abutment and wing walls. The outlets shall be as low as free drainage can be secured and the inside end shall be covered with broken stone or coarse gravel so placed as to permit free drainage and to prevent the filling from washing out. In hollow or cellular piers and abutments ample provisions shall be made for the free passage of water between the various cells and the outside in order to equalize the hydrostatic pressure.

c. Footings shall be proportioned so that the resultant of all forces lies within the middle third of the base. In designing footings, the combined compressive stress, due to bending in the several directions shall not exceed the allowable unit stress. In computing shearing stresses the load may be assumed to spread outward from the base of the 'neat-work' at an angle not greater than 30 degrees with the vertical. The shear along this 30 degree surface shall not exceed the allowable unit for diagonal tension. Footings under wing-walls shall not be considered as taking any part of the superstructure load.

Maintaining Batter: Should it be found necessary, in the judgment of the Engineer, to increase or decrease the depth of foundation from that shown on the plan, the thickness of the vertical wall, where the said wall joins the footing, shall be increased or decreased the same amount per foot as the main wall increases per foot of its height as shown on the plans. The footing width shall also be increased or decreased accordingly. If it is found necessary to increase the height of a reinforced concrete abutment, the design of the abutment shall be changed using a design that takes the additional height into consideration.

d. Abutments and wing walls may be plain gravity sections or reinforced cantilever or counterfort types. The earth pressure shall be taken as equivalent to the pressure imposed upon the vertical projections of the walls by a fluid the same height as the walls and weighing not less than 25# per cubic foot.

When abutments and wings are designed as separate retaining walls capable of withstanding the earth pressure back of them no reliance shall be placed upon the counterfort section of the wing-walls but a nominal amount of reinforcement shall be placed at the junction of the wings and abutments to tie the parts together.

When abutments and wings are designed as a unit, sufficient reinforcing shall be placed at the junction of the abutment and wings to insure the parts acting as a whole.

In the case of spans of less than 20 feet in length where no expansion joints are used, the abutment walls may be designed as a simple slab supported at the top and bottom, in which case the effective span length shall be the distance from center of top slab to the center of the footings. Where this assumption is used, the wall shall be keyed for its full width and length with the footings and the junctions of the wall and slab shall have a fillet reinforced with short diagonal bars.

All abutments, with the exception of those designed as slabs between footings and the superstructure, shall be stable with the filling complete in place and before the superstructure is placed.

Abutments for steel bridges shall be designed to protect the shoes from contact with the earth fill and to prevent wash from the roadway from reaching the bridge seat.

In abutment bents where the fill is allowed to run through, the columns shall have sufficient beam strength to resist the earth pressure back of them disregarding the earth in front.

c. Piers may be either mass or double shaft type and may be plain or reinforced. Dimensions of piers shall be proportioned by the forces to be resisted but for double shaft types of piers, the dimensions of the shafts at the point midway between the base and the cap shall be not less than would be required by the specifications governing plain concrete columns, in the case of plain piers, and by the rules governing reinforced columns in the case of reinforced piers. The two shafts shall be reinforced by concrete webs not less than 15 inches thick where the total height of the web is less than 20 feet. Where the height is greater than this, the web shall be at least 18 inches thick. These webs shall in all cases extend from above high water line to the low water line, and as much lower as the Engineer deems advisable.

Pivot piers for swing spans may be either mass or cellular construction. The circumferential and cell walls of cellular piers shall be not less than two feet in thickness, and shall have double systems of reinforcement consisting of not less than 5/8 square bars spaced not over 15 inches center to center horizontally and vertically. The footing shall cover the entire base of the pier and be proportioned to distribute the load over the entire area. The top shall be covered with a cap. Suitable passages for the equalization of water pressure shall be provided through the cell walls and the outside wall.

Protection of Reinforcing: The reinforcing in all concrete below water or against which earth rests shall be covered with not less than 3 inches of concrete. Construction joints below water shall be avoided where possible, and where unavoidable care should be exercised to make them as impervious as possible. In important structures they should be waterproofed by flashing with continuous sheets of noncorrosive metal.

General Type Requirements

Culverts: For culverts requiring an area of waterway of 12 square feet or less; plain or reinforced concrete arches or circularculverts, or reinforced concrete boxes.

For culverts having a waterway of more than 12 square feet:
Reinforced concrete slabs,

Concrete Bridges Span	Type
10 to 20 ft..... ..	Reinforced concrete slabs.
14 to 65 ft.....	Reinforced concrete T-beams. through or deck girders.

Roadways: In general, clear widths of roadways shall be as follows:
For culverts - 24 to 30 ft. clear roadway.
For bridges - 18 to 24 ft. clear roadway.

Loads

General: All parts of the structure shall be proportioned for the maximum stresses produced by the dead load, temperature, and live loads, with impact allowance added.

Dead Loads: The dead loads shall comprise the actual weight of all parts of the completed structure.

Live Loads: Live loads shall consist of the following:

For the floor and its supports, a load of 125 pounds per square foot of total floor surface or a typical truck depending upon which gives the most unfavorable condition of loading.

The space assumed to be occupied by the truck shall be 24 feet long and 9 feet wide. For bridges having a width of roadway not exceeding 16 feet, there shall be assumed one truck, and for bridges having roadways of more than 16 feet, two trucks.

Impact: On all concrete structures where the fill or ballast is less than two feet in depth, an allowance for impact shall be made to the extent of 25 per cent of all live loads stresses.

Loads to be Given on Drawings: The dead loads and the assumed live loads used for the design of each structure shall be shown on the drawing or stress sheet.

Distribution of Wheel Loads: On Concrete Slabs and Slab Culverts under shallow fills,(less than 3 feet) wheel loads shall be considered as concentrated in the direction of the span. At right angles to the direction of the span, they shall be considered as uniformly distributed over a width of slab equal to 0.5 of the span plus 2.5 feet. When these widths of slab for two wheels similarly placed on parallel elements of the slab overlap, both wheels shall be considered as uniformly distributed over a width of slab equal to 0.5 of the span plus 2.5 feet plus one half of the distance center to center of wheels. But in no case shall the design live load per foot of slab be less than the full specified live load that can come upon the slab divided by the total width of the slab.

The edges of slab bridges shall be strengthened by curbs cast ~~integral~~ Monolithically with the slab, or by other means, so proportioned that the outer-most 3' -0" of slab including the curb will be capable of supporting three-quarters of any concentrated load that can come near the edge.

At the ends where cut by expansion joints, floor slabs shall be supported by diaframs, resting on the abutments or by beams, so proportioned that the beam, including the depth of slab, will support the maximum concentration that can come on it. Diaframs and beams shall be cast ~~integral~~ monolithically with the slab.

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Culvert Under Fills: Where the depth of cover (fills and pavement) is 3' 0" or over, concentrated loads shall be considered as uniformly distributed over a square, the sides of which are equal to 1 3/4 times the depth of cover. When such areas from several concentrations overlap, the total load shall be considered as uniformly distributed over the area defined by the outside limits of the individual areas, but the total width of distribution must not exceed the total width of the slab. When the depth of cover exceeds 10 feet, the live load may be disregarded.

Modulus of Elasticity: The modulus of elasticity of steel shall be taken as 30,000,000 pounds per square inch, and of concrete as 2,000,000 pounds per square inch.

Co-efficient of Expansion: The co-efficient of expansion of concrete, plain or reinforced shall be taken as 0.000006.

Unit Stresses.

(Unless otherwise noted all unit stresses are given in pounds per square inch).

Concrete. Direct Compression.
Columns reinforced with longitudinal bars and separate lateral ties.....600-15L/D
But not to exceed.....450
Where L = unsupported length of column
D = least diameter of column (Steel core)
Piers and Pedestals.....450

Compression Due to Bending.
Beams and slabs.....650
Tension.....Zero
Shear (Diagonal Tension)
Beams without shear reinforcement,
Longitudinal bars not anchored....40
" " anchored.....60
Beams with shear reinforcement.120
Punching Shear.....120

Reinforcement. Tension
Beams and Slabs.....16,000
Compression...15 times stress in surrounding concrete.
Bond.
Bars not anchored.....80
Bars adequately anchored by hooks or otherwise.....120
(Note: The above allowable unit stress values for concrete and for bond on reinforcement are based on an ultimate compressive strength value of concrete of 2200 pounds per square inch at the age of 28 days.

The method of design Calculations for concrete and Reinforced Concrete shall, unless otherwise provided, be the same as outlined in the Report of the Joint Committee of the American Society for Civil Engineers.

Method of Measurement. The quantities of the various items which constitute the completed and accepted structure will be measured for payment according to the plans and specifications for the several items. Only accepted work will be included and the dimensions used will be those shown on the Plans, or ordered in writing.

Basis of Payment. The measured quantities, as provided above, will be paid for at the contract unit prices bid for the several pay items, which prices shall be full compensation for furnishing, hauling, and placing all materials, including materials and installation of roadway drains and expansion joints as specified on plans, and for all labor, equipment, tools, and necessary incidentals. Such payment shall constitute full payment for the completed structure ready for use, and no additional allowance will be made for cofferdam construction, form lumber, or other erection expenses.

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82. STEEL STRUCTURES.

Description. All steel structures shall be built as indicated on the Plans, conforming to line, grade, dimensions and design shown, and in accordance with the specifications for Piling, Concrete, Masonry, Structural Steel and other pay items which are to constitute the complete structure, and in conformity with such specifications prescribed under Concrete Bridges as are involved.

Materials and Construction Methods used shall be those prescribed for the several items which are to constitute the structure and in addition shall conform to the following requirements.

Fabrication.

All deformed structural material shall be properly straightened by methods which are non-injurious, prior to being laid off, punched, or otherwise worked in the shop. Sharp kinks and bends shall be cause for rejection.

The workmanship, and finish shall be first class and equal to the best practice in modern bridge shops. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished. No changes shall be made in any drawing after it has been approved except by the consent or direction of the Engineer in writing. Substitutions of sections having different dimensions than those shown on the Plans shall be made only when approved in writing by the Engineer.

Rivet Holes: When general reaming is not required, holes in material $\frac{3}{4}$ inch or less in thickness may be punched full size. Holes in material more than $\frac{3}{4}$ inch in thickness shall be sub-punched and reamed, or drilled from the solid.

Punched Holes: Full size punched holes shall be one-sixteenth inch larger than the nominal diameter of the rivet. The diameter of the die shall not exceed the diameter of the punch by more than three thirty-seconds inch. Holes must be clean cut, without torn or ragged edges. If any holes must be enlarged to admit the rivets, they shall be reamed.

Accuracy of Punched Holes: The punching of holes shall be so accurately done that, after assembling the component parts of a member, a cylindrical pin 1/8 inch smaller than the nominal diameter of the punched hole may be passed through at least 75 of any group of 100 contiguous holes in the same surface or in like proportion for any group of holes. If this requirement is not fulfilled the badly punched pieces shall be rejected. If any holes will not pass a pin 3/16 inch smaller than the nominal diameter of the punched hole, this shall be cause for rejection.

Drilled Holes: Drilled holes shall be 1/16 inch larger than the nominal diameter of the rivet. Burrs on the outside surfaces shall be removed with a tool producing a 1/16 inch fillet around the edge of the hole.

Sub-Punched and Reamed Holes: Sub-punched and reamed holes shall be punched 3/16 inch smaller than the nominal diameter of the rivet and shall then be reamed to a diameter 1/16 inch larger than the nominal diameter of the rivet. The punch and die shall have the same relative sizes as specified for full-size punched holes. Burrs produced by reaming shall be removed with a tool producing a 1/16 inch fillet around the edge of the hole.

Reaming of rivet holes shall be done with twist drills or with short taper reamers. Reamers preferably shall not be directed by hand. No oil or grease shall be used as a lubricant.

Accuracy of Reamed and Drilled Holes: Reamed or drilled holes shall be cylindrical and perpendicular to the member and their accuracy shall be the same as specified for punched holes except that after reaming or drilling 85 of any group of 100 contiguous holes in the same surface, or in like proportion for any group of holes, shall not show an offset greater than 1/32 inch between adjacent thicknesses of metal.

Drifting of Holes: The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal.

General Reaming: General reaming may be required, in which case a definite provision to this effect shall be included elsewhere in the contract.

When general reaming is required, all rivet holes in main members shall be sub-punched and reamed or drilled from the solid. This requirement shall not apply to rivet holes in top and bottom chord lateral members, lateral hangers, truss and girder sway bracings, and to the lateral plates, connection angles, etc., connecting these members to the main member of the structure. Connection plates or other parts acting both as main member material and secondary (lateral) sway bracing, etc.) member material shall generally have sub-punched and reamed holes in locations engaging similar holes in main members.

Reaming shall be done after the pieces forming a built member are assembled and firmly bolted together. No interchange of reamed parts will be permitted.

Field Connections: When general reaming is required, or in punched work when specifically required by the Engineer, holes for field connections, except those in lateral, longitudinal and sway bracing, shall be reamed or drilled. Riveted trusses shall be assembled in the shop, the parts adjusted to line and fit, and the holes for field connections reamed or drilled while so assembled. Holes for other field connections shall be reamed or drilled with the connecting parts assembled, or else reamed or drilled to a metal templet not less than 1" thick.

Shop Assembling: All surfaces of metal to be in contact when assembled shall be carefully painted with one coat of the paint specified for the shop coat. The paint shall be applied upon surfaces free from dirt, loose mill scale or other foreign matter and the parts shall be assembled while the paint is plastic.

The component parts of a built member shall be assembled, drift pinned to prevent lateral movement, and firmly bolted to draw the parts into close contact before reaming, drilling or riveting is begun. Assembled parts shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation.

The member shall be free from twists, bends, or other deformations.

Preparatory to shop riveting full-size punched material, the rivet holes shall be cleared for the admission of the rivets by reaming.

End connection angles, stiffener angles, etc., shall be carefully adjusted to correct locations and rigidly bolted, clamped or otherwise firmly held in place until riveted.

Match-Marking: Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

Rivets: The diameter of rivets indicated upon the plans shall be understood to mean their diameter before heating.

Heads of driven rivets shall be of approved shape, concentric with the shanks, true to size, full, neatly formed, free from fins, and in full contact with the surface of the member.

Field Rivets: Field rivets, for each size and length, shall be supplied in excess of the actual number to be driven to provide for losses due to misuse, improper driving or other contingencies. Rivets shall be free from furnace scale on their shanks, and from fins on the under side of the machine formed heads.

Bolts and Bolted Connections: Bolted connections shall not be used unless specifically authorized. Where bolted connections are permitted, the bolts furnished shall be unfinished bolts, (ordinary rough or machine bolts) or turned bolts, as specified or directed by the Engineer.

Unfinished Bolts: Unfinished bolts shall be standard bolts with hexagonal heads and nuts. The use of "button head" bolts will not be permitted. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal. The bolts will be of lengths which will extend entirely through their nuts but not more than $\frac{1}{4}$ inch beyond them. The diameter of the bolt holes shall be 1/16 inch greater than the diameter of the bolts used.

Turned bolts: Holes for turned bolts shall be carefully reamed or drilled and the bolts turned to a driving fit by being given a finishing cut. The threads shall be entirely outside of the holes and the heads and nuts shall be hexagonal. Approved nut-locks shall be used on all bolts unless permission to the contrary is secured from the Engineer. When nut-locks are not used, round washers having a thickness of 1/8 inch shall be placed under the nuts.

Riveting: Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. The heating of the points of rivets more than the remainder will not be permitted. When ready for driving, they shall be free from slag, scale, and other adhering matter, and when driven they shall completely fill the holes. Burned, burred, or otherwise defective rivets, or rivets which throw off sparks when taken from the furnace or forge shall not be driven.

Loose, burned, badly formed or otherwise defective rivets shall be cut out. Caulking and re-cupping of rivet heads will not be allowed. In cutting out defective rivets, care shall be taken not to injure the adjacent metal, and if necessary, the rivet shank shall be removed by drilling.

Countersinking shall be neatly done and countersunk rivets shall completely fill the holes.

Shop rivets shall be driven by direct-acting riveters where practicable. The riveting machine shall retain the pressure for a short time after the upsetting is complete.

Pneumatic hammers shall be used for field riveting except when the use of other hand tools for riveting is permitted by the Engineer.

Edge Planing: Sheared edges of material more than 5/8 inch in thickness shall, when required by the Engineer, be planed to a depth of not less than 1/8 inch. Re-entrant cuts shall be filleted before cutting.

Planning of Bearing Surfaces: Ends of columns taking bearing upon base and cap plates shall be milled to true surfaces and correct bevels after the main section of these members and the end connection angles have been fully riveted.

Caps and base plates of columns and the sole plates of girders and trusses shall have full contact when assembled. The plates, if warped or deformed, shall be hot-straightened, planed and otherwise treated to secure and accurate, uniform contact. After being riveted in place the excess metal of countersunk rivet heads shall be chipped smooth and flush with the surrounding metal and the surfaces which are to come in contact with other metal surfaces shall be planed or milled, if necessary, to secure proper contact. Correspondingly, the surfaces of base and sole plates which are to come in contact with masonry shall be rough finished, if free from warps or other deformations.

Surfaces of cast pedestals and shoes which are to come in contact with metal surfaces shall be planed and those which are to take bearing upon the masonry shall be rough finished.

In planing the surfaces of expansion bearings, the cut of the tool shall be in the direction of expansion.

Surfaces of bronze bearing plates intended for sliding contact, shall be carefully milled and polish-finished.

Abutting Joints: Abutting ends of compression members shall, after being riveted, be accurately faced to secure an even bearing when assembled in the structure.

Ends of tension members at splices shall be rough finished to secure close and neat but not contact fitting joints.

End Connection Angles: End connection angles of floor beams and stringers shall be flush with each other and accurately set as to position and length of member. In general, end connection angles shall not be finished unless required by the terms of the contract. However, faulty assembling and riveting may be cause for requiring them to be milled, in which case their thickness shall be reduced not to exceed 1/16 inch nor shall their rivet-bearing value be reduced below design requirements.

Built Members: The several pieces forming one built member shall be straight and close fitting. Such members shall be true to detailed dimensions and free from twists, bends, open joints, or other defects resulting from faulty fabrication and workmanship.

Lacing Bars: The ends of lacing bars shall be neatly rounded unless otherwise indicated.

Web Plates: Web plates of girders having no cover plates may be detailed with the top edge of the web flush with the backs of the flange angles. 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 $\frac{1}{2}$ inch less in width than the distance back to back of flange angles.

When web plates are spliced not more than 3/8 inch clearance between ends of plates will be allowed.

Web Stiffeners: End stiffener angles of girders and stffener angles intended as supports for Concentrated loads shall be milled or ground to secure a uniform even bearing against the flange angles. Intermediate stiffener angles shall fit sufficiently tight to exclude water after being painted.

Web Splices and Fillers: Web splice plates and fillers under stiffeners shall fit within 1/8 inch at each end.

Eye-Bars: Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect affecting their service strength. Heads shall be made by upsetting, rolling or forging. Welds in the body portions or in the heads of bars will not be permitted. The form of the heads may be determined by the dies in use at the works where the eye bars are to be made, if satisfactory to the Engineer. The thickness of head and neck shall not overrum more than 1/16 inch.

Boring: Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin-holes shall be located on the center line of the bar and in the centers of the heads. The holes in the ends of the bars shall be bored simultaneously and shall be so accurately located that when the bars of the same truss panels are placed in a pile, the pins may be completely inserted in the pin-holes without driving. All eye bars intended for the same location in the trusses shall be interchangeable.

Annealing: All eye-bars shall be annealed by heating uniformly to the proper temperature followed by slow and uniform cooling in the furnace. The temperature of the bars shall be under full control at all stages.

Forged pins, and other steel parts requiring their full strength which have been partially heated shall be subsequently annealed. Slight bends in pieces of secondary importance may be made without heating the metal. Crimped web stiffeners need not be annealed.

Pins and Rollers: Pins and rollers shall be accurately turned to detailed dimensions and shall be smooth, straight and free from flaws. The final surface shall be produced by a finishing cut.

Forged Pins: Pins having a diameter greater than 6 inches shall be forged and annealed.

Border Pins: Pins larger than 8 inches in diameter shall have a hole not less than 2 inches in diameter bored longitudinally through their centers. Pins showing defective interior conditions shall be rejected.

Boring Pin Holes: Pin Holes shall be bored true to detailed dimensions, smooth, and straight; at right angles with the axis of the member and parallel with each other unless otherwise required. A finishing cut shall always be made.

The length outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from detailed dimensions more than 1/32 inch. Boring of holes in built up members shall be done after the riveting is completed.

Pin Clearances: The difference in diameter between the pin and the pin hole shall be not more than 1/32 inch.

Welds: Welding of steel shall not be permitted except to remedy minor defects, and then only with the approval of the Engineer.

Screw Threads: Screw threads shall make close fits in the nuts and shall be U. S. Standard accept that for diameters greater than $1\frac{1}{2}$ inches, they shall be made with 6 threads to the inch.

Pilot and Driving Nuts: Two pilot nuts and two driving nuts shall be furnished for each size of pin, unless otherwise specified.

MILL AND SHOP INSPECTION.

Notice of Rolling and Fabrication: The contractor shall give ample notice to the Engineer of the beginning of work at the mill and shop, so that inspection may be provided. No material shall be rolled or fabricated before the Engineer has been notified where the orders have been placed.

Facilities for Inspection: The Contractor shall furnish all facilities for the inspection of material and workmanship in the mill and shop and Inspectors shall be allowed free access to the necessary parts of the premises.

Inspector's Authority: The Inspector shall have the power to reject materials or workmanship which do not fulfill the requirements of these specifications; but in cases of dispute the Contractor may appeal to the Engineer, whose decision shall be final.

Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the contractor from any responsibility in regard to imperfect material or workmanship and the necessity for replacing same.

Mill Orders and Shipping Statements: The Contractor shall furnish the Engineer with as many copies of mill orders and shipping statements as the Engineer may direct. The weights of the individual members shall be shown.

Cost of Testing: Unless otherwise provided, the Contractor shall furnish, without charge, test specimens as specified herein, and all labor, testing machines and tools necessary to prepare the specimens and to make the full-sized tests.

Rejections: The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

Marking and Shipping: 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, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

The weight of all tools and erection material shall be kept separate.

Anchor-bolts, washers, and other anchorage or grillage materials, shall be shipped to suit the requirements of the masonry construction.

Loading and Unloading: The loading, transportation, unloading, and piling of structural material shall be so conducted that the metal will be kept clean and free from injury by rough handling.

Erection.

Field Inspection: All work of erection shall be subject to the inspection of the Engineer who shall be given all facilities required for a thorough inspection of workmanship.

Material and workmanship not previously inspected will be inspected after its delivery to the side of the work.

Storage: All material shall be stored in such manner as to prevent deterioration by rust or loss of minor parts. No material shall be piled so as to rest upon the ground or in water, but must be placed on suitable skids or platforms.

Preparation of Bearing Area: Column bases, truss and girder pedestals and shoes shall haveaa full and uniform bearing upon the substructure masonry. Masonry bearing plates shall not be placed upon the bridge seat areas of piers or abutments which are improperly deformed or irregular.

The shoes and pedestals of truss and girder spans, the bases of columns, and the center and end bearings of swing spans shall be rigidly and permanently located to correct alignments and elevations. Unless otherwise provided, they shall be placed on a layer of canvas and red lead applied as follows;

Thoroughly swab the top surface of the bridge seat bearing area with red lead paint and place upon it three layers of 12 oz. to 14 oz. duck, each layer being thoroughly swabbed on its top surface with red lead paint. Place the superstructure shoes or pedestals in position while the paint is plastic.

Handling Members: The field assembling of the component parts of a structure shall involve the use of methods and appliances not likely to produce injury by twisting, bending, or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until its defects are corrected, and members seriously damaged in handling shall be rejected.

Alingment: Before beginning the field riveting, the structure shall be adjusted to correct grade and alignment and the elevation of panel points (ends of Floorbeams) properly regulated. For truss spans a slight excess camber will be permitted while the bottom chords are being riveted but the correct camber and relative elevations of panel points shall be secured before riveting the top chord joints, top lateral system and sway bracing.

Straightening Bent Materials The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the Engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry red color. After heating, the metal shall be cooled as slowly as possible.

Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

Assembling and Riveting: All field connections and splices shall be securely drift pinned and bolted before riveting. Important connections in trusses, girders, floor system, etc., shall have at least 50 per cent of the holes filled. An ample number of drift pins shall be used to prevent slipping at joints and splices.

The results obtained in the field assembling and riveting of the the members of a structure shall conform to the requirements for shop assembling and riveting. Field driven rivets shall be inspected and accepted before being painted.

Field riveting shall be done before the falsework is removed unless special permission to the contrary is given by the Engineer.

Railings shall not be riveted until the falsework has been removed.

Adjustment of Pinned Nuts: All nuts on pins shall be thoroughly tightened and the pins so located in the holes that the members shall take full and even bearing upon them.

Setting Anchor Bolts:- Anchor bolt holes shall be drilled in correct locations perpendicularly to the plane of the bridge seat, and the anchor bolts shall be set in Portland cement mortar therein. The mortar shall consist of one part cement to one part clean, fine-grained sand mixed sufficiently wet to flow freely.

Anchor bolts shall first be dropped into dry holes to assure their proper fit after setting. They shall then be set as follows: Fill the hole about two-thirds full of mortar and by a uniform, even pressure or by light blows with a hammer, (flogging and ramming will not be permitted) force the bolt down until the mortar rises to the top of the hole and the anchor bolt nut rests firmly against the metal shoe or pedestal. Remove all excess mortar which may have flushed out of the hole to permit proper field painting of the metal surfaces.

The location of the anchor bolts in relation to the slotted holes in expansion shoes shall be varied with the prevailing temperature. The nuts on anchor bolts at the expansion ends of spans shall permit the free movement of the span.

The holes may be drilled in accordance with the provisions of the above mentioned article or, if in concrete masonry may be formed by the insertion in the fresh concrete of oiled wooden plugs or metal pipe sleeves which are subsequently withdrawn after the concrete has partially set. When the holes are formed by the latter method, they shall be not less than four inches in diameter to allow for horizontal adjustment for the bolts.

In lieu of the above methods of placing, anchor bolts in concrete masonry may be set to exact location in the concrete when it is placed. In this case great care shall be exercised to insure the proper setting of the bolts and any inaccuracies which will be detrimental to the structure shall be corrected by suitable means.

Setting Bed Plates: Bed plates preferably shall be set on a layer of canvas and red lead as specified in these specifications. When bed plates are set in Portland cement mortar, no superstructure or other load shall be placed thereon until this mortar has been allowed to set for a period of at least ninety-six hours.

Placing Superstructure: No superstructure load shall be placed upon finished piers or abutments until the Engineer directs. In general a minimum time of twenty-one days shall be allowed for the hardening of the concrete before any superstructure load is placed thereon.

Tubular Steel Piers: The general requirements governing the depths of foundations as above set forth shall govern in the case of tubular steel piers except that steel tubes resting upon gravel foundation without piling shall in no case be carried to a depth less than 8 feet below the permanent bed of the stream and to such additional depth as may be necessary to eliminate all danger of undermining.

Tubular piers shall, in general, be sunk by the open dredging process, or by means of compressed air. The cross-sectional area of each tube shall be sufficient to provide the requisite bearing area and to provide spacing room for the requisite number of piles, in case piles are used. After the tubes are sunk to the desired elevation, the bottom shall be sealed by means of concrete deposited under water. After the seal has set sufficiently to permit, the tubes shall be unwatered and the balance of the concrete deposited in the dry. If the seal is to act in flexure against the hydrostatic head, the tubes must be weighed sufficiently to develop the necessary downward reaction and sufficient shear anchorage provided around the interior circumference of the tube to transfer this weight into the seal concrete.

Metal tubes shall be painted two coats of an approved structural paint before being sunk, and the exposed portions shall be given an additional coat after erection.

Piles used in connection with tubular steel piers shall be driven after the tubes are sunk unless otherwise permitted by the Engineer. When driven after the tubes are in place, the piles may be driven by means of a follower, provided that 1 pile out of every group of ten or one for every tube, shall be a long pile driven without a follower, such pile to be used as a test pile to determine the necessary length for the rest of the group. After the long pile is driven to the required penetration as determined by the bearing power formula, it shall be cut off to the required elevation.

If desired (and under written permission from the Engineer), tubular steel piers may be sunk in large holes which previously have been dredged for the purpose. In this case, piles may be driven in the dredged hole before the tubes are placed, cut off to the desired elevation, bound in cluster form if desired, and the tubes placed over them. If this procedure is followed, the excavated hole around the piers shall be carefully back filled.

Filling material for tubular piers shall be either Class "A" or Class "B" concrete as specified, except the bottom seal which shall be as specified for concrete deposited under water.

Painting.
Materials and Composition.

a. Paints shall consist of pigments of the required fineness and composition, ground to the desired consistency in raw or boiled linseed oil, to which shall be added additional oil, and a thinner, or drier, or both. All pigments, oils, thinners, and driers used shall be of the best quality, free from adulterants of any kind, and shall comply with the requirements given below for these materials.

b. All paint paste shall consist of the specified pigment or pigments ground in linseed oil to the required consistency. The paste must be so prepared that it is uniform in composition and consistency, will not cake or segregate in the retainers, and will easily break up in oil to form a smooth uniform paint of proper brushing consistency. The color, hiding power, and weight per gallon when specified shall be the same or equal to the approved sample.

c. To prepare a paint so that it will have the required consistency and during properties for the use intended, the paste shall be mixed with sufficient linseed oil, turpentine, and drier to produce a paint having these properties. Unless otherwise specified, the exact quantity of linseed oil, turpentine, and drier required for this purpose shall be determined by the Engineer.

d. Raw linseed oil used shall conform to the requirements of the A.S.T.M. Standard Specifications for Purity of Raw Linseed Oil from North American Seed D1-15, with subsequent amendments and additions thereto.

The boiled linseed oil used shall conform to the requirements of the A.S.T.M. Standard Specifications for Purity of Boiled Linseed Oil from North American Seed, D11-15, with subsequent amendments and additions thereto.

Furthermore, if permitted, raw and boiled linseed oil of South American seed shall meet the requirements of tentative specifications of A. S. T. M. DN-21T and D-78-21T.

e. Drier shall be composed of turpentine, lead and manganese oxides cooked in linseed oil. The proportion of lead shall be not less than three (3) times that of manganese. It shall contain no resin or varnish gums, and not more than seventy (70) per cent shall volatilize at 450 degrees F. When flowed on metal and allowed to dry, it shall produce an elastic film. The flash point shall not be lower than ninety-five (95) degrees F., when tested in an open cup tester. When a mixture of ten (10) per cent of drier with ninety (90) per cent pure raw linseed oil is flowed on a glass slab, which is then held nearly vertical, and is kept at a temperature of seventy (70) degrees F., with free access of air, the coating shall dry throughout, neither sticky nor brittle, in not over ten (10) hours.

f. Turpentine shall be the distillate commonly known as "Gum Turpentine", or "Spirits Turpentine" which is distilled from pine oleoresins or the product secured from resinous wood by extraction with volatile solvents, by steam or by destructive distillation. Either or both of these two products - gum spirits or wood turpentine - shall be furnished for use when so specified.

The turpentine shall be clear and free from suspended matter and water.

The color shall be "Standard" or better.

The specific gravity shall be not less than 0.862 nor more than 0.872 at 15.5° C.

The refractive index at 15.5° C. shall be not less than 1.468 nor more than 1.478.

The initial boiling point shall be not less than 150 nor more than 160° C.

Ninety (90) per cent of the turpentine shall distill below 170° C.

The polymerization residue shall not exceed two (2) per cent, and its refractive index at 15.5° C. shall be not less than 1.500.

g. Pure White Bead, Dry Pigment: The pigment shall be a pure basic carbonate of lead of the formula $2PbCO_3PbOH_2$, containing sixty-five (65) to seventy-five (75) per cent of lead carbonate, and shall conform to the requirements of tentative specifications A.S.T.M. D81-21T and subsequent revisions, and not more than two (2) per cent of total impurities, including moisture. It shall be ground to such fineness that it will all pass a 200-mesh sieve and contain not more than two (2) per cent material retained on a 325-mesh sieve.

Paste: The paste shall be the dry pigment ground in pure raw linseed oil in the manner specified above. It shall consist of:

	Percentages	
	Minimum	Maximum
Pigment	90	92
Linseed Oil	8	10
Moisture and other Volatile Matter		0.7
Coarse particles and "skins" (total residue retained on a 200-mesh sieve based on pigment)		2.0

Ready Mixed Paint: The ready mixed paint shall be prepared from the paste in the manner specified above.

h. Pure Zinc Oxide Paint. - Dry Pigment: The dry pigment shall consist of pure oxide of zinc which shall contain not less than ninety-eight (98) per cent of zinc oxide, nor more than two-tenths (0.2) per cent of Sulphur or two (2) per cent of total impurities including moisture. The pigment shall be so ground that it will all pass a 200-mesh sieve.

Paste: The paste shall be the dry pigment ground in oil as above specified. It shall consist of:

	Percentages	
	Minimum	Maximum
Pigment.....	82	86
Linseed.....	14	18
Coarse particles and "skins" (total residue left on a 200 mesh sieve, based on pigment)		0.5
Moisture and other Volatile matter.....		0.5

Ready Mixed Paint: The ready mixed paint shall be prepared from the paste in the manner specified above, in accordance with tentative specifications of A.S.T.M. 79-21S.

i. Red Lead. -Dry Pigment: The dry pigment shall consist entirely of the oxides of lead which shall conform to the requirements of A.S.T.M. Specifications D-83-21T 95% grade.

Paste: The paste shall be the pigment ground in oil as above specified. It shall consist of:

	Percentages	
	Minimum	Maximum
Pigment.....	92	95 or more
Linseed Oil.....	6	8
Moisture and other Volatile matter.....		0.5
Coarse particles and "skins" (total residue left on a 200-mesh sieve).....		0.5

Ready Mixed Paint: The ready mixed paint shall be prepared from the paste in the manner specified above.

The resulting paint, when mixed in the proportions given below and brushed on a smooth vertical metal surface, shall dry hard and elastic without running, streaking or sagging.

For Shop Coat.

Red Lead Paste.....	20 pounds
Raw Linseed Oil.....	4½ pints (0.430 #)
Turpentine.....	2 gills (7.3 oz.)
Liquid Drier.....	2 gills (12.0 oz)

The formula given above will produce one gallon of paint and should weigh twenty-five pounds (25#) and ten ounces.

j. Leaded Zinc Oxide. -- Dry Pigment: The dry pigment shall be a pure zinc oxide and a normal or basic lead sulphate. The pigment shall be so ground that it will all pass a 200 mesh sieve and the zinc oxide shall not contain more than one (1) per cent of soluble salts nor more than one and five-tenths (1.5) per cent of total impurities including moisture.

This type of paint shall be divided into two brands: "High leaded" and "Low Leaded". The high leaded paint shall contain not less than sixty (60) per cent of zinc oxide and the low leaded paint not less than ninety-three (93) per cent of zinc oxide, the remaining pigment in each case to be a normal or basic lead sulphate.

Paste: The paste shall be the dry pigment ground in oil as above specified. It shall consist of:

	Percentages. Minimum	Maximum
Pigment.....		88.0
Linseed Oil.....	12.0	
Moisture and other Volatile matter.....		0.5
Coarse particles and "skins" (total residue left on a 200-mesh sieve based on pigment).....		0.5

Ready Mixed Paint: The ready mixed paint shall be prepared from the paste in the manner specified above.

k. Sublimed Blue Lead. The Sublimed Blue Lead Pigment shall consist of Sublimed Blue Lead Fume, free from all adulterants and shall meet the following requirements;

Lead Sulphate ($PbSO_4$).....	45-55 per cent
Lead Oxide (PbO).....	30-40 per cent
Lead Sulphide (PbS).....	Not over 12 per cent
Lead Sulphite ($PbSO_3$).....	Not over 5 per cent
Zinc Oxide (ZnO).....	Not over 5 per cent
Carbon and undetermined.....	Not over 5 per cent

Sublimed Blue Lead Paint shall consist of either:

1. Sublimed blue Lead in Oil paste (90% Sublimed Blue Lead ground in 10% Raw Linseed Oil) mixed as follows:

100 lbs. Sublimed Blue Lead in Oil paste)
4 Gal. Pure Raw Linseed Oil)
2 Pts. Turpentine) For Field Coat.
2 Pts. Drier.)

2. A ready mixed paint made by grinding Pure Dry Sublimed Blue Lead in Pure Raw Linseed Oil in the following proportions:

90 lbs. Dry Sublimed Blue Lead)
5-1/3 gal. Raw Linseed Oil) For Field Coat.
2 Pts. Turpentine)
2 Pts. Drier)

l. Graphite. - Dry Pigment: The dry pigment shall be a pure amorphous and silicate rock to which may be added a small percentage of carbon black, iron oxide, or other oxides needed to secure a desired tint or color. The pigment shall be so ground that it will all pass a 200-mesh sieve, and contain not more than three (3) per cent of material retained on a 325-mesh sieve. The prepared pigment must contain not less than thirty-five (35) per cent nor more than fifty (50) per cent of graphite in the form of graphitic carbon.

Paste: The paste shall be the pigment ground in oil as above specified. It shall consist of:

	Percentages	
	Minimum	Maximum
Pigment.....	62	66
Linseed Oil.....	34	38
Moisture and other Volatile matter....		80
Coarse particles and "skins" (total per cent on a 325-mesh sieve, based on the pigment).....	3	6

Ready Mixed Paint: The ready mixed paint shall be prepared from the paste in the manner above.

The resulting paint when mixed in the proportions given below, and brushed on a smooth vertical metal surface shall dry hard and elastice without running, streaking, or sagging. It shall consist of:

	Percentages.	
	Minimum	Maximum
Pigment.....	30	35
Boiled Linseed Oil.....	65	70
Drier.....	5	6
Turpentine and Volatile Matter.....	3	6

All paints or paint materials shall be shipped in strong, substantial containers, plainly marked with the name, color, and weight of paint content, and name and address of the manufacturer.

n. Manufacturer's Guarantee. The manufacturer of each brand of paint submitted for acceptance under these specifications shall file with the Commission a certificate of analysis and Manufacturer's Guarantee, setting forth the trade name or brand of paint to be furnished together with a facsimile copy thereof and a typical analysis showing the percentage of each of the chemical elements in the pigment vehicle. The manufacturer's shall provide that all paint furnished under these specifications shall conform to the certified analysis as filed and to the statement of the various percentages of the ingredients on the receptacle or container. The manufacturer's guarantee shall be of the form furnished by the purchaser, and shall be sworn to by a person having legal authority to bind the company by his acts.

o. Sampling and Testing. Samples when required for testing purposes shall not be less than one (1) quart in amount. The paint shall be thoroughly stirred before selecting the sample.

In testing paint used under these specifications, the following:

1. Percent of Water in Paint Vehicle. Determination of water with Amyl Reagent.

2. Raw Linseed Oil. Methods of testing prescribed in A.S.T.M. Standard Specification for Purity of Raw Linseed Oil from North American Seed D1-15, and for South American Seed A.S.T.M. D-77-21T D78-21T.

3. Boiled Linseed Oil. Methods of testing prescribed in A.S.T.M. Standard Specification for Purity of Boiled Linseed Oil from North American Seed D-11-15, and for South American Seed A.S.T.M. D-77-21T D78-21T.

4. Determination of Volatile Oils in Vehicle. Bureau of Standards Misc. Pub. No. 15 p 40.

5. Paint Vehicle. Method in Bureau of Standards, Circ. No. 89.

6. Red Lead. A.S.T.M. Standard Methods Routine Analysis Dry Lead D-49-18.

7. White Lead. A. S. T. M. Standard Methods Routine Analysis of White Pigments D34-17.

8. Sublimed Blue Lead. Shall be made in accordance with method of analysis of Paint Materials, Sub-Committee 111 A.S.T.M. Vol. 22, part 1, and subsequent revisions thereto adopted by the society.

9. Zinc Oxide. A.S.T.M. Standard Methods of Routine Analysis of White Pigments D34-17.

10. Graphite Pigment. Methods of tests prescribed in Bulletin 1216 (U. S. Department of Agr.)

p. No sieve is to be used in the determination of the finances of the pigments for these paints which on examination under a 150 magnification lens in a microscope shows any irregularity of wire spacings in the mesh or shows any noticeable amount of wear on the sides of the wires.

Standard 325-Mesh Sieve: The 325-Mesh Sieve referred to in this specification is a woven rectangular mesh, wire sieve having not less than 322 nor more than 327 meshes per lineal inch in either direction. The nominal size of opening shall be .0017 inches square and the size of wire shall be .0014 inches diameter.

q. Inspection. The Contractor for these paints shall allow the State Inspector free access to all parts of his shops while work on those paints is being carried out; also the Contractor shall give the Inspector every reasonable facility to enable him to insure that these paints are being made in accordance with this specification.

r. Samples. Before work is commenced on the manufacture of these paints, the Contractor shall furnish the State Inspector with separate samples of all pigments and vehicles to be used in such paints; each such sample to be clearly labeled and marked to show the name of the material and the name and number of the paint in which it is to be used. When so requested, samples and analyses of all pigments, oils, thinners, or driers used, or paints furnished shall be supplied by the manufacturer within ten (10) days after request is made therefor. Before paint is shipped, the Inspector shall take individual samples from one barrel in each 5 for each kind of paint. Tests may be made on individual samples or on one composite sample for each 25 barrels of paint.

s. Paints which on analysis show more than a 3 per cent variation in the proportion of any pigments or vehicle, from that called for will be rejected.

Painting - Application.

a. The painting of metal structures shall include, unless otherwise provided in the contract, the proper preparation of the metal surfaces, the application, protecting and drying of the paint coatings, the protection of pedestrian, vehicular, or other traffic upon or under-neath the bridge structure, the protection of all portions of the structure (superstructure and substructure) against disfigurement by spatters, splashes and smirches of paint or of paint materials, and the supplying of all tools, tackle, scaffolding, labor, workmanship, and materials necessary for the entire work.

b. Number of Coats. All new structural steel work shall, unless otherwise especially provided upon the plans or in the contract, be painted three coats of paint. The first coat is to be applied immediately after the shop fabrication is complete except that all surfaces coming into contact are to be painted before being assembled. The second and third coats are to be applied after all erection is complete, except that immediately following the field riveting of the members, the heads of field rivets, and all abrasions of the shop coat due to handling at the shop, shipment, erection, etc., and all field erection marks shall be thoroughly covered with one coat of shop paint and permitted to become thoroughly dry before the first field coat is applied.

c. The color of each succeeding coat shall be sufficiently different from that previously applied to readily permit the discovery of an incomplete application of the paint coat. The colors of the coats shall be determined by the Engineer.

d. Weather Conditions: Paint shall be applied only when the air temperature is at or above forty degrees Fahrenheit (40° F.) It shall not be applied upon damp surfaces or upon metal containing frost, nor shall it be applied when the air is misty, or otherwise, in the opinion of the Engineer, unsatisfactory for the work.

Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting in open yards or upon erected structures shall not be done when the metal has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

e. Application: No wide brushes shall be used. All brushes shall be oval in shape.

The paint when applied shall be so manipulated under the brush as to produce a uniform, even coating in close contact with the metal or with previously applied paint. In general, the primary movement of the brush shall describe a series of small circles to thoroughly fill all irregularities in the surface, after which the coating shall be smoothed and thinned by a series of parallel strokes.

To secure a maximum thickness of paint film upon rivet heads, and edges of plates, angles or other rolled shapes these areas shall be "striped" in advance of the general painting, and shortly afterward shall begiven a second or "wash" coat when the general coat is applied. The paint shall be well worked into all joints and open spaces.

Paint shall be thoroughly stirred, preferably by means of mechanical mixers, before being removed from the containers, and to keep the pigments in suspension shall be kept stirred while being applied.

All painting must be done in a neat and workmanlike manner.

On all surfaces which are inaccessible for paint brushes, the paint shall be applied with sheep-skin daubers specially constructed for the purpose.

f. Removal of Improper Paint: All metal coated with impure or unauthorized paint shall be thoroughly cleaned and repainted to the satisfaction of the Engineer, at the expense of the Contractor.

g. Thinning: If it is necessary in cool weather to thin the paint in order that it shall spread more freely, this shall be done only by heating in hot water or on steam radiators.

h. Shop Cleaning: All surfaces of metal to be painted shall be thoroughly cleaned from rust, loose mill scale, dirt, oil or grease, and all other foreign substances. The removal of rust, scale, and dirt shall generally be done by the use of sand blast, metal brushes, scrapers, chisels, hammers, or other effective means. Oil and grease may be removed by the use of gasoline or benzine. Bristle or wood fiber brushes shall be used for removing loose dust.

i. Shop Painting: In shop riveted work, all surfaces coming into contact when shop assembled shall each be painted a good shop coat thoroughly and evenly applied before assembling. These pieces may be assembled while the paint is still wet.

When all fabrication work is complete and has been accepted as such, all surfaces not painted before assembling shall be painted a good shop coat. Shipping pieces shall not be loaded for shipment until thoroughly dry. No painting shall be done after loading material on cars.

j. Erection marks for the field identification of members shall be painted upon previously painted surfaces.

k. With the exception of abutting chord and column splices, column and truss shoe bases, machine finished surfaces shall be coated as soon as practicable after being accepted, with a hot mixture of white lead and tallow before removed from the shop. Surfaces of iron and steel castings milled for the purpose of removing scales, scabs, fins, blisters, or other surface deformations shall generally be given the shop coat of paint.

The composition used for coating machine finished surfaces shall be mixed in the following proportions:

4 lbs. pure tallow
2 lbs. pure white lead
1 qt. pure linseed oil.

l. Field Cleaning: When the erection work is complete including all riveting, straightening of bent metal, etc., all adhering rust, scale, dirt, grease, or other foreign matter shall be removed as specified under Shop Cleaning.

m. Field Painting. As soon as the field cleaning is done to the satisfaction of the Engineer, the heads of field rivets and any surfaces from which the shop coat of paint has become worn off or has otherwise become defective and all shipping and erection marks shall be thoroughly covered with one coat of the same paint as used in the shop and permitted to become thoroughly dry before the first field coat is applied.

When the paint applied for "touching up" rivet heads and abraded surfaces has become thoroughly dry, the first and second field coats may be applied. In no case shall a succeeding coat be applied until the previous coat has dried throughout the full thickness of the paint film.

All small cracks and cavities which have not become sealed in a watertight manner by the first field coat shall be filled with a pasty mixture of red lead and linseed oil before the second field coat is applied.

n. Scope of Work. Unless otherwise provided, maintenance painting shall consist of the removal of the rust, scale, dead paint, dirt, grease, or other foreign matter from the metal parts of portions of existing bridge structures and the application of paint thereon.

All metal surfaces not in close contact with other metal surfaces or with wooden floor or truss members, concrete, stone masonry, etc., shall be considered as exposed to deterioration by rusting and shall be thoroughly cleaned and painted the number of coats indicated in and made a part of the contract.

o. Number of Coats: Unless otherwise provided, metal after being cleaned to the satisfaction of the Engineer, shall be painted with at least two coats of paint.

p. Cleaning and Painting: The requirements and methods of procedure for maintenance, cleaning, and painting shall be the same as specified for shop and field painting.

Whenever roadway or sidewalk planking is laid too closely in contact with the metal to permit free access for proper cleaning and painting, the planks shall either be removed or shall be cut to provide at least a one-inch clearance for that purpose. The removal or the cutting of planks shall be done as directed by the Engineer. All planks removed shall be satisfactorily replaced and if broken or otherwise injured to an extent rendering them unfit for use, they shall be renewed at the expense of the Contractor.

Design Details.

In general, plans for steel bridges will not be approved except for structures spanning navigable channels, and for locations where the cost of concrete structures would be prohibitive.

Drawings: The State Highway Engineer will furnish designs, showing details preferred with usual conditions.

Alternate Designs: Bidders may submit alternate designs when agreeable to the State Highway Engineer, and when so provided for in the Notice to Contractors. Alternate designs shall have as great strength and general merits as the designs furnished by the State Highway Engineer. Bidders submitting alternate designs shall furnish stress sheets and general plans which shall show all dimensions and sectional area.

Size of Drawings: All drawings shall be 22 x 36 inches over all, with a margin of 2 inches on the left hand edge and one-half inch margins on the other edges.

Approval of Drawings: Upon the acceptance and execution of the contract, the Contractor shall prepare and furnish standard size working drawings showing complete details of all parts of the structure. Blue prints, in triplicate, of these drawings shall be submitted to the State Highway Engineer for his approval before any material is ordered or work begun in the shop. All details shall be subject to his modifications or approval.

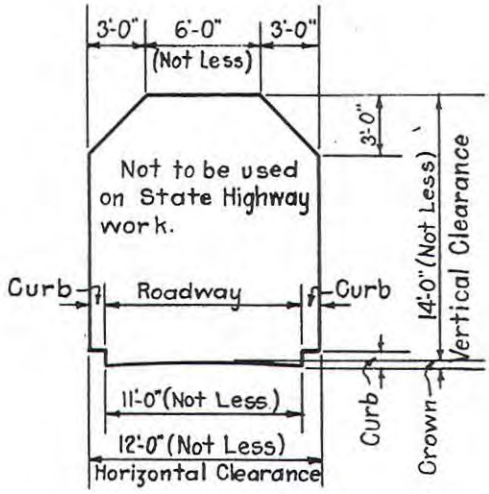
The Contractor alone shall be responsible for the correctness of the drawing, although the drawing may have been approved by the Engineer.

Prints for the State Highway Department: After drawings have been approved, the Contractor shall furnish the State Highway Department, without cost, five complete sets of prints and four sets of all shipping bills.

Name Plates: When specified one or more cast iron name plates of an approved design, giving the date of construction, the names of the State Highway Engineer, State Bridge Engineer, Consulting Bridge Engineer, County Engineer, County Commissioners' Court, and the Contractor for the Superstructure, shall be securely bolted to the superstructure at the point or points specified.

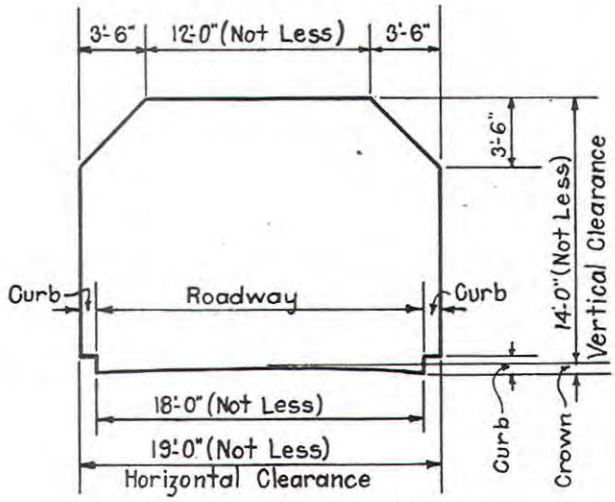
Width of Roadway and Sidewalk: The width of roadway shall be the clear width measured at right angles to the longitudinal center line of the bridge between the tops of curbs or guard timbers, if these exist; otherwise, it shall be the clear width inside to inside of the handrails or other fence-like protections paralleling the sides of the structure.

Upon structures having a sidewalk, the clear width of sidewalk shall be measured at right angles to the curb or guard timber and from the face thereof to the extreme inside portion of the handrail. For structures having trusses, girders, or parapet walls adjacent to the curbs, the width of sidewalk shall be measured from their extreme outside portions to the inside of the handrail.



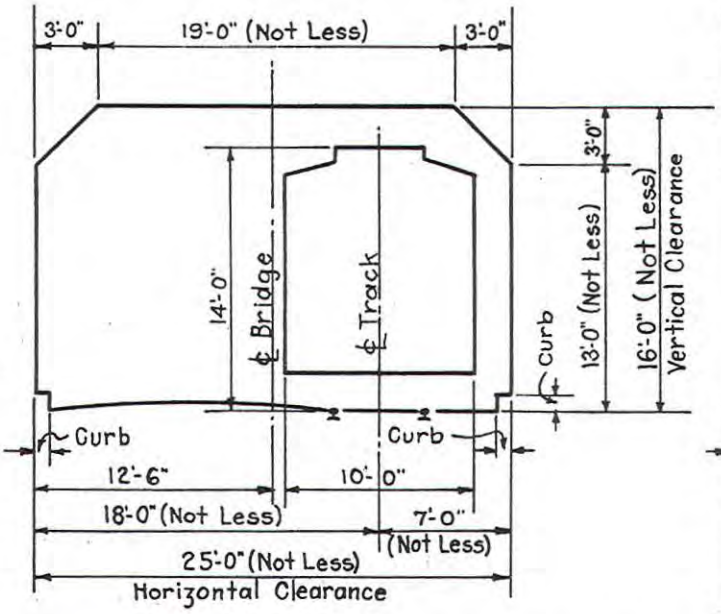
ONE WAY HIGHWAY TRAFFIC

Figure 1.



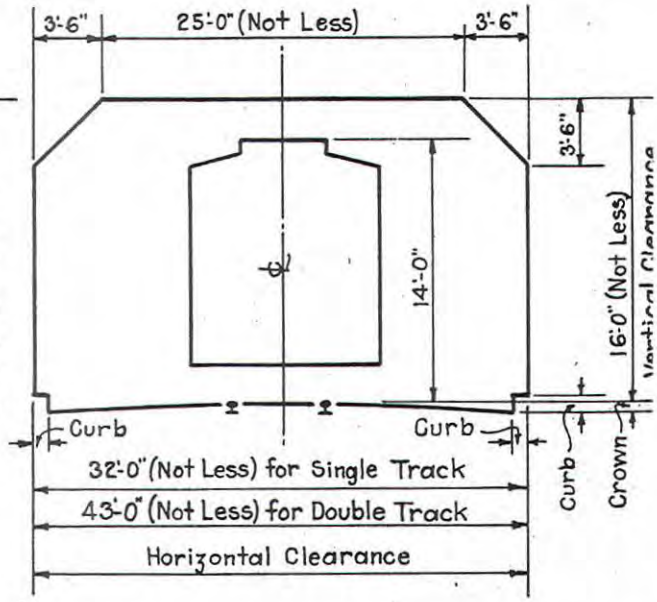
TWO WAY HIGHWAY TRAFFIC

Figure 2.



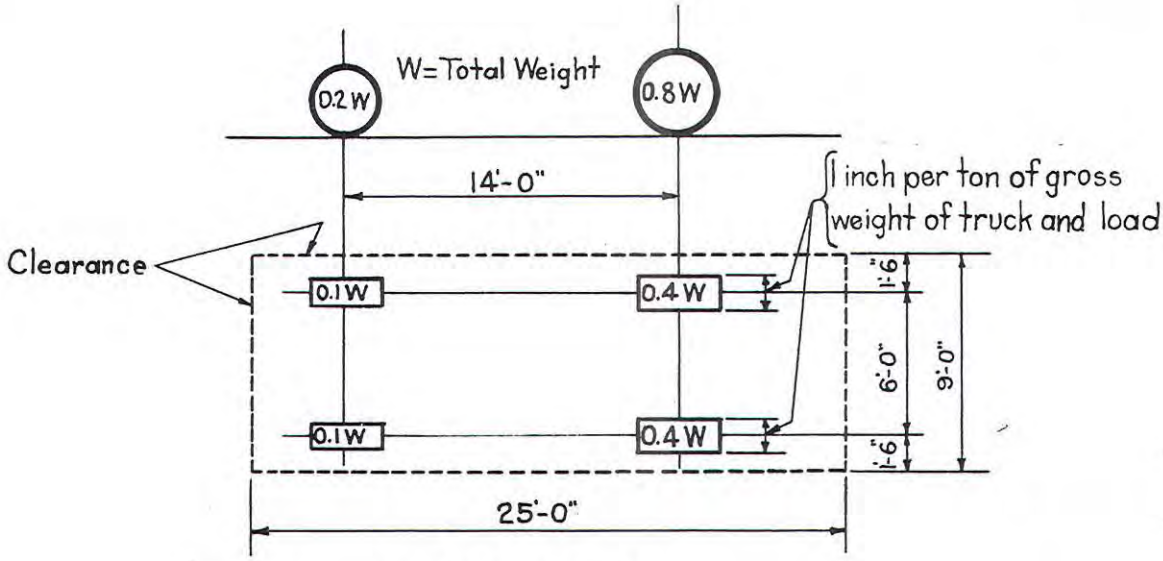
SINGLE TRACK RAILWAY AND ONE WAY HIGHWAY TRAFFIC

Figure 3.



ELECTRIC RAILWAY AND TWO WAY HIGHWAY TRAFFIC

Figure 4.



TYPICAL TRUCK

Figure 5.

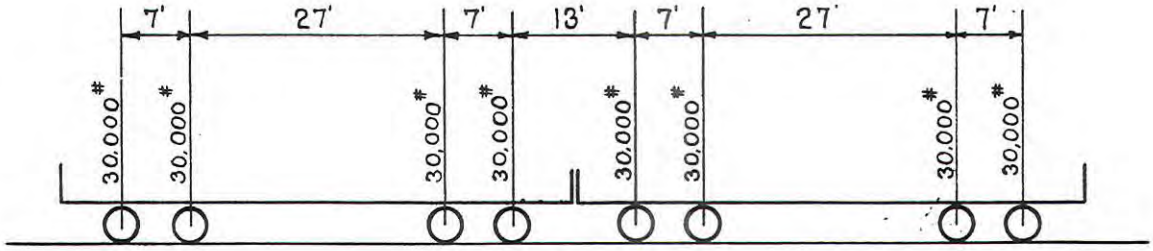


Figure 6.

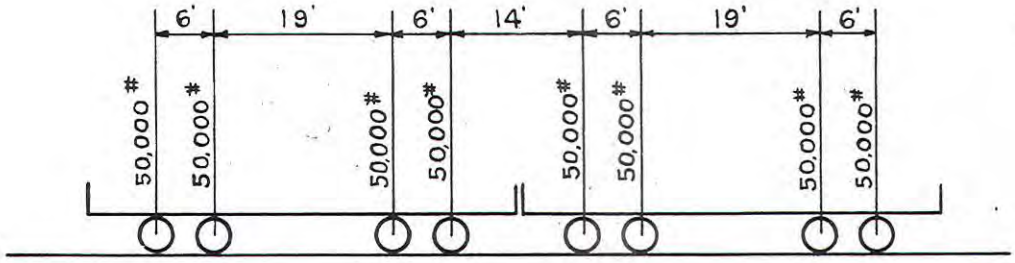


Figure 7.

Curbs: The width of curbs shall be not less than 6 inches and preferably shall be not less than 9 inches. Their heights shall be not less than 9 inches.

Clearances: The clearance width shall be the clear width available, and the clearance height shall be the clear height available, for the passage of vehicular traffic as shown on the clearance diagrams.

Unless otherwise provided, the several parts of the structure shall be constructed to secure the following limiting dimensions or clearances for traffic.

Bridges constructed for the use of one way highway traffic shall have a roadway clearance not less than that shown in the diagram, Figure 1. The roadway clearance for the use of two-way traffic shall be not less than that shown in Figure 2. The roadway width shall be increased at least 9 feet for each additional line of traffic.

Bridges constructed for the combined use of highway and electric railway traffic shall have roadway clearances not less than those shown in Figures 3 and 4.

In all cases involving curved tracks, the lateral clearances shall be increased an amount corresponding to that required to maintain the standard clearances. When the outer rail is super-elevated, the clearances shall be correspondingly increased.

Spacing of Trusses and Girders: Main trusses and girders shall be spaced a sufficient distance apart center to center to be secure against overturning by the assumed lateral and other forces.

Type of Bridges: The type of bridge to be used for various span lengths may be as follows:

Rolled Beams up to	40 feet.
Plate girders from	30 to 100 feet.
Low riveted trusses from	45 to 100 feet.
Riveted trusses from	90 to 150 feet.
Riveted or pin-connected trusses above	150 feet.

b. Loads: Unless otherwise provided, the component parts of a structure shall be proportioned for the stresses produced by the following loads with the assumed load distribution herein elsewhere prescribed. The stresses due to each shall be shown separately upon stress sheets.

Dead Load: The dead load shall consist of the weight of the structure complete, including the weight of the roadway floor, conduits, cables, or other public utility services supported thereon.

The following weights are to be used in computing the dead load:

Substance.	Weight per Cu. Ft. Lbs.
Steel	490
Iron, Cast	450
Bronze	524
Timber (treated or untreated)	60
Concrete	144
Loose sand and earth	100
Rammed sand or gravel	120
Macadam or gravel rolled	140
Cinder filling	60
Asphalt Wearing Surface	150
Granite block paving	160
Vitrified brick paving	150
Granolithic Pavement	150

Live Load: The integral parts of bridge floor systems, including their direct connections to trusses, girders, and viaduct towers and bents, shall be designed for the maximum stresses produced by truck concentrations. Floor beams, hangers, and all integral members or parts of trusses and girders subjected to the direct action of floor loads and impacts shall correspondingly be designed for truck concentrations. The truck dimensions and weight distributions used for design purposes shall be those of the typical or standard trucks shown in Figure 5. These standard trucks are designed by the letter "H", followed by a numeral indicating for each class its gross or total weight in tons.

The class of loading used shall be one of the following:

Loading H15. 15-ton trucks.
Loading H10. 10-ton trucks.

Live Load for Trusses and Girders: The trusses and girders of bridge spans and the columns of viaduct towers and bents shall be designed for the stresses produced by a load on each traffic lane composed of a uniform load per linear foot of lane with a concentrated load so located longitudinally therein as to produce maximum stresses. The concentrated load shall be considered as uniformly distributed transversely on a line having a length equal to the width of the lane. The standard truck clearance width of 9 feet shall be assumed as constituting the width of one traffic lane.

The class of loading used shall be one of the following:

Loading H15. A total load on each traffic lane composed of a uniform load of 450 lbs. per linear foot and a single concentrated load of 21,000 lbs.

Loading H10. A total load on each traffic lane composed of a uniform load of 300 lbs. per linear foot and a single concentrated load of 14,000 lbs.

Load Classification of Bridges: Bridges shall be classified or rated in relation to their capacities for safely supporting highway loads. In general, the division into classes and the corresponding loadings shall be as follows:

Class A. Bridges supporting normally heavy highway traffic units with occasional specially heavy loads. Class A bridges shall be designed for Loading H15.

Class B. Bridges of a temporary or semi-temporary nature supporting light highway traffic units. Class B bridges shall be designed for loading H10.

Application of Loads to Girders and Trusses: Girders and trusses shall be designed to support as many traffic lanes as the width of roadway will permit, assuming them to be placed symmetrically with regard to the roadway center lines

To provide for an increase in truss and girder stresses resulting from the passage of eccentrically placed loads and for a decrease in traffic lane intensity for increasing widths of roadway, the stresses obtained by the application of the above loading shall be multiplied by the coefficient "C" given by the following formulas:

Case 1. When "W" is less than 18 feet,

$$C = \frac{W}{9}$$

Case 11. When "W" is equal to or greater than 18 feet,

$$C = \frac{18 + W}{18n}$$

Where W = the width of roadway for bridges with two main girders or trusses; or the distance center to center of girders or trusses for bridges with more than twomain girders or trusses.
n = number of lanes of traffic.

Application of loads to Floor System: Bridge floor systems shall be designed to support as many trucks, not exceeding four, as the width of roadway will permit.

When the design of the floor system involves the placing of trucks adjacent to curbs, the extreme position of a truck shall be assumed as that in which the center of the outside wheel is 1' - 6" from the inside edge of the curb.

Sidewalk Loads: All sidewalk stringers and brackets shall be designed to support a live load of not less than 100 pounds per square foot of sidewalk area.

Girders or trusses supporting sidewalks shall be designed to support a sidewalk live load as determined by the following formula, provided that in no case shall the live load be less than 20 pounds per square foot of sidewalk area:

$$P = (80 - 0.125L)\ (1 - 0.025W)$$

Where P = Live load in pounds per square foot of sidewalk area

L = Loaded length of sidewalk in feet

W = Clear width of sidewalk in feet

No impact increment shall be added to sidewalk load.

In general, provision shall be made to prevent the encroachment roadway loads upon the sidewalk area. Whenever the details of the structure permit such encroachment, the sidewalks shall be designed for the roadway loads and impacts so involved.

All live load stresses, except those due to sidewalk loads and centrifugal tractive and wind forces, shall be increased by an allowance for dynamic, vibratory and impact effects.

For end floorbeams, floorbeam hangers, columns supporting floorbeam concentrations and all floorbeam connections, the impact allowance shall be 60% of the live load stress.

For all other portions of structures, the impact allowance or increment is expressed as a coefficient of the live load stress varying with the loaded length of the structure and the width of the roadway area. Its intensity is determined by the following formulas in which

I = impact coefficient

L = Loaded length in feet producing the maximum static stress in the member considered.

W = the width of roadway for bridges with two main girders or trusses; or the distance center to center of girders or trusses for bridges with more than two main girders or trusses.

For electric railway loads:

$$I = \frac{L + 900}{12L + 1200}$$

For highway loads:

When "W" is equal to or less than 18 feet,

$$I = \frac{L + 250}{10L + 500}$$

When "W" is greater than 18 feet,

$$I = \frac{36}{W + 18} \quad \frac{(L + 250)}{(10L + 500)}$$

[illegible] loads the maximum value of "I", as given by the above formulas [illegible] beams an[illegible]

In calc[illegible] lateral [illegible]

each wh[illegible] system [illegible] ed to s[illegible] wheel l[illegible] is the [illegible]

82.205 A-Wind Load: The force due to wind and lateral vibrations shall be taken as horizontal and shall be treated as a uniformly moving load acting only on the lateral and sway bracing. This lateral force shall be taken at 30 pounds per square foot on one and one-half times the side area of all trusses or girders plus the area of the railings and the vertical projection of the floor. In the case of truss spans it shall be considered as divided between the loaded and the unloaded chords in the proportion of two-thirds to the former and one-third to the latter. In addition to the foregoing, a moving load of 150 pounds per linear foot shall be considered as acting in the plane of the bridge floor on highway bridges and 300 pounds per linear foot upon bridges for combined highway and electric railway service. However, in the case of structures having a reinforced concrete floor slab engaging the flanges of the steel floor members, this additional loaded chord load need not be considered.

When the floor system is designed for two trucks, each interior stringer shall be proportioned to support that part of one rear wheel load, or those parts of one front wheel load and one rear wheel load, represented by a fraction whose numerator is the stringer specing in feet and whose denominator is:

3'- 6" for plank floors.
4'-10" for strip floors 4 inches or more in thickness and for wood blocks on 4" plank sub-floor.
4' -6" for reinforced concrete floors.

The live load supported by the outside stringers shall be the reaction of the truck wheels in the most unfavorable position, assuming the flooring to act as a single beam, but this live load shall in no case be less than would be required for interior stringers under the above requirements.

The above distribution rules govern only when the stringer spacing is not greater than the denominator which applies to the particular case under consideration. When the stringer spacing is greater than this distance, the stringer loads shall be determined by the reactions of the truck wheels placed in the most unfavorable position, assuming the flooring between stringers to act as simple beams.

The combined load capacity of the stringers in a panel shall be not less than the total live and dead load in the panel.

Bending Moment in Floorbeams: In determining bending moments in floor beams, each wheel load shall be assumed as concentrated at a point.

When stringers are omitted and the floor is supported directly on the floorbeams, the latter shall be proportioned to carry that fraction of one axle load, when the floor system is designed for one truck, or of two axle loads, when the floor system is designed for two trucks, whose numerator is the floorbeam spacing in feet and whose denominator is:

4' - 0" for plank floors.
5' - 0" for strip floors 4 inches or more in thickness and for wood blocks on 4" plank subfloor.
6' - 0" for reinforced concrete floors.

When the spacing of floorbeams exceeds the denominator given but is less than the axle spacing (14'-0") each beam shall be proportioned to carry the full axle load or loads.

When the floorbeam spacing exceeds the spacing of axles the load supported on each floorbeam shall be the maximum reaction due to the axle loads, assuming the flooring between floorbeams to act as a single beam.

d. Unit Stresses-Steel Structures: Unless otherwise provided, the several parts of a structure shall be so proportioned that the unit stresses will not exceed the following, except as provided for Structural Steel Design, under Combined Stresses, Secondary Stresses and Allowances for Overload. Unless otherwise noted, all unit stresses are given in pounds per square inch.

Structural Grade and Rivet Steel - Tensions:

Axial tension, structural members, net section.....16,000
Rivets in tension, where permitted - 50% of single shear values.
Bolts, area at root of thread.....10,000

Structural Grade and Rivet Steel - Compression:

Axial compression, gross section .....15000-50 l/r
but not to exceed 13500
l = length of member, in inches
r = least radius of gyration, in inches.

Structural Grade and Rivet Steel - Bending on Extreme Fiber:

Rolled shapes, built sections and girders,
net section.....16,000
Pins.....24,000

Structural Grade and Rivet Steel - Shear:

Girder webs, gross section.....10,000
Pins and shop driven rivets.....12,000
Power driven field rivets and turned bolts.....10,000
Hand driven rivets and unfinished bolts..... 7,500

Structural Grade and Rivet Steel - Bearings:

Pins, steel parts in contact and shop driven rivets...24,000
Power driven field rivets and turned bolts.....20,000
Hand driven rivets and unfinished bolts.....15,000
Expansion rollers, pound per linear inch..... 600d
where d = diameter of roller in inches.

Structural Grade and Rivet Steel - Countersunk Rivets:

In metal 3/8 inch thick and over, half the depth of countersink shall be omitted in calculating bearing area.

In metal less than 3/8 inch thick, countersunk rivets shall not be assumed to carry stress.

Structural Grade and Rivet Steel - Diagonal Tension:

In webs of girders and rolled beams, at sections where maximum shear and bending occur simultaneously.....16,000

Wrought Iron - Axial Tension.....12,000

Cast Steel - Bending on Extreme Fiber.....12,000
Cast Iron - Bending on Extreme Fiber..... 3,000

Cast Steel - Shear.....10,000
Cast Iron - Shear 3,000

Cast Steel - Bearing.....14,000
Cast Iron - Bearing.....10,000

Bronze sliding expansion bearings 3,000

Bearing on Concrete masonry and limestone masonry and better..... 500

Dimensions for Stress Calculation: For the calculation of stresses, effective span lengths shall be assumed as follows:

Beams and Girders, distance between centers of bearings. Trusses, distance between centers of end pins or of bearings. Floor-beams, distance between centers of trusses or girders. Stringers, distance between centers of floorbeams.

For the calculation of stresses, effective depths shall be assumed as follows:

Riveted Trusses, distance between centers of gravity of the chords.

Pin-connected Trusses, distance between centers of chord pins.

Plate Girders, distance between centers of gravity of the flanges but not to exceed the distance back to back of flange angles.

Reversal of Stress: Members subject to reversal of stress during the passage of live load shall be proportioned as follows: Determine the tensile and the compressive stresses and increase each by 50% of the smaller; then proportion the member so that it will be capable of resisting each increased stress. The connections shall be proportioned for the sum of the original stresses.

No pin-connected member shall be subjected to reversal of stress.

When the live load and dead load, stresses are of opposite sign, only 70% of the deal load stress shall be considered as effective in counteracting the live load stress.

Combined Stresses: Members subject to both axial and bending stresses shall be proportioned so that the combined fiber stresses will not exceed the allowable axial stress. Members continuous over panel points shall be proportioned for live and dead load bending moments equivalent to those computed for a simple beam having a span equal to one panel length.

Stresses due to Lateral and Longitudinal Forces and Temperature: In proportioning the various parts of the structure, provision shall be made for the following stress combinations:

Group A - Dead Load; Live Load; Impact; Centrifugal Force.

Group B - Lateral Force; Longitudinal Force; Temperature.

Members subject to the stresses of Group A in combination with the stresses of Group B, either direct or flexural or both, shall be designed for any of the following combinations at Unit Stresses 25% greater than those specified, but the resulting sections shall be not less than would be required if the stresses of Group A were considered alone.

1. The combined stresses of Group B in combination with Dead Load only.
2. The combined stresses of Group A in combination with 50% of the combined stresses of Group B.
3. The combined stresses of Group A in combination with Temperature only.

Secondary Stresses: Members and their details shall be proportioned to reduce secondary stresses to a minimum. In simple trusses without subdivided panels the secondary stresses due to deformation in any member whose width measured in the place of flexure is less than one-tenth of its length need not be considered. When this ratio is exceeded, or where subdivided panels are used, the secondary stresses shall be computed. In members designed for secondary stresses in combination with other stresses the specified allowable unit stresses may be increased 30% but the sections shall be not less than required for primary stresses.

Allowance for Over-Load: For the calculation of stress reversal or counterstresses, the specified live loads, either uniform or concentrated, shall be increased 100% and for this loading condition the specified unit stresses shall be increased not more than 50%. The resulting sections shall be not less than would have been required had the allowance for over-load not been considered.

Compression Flanges of Beams and Girders: The gross area of the compression flanges of beams and plate girders shall be not less than the gross area of the tension flanges.

The laterally unsupported length of the compression flanges of beams and girders shall not exceed 40 times the flange width. When the unsupported length of flange exceeds 12 times the flange width, the compressive stress in pounds per square inch shall not exceed:

$$19000 \frac{L}{b} \text{ (Maximum value, 16000 lbs.)}$$

where

L = length, in inches, of unsupported flange, between lateral connections or knee braces,

b = Flange width in inches.

Rolled beams shall be proportioned by the moments of inertia of their sections. Proper allowances shall be made for any reduction in strength due to rivet holes in the tension flange or to any reduction in allowable stress due to the length of unsupported compression flange.

Limiting Lengths of Members: The ratio of unsupported length to the least radius of gyration shall not exceed 120 for main compression and stiffening members nor 140 for laterals and sway bracing. In proportioning the top chords of low trusses the unsupported length shall be assumed as the length between the rigid verticals.

For main riveted tension members the ratio of length to least radius of gyration shall not exceed 200.

Effective Bearing Area: The effective bearing area of a pin, bolt, or rivet shall be its nominal diameter multiplied by the thickness of the metal on which it bears.

Effective Diameter of Rivets: In proportioning rivets, the nominal diameter of the rivet shall be used.

Size of Rivets: Rivets shall be of the size specified but generally shall be $\frac{5}{8}$ inch or 7/8 inch in diameter. 5/8 inch rivets shall not be used in members carrying calculated stress except in $2\frac{1}{2}$ inch legs of angles and in flanges of 6 inch and 7 inch beams and channels.

The diameter of rivets in angles carrying calculated stress shall not exceed one-fourth of the width of the leg in which they are driven. In angles whose size is not so determined 5/8 inch rivets may be used in 2 inch legs, $\frac{3}{4}$ inch rivets in $2\frac{1}{2}$ inch legs and 7/8 inch rivets in 3 inch legs.

In no case, except in handrails, shall structural shapes be used which do not admit the use of 5/8 inch diameter rivets.

Pitch of Rivets: The minimum allowable distance between centers of rivets shall be three times the diameter of the rivet but preferably shall be not less than the following:

For	7/8	inch	diameter	rivets	- 3 inches
"	3/4	"	"	"	- $2\frac{1}{2}$ "
"	5/8	"	"	"	- $2\frac{1}{4}$ "

The maximum allowable pitch in the line of stress shall not exceed 6 inches or 16 times the thickness of the thinest outside plate or angle connected, except in angles having two gage lines with rivets staggered where the pitch in each line may be twice the above with a maximum of 10 inches.

In webs of members composed of two or more plates in contact the rivets shall be spaced not more than ten inches between centers in gage and pitch, provided such rivets serve no other purpose than to hold the plates in close contact. Tension members composed of two angles in contact shall be stitch riveted using a pitch not greater than 12 inches.

Pitch in Ends of Compression Members: Panel Points shall be considered as Ends of Compression Members. In the ends of built compression members the pitch of rivets connecting the component parts of the member shall not exceed four times the diameter of the rivet for a length equal to $1\frac{1}{2}$ times the maximum width of member. Beyond this point the rivet pitch shall be gradually increased for a length equal to $1\frac{1}{2}$ times the maximum width of the member until the maximum spacing is reached. In angles having two lines of staggered rivets, in one leg, the pitch on each line may be twice that specified above but not greater than that allowed for the body of the member.

Edge Distance of Rivets: The minimum distance from the center of any rivet to a sheared edge shall be:

For 7/8 inch diameter rivets				- $1\frac{1}{2}$ inches
" 3/4 "	"	"		- $1\frac{1}{4}$ "
" 5/8 "	"	"		- 1 1/8 inches

The minimum distance from rolled or planned edges, except flanges of beams and channels, shall be:

For 7/8 inch diameter rivets				- $1\frac{1}{4}$ inches
" 3/4 "	"	"		- 1 1/8 inches
" 5/8 "	"	"		- 1 "

The maximum distance from any edge shall be eight times the thickness of the thinnest outside plate, but shall not exceed 5 inches.

Long Rivets: Long rivets subject to calculated stress and having a grip in excess of $4\frac{1}{2}$ diameters shall be increased in number at least one per cent for each additional 1/16 inch of grip. If the grip exceeds 6 times the diameter of the rivet, specially designed rivets shall be used.

Rivets in direct tension shall, in general, not be used. However, where so used their value shall be one-half that permitted for rivets in shear. Countersunk rivets shall not be used in tension.

Depth Ratios: Trusses preferably shall have a depth not less than 1/10 the span, plate girders a depth not less than 1/12 the span, and rolled beams a depth not less than 1/20 the span. If less depths than these are used, the sections shall be increased so that the maximum deflection will not be greater than if these limiting ratios had not been exceeded.

Parts accessible: The accessibility of all parts of a structure for inspection, cleaning and painting shall be insured by the proper proportioning of members and the design of their details.

Open Sections and Pockets: Closed sections shall in general be avoided. Pockets or depressions which will retain water shall be avoided as far as possible and those which are unavoidable shall be provided with effective drain holes or shall be effectively filled with water proof material.

Details shall be arranged so that the retention of dirt, leaves or other foreign matter will be reduced to a minimum. Wherever angles are used, either singly or in pairs, they preferably shall be placed with the vertical legs extending downward.

Symmetrical Sections: Main members shall be proportioned so that their neutral axes shall be as nearly as practicable in the center of the section.

In general, the gravity axes of main truss and other important members, meeting to form a joint, shall intersect in a common point so as to avoid eccentricity of stress. In cases of unavoidable eccentricity the members effected thereby shall be proportioned and the connection details designed to resist the stresses produced.

Effective Area of Angles in Tension: The effective area of single angles in tension shall be assumed as the net area of the connected leg plus 50% of the area of the unconnected leg.

The effective area of a double angle tension member shall be assumed as 80% of the net area of the member unless the end details and connections are such that the individual angles are held against bending in both directions, in which case the full net area may be used. When the angles connect to separate gusset plates, as in the case of a double-webbed truss, the gusset plates shall be stiffened by diaphragms in the line of the connected angles or by tie plates extending to the ends of the angles if they are to be considered as offering such resistance to bending that the full net area can be used. When the angles are connected back to back on opposite sides of a single gusset plate the support may be assumed to be sufficient to allow the use of the full net section.

Lug angles shall not be considered as effective in transmitting stress.

Strength of Connections: Unless otherwise provided all connections shall be proportioned to develop not less than the full strength of the members connected.

No connection, except for lacing bars and handrails, shall contain less than three rivets.

Splices: Continuous compression members in riveted structures, such as chords and trestle posts, shall have milled ends and full contact bearing at the splices.

All splices, whether in tension or compression, shall be proportioned to develop the full strength of the members spliced and no allowance shall be made for milled ends of compression members.

Splices shall be located as close to panel points as possible, and in general, shall be on that side of the panel point which is subjected to the smaller stress and outside of gusset plates.

The arrangement of the plates, angles or other splice elements shall be such as to make proper provision for the stresses in the component parts of the members spliced.

Indirect Splices: In all splice plates not in direct contact with the parts they connect, the number of rivets on each side of the joint shall be in excess of the number which would otherwise be required for a contact splice to the extent of two extra transverse lines for each intervening plate.

Fillers: Where indirect splices involve rivets carrying stress and passing through fillers, the fillers shall be extended beyond the splicing material and the extension secured by additional rivets sufficient in number to develop the section of the filler.

When the filler is less than $\frac{1}{4}$ inch thick the splicing materials shall also be extended.

Gusset Plates: Gusset or connecting plates shall be used for connecting all main members, except in pin-connected structures. In proportioning and detailing these plates the rivets connecting each member shall be located, as nearly as practicable, symmetrically with the axis of the member. However, the full development of the elements of the member shall be given due consideration. The gusset plates shall be of ample thickness to resist shear, direct stress and flexure acting on the weakest or critical section of maximum stress. Re-entrant cuts shall be avoided as far as possible.

Minimum Thickness of Metal: The minimum thickness of structural steel shall be 5/16 inch except for fillers and railings. However, gusset plates shall not be less than 3/8 inch in thickness.

Metal subjected to marked corrosive influence shall be increased in thickness.

Cast steel shall not be less than one inch and cast iron not less than $1\frac{1}{4}$ inch thick, except for filler blocks.

Compression Members: In built compression members the metal shall be concentrated as much as possible in the webs and flanges, so that the center of gravity of the section may be near the center line of the member as practicable.

Plates in Compression: Cover plates of built compression members and cover plates on the compression flanges of plate girders shall have a minimum thickness of 1/40, and the web plates of compression members a minimum thickness of 1/30, of the transverse distance between the lines of rivets connecting them to the flanges. However, failing to meet this requirement, the width of plate between the connecting lines of rivets in excess of 40 times the thickness for cover plates and 30 times the thickness for web plates, shall not be considered as effective in resisting stress.

Outstanding Flanges: Outstanding compression flanges of girders and main compression members shall have a minimum thickness of 1/12 of the width of outstanding flange. For lateral bracing and other secondary members this minimum thickness may be 1/14 of the width of the outstanding flange.

Tie Plates: The open sides of compression members shall be provided with lacing bars and shall have tie plates as near each end as practicable and at intermediate points where the lacing is interrupted. Compression members composed of two angles and cover plates shall have, on their open sides, ties composed of short lengths of channel section with the flanges riveted to the vertical legs of the angles.

Tension members composed of shapes shall have their separate segments connected by tie plates or by tie plates and lacing bars.

The thickness of the tie plates shall be not less than 1/50 of the distance between the connecting lines of rivets. The tie plates shall be connected by not less than 3 rivets on each side and in members having lacing bars the last rivet in the tie plate shall preferably also pass through the end of the adjacent bar.

For main compression members, the end tie plates shall have a length not less than $1\frac{1}{2}$ times the perpendicular distance between the lines of rivets connecting them to the member and with a rivet spacing of the preferred minimum, and the intermediate tie plates a length not less than that distance. For main tension members the end tie plates shall have the length above specified for end tie plates on main compression members and the length of the intermediate tie plates shall be not less than 3/4 the length specified for intermediate tie plates on compression members. In tension members whose elements are connected by tie plates only, the distance center to center of plates shall not exceed 5 feet.

For lateral struts and other secondary members, the length of end and intermediate tie plates shall be not less than 3/4 the perpendicular distance between the lines of rivets connecting them to the member.

Lacing Bars: The lacing of compression members shall be proportioned to resist a transverse shear not less than that calculated by the formula:

$$S = 300\ A$$

Where S = transverse shear in pounds

A = gross area of member in square inches.

This shear shall be considered as divided equally among all stiffening parts in parallel planes, whether made up of continuous plates or of lattice. The stress in the individual lacing bar shall be taken as the component of the shear, in the direction of the bar, in case single lacing is used and half that amount if double lacing is used. The size of the bar shall be determined by the column formula in which "L" shall be taken as the distance between the connections to the main sections.

The minimum width of lacing bars shall be:

For	7/8 inch	diameter	rivets	- $2\frac{1}{2}$	inches
"	3/4 "	"	"	- $2\frac{1}{4}$	"
"	5/8 "	"	"	- 2	"

Lacing bars having two rivets in each end shall be used for flanges 5 inches or more in width.

The minimum thickness of bars shall be 1/40 of the distance between end rivets in the case of single lacing and 1/60 of this distance for double lacing.

Double lacing, riveted at the intersections, shall be used when the perpendicular distance between rivet lines exceeds 15 inches.

The inclination of single lacing shall generally be about sixty degrees and for double lacing it shall be about forty five degrees to the axis of the member. Furthermore, the maximum spacing of lacing bars shall be such that the ratio of length to radius of gyration (r) for the portion of single flange between consecutive connections will be smaller than this ratio for the member as a whole.

Shapes of equivalent strength may be used instead of flats.

Net Section at Pins: Pin-connected riveted tension members shall have a net section, both through the pin hole and back of the pin hole, at least 25% in excess of the net section of the body of the member.

Net Section of Riveted Tension Members: In calculation the required area of riveted tension members, net sections shall be used in all cases, and in deducting rivet holes they shall be taken as 1/8 inch larger than the nominal diameter of the rivet.

The net section shall be the least area which can be obtained by deducting from the gross sectional area, the area of holes cut by any straight or zigzag section across the member, counting the full area of the first hole and a fractional part of each succeeding hole, the fractional part being determined by the formula:

$$x = 1 - \frac{S^2}{4\,gh}$$

where x = fraction of rivet hole to be deducted.

S = stagger or longitudinal spacing of rivets with respect to rivet on last gage line.

g = distance between gage lines, or transverse spacing.

h = diameter of rivet holes, or nominal diameter of rivet plus 1/8 inch.

Location of Pins: Pins shall be located, with respect to the neutral axis of the members, so as to reduce to a minimum secondary stresses due to bending.

Pin Plates: Pin plates shall be of sufficient thickness to provide the required bearing area upon the pin; they shall be as wide as the dimensions of the member will allow; and their length, measured from pin center to end, shall be at least equal to the width. Pin plates shall contain sufficient rivets to distribute their due proportion of the pin pressure to the full cross section of the members; only the rivets located within two lines drawn from the pin center toward the body of the member and inclined at 45 degrees to the axis of the member shall be considered effective for this purpose. In the case of members composed of web plates and flange angles (with or without a cover plate) there shall be at least one outside pin plate covering the vertical legs of the flange angles.

At the ends of compression members at least one pair of pin plates shall extend not less than 6 inches beyond the near edge of the tie plate.

All pin-connected compression members shall be provided with hinge plates having a minimum thickness of 3/8 inch.

Forked Ends: Forked ends on compression members will be permitted only when unavoidable. When used, a sufficient number of pin plates shall be provided to give each jaw the full strength of the compression member. At least one pair of these plates shall extend to the far edge of the tie plates, and the others not less than 6 inches beyond the near edge of the tie plates.

Pins and Pin Nuts: Pins shall be proportioned for the maximum shears and bending moments by the stresses in the members connected. If there are eye-bars among the parts connected, the diameter of the pin shall be not less than 2/3 of the width of the widest bar attached. Pins shall be of sufficient length to secure a full bearing of all parts connected upon the turned body of the pin. They shall be secured in position by hexagonal chambered nuts or by hexagonal solid nuts with washers. Where the pins are bored, through rods with cap washers may be used. In general, malleable castings conforming to the requirements of "Material Details", item 100.28, shall be used for pin nuts. Pin nuts shall be secured by cotters in the screw ends.

Bolts: Unless specifically authorized, bolted connections will not be permitted. Bolts, when used, shall be unfinished or turned as specified and shall meet the requirements of Item 59.31.

Bolts in tension shall have double nuts.

Upset Ends: Bars and rods with screw ends shall be upset to provide a cross sectional area at the root of the thread which shall exceed the net section of the body of the member by at least 15 per cent.

Sleeve Nuts: Sleeve nuts shall not be used.

Expansion: Provision for expansion and contraction, to the extent of 1/8 inch for each 10 feet of span, shall be made for all bridges. Expansion ends shall be firmly secured against lifting or lateral movement.

Expansion Bearings: Spans of less than 70 feet may be arranged to slide upon metal plates with smooth surfaces. Spans of 70 feet and over shall be provided with rollers or rockers or with the special sliding bearings described below. Neither rollers nor rockers shall be used for expansion bearings at the top of trestle posts.

Fixed Bearings: Fixed bearings shall be firmly anchored.

Hinged or Pin Bearings: Spans of 70 feet and over shall have hinged or pin bearings at both ends. The pedestals or shoes shall be so designed that all loads will act through the end pins which will be located directly over the geometrical center of the bearings.

Rollers: Expansion rollers shall be not less than 4 inches in diameter for span lengths of 100 feet or less and this minimum shall be increased not less than 1 inch for each additional 100 feet of span, and proportionally for intermediate lengths. They shall be connected together by substantial side bars and shall be effectually guided so as to prevent lateral movement, skewing, or creeping. The rollers and bearing plates shall be protected from dirt and water as far as possible, and the construction shall be such that water will not be retained and that the roller nests may be inspected and cleaned with the minimum difficulty.

Rockers: Pin bearing expansion rockers shall be of cast steel or cast iron.

Special Sliding Expansion Bearings: Sliding plates for the expansion bearings of spans of 70 feet and over shall be of Class A bronze, as prescribed under item "Structural Steel". These plates shall be chamfered at the ends and shall be held securely in position, usually by being inset into the metal of the pedestals and sole plates. Provision shall be made against any accumulation of dirt which will obstruct their movement.

Pedestals and Shoes: Pedestals and shoes shall be designed to secure rigidity and stability and to distribute the reaction uniformly over the entire bearing area. Preferably, they shall be made of cast steel or structural steel. The bottom bearing widths shall not exceed the top bearing widths by more than twice the depth of pedestal and, when involving pin bearings, this depth shall be measured from the center of pin.

Where built pedestals and shoes are used, the web plates and the angles connecting them to the base plates shall be not less than $\frac{1}{2}$ inch thick. If the size of the pedestal permits, the webs shall be rigidly connected transversely.

Inclined Bearings: For spans on an inclined grade and without pin or hinged bearings, the sole plates shall be beveled so that the substructure bridge seats will be level.

Anchor Bolts: Trusses, girders and 1-beam spans shall be securely anchored to their substructures. Anchor bolts shall be roughened by being screw-threaded or swedged to secure a satisfactory grip upon the material used to embed them in the holes.

The following are the minimum requirements for each bearing:

For 1-beam spans, the outer beams shall be anchored at each end with two bolts 1 inch in diameter, set 10 inches in the masonry.

For girder and truss spans, 50 feet in length or less, 2 bolts

1 inch diameter, set 10 inches in masonry.
51 to 100 feet in length, 2 bolts, $1\frac{1}{4}$ inch diameter, set 1'-0" in masonry.
101 to 150 feet in length, 2 bolts, $1\frac{1}{2}$ inch diameter, set 15" in masonry.
101 to 150 feet in length, 4 bolts, $1\frac{1}{2}$ inch diameter, set 1'-6" in masonry.

Anchor bolts subject to tension, as in the column bases of trestle bents and towers, shall be designed to engage a mass of masonry which will secure a resistance equal to $1\frac{1}{2}$ times the calculated uplift.

Floor System.

Floorbeams: Floorbeams preferably shall be at right angles to the trusses or main girders and shall be rigidly connected thereto. In general, floorbeam connections shall be located above the bottom chord and in riveted work, the bottom chord lateral system shall engage both the bottom chord and the floorbeam. Floorbeam connections to pin-connected trusses preferably shall be above the bottom chord pins, but, if located below, the vertical posts shall be extended below the pins to secure rigid connections to the floorbeams.

End Floorbeams: Except in skew bridges, end floorbeams shall be provided in all truss and girder spans. End floorbeams preferably shall be designed to permit the use of jacks for the future lifting of the superstructure, under which condition the specified unit stresses shall not be exceeded by more than 50 per cent.

End floorbeams shall be arranged to permit future painting of the sides of the beams adjacent to the abutment backwalls.

Stringers: Steel stringers preferably shall be riveted between the floorbeams, with end connections to the floorbeam webs.

End Struts: When end floorbeams are not used, the end panel stringers shall be secured in correct locations by end struts securely connected to the stringers and to the main trusses or girders. The end panel lateral bracing shall be rigidly attached to the main trusses or girders and shall also be attached to the end struts. Adequate provision shall be made for the expansion movement of stringers.

End Connections for Floorbeams and Stringers: The end connection angles of floorbeams and stringers shall be not less than 3/8 inch in thickness. When milled ends are required, the thickness of connection angles shall be 1/16 inch greater than for connection angles not required to be milled. Except in cases of special end floorbeam details, end connections for floorbeams and stringers shall be made with two angles at each end. Bracket or shelf angles which may be used to furnish support during erection shall not be considered in determining the number of rivets required to transmit end shears.

End connection angles shall develop the full depth of the webs by having a length as great as the flanges will permit.

In the preparation of end connection details, special care shall be exercised to provide ample clearance for the driving of field connection rivets.

The use of any type of floorbeam hanger which does not prevent all rotation or longitudinal motion of the floorbeam, will not be permitted.

Expansion Joints: To provide for expansion and construction movement, suitable floor expansion joints shall be provided at the expansion ends of all spans and at other points where they may be required.

Apron plates, when used, shall be designed to properly bridge the joint and to prevent, as far as possible, the deposit of roadway debris upon the bridge seat.

Bracing.

Design of Bracing: Lateral, longitudinal and transverse bracing shall be composed of angles or other shapes offering resistance to deformation when subjected to compressive stress, and shall have riveted connections.

In general, bracing shall consist of a double system of diagonal tension members with transverse compression members. The diagonals in each system shall be proportioned to carry the total lateral stress in tension, the transverse struts, (or floorbeams) acting as compression members for both systems.

All intersections of lateral and sway bracing shall be riveted to add rigidity and prevent deformations.

Lateral Bracing: Bottom lateral bracing shall be provided in all bridges except 1-beam spans, from which it may be omitted. Bottom laterals preferably shall be supported by rigid hangers at the intersections.

Top lateral bracing shall be provided in deck spans and in through spans having sufficient head room.

Lateral bracing for compression chords shall preferably consist of either two or four angle latticed sections; and so designed as to effectively engage both flanges of the chords.

Lateral bracing shall have concentric connections to chords at end joints, and preferably throughout. The connections between the lateral bracing and the chords shall be designed to avoid, as far as possible, any bending stress in the truss members.

Portal and Sway Bracing: Through truss spans shall have portal bracing, preferably of the two plane or box type, rigidly connected to the end post and top chord flanges, and constructed as deep as the minimum clearance will allow. When a single plane portal is used it preferably shall be located in the central transverse plane of the end posts, with diaphragms between the webs of the posts to provide for a proper distribution of the portal stresses. The portal bracing shall be designed to take the full end reaction of the top chord lateral system and the end posts shall be designed to transfer this reaction to the truss bearings.

Deck truss spans shall have adequate sway bracing at the ends and at all intermediate panel points. This bracing shall occupy the full depth of the trusses below the floor system. The bracing shall be proportioned to transfer the end reaction of the top lateral system to the substructure.

Through truss spans shall have sway bracing at each intermediate panel point if the height of the trusses is such as to permit a depth of 5 feet or more for the bracing. When the height of the trusses will not permit of such depth, the top lateral struts shall be provided with knee braces. Top lateral struts shall be at least as deep as the top chord. Sway bracing shall be of ample strength to transfer one-half of the wind pressure to the leeward truss.

Cross Frames: Deck plate girder spans shall be provided with cross frames at each end proportioned to resist all lateral forces and shall have intermediate cross frames at intervals not exceeding 15 feet. These frames shall be connected to the outstanding lags of the stiffener angles and to the girder flanges.

Low Truss Spans: The vertical truss members and the floorbeam connections of low truss spans shall be proportioned to resist a lateral force, applied at the top chord panel points of the truss determined by the following equation:

$$R = 150 (A / P)$$

where R = lateral force in pounds

A = area of cross section of chord in square inches

P = panel length in feet

This rigidity may be secured in part by extending one or both of the floorbeam connection angles upward along the inside of the post. Preferably outrigger brackets attached to the vertical posts on the outside of the trusses shall not be used.

Through Girder Spans: Through plate girder spans shall be stiffened against lateral deformations by means of gusset plates, or knee braces with solid webs, attached to the stiffener angles and floorbeams. If the unsupported length of the inclined edge of the gusset plate exceeds 60 times its thickness, the gusset plate shall have stiffener angles riveted along its edge.

These braces generally shall extend to the clearance line and preferably shall be spaced not farther apart than 15 feet.

Railings: Substantial railings shall be provided along each side of the bridge for the protection of traffic. In general, the railings shall be two classes, viz:

1. Railings suitable for use on country bridges which are not subject to general pedestrian traffic.

2. Railings for the protection of pedestrians on bridge in cities or villages.

The top rail of all railings shall be located approximately 3' 6" above the bridge floor and shall be capable of resisting a horizontal force of 100 pounds per linear foot.

Railings of the first class may consist of not less than two lines of horizontal rails of approved section.

Railings of the second class shall consist of an upper and lower horizontal rail connected by a suitable web. The clear distance between the floor and the lower rail shall not exceed 6 inches.

Preferably the unsupported length of any rail section shall not exceed 8 feet and all connections to posts, truss members, etc., shall contain not less than two rivets each. Ample provision shall be made for movement due to temperature.

Plate Girders.

Proportioning: Plate girders shall be proportioned either by assuming the flanges to be concentrated at their centers of gravity or by the moment of inertia of the net section. In the former case 1/8 of the gross area of the web is available as net flange area, but the effective depth shall not be assumed to be greater than the distance back to back of flange angles. For girders having unusual cross sections, the moment of inertia method shall be used.

Flange Sections: The gross section of the compression flange shall be not less than the gross section of the tension flange. The compression flange preferably shall be stayed against lateral deflection at intervals not exceeding 12 times its width.

The flange angles shall form as large a postion of the gross area of the flange as practicable.

When flange cover plates are used, at least one plate on the top flange shall extend the full length of the girder. Any additional flange cover plates shall be of such length as to allow two rows of rivets to be placed at each end of the plate beyond its theoretical end, and there shall be a sufficient number of rivets at the ends of each plate to develop its full stress value before the theoretical end of the next outside plate is reached.

Flange cover plates shall be equal in thickness, or shall diminish in thickness from the flange angles outward. No plate shall have a thickness greater than that of the flange angles.

Web Plates: Web Plates shall be proportioned for both the vertical and horizontal shearing stresses. Splices in web plates shall be avoided as far as possible, but, when used, they shall be designed to develop the full value of the web plate for both bending and shearing stresses.

Flange Rivets: The number of rivets connecting the flange angles to the web plates shall be sufficient to develop the increment of flange stress transmitted to the flange angles, combined with any load that is applied directly to the flange. For electric railways, one-wheel load, when applied directly to the flange, shall be assumed to be distributed uniformly over a length of 3 feet.

Flange Splices: Splices in flange members shall not be used except by special permission of the Engineer. Two members shall not be spliced at the same cross section, and if practicable, splices shall be located at points where there is an excess of section. The net section of the splice shall exceed by 10 per cent the net section of the member spliced. Flange angle splices shall consist of two angles, one on each side. Splice angles shall be fitted to secure close contact with the material spliced.

Web Splices: Web plates shall be symmetrically spliced by plates on each side. The splice shall be equal in strength to the web in both shear and moment. There shall be at least two rows of rivets on each side of the joint.

End Stiffeners: Plate girders shall have stiffener angles over end bearings, the outstanding legs of which shall be as wide as the flange angles will allow and shall fit tightly against them. These end stiffeners shall be proportioned for bearing on the outstanding legs of the flange angles no allowance being made for the legs fitted to the fillets of the flange angles. End stiffeners shall be arranged to transmit the total end reaction and to distribute it over the bearings. They shall not be crimped and the connection to the web shall contain a sufficient number of rivets to transmit the entire reaction.

Intermediate Stiffeners: Intermediate stiffeners angles shall be riveted in pairs to the web of the girder. The outstanding leg of each angle shall have a width of not more than 16 times its thickness and not less than 2 inches plus 1/30 of the depth of the girder.

Intermediate stiffeners shall be spaced at intervals not exceeding:

(a) 6 feet;
(b) The depth of the web;
(c) The distance given by the formula.

$$d = \frac{t}{40}(12000 - S)$$

where
d = distance between rivet lines of stiffeners in inches.
t = thickness of web in inches.
s = web shear in pounds per square inch at the point considered.

When the depth of the web between the flange angles or side plates is less than 60 times the web thickness, intermediate stiffeners may be omitted.

Intermediate stiffener angles shall be placed at points of concentrated loading and shall be designed to transmit the reactions to the girder web. Such stiffeners shall not be crimped.

Other intermediate stiffeners may be crimped.

Ends of Through Girders: The upper corners of through plate girders, where exposed, shall be neatly rounded to a radius consistent with the size of the flange angles and the vertical height of the girder above the roadway. The first flange plate or a plate of the same width will be bent around the curve and continued to the bottom of the girder. In a bridge consisting of two or more spans, only the corners on the extreme ends need to be rounded, unless the spans have girders of varying heights, in which case the higher girders shall have their top flanges neatly curved down at the ends to meet the top corners of the girders in the adjacent spans.

End Bearings: End bearings of girders on masonry shall be raised above the bridge seat by metal pedestals or plates a height of at least 2 inches.

Sole and Masonry Plates: Sole and masonry plates shall each be not less than 3/4 inch thick.

Camber: In general, camber will not be required in plate girders except for long spans or special conditions. When used, it shall be sufficient in amount to meet the requirements of the engineer.

Trusses

Main Features: Preference will be given to trusses with single intersecting web members or other forms of trusses possessing the least ambiguity in computed stresses and the greatest elements of serviceability. Adjustable members in any part of the structure preferably shall be avoided. Members shall be symmetrical about the central plates of trusses and all parts shall be so designed that they can be inspected, cleaned and painted.

Through riveted and pin-connected spans will generally have inclined end posts. Low truss spans shall be of the riveted type. In low truss spans, laterally unsupported hip joints or "flying hips" shall be avoided.

Top Chords and End Posts: Top chords and end posts of low and through truss spans shall be made usually of two side segments with one cover plate and with tie plates and lacing on the open side. In chords of light section, tie plates and lacing may be used in place of a cover plate.

Top chords of deck trusses subjected to direct loading shall be designed for the cross bending occasioned by the dead, live, and impact loads of the floor system, in addition to the direct chord stresses, and all top chord splices shall be proportioned for those stresses and any shearing stresses they may receive. Where the shape of the truss permits, compression chords shall be built continuous, with splices located as near the panel points as possible and preferably on the side subjected to the samller stress.

The top chord sections of low truss spans shall be so proportioned that the radius of gyration about the vertical axis of the member shall be at least $1\frac{1}{2}$ times the radius of gyration about the horizontal axis.

Bottom Chords: The bottom chords of riveted trusses generally shall be spliced outside of gusset plates near panel points and on the side farthest away from the center of the span.

Bottom chords composed of angles preferably shall be detailed with the vertical legs of the angles extending downward.

Working Lines and Gravity Axes: For compression members formed of side segments and a cover plate, the working line shall coincide as nearly as practicable with the gravity axis of the section. For symmetrical sections the working line shall coincide with the gravity axis. For two angle bottom chord or diagonal members the working line may be taken as the gage line nearest the back of the angle.

Camber: Trusses shall in general be given a camber by increasing the length of the top chords an amount in each panel length equal to three-sixteenths inch for each ten feet of their horizontal projection.

Rigid Members in Pin-Connected Trusses: Pin-connected trusses shall have stiff riveted members in the bottom chords of the first two main panels at each end of the span and all web members performing the function of suspenders shall be of stiff riveted construction.

Counters and Adjustable Members: Rigid counters are preferred. Adjustable counters, when used, shall have open turn-buckles and in the design of these members an allowance of 10,000 pounds shall be made for initial stress. Only one set of diagonals in any panel shall be adjustable. Sleeve nuts and loop bars shall not be used.

Eye-Bars: Eye-bar heads shall have a cross sectional area through the center of the pin hole exceeding that of the body of the bar by at least 40 per cent. The net section adjacent to the head shall be not less than that of the main body of the bar. The thickness of the bar shall be not less than 1/8 of the width and not greater than 2 inches. The forms of the head shall be submitted to the Engineer for approval before the bars are made. The diameter of the pin shall be not less than 2/3 of the width of the widest bar connected.

Packing Eye-Bars: The eye-bars of a set shall be packed symmetrically about the central plane of the truss and as nearly parallel as practicable, but in no case shall the inclination of any bar to the plane of the truss exceed 1/16 inch per foot. Bars shall be packed as closely as practicable and hold against lateral movement, but they shall be arranged so that adjacent bars in the same panel will be separated by at least 3/4 inch.

All intersecting diagonal bars not far enough apart to clear each other at all times shall be well clamped together at intersections.

Steel filling rings shall be provided, when required, to prevent lateral movements of eye-bars or other members connected upon pins.

Diaphragms: Diaphragms shall be provided in the trusses at the end connections of all floorbeams. In general, such diaphragms shall extend down to the bottom flange of the floorbeam and for at least two rivet spaces above the top flange.

The gusset plates engaging the pedestal pin at the end of a truss shall be rigidly connected by a diaphragm which shall , in general take direct bearing on the pin. Similarly, the pedestal webs shall, where practicable, be connected by diaphragms which shall in general take bearing on the beam.

A diaphragm shall be provided between gusset plates engaging main members whenever the end tie plate is located at a distance of 4 feet or more from the point of intersection of the members. In general, the web of this diaphragm shall be located in the plane of the latticed flange.

Sole and Masonry Plates: Sole and masonry plates supporting trusses and columns shall each have a thickness of not less than 3/4 inch. The bottom chords of trusses shall be raised above the bridge seat at least 2 inches by the use of metal plates or pedestals.

Viaducts

Type: Viaducts shall consist usually of alternate tower spans and free spans of plate girders or riveted trusses supported on trestle towers. However, in viaducts having a column height less than 35 feet, trestle bents may alternate with the towers.

In viaducts requiring freedom of waterway and in structures having a less total column height than 20 feet, the number of intermediate trestle bents may be increased over that specified above but, in general, shall not exceed four in number. Ample rigidity shall be secured in the attachment of the superimposed spans to the column caps of the bents.

Bents and Towers: Each trestle bent shall be composed preferably of two main supporting columns. Towers shall be composed of two bents rigidly braced and strutted both longitudinally and transversely.

Single Bents: Where viaduct spans are supported on single bents, such bents, if less than 20-feet in heights, shall be pin-connected to their base sections or shall be designed to resist bending.

Batter: Columns preferably shall have a transverse batter of not less than 1 horizontal to 12 vertical.

Depth of Girders: The depth of plate girders in viaducts preferably shall be uniform.

Girder Connections: Girders of tower spans shall be fastened at each end to the tops of the columns or to the cross girders. Girders between towers shall have one end riveted, and shall be provided with an effective expansion joint at the other end. No bracing or sway frame shall be common to abutting spans.

Bracing: Towers shall be thoroughly braced, both transversely and longitudinally, with a double system of stiff tension diagonals with riveted connections. Longitudinal and transverse struts shall be placed at caps and bases and at all intermediate panel points. All bracing connections are to be made by gusset plates.

Column splices generally shall be located close to and above the panel points of the bracing.

Horizontal diagonal bracing shall be provided at the tops and bases of towers and at least at all intermediate panel points of the lateral bracing where the tower columns are spliced.

Provision shall be made in column bearings for expansion of tower bracing. The struts at the base of towers shall be strong enough to slide the movable shoes with the structure unloaded. The coefficient of friction shall be taken at 0.3.

Sole and Masonry Plates: Sole and Masonry plates shall each be not less than 3/4 inch thick.

Anchorage: Viaduct bents preferably shall have a sufficient spread at the base to prevent tension in any windward leg. When this is impracticable, the column anchorages shall be designed to safely resist not less than $1\frac{1}{2}$ times the calculated uplift.

Method of Measurement. The quantities of the various pay items which constitute the structure constructed and completed in accordance with this specification and accepted, shall be measured for payment according to the Plans and specifications for the several items, and in terms of the corresponding units prescribed for the several pay items.

Basis of Payment. These measured quantities shall be paid for at the Contract unit prices bid for the several pay items, which payment and prices shall be full compensation for furnishing, fabricating transporting and erecting all materials, for all shop work, painting and field work, for all labor, equipment, tools and incidentals necessary to complete the structures ready for use.

83. TIMBER STRUCTURES

Description. All timber structures shall be built as indicated on the Plans conforming to line, grade, dimensions and design shown and in accordance with the Specifications for Piling, Concrete, Untreated Timber, Treated Timber, and other pay items which are to constitute the complete structure.

Material. (1) All timber shall be sound and sawed standard size, straight, out of wind, and shall be free from defects such as decay, worn holes, injurious shakes, checks and crooked, cross or spiral grain, large, loose or unsound knots, knots in groups, large pitch pockets, or other defects that might impair its strength and durability. Unless otherwise specified wane may show on only one corner of a piece. Wane shall not exceed one-half the length of the piece nor measure more than one inch across the face of the wane. Not more than 10 per cent of the pieces of one size may show any wane.

(2) Standard Size and Dressing. Rough timbers sawed to "Standard Size" shall be interpreted to mean that sawn rough timber shall not be over $\frac{1}{4}$ inch scant from actual size specified. For instance, a 12 x 12-inch timber shall measure not less than 11-3/4 x 11-3/4 inches. "Standard Dressing" shall be interpreted to mean that not more than 1/4 inch shall be allowed for dressing each surface. For instance, a standard 12 x 12-inch timber, dressed four sides, shall measure not less than 11-1/2 x 11-1/2 inches.

(3) All timber shall be classified as "Dense," or "Sound" and as "Treated" or "Untreated".

(4) "Sound Timber" shall meet all the requirements set forth above and may be used for columns, sills, wheelguards, bulkhead sheeting and bracing.

(5) "Dense Timber" shall be required for truss members, floor beams, stringers, caps and flooring. Dense timber shall meet all the requirements set forth above and shall be classified as follows: (a) Dense timber of Longleaf Pine, Shortleaf Pine, and Cuban Pine; (b) Dense Timber of Coast Region Douglas Fir; and (c) Dense timber of other species.

(a) Dense timber of Longleaf Pine, Shortleaf Pine and Cuban Pine shall show at one end or the other an average of at least six annual rings per inch and at least 1/3 summerwood, all measured over the third, fourth and fifth inches on a radial line from the pith. Wide ringed material excluded by this rule shall be acceptable provided the amount of summerwood as above measured shall be at least one-half. The contrast in color between summerwood and springwood shall be sharp, and the summerwood shall be dark in color except in pieces having more than one-half summerwood.

In cases where timbers do not contain pith and it is impossible to locate it with any degree of accuracy, same inspection shall be made over three inches in an approximate radial line beginning at the edge nearest the pith in timbers over three inches in thickness, and in the second inch of the piece nearest to the pith in timbers three inches or less in thickness.

In dimension material containing the pith but not a five-inch radial line, which is less than 2 x 8 inches in section, or less than 8 inches in width, that does not show over 16 square inches on the cross section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-inch radial line, the inspection shall apply to the third inch farthest from pith.

(b) Dense timber of Coast Region Douglas Fir shall be strong timber of medium rate of growth and show on one end or the other an average of at least six annual rings per inch, and at least one-third summerwood measured over three inches on a line located as hereinafter described. Wide ringed material, excluded by this rule, shall be acceptable provided the amount of summerwood as above measured shall be at least one-half. Material in which the proportion of summerwood is not clearly discernible shall not be used.

When the least dimension is five inches or more, the pith being present, the line over which the rate of growth and percentage of summerwood measurements shall be made, shall run from the pith to the corner farthest from the pith. The 3-inch line shall begin at a distance from the pith equal to two inches less than one-half the least dimensions of the piece.

For all pieces not having the pith present, the center of the 3-inch line shall be at the center of the end of the piece, and the direction of the 3-inch line shall be at right angles to the annual rings.

If a radial line of three inches cannot be obtained, the measurement shall be made over the entire radial line that is available.

(c) Dense Timber of Other Species. Other species of timber for truss members, floor beams, caps and flooring shall be strictly first quality.

6 ~~(7)~~ Untreated Timber. For designs based on a fiber stress in bending of 1500 to 1600 pounds per square inch, one of the following species of Timber shall be used:

Douglas Fir from Pacific Coast Region
Longleaf Pine
Cuban Pine
White Oak

Heart Requirement . All untreated timber shall show at least eighty-five (85) per cent heartwood on any girth.

(7) Treated Timber. Timber treated by a pressure method to retain 8 to 12 pounds of oil per cubic foot, as hereinafter specified, and so treated that all sapwood is entirely impregnated with creosote oil, shall fulfill the requirements for untreated timber except that there shall be no heart wood requirement.

For designs based on a fiber stress in bending of 1500 to 1600 pounds per square inch, one of the following species of timber shall be used:

Douglas Fir from Pacific Coast Region
Longleaf Pine
Cuban Pine
Shortleaf Pine
White Oak

Preservation Treatment. Timber to be treated for preservation shall be cut and framed prior to treatment. After treatment no unnecessary cutting of treated piles or timber will be allowed.

The range of pressure, temperature and time duration shall be controlled so as to result in maximum penetration by the quantity of preservative injected, which shall permeate all of the sapwood and as much of the heartwood as practicable.

The amount of preservative and manner of treatment shall be as indicated on the plans and shall fulfill the following requirements:

Timber shall be treated with the preservative specified by any standard full cell process to retain not less than 12 pounds of the preservative per cubic foot or by any standard empty cell process to retain not less than 8 pounds of the preservative per cubic foot, except Douglas Fir, which shall be treated to retain not-less than 10 pounds by any standard full cell process or 6 pounds by any standard empty cell process.

The preservative shall be one of the following grades of creosote oil or creosote coal tar solution as directed by the Engineer, or indicated on the plans, and shall meet the following requirements:

	Creosote Oil			Creosote Coal Tar Solution
	Grade 1	Grade 2	Grade 3	
It shall not contain water in excess of	3%	3%	3%	3%
It shall not contain matter insoluble in benzol in excess of	0.5%	0.5%	0.5%	2%
Specific gravity of oil at 38/15.5°C., shall not be less than	1.03	1.03	1.03	1.05 to 1.12
The distillate based on water-free oil shall be within the following limits up to 210°C. not more than	5%	8%	10%	5%
Up to 235°C., not more than	25%	35%	40%	25%
The float test of residue above 355°C. shall not exceed 50 sec. at 70° C. if the distillation residue above 355°C. exceeds	5%	5%	5%	26%
Coke residue of oil not more than	2%	2%	2%	6%

The foregoing tests shall be made in accordance with Standard Methods of A. S. T. M. Designation D38-18.

Method of Construction. Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. It shall be handled with rope slings. Cant dogs, hooks or pike-poles shall not be used.

All places where the surface of treated timber is broken by cutting, boring or otherwise, shall be thoroughly coated with hot creosote oil and then with a coating of hot tar pitch.

Pile caps shall be level and have full even bearing on all piles in the bent and be secured to each pile by a 3/4" diameter drift bolt extending at least nine inches into the pile.

Truss and bent timbers shall be accurately cut, and framed to a close fit in such manner that they will have even bearing over the entire contact surface of the joint. No blocking or shimming of any kind will be allowed in making joints, nor will open joints be accepted. Mortises shall be true to size for their full depth and tenons shall make snug fit therein. All bolt holes shall be bored with an augur 1/16" smaller in diameter than the bolt. Mortises and tenons shall be "draw bored."

Stringers shall be sized at bearings. Outside stringers may have butt joints but interior stringers shall be framed to bear over the full width of floor beam or cap at each end. The ends shall be separated at least one-half inch for the circulation of air and shall be securely fastened to the timber on which they rest.

Where width of stringers is less than one-third of the depth, then 2 lines of 2x4 bracing placed at quarter points of span shall be used.

Roadway floor plank shall have a nominal thickness either of four or three inches as specified, and an actual width of not less than nine and one-half inches. Side-walk floor plank shall be surfaced to uniform thickness. It shall have an actual minimum width of five and one-half inches and thickness of one and five-eights inches.

All floor plank shall be laid heart side down with one-quarter inch openings and be spiked to each stringer or nailing strip with at least two 7-inch spikes for 4-inch plank and two 6-inch spikes for 3-inch plank. Rough plank shall be carefully graded as to thickness before laying, and be laid so that no two adjacent planks vary in thickness more than 1/16 of an inch. All floors shall be cut to a straight line along the sides of the roadway and walkway.

Wheel guards, as shown on the plans, shall be constructed on each side of the road. They shall be raised from the floor by blocks three inches thick by one foot long, spaced about five feet apart center to center, and be fastened in place by a 5/8-inch bolt passing through the wheel guard, each block and floor plank.

Railings shall be built in accordance with the designs shown on the plans, and shall be constructed in a workmanlike and substantial manner. Unless otherwise noted, all railing material shall be dressed on four sides.

~~(k) Pins.~~ Pins may be turned, or split and drawn, from clear sound wood of the kind specified on the plans. They shall be made 6 inches longer than the required finished length, and when driven into place shall have their ends sawed off flush with the surface of the member.

Turned pins shall be made from square stock sawed parallel to the grain. One end shall be left square for about 1 inch and the other shall have a dull point. The body of the pin shall be uniform in diameter and 1/16 inch larger than the diameter of the hole. The finished pins shall be free from knots, knot holes, pockets, splits, or flaws which might impair their strength.

Split and drawn pins shall be made from straight grained green lumber and be allowed to season. One end shall be hardened and pointed by charring. They shall be octagonal in shape and when seasoned, the diameter between parallel faces shall be the same as the diameter of the holes in which they are to be driven.

Bolts shall be of the sizes specified and must be perfect in every respect. They shall have square heads and nuts, and screw threads shall make close fits in the nuts. All bolts shall be effectually checked after the nuts are adjusted.

Washers shall be used between all bolt heads and nuts, and the 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 size of the square shall be equal to four times, and the thickness equal to one-half the diameter of the bolt.

Painting Treated Timbers. Hot creosote oil shall be poured into the bolt before the insertion of the bolts, in such a manner that the entire surface of the holes shall receive a coating of the oil. After the necessary cutting has been done to receive the cap, the heads of piles shall be given three coats of hot creosote oil. They shall then be covered with a coat of hot tar pitch over which shall be placed a sheet of 3-ply roofing felt or galvanized iron, or a covering may be built up of alternate layers of hot tar pitch and loose woven fabric similar to membrane water-proofing, using four layers of pitch and three of the fabric. The cover shall measure at least six inches more in each dimension than the diameter of the pile, and shall be bent down over the pile and the edges fastened with large headed nails, or secured by binding with galvanized wire. After the cover is in place the cap shall be placed and drift-bolted as prescribed above.

Painting Untreated Timbers. In structures of untreated timber the following surfaces shall be thoroughly coated with a thick coat of red lead paint, hot tar, hot asphaltum, or hot coal tar creosote before assembling:- Heads of piles, end, tops, and all contact surfaces of pile caps, floor beams, and stringer ends, joints and all contact surfaces of truss members, laterals, and braces. The back face of bulkheads and all other timber in contact with earth shall be thoroughly coated with one of the materials specified above, or a Carbolineum.

Unless otherwise specified, ralings shall be made of untreated dressed lumber and shall be painted with three coats of paint composed of 75% pure lead and 25% zinc white by weight, mixed in pure, raw linseed oil. Turpentine dryer shall be added to the paint in the average proportions of one-half pint of dryer to one gallon of paint.

All bolts passing through non-resinous wood shall be painted with two coats of red lead paint at least 85% pure.

Design Details. Features of Loading are prescribed under Design Detailsfor Steel Structures. Unit stresses will be as shown on Plans.

Method of Measurement. "Treated Timber" and "Untreated Timber" complete in place according to the plans and these specifications will be measured separately by the thousand feet board measure. Measurements will be computed from the dimensions shown on plans, unless changes in such dimensions have been authorized by the Engineer. "Standard" timber sizes will be used in computations. This measurement will include only such timber as is a part of the completed and accepted work, and will not include timber used for erection purposes, such as falsework, forms, bracing, shoeting, etc. Any concrete masonry, or any supplementary floor wearing tops, shown on plans will be measured as provided in pertinent specifications.

Basis of Payment. Timber Structures complete in place will be paid for by the quantities as above measured at the contract unit price per thousand feet board measure bid for "Untreated Bridge Timber" or "Treated Bridge Timber," as the case may be, complete in place according to the plans or as directed by the Engineer, which prices shall be full compensation for all materials, hardware, equipment, tools, labor, painting, preservative treatment, and all incidentals necessary to complete the structure ready for use; provided, however, that Piling, Concrete, masonry and supplementary floor wearing tops shown on plans will be paid for as provided in pertinent specifications.

84. CULVERTS AND RETAINING WALLS

Description. All concrete and masonry culverts, all pipe culverts, end-walls, and retaining walls, shall be built as indicated on the Plans, conforming to line, grade, dimensions, and design shown, and in accordance with the specifications for "Concrete," "Masonry," and "Pipe," of the several varieties, and other pay items which are to constitute the complete structures.

Materials. and material requirements shall be as prescribed for the several pay items involved.

Construction Methods. All foundations shall be inspected and approved by the Engineer previous to placing any masonry of footing. All excavations shall be carried to depth of foundation materials satisfactory to the Engineer regardless of the elevations shown on the Plans, and unsuitable material shall be replaced with approved material if required. If rock bottom is secured, the excavation shall be done insuch a manner as to allow the solid rock to be exposed and prepared in horizontal beds for receiving the masonry. All loose and disintegrated rock shall be removed.

Pipe culverts under the roadbed shall be so placed that the minimum distance from finished grade of roadway to the top of pipe shall be as provided in the following table:

TABLE OF MINIMUM DEPTHS OF GOOD FILL OR BALLAST OVER PIPE CULVERTS

(On center line of roadway C, and outer edge of shoulder S.)

Inside Diam.	Cast Iron		Vitrified Clay and Corr. Gal. Metal		Concrete		Inside Diam.
	C	S	C	S	C	S	
12"	1'-0"	8"	1'-6"	1'-0"	1'-0"	8"	12"
14"	1'-0"						14"
15"			1'-6"	1'-0"	1'-0"		15"
16"	1'-0"	8"					16"
18"	1'-0"	8"	1'-6"	1'-0"	1'-0"	8"	18"
24"	1'-0"	8"	2'-0"	1'-0"	1'-0"	8"	24"
30"	1'-3"	8"	2'-6"	1'-0"	1'-3"	8"	30"
36"	1'-6"	8"	3'-0"	1'-0"	1'-6"	8"	36"
42"	1'-9"	8"					42"
48"	2'-0"	8"					48"

Note: If the material in the fill contains much clay, silt, or loam, increase the above minimum by 4".

When pipe is of the bell and spigot type, the bell end of the pipe shall be laid up grade and all joints shall be made water tight with 1 to 2 Portland cement mortar. Before succeeding sections of pipe are laid, the lower portion of the hub of the preceding pipe shall be plastered on the inside with cement mortar of sufficient thickness to bring the inner surfaces of the abutting pipes even. After the pipe is laid, the remainder of the joint shall be filled with similar material, and sufficient additional material shall be used to form a bead around the joint. The inside of the joint shall be wiped and finished smooth. After initial set, the cement on the outside shall be protected from the air and sun with an earth covering. The bottom of the trench shall be so shaped as to support each section of the pipe the full length of the body and shall have depressions cut to take the bell of the pipe. Wherever solid rock occurs in a culvert trench it shall be excavated to a depth of at least 6 inches below the pipe and the space thus made refilled with selected fine material. In like manner, earthy material that is not sufficiently firm to support the pipe uniformly shall be excavated and replaced by selected fine material. In refilling the pipe trench the material for backfill shall be free from large stones for a depth of nine inches around the pipe, and shall be placed carefully under and around the pipe and tamped to give the pipe a uniform bearing throughout. The ends of all pipe culverts shall be protected by concrete or masonry end walls unless otherwise ordered by the Engineer.

Method of Measurement. The quantities of the various pay items which constitute the completed and accepted structures will be measured for payment according to the Plans and specifications for the several items. Only accepted work will be included and the dimensions used will be the neat dimensions shown on the Plans or ordered in writing.

Basis of Payment. The measured quantities as provided above, will be paid for at the contract unit prices bid for the several items, which prices shall be full compensation for furnishing, hauling and placing all material, all labor, equipment, tools and necessary incidentals. Such payment shall constitute full payment for the completed structure ready for use. Whenever the construction of the new structures involves the removal or demolition of an existing structure, unless otherwise expressly provided, such removal or demolition shall not be paid for directly, but shall be considered as subsidiary work pertaining to Excavation or to prescribed pay items involved in the work.

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85. CONCRETE

Description. Concrete shall be composed of Portland Cement, fine and coarse aggregate, each measured separately and accurately by volume, and water, mixed as provided in these specifications, and shall be constructed where, and of the form, dimensions, and design shown on the Plans. Concrete shall be classified and proportioned by volume as follows, and in no event shall the number of bags of cement used per cubic yard of concrete in place be less than number required below: of 94 pounds each

Class	Parts Aggregate to 1 cement	Bags Cement to Cu. Yd.
A	6	6.0
B	$7\frac{1}{2}$	5.0
C	9	4.5
D	5	7.0

The Engineer shall regulate the proportion of fine to coarse aggregate to secure the maximum density and in general the proportions in terms of the 3 ingredients shall approximate the following normal ratios for the several classes of concrete:

Class A 1 - 2 - 4
Class B 1 - $2\frac{1}{2}$-5
Class C 1 - 3 - 6
Class D 1 - 2 - 3

When the class of concrete required is not expressly indicated on the Plans, the following requirements shall govern:

1. For superstructure , arch rings, walls or other parts of a structure having a least dimension less than 1 foot, and for all heavily reinforced concrete except where class D is used, and for concrete deposited under water, Class A concrete shall be used.

2. For substructures having a minimum thickness of at least 1 foot, and in which all steel is embedded at least 3 inches,(5" where below low water),and does not carry calculated stress, Class B concrete shall be used.

3. For unreinforced footings, not deposited under water, Class C concrete shall be used.

4. For railing, rail posts, and other very thin sections Class D concrete shall be used.

Materials. The Coarse Aggregate shall consist of Broken Stone or Gravel conforming to the following requirements;

Broken stone shall consist of clean tough durable fragments of rock (excluding schist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces, soft or disintegrated stone, dirt, organic or other injurious matter occurring either free or as a coating on the Stone. All stone shall have a per cent of wear of not more than 6. All limestone shall meet the requirements of the Soundness Test.

Gravel shall consist of clean hard durable uncoated pebbles having a per cent of wear of not more than 15 (abrasion test for gravel) and shall be free from, soft, thin or laminated pieces, disintegrated Stone, dirt, organic or other injurious matter occurring either free or as a coating on the Stone. Where reinforcing steel is to be used gravel shall be free from salt and alkali. Pit or Bank run gravel shall not be used.

Grading: Coarse Aggregate shall be well graded, and when tested by laboratory methods, 95 to 100% shall be retained on the $\frac{1}{4}$-inch screen for all classes.

For Class A, 95 to 100% shall pass the $1\frac{1}{2}$, and 40 to 75 shall pass the 3/4 inch screen. For Massive sections of AConcrete Class B grading may be used when expressly permitted.

For Class B 95 to 100% shall pass the $2\frac{1}{2}$, and 40 to 75% shall pass the $1\frac{1}{4}$ and be retained on the 3/4 inch screen.

For Class C 95 to 100% shall pass the 3, and 40 to 75% shall pass the $1\frac{1}{2}$ and be retained on the 1 inch screen.

For Class D all shall pass the 3/4, and 30 to 75 shall pass the $\frac{1}{2}$ inch screen.

When "A" concrete is required in thin sections less than 6 inches in thickness, the material shall all pass the 3/4 inch screen.

Coarse Aggregate conforming in all respects to the above requirements except grading may be used, provided that concrete made from such material meets the requirements of the Strength Test hereinafter specified.

Fine Aggregate shall consist of sand, or a combination of sand and not more than 50% of stone screenings, conforming to the following requirements:

Sand shall be composed of clean, hard, durable uncoated grains, free from lumps, soft or flaky particles, loam, organic or other injurious matter. Where reinforcing steel is to be used sand shall be free from salt and alkali.

Stone screenings shall consist of the clean dustless product resulting from the crushing of stone, meeting all the requirements for Coarse Aggregate except for grading, and free from lumps.

Fine Aggregate shall be well graded from coarse to fine and shall meet the following requirements:

Passing the $\frac{1}{4}$ inch screen	95 to 100%
Passing 20 mesh sieve	35 to 70%
Passing 50 mesh sieve	5 to 30%
Passing 100 mesh sieve	0 to 5%

Weight removed by elutriation test not more than 3%

When subjected to the color test for organic impurities, the Fine Aggregate shall not show a color darker than the standard color.

Fine Aggregate conforming to all requirements except grading and color, and mortar strength hereinafter specified, may be used provided that concrete made from such material shall meet the requirements of the Concrete Strength Test hereinafter specified.

The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness.

[illegible] shall not be used until the source of supply has been approved. If at any time the water from this source shall become of unsatisfactory quality or insufficient quantity the Contractor may be required to provide satisfactory water from some other source. Water of doubtful quality shall be tested in briquets as provided under "Mortar Strength" of this specification and the test results shall be equal to those made from water of known satisfactory quality.

Mortar Strength: When the Fine Aggregate is mixed with Portland cement in the proportion of 1:3, the tensile or compressive strength ratio compared to Ottawa sand mortar briquettes of the same proportions and consistency shall be not less than 100% at 7 and 28 days.

Concrete Strength Test: Concrete materials may be submitted to the following test and shall be considered to pass the Concrete Strength Test when the following strength requirements are fulfilled. In no case, however, shall aggregate be used which contains more than 3% of material removable by the Elutriation Test, nor shall coarse aggregate contain more than 1½% of clay or dust.

The Coarse Aggregate, Fine Aggregate and Cement and Water proposed for use, shall be mixed in the same proportions and to the same consistency that they are to be used in the work, and tested as prescribed in U.S. Department of Agriculture Bulletin No. 1216, and at least the following compression strengths shall be obtained, for the several classes:

Class	7 day test	28 day test
A	1300	2000
B	1000	1700
C	900	1500
D	1700	2500

The 7 day requirements may be waived. The exact proportions may be varied, with the approval of the Engineer, to obtain the strength desired and the new proportions used in the work, but the proportions of cement to total aggregate shall not be less than hereinafter prescribed, only such proportions shall be used as will produce a workable mixture, and no allowance shall be made the Contractor for altered or additional work or material involved in the reproportioning.

Hydrated Lime: This material delivered to the work in the original packages may be used to an amount not exceeding 10% by volume of the Portland cement. Each package shall be clearly marked to show the brand, the net weight, the name of the manufacturer, and place of manufacture. It shall comply with the correct specifications of the "American Society for Testing Materials." current

For hand mixed concrete the lime shall be well mixed while dry, It shall be considered as an additional material, not as replacing any cement. The use of hydrated lime, unless otherwise specified, is optional with the Contractor except that it shall not be used in concrete deposited under water, and no compensation for it will be allowed the Contractor.

All sampling of materials shall be as required in U. S. Department of Agriculture Bulletin No. 1216. Cement shall be packed, shipped, stored and inspected as prescribed in Bulletin No. 1216.

The method of storing and handling aggregate on the work shall be such as to avoid segregation of sizes, and mixture of the material with mud, dust or trash. When deemed necessary, the Engineer may order the use of platforms for the storage of coarse aggregate. Aggregate shipped in dirty cars or containers, or that becomes mixed with weeds, dirt or foreign material or that is not uniform, or the component parts of which have become segregated will be rejected. Preferably no aggregate shall be stored or dumped on the road bed.

Construction Methods: All equipment, tools and machinery used for hauling materials and performing any part of the work must be approved by the Engineer and must be maintained in satisfactory working condition.

Falsework for supporting concrete work shall be built on foundations of sufficient strength to carry the load without appreciable deformation. Falsework which cannot be founded on solid footings must be supported by ample falsework piling. Falsework shall be designed to carry the full loads coming upon it. For single span bridges falsework shall be given a permanent camber equal to one-twentieth inch per foot of clear span. Multiple span bridges shall be given the amount of camber specified on the Plans. In general, double wedges or other suitable means shall be provided for constructing falsework and forms to correct lines. On important structures, when requested by the Engineer, the Contractor shall submit plans for falsework and forms for checking and approval before the falsework is constructed. No extra compensation will be allowed for falsework.

Wood or metal forms shall be constructed of materials sufficient in strength to hold the concrete without bulging between supports. The material to be used in wood forms for exposed surfaces shall be sized and dressed lumber, free from knot holes, loose knots, cracks, splits, or other defects affecting its strength, the accuracy or the appearance of the finished concrete surfaces, and in general shall be at least $1\frac{1}{2}$ inches thick. Tongue and grooved material may be required by the Engineer. If metal forms are used all bolt and rivet holes shall be counter-sunk so that a plane smooth surface will be obtained.

In designing forms and centering, the concrete shall be treated as a liquid weighing 150 pounds per cubic foot for vertical loads, and 85 pounds per cubic foot for horizontal pressure. The unsupported length of the wooden columns and compression members shall not exceed 30 times the diameter or least side.

Forms shall be so designed and constructed that they may be removed without injury to the concrete. Blocks and bracing shall be removed with the forms and in no case shall any portion of the wood forms be left in the concrete. Special attention shall be paid to the ties and bracing, and where the forms appear to be insufficiently braced, or unsatisfactorily built, either before or during construction, the Engineer shall order the work to be stopped until the defects have been corrected to his satisfaction. If the forms bulge or sag at any point when the concrete is placed in them, the portion of concrete causing the distortion shall be immediately removed and the forms properly repaired and strengthened before continuing the work. The forms shall be so constructed that the finished concrete shall be of the form and dimensions as shown on the plans and true to line and grade.

Forms shall be filleted at all sharp corners and shall be given a bevel in the case of all projections such as girders, copings, etc., sufficient to insure their easy removal.

To insure a first-class surface finish on the concrete, the forms shall be painted with a colorless oil, or some other satisfactory means taken to prevent the concrete adhering to them. The forms shall be thoroughly drenched with water immediately before the concrete is placed in them. They shall be inspected immediately preceding the placing of concrete, any bulging or warping shall be remedied, and all dirt, sawdust, shavings or other debris within the forms shall be removed.

For narrow walls where access to the bottom of the forms is not readily attainable otherwise, the lower form boards shall be left loose so that they may be removed for cleaning out all chips, dirt, sawdust or other extraneous material immediately prior to placing concrete.

Form lumber which is used a second time shall be thoroughly cleaned and shall be free from bulge, splits or warps.

Measuring Materials. All materials shall be separately and accurately measured, by volume unless otherwise specified, and each batch shall be uniform. The Coarse and Fine Aggregate shall be measured loose and separately. No computed change in volume for moisture content shall be considered. A bag of cement (American) as packed by the manufacturers and weighing 94 pounds shall be considered 1 cubic foot. The Contractor shall furnish and use approved measuring boxes, pans or mechanical devices, which in operation will give the exact volumes of coarse and fine aggregate required for the several classes of concrete required, and so designed and plainly marked that the Inspector can accurately and conveniently check the quantities of each aggregate actually being used.

Consistency: The quantity of water to be used shall be determined by the Engineer, and not varied without his consent. The Contractor shall furnish and use with the mixer an approved adjustable water measuring device which will prevent excess water flowing into the mixer in order that the consistency may be under positive control, and that all batches may be of the same consistency.

In general the minimum amount of water shall be used which will produce the required workability. The mortar shall cling to the coarse aggregate, and shall show no free water when removed from the mixer. The concrete when being transported in a clean metal chutes at an angle of 30° to the horizontal shall slide, and not flow, and when dropped directly from the discharge chute of the mixer, shall flatten out at the center of the pile, but shall stand up and not flow at the edges. The upper surface of the set concrete shall show a cement film upon the surface, but shall be free from laitance. In no case shall an amount of water be used sufficient to cause the collection of a surplus on the surface.

Mixing Conditions: The concrete shall be mixed in the quantities required for immediate use and any which has developed initial set, or which is not in place within 30 minutes after the water has been added, shall not be used. No concrete shall be mixed while the air temperature is at or below 35 degrees F. without the approval of the Engineer. Retempering of concrete or mortar will not be allowed.

Mixing: The mixing shall be done in a batch-mixer of approved type which will insure the uniform distribution of the material throughout the mass so that the mixture is uniform in color and smooth in appearance. The mixing shall continue for a minimum time of 1½ minutes after all the ingredients are assembled in the drum, during which time the drum shall revolve at the speed for which it was designed but shall make not less than 14 nor more than 20 revolutions per minute. The mixer shall be equipped with an attachment for satisfactorily locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch. The mixer shall be equipped with bucket and boom delivery unless otherwise permitted by the Engineer, have a capacity of not less 3 bags of cement per batch of concrete of the composition herein specified, and a speed regulator to hold the mixer to its normal speed of revolution.

Hand Mixing: Hand mixing will not be allowed except with the specific permission of the Engineer on very small jobs or in case of an emergency. When hand mixing is permitted it shall be done on a water-tight platform. The fine aggregate and cement shall first be mixed until a uniform color is attained and then spread over the mixing board in a thin layer.

The coarse aggregate, which shall have been previously drenched, shall then be spread over the fine aggregate and cement in a unifrom layer and the whole mass turned as the water is added.

After the water has been added, the mass shall be turned at least six times, and more if necessary, to make the mixture uniform in color and smooth in appearance. Hand-mixed batches shall not exceed one-half cubic yard in volume.

Placing: No concrete shall be poured in foundation until the Engineer has approved the depth and character of the foundation, nor shall any concrete be poured in forms until the Engineer has approved the placing of the steel.

The concrete shall be placed in the forms immediately after mixing and in such manner as to avoid the separation or segregation of the aggregate. The mixing plant shall be equipped and arranged so as to permit the mixing and placing of the concrete quickly and uniformly.

In depositing the concrete, care shall be taken to entirely fill the form, and to compact the concrete by continuous tamping , slicing and spading, but not to bulge or distort the forms or to disturb their alignment. Any porous section shall be removed at the expense of the Contractor.

When concrete is deposited through chutes, the angle of the same with the horizontal shall be such as will allow the concrete to slide slowly and without separation of the aggregate. The delivery from the spout shall be as close as possible to the point of deposit. Chutes shall preferably be of metal, but if of wood, metal lined, they shall be kept clean and free from material adhering to their sides and shall be thoroughly flushed with water before and after each run.

The use of long chutes will be allowed only with written permission of the Engineer, and such permission will not be given for work which will be exposed to salt or brackish water.

Pipes when used shall be kept full of concrete, and the discharge end shall be kept buried in fresh concrete, and shall meet the requirements prescribed for tremies.

Depositing large quantities at one point in the forms, and running and working it along the forms, will not be permitted. Special care shall be taken in filling the forms, to work the coarser aggregate away from the face of the forms and to force the concrete under and around the reinforcement. The concrete shall be worked with a steel slicing rod, or other satisfactory implement, in such a manner as to bring a thick layer of mortar in contact with the forms and reinforcement, and to prevent the formation of pockets of stone.

All faces shall be spaded. Portions inaccessible to slicing rod or spade shall be worked by vibrating the forms by wooden mallets or as directed by the Engineer. After the concrete has taken its initial set care shall be exercised to prevent walking on the concrete, to avoid jarring the forms or knocking or straining projecting reinforcement.

Concrete shall be placed in continuous horizontal layers in general not over one foot in thickness. When a monolithic layer cannot be completed in one operation, it shall be terminated with a vertical bulk head. No feathering out will be tolerated. The batches of concrete shall follow the preceding batch closely before any initial set can take place in order to prevent lines of demarcation between batches. Successive horizontal layers shall be bonded to each other. The surface of each layer shall be left rough or other provision for bonding made as required.

Joints: Joints may be Constructed Joints or Expansion Joints of either the sliding or filled type.

Construction Joints: Wherever the work of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. So far as possible the location of construction joints shall be planned in advance and the placing of concrete carried continuously from joint to joint. These joints shall be perpendicular to the principal lines of stress and, in general, shall be located at points of minimum shear.

Where dowels, reinforcing bars, or other adequate ties are not shown on the Plans or required by the Engineer, keys shall be made by embedding water-soaked beveled timbers of a size shown on the details, or as directed by the Engineer, in the soft concrete, which shall be removed when the concrete has set. In resuming work, the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance or other soft material, with stiff wire brushes, and if deemed necessary by the Engineer, shall be roughened with a steel tool. The surface shall then be thoroughly washed with clean water and painted with a thick coat of neat cement mortar after which the placing of concrete may proceed.

No Concrete work shall be stopped or temporarily discontinued within 18 inches of the top of any finished surface, unless such work is finished with a coping having a thickness less than 18 inches, in which case the joint shall be made at the under line of the coping.

In construction joints exposed to view where seepage of water is particularly objectionable, a metal baffle strip, preferably of copper, zinc or sheet lead, shall be inserted. The strip shall be placed not less than 3 inches from the face of the concrete and shall extend into each section of the concrete a distance of not less than 2 inches.

Sliding Joints shall be constructed as provided at ends of slabs, girders or beams or between walls etc. The surface of the supporting concrete shall be given a smooth finish and covered with two layers of 3-ply roofing felt or other material as prescribed to separate the concrete. All metal sliding surfaces shall be coated with graphite and grease just before being placed in position, and care shall be exercised to prevent any deposit of concrete which will interfere with the sliding action.

Concreting in Cold Weather: No concrete shall be placed when the atmospheric temperature is below 35 degrees Fahrenheit unless permission to do so is granted in writing by the Engineer. When such permission is given the following requirements shall govern:

The Contractor shall furnish sufficient canvas and framework, or other type of housing to enclose and protect the structure in such a way that the air surrounding the fresh concrete can be kept at a temperature of not less than 45 degrees Fahrenheit for a period of 5 days after the concrete is placed.

Sufficient heating apparatus, such as stoves, salamanders, or steam equipment, and fuel to furnish all required heat, shall be supplied. All water used for mixing concrete shall be heated to a temperature of at least 70 degrees, but not over 150 degrees Fahrenheit. Aggregates shall be heated either by steam or by dry heat to a temperature of at least 70 degrees, but not over 150 degrees Fahrenheit. The heating apparatus shall be such as to heat the mass uniformly and preclude the possibility of the occurrence of hot spots which will burn the material. The temperature of the mixed concrete shall not be less than 60 degrees Fahrenheit at the time of placing in the forms.

The Contractor shall assume all risk connected with the placing of concrete during freezing weather and permission given by the Engineer to place concrete during such time will in no way relieve the Contractor of responsibility for satisfactory results. Should concrete placed under such conditions prove unsatisfactory, it shall be rejected. It is understood that the Contractor is responsible for the quality and strength of concrete placed under any weather conditions.

Depositing in Water: Concrete shall be deposited in water only with the permission of the Engineer and under his supervision. It shall be Class "A" concrete with 10% of excess cement. The coffordams shall be sufficiently tight to prevent any current passing through the space in which the concrete is to be deposited. Pumping will not be permitted in the coffordams while the concrete is being placed, nor until it has reached its initial set.

When depositing in water is allowed the concrete shall be carefully placed in the space in which it is to remain 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. No concrete shall be placed in running water, and forms which are not reasonably water-tight shall not be used for holding concrete deposited under water. Depositing shall be regulated to produce approximately horizontal surfaces.

When a tremie is used, it shall consist of a tube having a diameter of not less than 10 inches, constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit the free movement of the discharge end over the entire top surface of the work and shall be such as to permit it to be rapidly lowered when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow is then stopped by lowering the tremie. The flow shall be continuous and in no case shall be interrupted until the work is complete.

When concrete is placed by means of a bottom dump bucket, the bucket shall have a capacity of not less than $\frac{1}{2}$ cubic yard, The bucket shall be lowered gradually and carefully until it rests upon the concrete already placed. It shall then be raised very slowly during the discharge travel, the intent being to maintain, as nearly as possible still water at the point of discharge and to avoid agitating the mixture.

Rubble or Cyclopean Concrete: Rubble or cyclopean concrete shall consist of either Class "B" or Class "C" concrete in which is imbedded large individual stones in accordance with the following requirements.

This class of concrete shall be used only in massive piers, gravity abutments and heavy footings and only with the approval of the Engineer.

The stone for this class of work shall be of the quality required for coarse aggregate, and may be one-man stone or derrick stone as specified hereinbelow.

The stone shall be carefully placed (not dropped or cast) and the method of placing shall be such as to avoid injury to the forms or to the partially set adjacent masonry. Stratified stone shall be placed upon its natural bed. All stone shall be thoroughly saturated with water before being placed.

The total volume of the stone used shall not be greater than one-third of the total volume of the portion of the work in which it is placed.

For walls or piers greater than 2 feet in thickness, one-man stone may be used. Each stone shall be completely surrounded by a layer of concrete not less than 6 inches in thickness. No stone shall extend above a point one foot below the top surface of any wall or pier nor shall it extend within less than 8 inches of any coping.

For walls or piers greater than 4 feet in thickness derrick stone may be used. Each stone shall be completely surrounded by a layer of concrete not less than one foot in thickness. No stone shall extend above a point of 2 feet below the top surface of any wall or pier nor shall it extend within less than 8 inches of any coping.

Concrete Exposed to Sea Water: For concrete exposed to the action of sea water, the following requirements shall govern:

Concrete for walls 2 feet or less in thickness shall be mixed in the proportions specified for Class "A" concrete with ten per cent additional cement. For mass walls, that portion of the surface exposed to the action of salt water and for a distance of at least 2 feet inward from the exterior of the mass shall be constructed as above specified, while the interior of the mass may be constructed of concrete as specified on the Plans and mixed in the ordinary manner. The original surface as the concrete comes from the forms shall be left undisturbed. In order to secure a thick and dense surface film, the form surfaces shall be heavily coated with shellac or an approved form oil. No construction joints shall be located between points 2 feet below extreme low water and 4 feet above extreme high water.

In general, reinforced concrete shall not be used in sea water. However, when it is used, the reinforcement shall be placed as far from the surface as is consistent with the design and shall be proportioned to withstand a stress of not more than 3/4 of the allowable stress. The minimum clear distance from the face of the concrete to the nearest face of any reinforcing bar shall in no case be less than 5 inches except in precast concrete piles where a 3 inch minimum may be used.

Concrete exposed to the action of drift or to impact and abrasion from any cause shall be protected by encasing that portion of the surface, extending from an elevation at least 4 feet above high tide to an elevation 4 feet below low tide, with a special sheathing or protective armor as shown on the Plans or noted in the supplemental specifications and provision shall be made in the size of the original cofferdam for sufficient clearance to permit access to the masonry surface for the installation and effective anchorage of this sheathing.

The protective armor above noted may be of metal plates, a vitrified brick or dense stone facing, a dense mortar facing placed simultaneously with the interior of the wall by means of baffle plates, treated timber sheathing or other approved construction.

When so specified, the cofferdam may be constructed above the mud line with treated material and left permanently in place. In this case, the space between the neat masonry lines and the interior of the cofferdam shall be filled with waterproof material.

Concrete between the tide limits above specified shall not in any case, be deposited in sea water. In no case shall fresh concrete within these limits be exposed to the action of sea water nor shall salt water be allowed to come in contact with the concrete until it shall have been allowed to set for at least 30 days and preferably for a longer period.

Concrete piles when used in alkali soils shall, unless otherwise specified, be subject to the same requirements as are provided hereinabove for concrete piles in sea water.

Concrete exposed to Alkali Soils or Water: In general, the same requirements as above specified for concrete in sea water shall govern the construction of concrete in alkali soils or water. When so specified, the forms below the ground line may be constructed of treated timber, waterproofed with a brush coating of a suitable bituminous material, and left permanently in place. In lieu of the above, the surface of the concrete below ground may be treated with an approved system of membrane waterproofing or may be protected by a sheathing of suitable design. Concrete shall not be allowed to come in contact with alkali soil or water until it shall have been allowed to set for at least thirty days and for a longer period if possible. No construction joints shall be permitted below an elevation of two feet above the ground line. The surface film shall be left intact as it comes from the forms. To secure a heavy and dense surface film, the form surfaces shall be heavily coated with shellac or an approved from oil. The soil around footings placed in alkali soil shall be thoroughly and effectively drained to avoid a concentration of salts at or around the footings.

Removal of Forms: In order to make possible the obtaining of a satisfactory surface finish, forms on ornamental work, railings, parapets, and exposed vertical surfaces shall be removed in not less than 12 nor more than 48 hours, depending upon weather conditions. Forms shall always be removed from columns before removing shoring from beneath beams and girders, in order to determine the condition of concrete in the columns.

The following table shall serve as a guide for the minimum time required before the removal of forms, not counting the days in which the temperature is below 40 degrees Fahrenheit.

Centering under beams	28 days
Floor slabs	14 to 28 days
Walls	7 days
Columns	10 days
The sides of beams, and all other parts	7 days

No forms whatever shall be removed at any time without the consent of the Engineer. Such consent shall not relieve the Contractor of responsibility for the safety of the work. As soon as the forms are removed all bolts, wires, or other appliances which hold the forms and which pass through the concrete shall be cut off or set back one inch below the surface. All rough places, holes and porous spots shall be filled with mortar composed of 1 part Portland Cement to 2 parts sand.

Defective Work: Any defective work discovered after the forms have been removed, shall be removed immediately and renewed. If the surface of the concrete is bulged, uneven, or shows excess honey combing or form marks, which in the opinion of the Engineer cannot be repaired satisfactorily, the entire section shall be removed and renewed and no compensation will be allowed for the work or material.

Curing Concrete: Careful attention shall be given by the Contractor to the proper curing of concrete handrails, floors and finished surfaces. Such surfaces shall be protected from the sun and the whole structure shall be kept wet for a period of at least 7 days. All concrete floors shall be covered as soon as possible with sand, earth, or other suitable material and kept thoroughly moistened for a period of at least 10 days by sprinkling each morning and evening, or more frequently if deemed necessary by the Engineer. The covering material shall not be cleared from the surface of the concrete floor for a period of at least twenty-eight days.

Unless otherwise permitted by the Engineer, concrete bridge floors shall be closed to traffic for a period of at least twenty-one days after placing , and for such additional time as it may be deemed advisable.

Finish: The external surface of concrete shall be given one of the following finishes as required on Plans.

Class 1 - surface finish: As soon as the pointing has set sufficiently to permit it, the entire surface shall be thoroughly wet with a brush and rubbed with a No. 16 carborundum stone or an abrasive of equal quality bringing the surface to a paste. The rubbing shall be continued sufficiently to remove all form marks, and projections, producing a smooth dense surface without pits or irregularities.

The material which, in the above process has been ground to a paste, shall be carefully spread or brushed uniformly over the entire surface and allowed to take a "reset". The final finish shall be obtained by a thorough rubbing with a No. 30 carborundum stone or an abrasive of equal quality This rubbing shall continue until the entire surface is of a smooth texture and uniform in color.

After the final rubbing is completed, the surface shall be thoroughly drenched and kept wet for a period of seven days, unless otherwise directed.

Railing balusters and other precast members which have been disfigured by the drip from the abrasive shall be thoroughly cleaned by means of a dilute solution of muriatic acid.

Class 2 - Surface Finish: After the pointing has set sufficiently to permit it, the entire surface shall be thoroughly wetted and rubbed with a No. 16 carborundum stone or an abrasive of equal quality to bring the surface to a smooth texture and remove all form marks. The paste formed by the rubbing as above described may be finished by carefully stripping with a clean brush, or it may be spread uniformly over the surface and allowed to take a "reset," after which it may be finished by floating with a canvas, carpet-faced or cork float or rubbed down with dry burlap.

Treatment and Finish for Horizontal Surfaces not Subjected to Wear: All upper horizontal surfaces such as the tops of handrail posts and caps and the tops of parapets, copings, and bridge seats shall be formed by placing an excess of material in the forms and removing or striking off such excess with a wooden templet, forcing the coarse aggregate below the mortar surface. The use of mortar topping for concrete railing caps and other surfaces falling under this classification shall in no case be permitted.

The final finish for caps and railings shall be obtained in one of the following ways:

(a) Brush Finish: After the concrete has been struck off as above described, the surface shall be thoroughly worked and floated with a wooden, canvas, or cork float, the operation to be performed by skilled and experienced concrete finishers. Before this last finish has set, the surface shall be lightly striped with a fine brush to remove the surface cement film, leaving a fine-grained, smooth, but sanded texture.

(b) Float Finish: In lieu of the above, the surface may be finished with a rough carpet float or other suitable device leaving the surface even, but distinctly sandy or pebbled in texture.

(c) Ground or Terrazzo Finish: When specified, the upper surface of rail caps, parapets, etc., may be finished by grinding with a carborundum stone, or equally good abrasive, to a smooth dense, terrazzo finish. Finish of this character shall be done as follows:

Using a No. 16 carborundum stone or an abrasive of equal quality, the surface shall be ground dry or in water until it is smooth and the individual pebbles and aggregate particles are cut and polished. The surface shall then be completely cleansed with water, and the final rubbing done by means of a No. 30 stone. The finished surface shall present the texture of polished marble and shall show the various aggregate particles in polished outline.

(d) Other Types: Special types of rail cap finish such as "tooled finish,""sand blasted finish," etc., shall be done in accordance with the general requirements governing "Special Surface Finishes" as hereinafter provided.

Special Surface Finishes: When so specified, special surface finishes may be employed for ornamental panels, coping and like construction. In general, the method and manner of performing this work will be fully provided for in the special provisions for the particular work in question.

In each case, the Contractor shall be required to prepare test or sample panels under the direction of the Engineer and 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.

Following are typical general requirements for the principal types of special surface finishes.

Tooled Finish: Finish of this character for panels and other like work may be secured by the use of a bush-hammer, pick, crandall, or other approved tool. Air tools shall preferably be employed. No tooling shall be done until the concrete has set for at least fourteen days and as much longer as may be necessary to prevent the aggregate particles from being "picked" out of the surface. The finished surface shall show a grouping of broken aggregate particles in a matrix of mortar, each aggregate particle being in slight relief.

Sand Blast Finish: The type of finish, required in this method shall be similar to that above described for tooled finish, but finer grained in texture. The sand blasting must be done by means of approved equipment and in such manner as to produce an even, fine grained surface in which the mortar has been cut away leaving the aggregate particles exposed.

Wire Brush or Scrubbed Finish: This type of finish shall be produced by scrubbing the surface of a green concrete with stiff wire or fiber brushes using a solution of muriatic acid in the proportion of 1 part acid to 4 parts water. As soon as the forms are removed and while the concrete is yet comparatively green, the surface shall be thoroughly and evenly scrubbed as above described until the cement film or surface is completely removed and the aggregate particles are exposed leaving an even pebbled texture presenting an appearance grading from that of fine granite to coarse conglomerate, depending upon the size and grading of aggregate used. Granite chips or colored aggregates may be used in this connection if desired. As soon as the scrubbing has progressed sufficiently to produce the texture desired, the entire surface shall be thoroughly washed with water to which a small amount of ammonia has been added, to remove all traces of the acid.

Methods of Measurement. All concrete conforming to the specifications and Plans and placed as directed shall be measured by the cubic yard in place. In computing the concrete yardage for payment, the dimensions used shall be those shown on plans or ordered in writing by the Engineer. No measurements or other allowances will be made for work or material for forms, falsework, coffordams, pumping, bracing, etc. No deductions in measurement will be made for panelling less than 6 inches in width.

Basis of Payment. Payment will be made for the yardage of accepted concrete measured as prescribed above at the contract unit price bid per cubic yard for Class, A, Class B, Class C or Class D concrete, as the case may be. Such payment will be full compensation for all materials, forms, falsework, placing and finishing, all equipment, tools, labor and incidentals necessary to complete the item, except that steel reinforcement will be paid for as a separate item.

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86. REINFORCING STEEL

Description. Under this item, reinforcing steel of the type, size and quantity designated shall be furnished and placed in concrete structures as required by these specifications and shown on the Plans.

Materials. Reinforcing steel shall meet the requirements of the American Society for Testing Materials, Standard Specifications for Billet Steel Concrete Reinforcement bars, Serial Designation A15-14, with subsequent amendments. Unless otherwise designated upon the Plans, all bar or fabric reinforcement shall be made from open hearth steel of the structural grade. Intermediate grade may be used if authorized by the Engineer.

When deformed bars are specified, the form of the bar must be such as to provide a net section at all points equivalent to that of a plain square or round bar of equal nominal size. Twisted bars will be used only by permission of the Engineer.

Steel fabric for this style of reinforcement shall be cold drawn from rods hot rolled from billets. The wire, after fabrication, shall have a minimum tensile strength of seventy thousand pounds per square inch, and shall withstand being bent cold, around its own diameter, through one hundred and eighty degrees, without cracking on the outside of the bent portion.

Construction Methods. Steel reinforcement shall be stored above the surface of the ground upon platforms, skids or other supports, and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, it shall be free from dirt, scale, dust, paint, oil or other foreign material.

The reinforcement shall preferably be bent cold to the shapes indicated on the Plans in the shop before shipment and not in the field.

Steel reinforcement shall be placed in the exact position as shown on the plans and held securely in place during the placing of the concrete. Vertical stirrups shall always pass around the main tension members and be securely attached thereto. The reinforcing steel in all concrete masonry walls shall be spaced its proper distance from the face of the forms by means of approved precast mortar or concrete blocks. All horizontal reinforced steel shall be spaced vertically by means of approved precast mortar or concrete blocks. All reinforcing steel shall be wired together at the intersections as shown on the Plans or as directed by the Engineer. Before any concrete is placed all mortar shall be cleaned from the reinforcement.

No concrete shall be deposited until the Engineer shall have inspected the placing of the reinforcing metal and given permission to place concrete. All concrete placed in voilation of this provision shall be rejected and removed.

Splices. All reinforcement shall be furnished in the full lengths indicated upon the Plans. No splicing of bars, except where shown on the Plans, will be permitted without the written approval of the Engineer. Splices which are permitted will have a length of not less than 40 times the nominal diameter of the reinforcement, and shall be well distributed or else located at points of low tensile stress. No splices will be permitted at points where the section is not sufficient to provide a minimum distance of two inches between the splice and the nearest adjacent 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.

Sheets of metal mesh shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges.

Basis of Payment. The reinforcing steel used in concrete structures will be paid for at the contract price per pound for the theoretical weight, as shown on Plans and this price shall be payment in full for furnishing, bending, fabricating, and placing the reinforcement, for all clips, metal spacers, ties, wire or other material used for fastening reinforcement in place., and for all tools, labor, equipment and all incidentals necessary to complete this work. Reinforcement for concrete railing and piling shall be paid for as provided for in the specifications for those items.

83-94-1622-22

87. STRUCTURAL STEEL

Description. This item shall consist of Structural steel, Rivet, and Eyebar, Steel, Steel Forgings, Wrought Iron, Steel Castings, Gray Iron Castings, Malleable Castings and Phosphor Bronze, complying with the dimensions and shapes prescribed on the Plans, shall be furnished, placed and erected as shown thereon in accordance with these specifications.

Materials. Structural steel, Rivet and Eyebar Steel shall fulfill the requirements of the Standard Specifications of the American Society for Testing Materials for Structural Steel for Bridges, Serial Designation A7-21 with amendments to date. The other materials mentioned above shall be manufactured according to the Standard Specifications of the American Society for Testing Materials, Serial Designation, A20-21, A41-18, A27-21, A48-18, A47-19, B22-21 with amendments to date. A coupon giving the analysis of the melt from which the material was made shall be furnished with each shipment.

In attition materials shall conform to the following requirements and shall be in all respects satisfactory to the Engineer.

Except where otherwise provided, all members shall be of structural steel and rivets shall be of rivet steel. Forgings shall be of carbon steel, and shall be thoroughly annealed before machine finishing. Castings shall be of cast steel or cast iron, but, in general, cast iron shall be used only for the unimportant parts. Phosphor bronze may be used in expansion bearings. Class A metal shall be used for this purpose.

Structural material delivered at the bridge shop receiving yard shall be stored above the surface of the ground upon platforms, skids, or other supports, and shall be protected as far as practicable from the surface deterioration by exposure to conditions producing rust. It shall be kept free from accumulations of dirt, oil, or other foreign matter. Fabricated material stored prior to shipment shall be subject to the same conditions of storage as the unfabricated material in the shop receiving yard.

Construction Methods. Structural steel shall be inspected, tested, handled, fabricated and erected as prescribed under "Steel Structures." The workmanship shall be satisfactory to the Engineer, and in conformity with the Plans.

Weight Determination. The payment shall be based on the weight of metal in the fabricated structure, including field rivets shipped. The weight or erection Bolts, field, paint, and all boxes, crates or other containers used for packing, together with sills, struts, and rods used for supporting members during transportation shall be excluded.

Weights paid for shall be shop scale weights unless otherwise provided. If specified in the contract or permitted by the Engineer, computed weights as hereinafter provided may be made the basis of payment.

For the purpose of payment, such minor items as bearing plates, pedestals, etc., shall, unless otherwise provided, be considered as structural steel even though made of other materials.

Payment for all material used in full size tests shall be made on a pound price basis. The scarp value of all material tested to destruction shall be allowed as a credit upon such payments. Payment will not be allowed for material used in full size tests, which does not comply with the specifications.

Variation in Weight. If the weight of any member is more than 2 percent less than the computed weight, it may be cause for rejection.

If the total scale weight of any structure exceeds the computed weight by more than 2 percent, the weight in excess of 2 percent above the computed weight shall not be paid for.

Finished work shall be weighed in the presence of the Inspector. The Contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various parts.

The weight of steel shall be assumed at 490 pounds per cubic foot. The weight of cast iron shall be assumed at 450 pounds per cubic foot.

The weights of rolled shapes and of plates up to and including 36 inches in width, shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts, and open holes.

The weights of plates wider than 36 inches shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts and open holes. To this shall be added one-half of the allowed percentages of overrun in weight given in the Standard Specification for Structural Steel for Bridges, Serial Designation A7-21, of the American Society for Testing Materials.

The weight of heads of shop driven rivets shall be included in the computed weight, assuming the weights to be as follows:

Diameter of Rivet	Weight for 100 heads.
1/2"	4.0 Lbs.
5/8"	7.5 Lbs.
3/4"	12.5 Lbs.
7/8"	18.5 Lbs.
1"	27.0 Lbs.

The weight of castings shall be computed from the dimensions shown on the approved shop drawings, with an addition of 10 per cent for fillets and overrun.

To the total computed weight of metal may be added an allowance of 0.4 of one per cent for shop paint.

Beofre final payment is made the Contractor shall furnish the Engineer four sets of bills showing tabulated scale weights and four sets of bills showing weights computed from Shop Detail Plans.

Basis of Payment. Structural Steel shall be paid for at the contract unit price bid per pound for "Structural Steel" which price shall be full compensation for all material, fabrication, shop work, transportation and erection, all equipment, tools, labor and incidentals necessary to complete the work.

When there is no separate item for structural steel, metal drains or expansion plates used in the construction of concrete bridges, these materials will be paid for at the same price bid for steel reinforcement unless otherwise provided.

88. DRY RUBBLE MASONRY

Description. This item shall be composed of approved stones laid up without mortar and so as to fit neatly and firmly, and shall be constructed in accordance with these specifications and in conformity with the form, dimensions, and design prescribed on the Plans or directed by the Engineer in writing.

Materials. The stones shall be sound, durable, free from structural defects, and shall be free from rounded, worn, or weathered surfaces, and clean of earth, clay or other foreign substances. No stone shall be used which has a minimum thickness of less than five inches, a minimum width of less than twelve inches, or which is less than one-half cubic foot in volume. In the lower course of a dry rubble wall, no stone shall be used which has a volume of less than one cubic foot. Small stones may be used for pinning and filling interstices in the heart of the wall.

Method of Construction. All dry rubble masonry shall be constructed by experienced workmen. The stone shall be roughly dressed on beds and joints and laid on natural beds, being well bonded, and breaking joints at least six inches. The stone must be laid with their bedding planes and lines of stratification in a horizontal position. Stones too large to be properly placed by hand shall be handled with a crane or derrick. Face stone shall be so laid that the exposed faces are practically parallel with the face of the wall. The joints on the face shall not be over 2 inches in width, other joints not over 4 inches in width. Headers shall be distributed uniformly through the wall, so as to form approximately one-fifth of the exposed faces, and shall extend through the face wall and into the backing a distance at least equal to their thickness. Where a wall is less than eighteen inches in thickness, the headers shall extend entirely through from front to back face. Where the wall is more than eighteen inches thick, the headers shall either extend entirely through or overlap at least six inches. Walls shall be built up so as to leave no appreciable open spaces, and only sufficient spalls shall be used to wedge the larger stones in place.

The top two layers of stone shall be laid in cement mortar composed of 1 part of Portland cement and 2 parts concrete sand. Sufficient mortar shall be used to completely fill all voids and the stones firmly embedded in the mortar. The top of the wall shall be pointed up in a neat workmanlike manner and the excess mortar leveled off to a smooth even surface.

Basis of Payment. This work will be measured in accordance with the dimensions shown on the plans, except where changes are ordered by the Engineer, and will be paid for at the unit price bid per cubic yard for "Dry Rubble Masonry" complete in place, which price will be full compensation for the coping and for all materials, equipment, tools, labor, and incidentals necessary to complete the item.

89. MORTAR RUBBLE MASONRY

Description. This item shall be composed of approved stones laid up in Portland Cement mortar, and shall be constructed in accordance with these specifications and in conformity with the form, dimensions, and design furnished on the plans or as directed in writing by the Engineer.

Materials. The Portland cement, sand, and water for the mortar shall be such as to conform with the respective requirements for these materials as contained in the specifications hereinbefore given for concrete.

The stone for rubble masonry shall be clean, hard, and of a kind known to be durable. All weathered stone shall be rejected. The individual stones shall have a thickness of not less than 3 inches and a width of not less than 8 inches. No stone shall have a length less than one and one-half times its width.

Construction Methods. All rubble masonry shall be constructed by experienced workmen. Selected stones, roughly squared and pitched to lines, shall be used at all angles and ends of walls. All stones shall be thoroughly wet prior to laying and be laid with practically horizontal beds. Large flat stones shall be selected for the bottom course. The stone must be laid with their bedding planes and lines of stratification in a horizontal position. Face stones shall be so laid that the exposed faces are practically parallel with the face of the wall and no projections extend over 2 inches beyond the face of the wall. All stones shall be fully bedded in Portland cement mortar, mixed in the proportion of one part of cement to two parts of sand, and shall be so placed as to break joints at least six inches and form a firm bond. Mortar which is not used within thirty minutes after water has been added shall be wasted. Retempering of mortar will not be permitted.

For mortar the sand and cement shall first be mixed dry in a tight box until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains consistency such that it can be easily handled and spread with a trowel.

Headers shall be distributed uniformly through the walls of the structures so as to form at least one-fifth of the exposed faces. They shall be of such lengths as to extend through the face wall into the backing a distance at least equal to the thickness of the headers, and where a wall is less than eighteen inches in thickness the headers shall extend entirely through from front to back face.

The interior of the walls shall be built up with the stones of which it is composed embedded in mortar and the voids filled with mortar and packed with spalls so that no open spaces will be left. Horizontal joints in the face shall not exceed one inch in thickness and vertical joints shall not exceed at any point two inches in width. No spalls shall be used in the face of a wall, and the face stones shall be so well bedded that none will be needed. Walls shall be provided with "weep holes" wherever called for on the plans or directed by the Engineer. If a stone is loosened after the mortar has set, it shall be removed, the mortar cleaned, and the stone relaid with fresh mortar.

This class of masonry shall be finished with a concrete coping or with a top course consisting of roughly shaped stones, not less than eight inches thick, from one and one-half to four feet long, and wide enough to cover the top of the wall, set in full mortar beds as shown on plans.

Copings, bridge seats, and back walls, when required, shall be made of the dimensions and materials shown on the plans, and when not otherwise specified shall be of Class A concrete. Copings shall be made in sections extending at least the full width of the wall, not less than eight inches thick, and in sections of from five to eight feet long. The sections may be cast in place or be molded and set in place in full mortar beds.

After the stone is all laid as above specified, the face joints shall be thoroughly cleaned of all mortar to a depth of one inch. The joints shall then be wetted and pointed with Portland cement mortar, mixed in the proportion of one part of cement to two parts of sand and suitable pigment to give the color required by the Engineer. No pointing shall be done in freezing weather, and any work damaged by frost shall be removed and replaced. Excess mortar must not be splashed against or rubbed on the face of the stone. The faces of the stone must be free from all mortar marks; any stone coated with mortar must be cleaned in the manner required by the Engineer. The wall must be kept wet while pointing is being done. In hot or dry weather the pointed masonry shall be satisfactorily protected from the sun and kept wet for a period of three days after completion.

No masonry shall be laid in freezing weather without the permission of the Engineer and the use of such precautions as he may direct to be taken. In hot or dry weather, the masonry shall be protected from the sun for at least three days after laying.

Basis of Payment. This work shall be measured complete in place in accordance with the dimensions shown on the plans, except where changes are ordered by the Engineer, and will be paid for at the unit price bid per cubic yard for "Mortar Rubble Masonry" complete in place, which price will be full compensation for the concrete coping or stone top course, whichever is required, and for all materials, equipment, tools, labor, and incidentals necessary to complete the item. The coping will be included in the measurement.

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90. REINFORCED CONCRETE PIPE

Description. Under this item reinforced concrete pipe conforming to these specifications, of the sizes and dimensions shown on the plans, shall be furnished and placed as directed.

Materials. Reinforced concrete pipe for culverts shall be of the bell and spigot type, or other type approved by the Engineer, with positive connection between sections, but the joints must be as strong as the body of the pipe and all reinforcement must be protected by at least 3/4 of an inch of concrete. The pipe shall be cast in sections not less than 3 feet nor more than 8 feet in length. All pipe shall be properly cured at least 2 weeks.

All concrete surfaces shall be reasonably true and even, free from porous or scaly spots, spalled edges and stone pockets. The sections shall be straight and true to the dimensions shown on the plans and shall have a uniform thickness throughout. Pipes having defective spots patched over shall not be used.

Portland Cement Concrete. Portland cement concrete used in the construction of reinforced concrete pipe shall conform to the requirements for Class D Concrete.

Reinforcement.. Reinforcement shall consist of woven wire mesh, expanded metal, rods, hoops, spirals or other forms adopted by the manufacturer and approved by the Engineer, and shall extend into the bell of the pipe. All reinforcement shall be manufactured from material that meets the requirements of the Standard Specifications for Billet Steel Concrete Reinforcement Bars of the American Society for Testing Materials, Serial A15-14.

Manufactured Pipe: Before purchasing pipe the Contractor shall secure approval by the Engineer of the materials, methods and specifications used by the manufacturers.

Load Test. When tested by the three point method of applying load in the curshing test as prescribed in U. S. Department of Agriculture Bulletin No. 1216, the pipe must show no crack under a load of 1000-D, where "D" is the inside diameter of the barrel in feet, and shall develop an ultimate strength of 1500-D.

Absorption. The maximum average absorption as obtained by the absorption test as prescribed in Bulletin No. 1216, shall not exceed 8 per cent by weight.

Method of Measurement and Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot for "Reinforced Concrete Pipe" of the several sizes, measured complete in place, which price shall be full compensation for furnishing, hauling and installing the pipe, for preparation of bed and backfilling, and for all material, equipment, tools, labor and incidentals necessary to complete the work, but shall not be payment for excavation nor for concrete or masonry end walls.

91. CAST IRON PIPE

Description. Under this item cast iron pipe conforming to these specifications, of the sizes and dimensions shown on the Plans, shall be furnished and placed as directed.

Materials. Cast iron pipe shall be of good quality, of the bell and spigot type, and all pipe shall be made of cast iron of such character as to be strong, tough and of even grain, and soft enough to admit of satisfactory drilling and cutting; the metal shall be made without any admixture of cinder iron and other inferior metal and the surface of the pipe shall be free from scales, lumps, blisters and holes, and other defects impairing its strength or utility; it shall be solid, round and cast vertical. It shall be in sections not less than 3 feet in length and with the inner and outer surfaces true concentric cylinders. It may be plain, smooth and straight cast iron water pipe or it may be approved corrugated cast iron or approved rib cast iron culvert pipe. Corrugations, when present, shall have a pitch of not more than 3 inches and a depth of not less than 1/2 inch. The pipe shall be heated to 300°F. and coated inside and outside by dipping in coal tar pitch or varnish.

The pipe shall have a minimum thickness and weight as shown in the following tables, and no pipe shall be accepted the weight of which is more than 5 per cent less than the weights given:

Plain Cast Iron Pipe

Inside Diameter Inches	Minimum Thickness Inches	Weight per foot Pounds
12	3/8	50
16	7/16	75
18	1/2	85

Inside Diameter Inches	Minimum Thickness Inches	Weight per Foot Pounds
24	1/2	145
30	5/8	180
36	11/16	250

Corrugated or Ribbed Cast Iron Pipe

Inside Diameter Inches	Minimum Thickness Inches	Weight per Foot Pounds
16	1/4	60
18	1/4	65
24	5/16	90
30	5/16	135
36	3/8	175

The pipe shall have sufficient strength so that when tested with the three point standard crushing test as prescribed in the Bulletin No. 1216, it will show a load supporting capacity in pounds per linear foot of at least 1500-D where "D" equals the inside diameter of the pipe in feet.

No pipe will be accepted, the weight of which shall be over five per cent less than the required standard weight.

Each section of cast iron pipe shall be coated inside and outside with coal-tar pitch varnish, to which sufficient linseed oil has been added to make a smooth coat, tough and tenacious when cold, with no tendency to scale off.

Method of Measurement and Basis of Payment. This item shall be paid for at the contract prices bid per linear foot of "Cast Iron Pipe" of the several sizes measured complete in place, which prices shall be full compensation for furnishing, hauling and installing the pipe, for preparation of bed and back filling, and for all material, equipment, tools, labor and incidentals necessary to complete the work, but shall not be payment for excavation or for concrete or masonry end-walls.

83-94-1622-30

92. CORRUGATED GALVANIZED METAL PIPE

Description. This item shall consist of furnishing and placing corrugated galvanized metal pipe conforming to these specifications. The pipe shall be furnished of the sizes and dimensions required and shall be installed 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 and grades given.

Materials. Corrugated metal pipe shall be fabricated from corrugated sheets, the base metal of which shall be made by the open hearth process. The base metal in the finished sheets shall conform to the following chemical requirements: (The arrangement of types given below does not indicate preference.)

Ladle Analysis of Base Metal

	Pure Iron	Copper Iron	Copper Steel	Copper Molybdenum Iron
Sulphur - - - -	not more than 0.04%	Not more than 0.04%	Not more than 0.05%	Not more than 0.04%
Phosphorus - -	Not more than 0.015%	Not more than 0.015%	Not more than 0.04%	Molybdenum Not less than .05%
Total of carbon sulphur, phosphorous manganese, and silicon	Not more than 0.16%	Not more than 0.25%	Not more than 0.7%	Not more than 0.25%
Copper- - - -	Optional	Not less than 0.20%	Not less than 0.20%	Not less than 0.40%

Note:- A permissible variation of four hundredths (4-100) per cent will be allowed for total impurities and one-hundredth (1-100) per cent for sulphur in analysis of finished sheet.

Rivets: All rivets shall be of the same material as the base metal specified for the corrugated sheets. They shall be thoroughly galvanized or sherardized.

Weight Tolerance: The average weight per square foot of the culvert sheets, as determined by weighing in lots not exceeding 6000 pounds shall not vary from the theoretical weight by more than 5% either way for each lot of one gauge or size.

Spelter: The base metal sheets shall be uniformly galvanized on both sides by the hot process. A uniform coating of Prime Western Spelter shall be applied at the rate of not less than two ounces per square foot of metal. If the average spelter coating as determined from samples shows less than two ounces of spelter per square foot of metal, or if any one sample shows less than 1.8 ounces of spelter per square foot of metal, the shipment shall be rejected. Sheets having blister spots, holes or other imperfections in the galvanizing after corrugating shall be rejected.

Bidders shall state in proposal the typical chemical composition, brand of metal, trade name, and name of manufacturer of the material to be furnished.

No metal will be accepted under these specifications and no bids will be considered for the materials above described until after the sheet manufacturer's certified analysis and manufacturer's guarantee have been passed upon by the Engineer and accepted.

Misbranding or other misrepresentation, and non-uniformity of product, will each be considered a sufficient reason to discontinue the acceptance of any brand under these specifications, and the notice of discontinuance of any brand sent to the sheet manufacturer will be considered to be notice to any culvert companies which handle that particular brand.

The manufacturer of each brand shall file with the Engineer a certificate setting forth the name or brand of metal to be furnished and a typical analysis showing the percentage of each of the five above mentioned chemical elements. The certificate shall be sworn to for the manufacturing company by a person having legal authority to bind the company.

The manufacturer of the sheets 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 purchaser when not in conformity with the specified analysis, gauge or spelter coating, and the guarantee shall be so worded as to remain in effect so long as the manufacturer continues to furnish material.

No culverts will be accepted unless the metal is identified by a stamp on each section showing: -

1st, Name of sheet manufacturer,
2nd, Name of brand
3rd, The gauge.

The identification brands shall be placed on the sheets by the manufacturers of the sheets, in such a way that when rolled into culverts such identification shall appear on the outside of each section of each pipe. Pipe having any section not so stamped shall be promptly rejected.

Laboratory tests shall follow the methods of the U. S. Department of Agriculture Bulletin No. 1216. The analysis made by the chemists or inspection bureau designated or approved by the Engineer shall be taken as final, but before any considerable shipment is rejected a check analysis shall be made.

If the Engineer so elects he may have the material inspected at the rolling mill or the culverts inspected in the shop where they are fabricated. He may require a chemical analysis from the mill for any heat, also a physical test of the properties of the metal taken from any heat, to be made by the mill. The inspection both at the mill and at the shop shall be made under the direction of the Engineer. The Engineer, or his representative, shall have free access to the mill or shop for inspection purposes and every facility shall be extended to him for this purpose. Any material or pipe included in any shipment which has been rejected at the mill or shop will be considered sufficient cause for the rejection of the entire shipment.

All rivets shall be driven cold in such a manner that the plates shall be drawn tightly together throughout the entire lap. No rivet shall be closer than twice its diameter from the edge of the metal. All rivets shall have neat, workmanlike and full hemispherical heads or heads of a form acceptable to the Engineer: shall be driven without bending; and must completely fill the hole. Longitudinal seams of thirty and thirty-six inch pipe shall be double riveted. Circumferential shop riveted seams shall have a maximum rivet spacing of six inches and shall lap at least one full corrugation, except that six rivets will be sufficient in twelve-inch pipe.

If a band is used for end finish, it shall be riveted around the end of the culvert with rivets at intervals of ten inches or less. This band shall be of galvanized metal equivalent in cross section to 3/8 x 1 inch for 16-gauge metal, 3/8 x $1\frac{1}{2}$ inches for 14-gauge metal and 12 gauge metal.

Field joints shall be made with bands of the same material as the culvert, and shall be not less than seven and one-half inches wide, so constructed as to lap an equal portion of each of the culvert sections to be connected Such bands shall be connected at the ends by angles having minimum dimensions of $1\frac{1}{2}$ x $1\frac{1}{2}$ x 1/8 inch, and of length equal to full width of band, or by other approved connections of suitable strength. Each connection shall be fastened by at least two bolts not less than 1/2 inch in diameter. All such connections shall be made of galvanized metal of the same quality as the base metal in the culvert.

It is the essence of these specifications that in addition to compliance with the details of construction, the completed pipe shall show careful, finished workmanship in all particulars.

Culvert pipe 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. This requirement applies not only to the individual pipe 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 pipe or in general in any shipment, shall constitute sufficient cause for rejection:

Uneven laps
Elliptical shaping
Variation from a straight center line
Ragged or diagonal sheared edges
Loose, unevenly lined or spaced rivets
Poorly formed rivet heads
Unfinished ends
Illegible brands
Lack of rigidity
Bruised, scaled or broken spelter coating
Dents or bends in the metal itself

The field inspection shall be made by the Engineer, who shall be furnished by the Contractor with an itemized statement of the sizes and lengths of culvert pipe in each shipment. This inspection shall include an examination of the culvert pipe for deficiencies in length of sheets used, nominal specified diameter, net length of finished culvert pipe, 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 inspection shall be made promptly upon notification by the Contractor of the arrival of the material.

The pipe making up the shipment shall fully meet the requirements of these specifications, and if fifty per cent of the pipe in any shipment fails to meet these requirements the entire shipment may be rejected.

When samples are taken for chemical analysis and determination of weight of spelter coating, at least one sample from which a specimen two and one-quarter inches square may be prepared shall be selected from each ten culverts of a shipment, and not less than three samples shall represent any one shipment.

The pipe shall be laid in the trench with the separate sections firmly joined together and with outside laps of circumferential joints pointing up stream and with longitudinal laps on the sides. Any metal in joints which is not thoroughly protected by galvanizing shall be coated with a suitable asphaltum paint.

Method of Measurement and Basis of Payment. This item shall be paid for at the contract prices bid per linear foot of "Corrugated Galvanized Metal Pipe" of the several sizes measured complete in place, which price shall be full compensation for furnishing, hauling and installing the pipe, for preparation of bed and backfilling, and for all material, equipment, tools, labor and incidentals, but shall not be payment for excavation nor for concrete or masonry end wall.

83-94-1622-33

93. VITRIFIED CLAY PIPE

Description. Under this item vitrified clay pipe conforming to these specifications, of the sizes and dimensions shown on the Plans, shall be furnished and placed as directed.

Materials and Manufacture. Vitirfied clay pipe shall be of the hub and spigot type, of first quality, sound, thoroughly and perfectly burned, without warps, cracks, or other imperfections, and shall be fully and smoothly glazed over the entire inner and outer surfaces, except that the inside of the hub and the outside of the spigot may be unglazed for two-thirds of the depth of the hub. On all other portions of the pipe, the glazing shall completely cover and form an integral part of the pipe body. If glazed, the inside of the hub and the outside of the spigot shall be scored in 3 parallel lines extending completely around the circumference. This pipe shall be manufactured at a suitable temperature to secure a tough, vitreous material which, when broken, shall show a dense and solid body, without detrimental cracks or laminations. It shall be of such toughness that it may be cut with a chisel and hammer, and when struck with a hammer shall give a metallic ring.

The pipe shall have sufficient strength so that when tested with the three point standard crushing test as prescribed in the U. S. Department of Agriculture Bulletin No. 1216, it will show a load supporting capacity in pounds per linear foot of at least 1500-D where "D" equals the inside diameter of the pipe in feet.

The minimum length of sections, thickness, and the depth of hub shall be as follows:

Size Inches	Minimum Length Feet	Thickness Inches	Depth of Hub Inches
12	2	1	3
15	2	1-1/4	3
18	2	1-1/2	3-1/4
20	2	1-2/3	3-1/4
22	2	1-5/6	3-3/4
24	2	2	4
27	2-1/2	2-1/4	4
30	2-1/2	2-1/2	4
33	2-1/2	2-5/8	5
36	2-1/2	2-3/4	5
42	2-1/2	3-1/2	5

Method of Measurement and Basis of Payment. This item shall be paid for at the contract prices bid per linear foot of "Vitrified Clay Pipe" of the several sizes measured complete in place, which prices shall be full compensation for furnishing, hauling, and installing the pipe, for preparation of bed and back filling, and for all material, equipment, tools, labor, and incidentals necessary to complete the work, but shall not be payment for excavation or for concrete or masonry end-walls.

94. RELAYING CULVERT PIPE

Description. This item shall consist of the careful removal and preserving of pipe from existing pipe culverts as ordered and relaying the same as shown on the Plans or as designated by the Engineer. In accordance with those specifications for the type of pipe involved and in conformity with the lines and grades. given.

Method of Measurement. This item shall be measured by the actual number of linear foot of pipe complete in place as required.

Basis of Payment. This item measured as provided above, shall be paid for at the contract unit price bid per linear foot for "Relaying Culvert Pipe" 18 inch diameter and under or "Relaying Culvert Pipe over 18 inches diameter" as the case may be, which price shall be full compensation for the removal, preservation, and relaying of the pipe, all new material necessary except pipe, all labor, equipment, tools and incidentals necessary to complete the work, but shall not be payment for excavation, nor for concrete or masonry headwalls.

83-94-1622-35

100. INCIDENTAL CONSTRUCTION

101. SODDING

Description. This item shall consist of providing and planting approved live sod on earth slopes or shoulders, when and as directed for protection against erosion.

The sods shall be of suitable size, variety and character for the purpose selected and for the soil upon which they are to be planted, for vigorous and hardy growth, and approved by the Engineer.

On embankments constructed on soil which is easily eroded or on sections subject to overflow, and where climatic conditions are favorable to the easy rooting of "Bermuda Grass" or "Rescue Grass" or "Bun Clover" or "Japanese Clover" and if in the opinion of the Engineer it is necessary, the Contractor shall provide and plant as directed, such sods, or tufts of some suitable grass.

Where sodding is to be done, tufts of suitable grass shall be placed on slope just underneath the shoulder line so as to form one continuous strip of turf about three inches wide and on remainder of slope and upon shoulders similar tufts of grass about three inches in diameter shall be spaced approximately twelve inches center to center in rows. Sodding shall be done at such times as the Engineer may direct and in such manner that the grass will at once take root.

Basis of Payment. Sodding completed and accepted by the Engineer will be paid for at the contract unit price bid per 100 linear feet of roadway sodded on both sides to the width required by the Engineer, which price shall be full compensation for furnishing and planting the sod, all labor, equipment, tools and incidentals necessary to complete the work. The average width of sodding for the unit price bid shall be construed to mean an average width of not over 30 feet.

102. SEEDING

Description. This item shall consist of seeding with grass earth slopes, and shoulders as ordered.

The seeds shall be of a variety suitable to the soil, conditions and purpose involved, and which will form a suitable sod as required.

The seeding shall be done at proper time and season, when and as directed by the Engineer.

Basis of Payment. Seeding, completed and accepted, shall be paid for at the contract unit price bid per 100 linear feet of roadway seeded on both sides to the width required by the Engineer, which price shall be full compensation for preparing the ground and furnishing and sowing the seed, all labor, equipment, tools, and incidentals necessary to complete the work. The average width of seeding for the unit price bid shall be construed to mean an average width of not over 30 feet.

103. UNTREATED TIMBER PILING

Description. This item shall consist of round or square timber piles of the kind and dimensions specified, and in conformity with the pertinent designated Plans. They shall be driven in accordance with these specifications in the location and to the elevation shown on Plans or as directed by the Engineer.

Except for trestle work, timber piles shall be used only below permanent ground water level. Untreated timber piles shall not be used in water which is infested by marine borers. In general, the penetration for any pile shall be not less than 10 feet in hard material and not less than one-third the length of the pile nor less than 20 feet in soft material. For foundation work, no piling shall be used to penetrate a very soft upper stratum overlying a hard stratum unless the piles penetrate the hard material a sufficient distance to rigidly fix the ends.

Material for Foundation Piles: These piles may be of any species which will satisfactorily stand driving. They shall be cut from live, sound trees, shall be solid and free from defects such as injurious ring shakes, large unsound, or loose knots, decay, or other defects which might impair their strength or durability. They shall be cut from above the ground swell and have a uniform taper and shall be free from short bends. A straight line drawn from the center of the butt to the center of the tip shall lie wholly within the body of the pile. Piles shall be peeled soon after cutting. All knots shall be trimmed close to the body of the pile. For round piles, the minimum diameter at the tip shall be eight inches, and at the butt shall be twelve inches. The maximum diameter at the butt shall be twenty inches. Square piles shall be uniform in cross section, not less than ten by twelve inches for lengths over thirty feet.

If possible, piles shall be full length. Where the length required is greater than is practical to obtain, they may, upon written approval of the Engineer, be spliced. All splices shall be made in accordance with detail plans, prepared to meet the special conditions encountered and which shall be approved before the piles are driven.

Material for Trestle Piles and Foundation Piles for Trestle Bents. These piles shall meet the requirements for timber "Foundation Piles" and in addition shall be of durable timber. The species required will be Post Oak, White Oak, Red or Black Cypress, or Long Leaf Yellow Pine (80 per cent heart.)

Construction Methods. Piles shall not be driven until after the excavation is complete. Any material forced up between the piles shall be removed to correct elevation before masonry for the foundation is placed. Timber piles shall be driven with a gravity hammer, steam hammer, water jets, or a combination of water jets and hammer. The driving of piling with followers shall be avoided if practicable, and shall be done under written permission of the Engineer only. When followers are used, one pile from every group of ten shall be a long pile driven without a follower and shall be used as a test pile to determine the average bearing power of the group. Collars or bands to protect timber piles against splitting and brooming shall be provided where necessary. Timber piles shall be pointed where soil conditions require it. When necessary, the piles shall be shod with metal shoes of a design satisfactory to the Engineer, the points of the piles being carefully shaped to secure an even and uniform bearing on the shoes.

Gravity hammers for driving timber piles shall weigh not less than 2000 pounds and the fall shall be so regulated as to avoid injury to the pile, and in no case shall exceed 20 feet. Piles shall be driven with a variation of not more than one-quarter inch per foot from the vertical or from the batter line indicated. All piles raised during the process of driving adjacent piles shall be driven down again if required by the Engineer.

When required, the size and number of piles shall be determined by actual loading tests. In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, together with suitable apparatus for accurately determining the superimposed weight and the settlement under each increment of load. The safe allowable load shall be considered as 50 per cent of that load which, after 48 hours application causes a permanent settlement measured at the top of the pile, of not more than one-fourth inch. At least, one pile of each group of one hundred piles shall be thus tested.

Timber Piles: In the absence of loading tests, the safe bearing values for timber piles shall be determined by the following formulas:

$$P = \frac{2WH}{S + 1.0} \quad \text{for gravity hammers}$$

$$P = \frac{2WH}{S + 0.1} \quad \text{for single-acting steam hammers}$$

$$P = \frac{2H(W + AP)}{2 + 0.1} \quad \text{for double-acting steam hammers}$$

where
- P = safe bearing power in pounds
- W = Weight, in pounds, of striking parts of hammer
- H = height of fall in feet
- A = area of piston in square inches
- P = steam pressure in pounds per square inch
- S = the average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammer.

The above formulas are applicable only when
- (a) The hammer has a free fall.
- (b) The head of the pile is free from broomed or crushed wood fiber.
- (c) The penetration is at a reasonably quick and uniform rate.
- (d) There is no sensible bounce after the blow. Twice the height of the bounce shall be deducted from "H" to determine its true value in the formula.

The bearing powers of timber piles, as determined by the foregoing formulas, shall be considered effective only when they are less than the crushing strengths of the piles. In general, piles shall be required to develop a bearing capacity of not less than 15 tons nor more than 25 tons. However, the character of the soil penetrated, conditions of driving, distribution, sizes and lengths of the piles involved, and the computed load per pile shall be given due consideration in determining the reliabilityof driven pile.

In case water jets are used in connection with the driving, the bearing power shall be determined by the above formulas, from the results of driving after the jets have been withdrawn, or a load test may be applied.

The tops of foundation piles shall be embedded in the concrete footing at least one foot, and where seals of concrete deposited in water are used with piles, the piles shall project at least one foot above the top of the seal concrete. They shall be cut off level at such elevation that the tops of the piles will be always wet.

Foundation piles for framed bents shall be cut off level approximately three feet above the surface of the ground and the cap rigidly secured to each pile by drift bolts extending at least nine inches into the pile.

Trestle piles shall be cut off level at the elevation shown on the plans and the caps secured as described above. If the cut-off is ten feet or more above the ground line, timber piles shall be braced by diagonal cross bracing composed of three inch by ten inch timbers, secured to the piles by three-quarter inch diameter through bolts.

In bents of untreated piles the heads of the piles shall be thoroughly coated with a thick protective coat of red lead paint, hot tar, hot asphaltum, or hot coal tar creosote before the caps are placed.

The tops of all piling shall be sawed to a true plane as shown on the plans, and at the elevation fixed by the Engineer. Piles which support timber caps or grillage work shall be sawed to the exact plane of the superimposed structure and shall exactly fit it. Broken, split, or misplaced piles shall be drawn and properly replaced. Piles driven below the cut-off grade fixed by the Engineer shall be withdrawn and replaced by new and, if necessary, longer piles at the expense of the contractor.

Basis of Payment. All piling left in place in the structure will be paid for at the contract unit price bid per linear foot for "Untreated Timber Piling" complete in place, which price shall be full compensation for furnishing all piling, all materials, equipment, tools, labor, and incidentals necessary to complete the work. No allowance will be made for falsework piling. Payment will be made at this price for only the actual number of feet of piles left in place in the completed work, and no allowance will be made for any piles which are not driven in accordance with the specifications, or as ordered by and made acceptable to the Engineer.

104. TREATED TIMBER PILING

Description. This item shall consist of round or square treated timber piles of the kind and dimensions specified and in conformity with the pertinent designated Plans. They shall be driven in accordance with these specifications in the location and to the elevation shown on the Plans or as directed by the Engineer.

Materials. Requirements for Treated Foundation Piles, Treated Trestle Piles, and Treated Foundation Piles for Trestle Bents shall be identical with the corresponding requirements for Untreated Timber Piles with the additional requirements following:

Piles shall be treated with the creosote oil or creosote coal tar solution described in the specifications for "Timber Structures." The ranges of pressure, temperature, and time duration of treatment shall be controlled so as to result in maximum penetration of the quantity of preservative injected, which shall permeate all of the sapwood and as much of the heartwood as practicable. For general construction, not in sea-water, piles shall be treated to retain not less than twelve pounds of the preservative per cubic foot of wood by any full cell process, or not less than eight pounds by any standard empty cell process.

Construction Methods. for Treated Timber Piling shall be identical with those prescribed for Untreated Timber Piling, ~~except that the heads of piles need not be coated with protective paint.~~ The following additional requirements apply to Treated Timber Piling.

Treated piles and timbers shall be carefully handled without sudden dropping, breaking of outer fibres, bruising or penetrating the surface with tools. They shall be handled with rope slings. Cant dogs, hooks, or pile poles shall not be used where such tools will penetrate into the untreated wood.

All places where the surface of treated piles or timbers is broken by cutting, boring or otherwise, shall be thoroughly coated with hot creosote oil and then with a coating of hot tar pitch. Hot creosote oil shall be poured into the bolt holes before the insertion of the bolts in such manner that the entire surface of the holes shall receive coating of the oil.

Basis of Payment. All piling left in place in the structure will be paid for at the contract unit price bid per linear foot for "Treated Timber Piling" complete in place, which price shall be full compensation for furnishing all piling, all treating, all materials, equipment, tools, labor, and incidentals necessary to complete the work. No allowance will be made for falsework piling. Payment will be made at this price for only the actual number of feet of piles left in place in the completed work, and no allowance will be made for any piles which are not driven in accordance with the specifications, or as ordered by and made acceptable to the Engineer.

100 **After the necessary cutting has been done to receive the cap, the heads of piles shall be given three coats of hot creosote oil. They shall then be covered with a coat of hot tar pitch over which shall be placed a sheet of three ply roofing felt or galvanized iron, or a covering may be built up of alternate layers of hot tar pitch and loose woven fabric similar to membrane water-proofing, using four layers of pitch and three of the fabric. The cover shall measure at least six inches more in each dimension than the diameter of the pile, and shall be bent down over the pile and the edges fastened with large headed nails, or secured by binding with galvanized wire. After the cover is in place the cap shall be placed and drift bolted as prescribed.**

105. PRECAST CONCRETE PILING

Description. This item shall consist of piles precast of Portland cement concrete made and reinforced in accordance with these specifications and in conformity with the pertinent designated Plans. They shall be driven in accordance with these specifications in the location and to the elevation shown on the plans or as directed by the Engineer.

Materials and Design. All concrete materials and their preparation and placing shall be in accordance with the requirements for Class D concrete. (All coarse aggregate to pass a 3/4 inch ring). It shall be the charge of the Contractor to order materials for and cast and manufacture the requisite lengths and amount of piling to complete the required structure or work.

Precast concrete piles may be square, circular, or octagonal in section. If a square section is employed, the corners shall be chamfered at least one inch. Piles shall preferably be cast with a driving point and for hard driving shall preferably be shod with a metal shoe of approved pattern. Piling may be either of uniform section or tapered as desired. Tapered piling shall not, in general , be used for trestle construction except for that portion of the pile which lies below the ground line: nor shall tapered piles be used in any location where the piles are to act as columns. In general, concrete piles shall have a cross sectional area, measured above the taper, of not less than 140 square inches and when they are to be used in salt water, they shall have a cross sectional area of not less than 220 square inches.

The length shall not exceed thirty times the average diameter for piles driven through firm soil, and shall not exceed fifteen times the average diameter for piles driven to rock through loose, wet soil, or filled ground. When lateral support is deficient so that the piles act as columns, they shall be designed as columns.

Reinforcement shall conform to the requirements for Reinforcing Steel of these Specifications, and the weight and dimensions shall be as shown on Plans.

Reinforcement for precast concrete piling shall consist of longitudinal bars in combination with lateral reinforcement in the form of hoops or spirals. The longitudinal reinforcement shall be not less than one per cent and preferably not less than one and one-half per cent of the total cross-section of the pile. The reinforcement shall be placed at a clear distance from the face of the pile of not less than 2 inches and when the piles are for use in salt water or alkali soils, this clear distance shall be not less than 3 inches. The driving point and also the top of the pile shall be protected against impact by means of special spiral winding or bands designed for this purpose. The reinforcing system shall preferably be of the "unit" type, rigidly wired or fastened at all intersections and held to true position in the forms by means of concrete blocks or other suitable device. Where piles exceed fifty-five feet in length, additional longitudinal reinforcement shall be added throughout the central one-third of the length. Piling under retaining walls abutments, etc., shall be designed to withstand the lateral stresses induced.

Where waterproofing is to be used, special specifications will be given and the work shall be in accordance therewith.

Forms shall be accessible for tamping and consolidation of the concrete. Under good weather curing conditions, side forms may be removed at any time not less than twenty-four hours subsequent to placing concrete, but the entire pile shall remain supported for at least seven days, and shall not be subject to and handling stress until the concrete has set for at least twenty-one days, and for a longer period in cold weather, the additional time to be determined by the Engineer.

Casting: Piling may be cast either in a vertical or horizontal position. When vertical forms are used, special care shall be exercised to puddle and tamp the concrete around the reinforcing and to avoid the formation of stone pockets. When horizontal forms are used, the piles shall not be cast in tiers.

During the placing of concrete, the forms shall be vibrated by tapping with a hammer of wooden mail. Concrete shall be placed continuously in each pile and shall be carefully spaded, puddled, and tamped, special care being exercised to avoid horizontal or diagonal cleavage planes, and to see that the reinforcement is properly embedded in the concrete.

Finish: As soon as the forms are removed, concrete piles shall be carefully pointed with 1:2 mortar, filling up all cavities or irregularities.

Trestle piling exposed to view shall be finished above the ground line in accordance with the provisions governing the finishing of concrete columns. Foundation piling, that portion of trestle piling which will be below the ground surface, and piles for use in sea water or alkali soils shall not be finished except by pointing as above set forth.

Curing: Concrete piles shall be cured in accordance with the general provisions governing the curing of concrete as elsewhere provided. As soon as the piles have set sufficiently to permit, they shall be removed from the forms and piled in a curing pile separated from each other by wood spacing blocks. No pile shall be driven until it has set for at least thirty days and in cold weather for a longer period as determined by the Engineer. Concrete piles for use in sea water or alkali soils shall be cured for not less than 60 days before being used.

Storage and Handling of Precast Concrete Piling: For precast piles, the method of storing and handling shall be such as to eliminate the danger of fracture by impact or undue bending stresses, in curing or transporting the piles from the molds and into the leads. In general concrete piles shall be lifted by means of a suitable bridle or sling attached to the pile at points not over twenty feet apart. In no case shall the method of handling be such as to induce stresses in the concrete of more than 650 pounds compression per square inch or in the reinforcing steel in excess of 12,000 pounds per square inch allowing one hundred per cent of the calculated load for impact and shock effects.

In handling piles for use in sea water or alkali soils, special care shall be exercised to avoid injury to the surface of the pile.

Concrete piles when properly designed, constructed and placed, may be subjected to loads as determined by tests or formula, but not to exceed 300 pounds per square inch of total cross section at the smallest effective point and generally not to exceed 25 tons per pile with a maximum limit of 30 tons per pile.

Construction Methods. Requirements for equipment and driving large concrete piles will be covered by special specifications.

Hammers for Concrete Piles: Concrete piles preferably shall be driven with steam hammers. Steam hammers for this purpose shall develop an energy per blow at each full stroke of the piston of not less than 12,000 foot pounds, except in sandy material when used in combination with a suitable water jet having a pressure of 125 pounds per square inch at end of nozzle; the above requirements may be modified.

Gravity hammers, when their use is permitted shall weigh not less than the weight of the pile and the maximum drop shall not exceed 8 feet.

Water Jets: Water jets may be used, either alone or in combination with a hammer. The volume and pressure of the water at the jet nozzles, and the number of jets used, shall be sufficient to freely erode the material adjacent to the pile.

If water jets and a hammer are used for driving, the jets shall be withdrawn and the piles shall be driven by the hammer to secure the final penetration. This procedure may be varied if the desired results are not obtained.

Piles shall be driven with a variation of not more than one-quarter inch per foot from the vertical or from the batter line indicated.

Loading Tests: When required, the size and number of piles shall be determined by actual loading tests. In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, together with suitable apparatus for accurately determining the superimposed weight and the settlement of the pile under each increment of load. The safe allowable load shall be considered as 50 per cent of that load which, after 48 hours application, causes a permanent settlement, measured at the top of the pile, of not more than one-fourth inch. At least one pile for each group of one hundred piles shall be thus tested.

Concrete Piles: In the absence of the loading tests, the safe bearing values for piles shall be determined by the following formulas.

$$P = \frac{2\,WH}{S + 1.0} \quad \text{for gravity hammers}$$

$$P = \frac{2\,WH}{S + 0.1} \quad \text{for single-acting steam hammers}$$

$$P = \frac{2H(W + Ap)}{S + 0.1} \quad \text{for double-acting steam hammers}$$

where P = safe bearing power in pounds
W = weight, in pounds, of striking parts of hammer
H = Height of fall in feet
A = area of piston in square inches
P = steam pressure in pounds per square inch at the hammer
S = the average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammers.

The above formulas are applicable only when

(a) The hammer has a free fall.
(c) The penetration is at a reasonably quick and uniform rate.
(d) There is no sensible bounce after the blow. Twice the height of the bounce shall be deducted from "H" to determine its true value in the formula.

In case water jets are used in connection with the driving, the bearing power shall be determined by the above formulas from the results of driving after the jets have been withdrawn, or a load test may be applied.

Concrete Piles: The bearing values for concrete piles shall be determined by means of the loading tests above specified. The formulas specified above for timber piling may be used as a rough approximation for precast concrete piles.

When required, the Contractor shall drive test piles of a length and at the location designated by the Engineer. These piles shall be of greater length than the length assumed in the design in order to provide for any variation in soil conditions.

Jetting piles shall extend to a good solid stratum. Their carrying capacity shall be determined by actual tests or, if driven with the aid of a jet and for the last five blows of the gravity hammer or last twenty blows of the steam hammer, driven without any jet, the same formula may be applied as in the case of driven piles.

Extensions, splices, or "building-ups" on concrete piles shall be avoided but when necessary they shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel exposed for a length of forty diameters, the final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary form work shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used originally in the pile. Just prior to placing concrete, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement. The forms shall remain in place not less than 7 days and shall then be carefully removed and the entire exposed surface of the pile finished as above specified.

Methods of Measurement. Only the actual number of linear feet of accepted piles left in place in the completed work shall be measured. No allowance will be made for cut-offs or any unaccepted footage. "Build-Ups" constructed as required shall be measured as piling, provided that no allowance will be made for "build-ups" which are made necessary by damage to the piles during driving.

Basis of Payment. The piling measured as provided above, will be paid for at the contract unit price bid per linear foot for "Precast Concrete Piling," which price will be full compensation for furnishing all materials, equipment, labor, and incidentals necessary to complete the work, except that test piles ordered but not used in the work be paid for as Extra Work.

100-120-1623-10

106. CAST IN PLACE CONCRETE PILING

Description. These piles shall consist of a metal shell driven in the location and to the elevation shown on the Plans, which shall remain in place, and concrete cast in place in the shell, all as prescribed in these specifications.

Materials, and requirements for concrete and reinforcing steel shall be the same as prescribed for "Precast Concrete Piling," with the additional requirement that in all cases the reinforcement shall be of the unit system, rigidly fastened together and lowered into the shell. No loose bars will be permitted.

Metal Shells: The metal shall be of a sufficient thickness and reinforced to such an extent that it will hold its original form and show no signs of distortion after the core has been withdrawn. The design of the shell shall be submitted to and approved by the Engineer before any driving is done. After the shell has been driven and the core withdrawn, it shall be inspected and approved before any concrete is placed. No payment will be made for any shell which has been improperly driven, is broken, or otherwise defective, and, if necessary, any such shell shall be removed and replaced.

Construction Methods. No concrete shall be placed until all driving within a radius of 15 feet has been completed, or until all the shells for any one bent have been completely driven. If this cannot be done, all driving within the above limits, shall be discontinued until the concrete in the last pile cast has set at least 7 days, and no load shall be allowed on any pile cast less than 7 days.

Concrete shall be placed continuously in each pile, care being used to fill every part of the shell and to work concrete around the reinforcement without displacing it. No concrete shall be placed in shells containing an accumulation of water.

Method of Measurement. Only the actual number of linear feet of accepted piles left in place in the completed work shall be measured. No allowance will be made for cut-offs or any unaccepted footage.

Basis of Payment. The piling measured as provided above, will be paid for at the contract unit price bid per linear foot for "Cast in Place Concrete Piling," which price will be full compensation for furnishing and driving the shells, for all materials, equipment, labor, and incidentals necessary to complete the work, except that test piles ordered but not used in the work will be paid for as Extra Work.

100-120-1623-11

107. PLAIN RIPRAP

Description. This item shall consist of a protective course or layer of "One man" stone laid on slopes and at such places as shown on the Plans or as designated by the Engineer, and filled with spalls and shall be constructed in accordance with these specifications and in conformity with the depth of course and other details shown on the pertinent cross sections.

Material. The "One man stone" shall be free from structural defects, of approved quality, not less than 1/3 of a cubic foot in volume, and not less than 3 inches thick. The width of the stones shall not be less than twice the thickness. The spalls shall be of material of similar quality.

Construction Methods. Slopes, where riprap is used, shall be no steeper than the angel of repose unless otherwise indicated or directed. The stone shall be bedded, one against the other, with the ends in contact. The spaces between the larger stone shall be filled with spalls of suitable size, and all spalls shall be rammed thoroughly into place. The finished surface of the riprap shall present an even, tight surface true to the lines, grades, and sections given.

Method of Measurement. This item shall be measured by the square yard complete in place. The measurement shall be made parallel to the face and not necessarily horizontally.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price bid per square yard for "Plain Riprap" which price shall be full compensation for furnishing and hauling all material, for all quarrying involved, for all labor, equipment tools and incidentals necessary to complete the work.

100-120-1623-12

108. GROUTED RIPRAP

Description. This item shall consist of a protective course or layer of "One man" stone laid on slopes and at such places as shown on the Plans or as designated by the Engineer, and grouted, and shall be constructed in accordance with these specifications, and in conformity with the depth of course and other details shown on the pertinent cross sections.

Material. The "One man stone" shall be free from structural defects, of approved quality, not less than 1/10 of a cubic foot in volume, and not less than 4 inches thick and 5 inches wide.

Construction Methods. Slopes, where riprap is used, shall be no steeper than the angle of repose unless otherwise indicated or directed. The stone shall be bedded, one against the other, with the ends in contact.

Application of Grout Filler. After the stones have been tamped, inspected, and approved, the spaces between the stones shall be filled with cement grout consisting of 1 part Portland cement and 2 parts approved sand.

Method of Measurement. This item shall be measured by the square yard complete in place. The measurement shall be made parallel to the face and not necessarily horizontally.

Basis of Payment. The yardage of completed and accepted work measured as provided above shall be paid for at the contract unit price bid per square yard for "Grouted Riprap" which price shall be full compensation for furnishing and hauling all material, for all quarrying involved, for all labor, equipment, tools and incidentals necessary to complete the work.

100-120-1623-13

109. STONE UNDERDRAIN

Description. This item shall consist of course random stone hand-laid in the bottom of a graded ditch so as to furnish free drainage through the open voids, covered with other material, the whole constructed at such places as shown on the Plans or as designated by the Engineer, in accordance with those specifications and in conformity with the pertinent required cross section.

Material. The bottom course shall consist of approved, durable, rough slabs of stone approximating 10 inches in depth, from 1 to 5 inches in width, and a length greater than the depth. The top course shall consist of durable slabs of stone from 1 to 3 inches in thickness. If sufficient local stone of the above quality is not available for top course stone, there may be substituted wholly or in part, approved, durable crushed or napped rock, crushed slag, or gravel of such size as will pass through a $2\frac{1}{2}$ inch screen and be retained on a 3/4 inch screen.

Construction Methods. Where indicated or directed, the Contractor shall excavate a trench of the required dimensions. The bottom of the trench shall be finished to the grade given, shall be smooth and firm, and tamped if necessary.

The bottom course stone shall be set carefully by hand, longitudinally with the trench, in vertical position, side by side, so as to give maximum voids. The vertical joints between ends of bottom course stone shall be staggered, and the bottom course in place shall approximate 10 inches in depth.

The top course stones shall be placed over the bottom course to fill the trench to the required depth. The slabs shall be laid flat over the bottom course stone, to cover it as completely as practicable , with joints close and staggered and necessary voids filled with napped or crushed stone, or gravel, The remainder of the trench shall be filled with suitable earth, which shall be compacted thoroughly by tamping in 4 inch layers. Suitable outlets shall be provided and protected with small headwalls or dry stone box openings of similar construction.

Method of Measurement. The linear measurement will be the actual length complete in place including the outlets or headwalls.

Basis of Payment. This item will be paid for at the contract unit price bid per linear foot of "Stone Underdrain" which price shall be full compensation for excavating the trench and back filling the same, furnishing and placing all material, constructing headwalls, equipment, tools for all labor and incidentals necessary to complete the work.

110. VITRIFIED TILE UNDERDRAIN

Description. This item shall consist of open joint vitrified clay pipe laid in a graded trench in a layer of gravel or crushed stone, covered with coarser material, the whole constructed at such places as shown on the Plans or as designated by the Engineer and in accordance with these specifications and in conformity with the pertinent required cross section.

Materials. The pipe shall be of first quality, hub and spigot style vitrified clay drain pipe, sound, thoroughly and perfectly burned, without warps, cracks, or other imperfections and unglazed. It shall be manufactured in lengths of not more than 2 feet, and shall be sufficiently tough so that it may be cut with a chisel and hammer. Unless otherwise specified or directed, the pipe shall be 4 inches in inside diameter.

The gravel or crushed stone for the bottom of the trench shall be of approved quality, clean and durable, which will pass the $1\frac{1}{2}$ inch screen and be retained on the 5/8 inch screen. The coarser material to be laid immediately above the pipe shall be of the same quality, passing the 3 inch screen and retained on the $1\frac{1}{2}$ inch screen.

Construction Methods. Where indicated or directed, the trench shall be excavated carefully to such depth as is required to permit the pipe to be laid to the grade desired.

The bottom course of stone shall be placed and tamped to a uniform depth of 2 inches and shall be true to grade.

The pipe shall then be bedded firmly on the bottom course of stone, with the hub end upgrade and the spigot end fully entered into the adjacent hub. The pipe joints shall then be covered with approved 2 ply tar strips, not less than 6 inches in width and of sufficient length to permit of the ends being turned outward and laid flat on the bottom course of stone, on either side of the pipe, for a distance of 3 inches.

After the pipes have been laid and approved, the coarser material shall be placed carefully, so as not to displace the pipe or joint covering, around and over the pipe to the required depth above the bottom of the pipe. The remainder of the trench shall be filled with suitable earth which shall be tamped in layers of 4 inches. Lateral connections of the drain shall be made with "Specials" as required. The drain shall be brought to a satisfactory outlet which shall be protected with headwalls and screens, as directed.

When a foundation drain is to be built it shall be constructed under curbs, gutters or where otherwise indicated, in accordance with the methods described above, except that the stone fill shall only be made for 10 inches above the bottom of the pipe and only stone of the size specified for the bottom of the trench shall be used throughout this underdrain.

Method of Measurement. The linear measurement will be the actual length of pipe as installed.

Basis of Payment. This item will be paid for at the contract unit price bid per linear foot for "Vitrified Tile Underdrain" or Vitrified Tile Foundation Underdrain", as the case may be, which price shall be full compensation for excavating the trench and back filling the same, for furnishing the pipe, all material, labor, equipment, tools, and incidentals necessary to complete the work. Headwalls will be paid for under the corresponding item.

111. CEMENT JOINT TILE OUTLETS FOR UNDERDRAINS

Description. This item shall consist of cement jointed vitrified clay pipe laid in a graded trench, 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 pertinent required cross section.

Material. The pipe shall be of 4 inch diameter unless otherwise specified, and shall fulfill the requirements for pipe vitrified tile underdrain.

The mortar for cementing the joints shall be composed of 1 part of Portland cement, and 2 parts of approved, clean, durable sand of such size as will pass a 1/8 inch screen, mixed with water to form a plastic mortar.

Construction Methods. Where indicated or directed, the trench shall be excavated to the lines and grades given, and the bottom of the trench shall be uniformly firm and smooth, and recesses shall be excavated to receive the hubs.

The pipe shall be laid carefully and firmly upon the bottom of the trench with the hub end upgrade and the spigot end fully entered into the adjacent hub. The joints shall be calked with cement mortar and after each joint is filled and finished on the outside, it shall be wiped clean on the inside. Lateral connections shall be made with suitable "Specials." These outlets shall be protected with headwalls and screens as required.

After the pipe as laid has been approved, the trench shall be refilled carefully with suitable earth, which shall be tamped firmly around and over the pipe in layers of 4 inches.

Method of Measurement. The linear measurement shall be the actual length of pipe as installed.

Basis of Payment. This item will be paid for at the contract unit price bid per linear foot for "Cement Joint Tile Outlets for Underdrains," which price shall be full compensation for excavating the trench and back filling the same, for furnishing the pipe, all material, labor, equipment, tools, and incidentals necessary to complete the work. Head walls will be paid for under the corresponding item.

100-120-1623-16

112. CONCRETE CURBING

Description. This item shall consist of an independent curbing composed of Portland Cement Concrete and shall be constructed in accordance with these specifications and in conformity with the lines, grades, and typical cross sections shown on the Plans.

Material. The material shall be as prescribed for Class A concrete.

Construction Methods. All requirements prescribed for Class A concrete shall apply. Forms, if of wood, shall be of 2 inch plank, surfaced: or if of metal shall be of approved section, shall be straight, free from warp, and of depth equal to the depth of the curb.

Excavation for Curbing. Excavation shall be made to the required depth and the sub-grade or base upon which the curb is to be set shall be compacted to a firm, even surface.

Where foundation under-drain is to be placed under the curbing, the excavation for the curbing shall be made in conjunction with the excavation for the under-drain.

The concrete shall be placed in the forms to the depth specified, in layers of 4 to 5 inches, and tamped and spaded until mortar entirely covers its surface. The top of the curbing shall be floated smooth, and the outer edge shall be rounded to a radius of 1 inch while the concrete is still soft.

The curbing shall be constructed in uniform length sections of 50 foot lengths except on sharp curves or for closure. No sections shall be less than 10 foot. These sections shall be separated by strips of one-fourth inch in thickness, of prepared asphalt or other suitable materials, placed perpendicular to and at right angles to the longitudinal section of the curbing. Holes shall be made in the asphalt or other prepared joint, to allow dowel pins to pass through. Two 3/4 inch round, smooth steel bars, three feet in length shall be placed at each joint as shown on plans. These dowels shall be dipped in tar or asphalt to insure freedom of movement.

The forms shall be removed within twenty-four hours after the concrete has been placed. The top of the curbing shall be rubbed down immediately to a smooth and uniform surface. As soon as finished, the curbing shall be protected from the elements by covering with 2 or 3 inches of earth. The earth shall be kept damp for a period of 3 days, and the covering shall remain for a period of 2 weeks, or for a longer period, if in the opinion of the Engineer it is desirable.

The Contractor shall protect the curbing while curing, and keep it in first class condition until the completion of the contract. Any curbing which is damaged at any time previous to the final acceptance of the work shall be removed and replaced with satisfactory curbing at the Contractor's expense.

After the concrete has set sufficiently, the spaces in front and back of the curbing shall be refilled to the required elevation with suitable material which shall be tamped in layers of not more than 6 inches until firm and solid.

Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot for "Concrete Curbing" complete in place, which price shall be full compensation for all excavation, for furnishing and placing all materials, all labor, equipment, tools and incidentals necessary to complete the work.

113. STONE CURBING

Description. This item shall consist of an independent curbing composed of approved dressed stone and shall be constructed in accordance with these specifications and in conformity with the lines, grades, and typical cross sections shown on the Plans.

Materials. The straight five-inch stone curbing shall consist of approved stone, free from structural defects. It shall be five inches in thickness, not less than twenty inches in depth and in lengths of not less than four nor more than eight feet. The top surface shall be dressed and leveled one-quarter inch, the face shall be dressed and the end cut square to a depth of not less than twelve inches below the top and the back dressed to a depth of three inches. The top and dressed face shall be free from depressions, projections or other irregularities and defects.

The straight six-inch stone curbing shall consist of approved stone, neither laminated nor stratified. It shall be hammer dressed on the face to a depth of not less than twelve inches below the top, on the entire top surface and for a depth of three inches on the back. The ends shall be cut square for the full depth and width of the stone. This curbing shall be six inches in width on the top, not less than twenty inches in depth and not less than eight inches in width at the base.

If eight-inch curbing is specified, it shall be of the same quality as straight six-inch curbing and eight inches in width on the top, not less than twenty-four inches in depth and not less than ten inches in width at the base.

Straight six or eight-inch stone curbing shall be in length of not less than six feet, except when necessary for closures, where no piece shall be less than four feet in length.

All curved curbing shall consist of approved first quality stone having a width at the top of six or eight inches as specified and the bottom shall be not less than two inches wider than the top. It shall be dressed, and of the depth as specified for the straight curbing, and in lengths of not less than five feet. It shall be cut exactly true to the radius specified and with a tangent or tangents if required.

Construction Methods. Excavation shall be made to the required depth and the subgrade or base upon which the curb is to be set shall be compacted to a firm, even surface. Where foundation underdrain is to be placed under the curbing the excavation for the curbing shall be made in conjunction with the excavation for the underdrain.

The curbing shall be set on edge in straight lines and the top surface shall conform to the lines and grades given.

All joints and curbing adjacent to inlets and other structures, shall be straight and true throughout the entire depth. The joints in the straight five-inch stone curbing, whether set or reset shall not exceed one-quarter an inch for a distance of twelve inches from the top, but may be wider from this point to the bottom. The joints in curbing shall not exceed one-quarter of an inch for the full depth. All joints shall be pointed and made water-tight from the base to the top of the curbing with a stiff mortar composed of one part of Portland cement and two parts of approved sand.

Where indicated or directed, drainage openings shall be made through the curbing at the elevation and of the size required. The curbing shall be backed with suitable material which shall be tamped until firm.

Basis of Payment. This item shall be paid for at the contract unit prices bid per linear foot complete in place for "Straight Five-Inch Stone Curbing", "Straight Six-Inch Stone Curbing", "Straight Eight-Inch Stone Curbing", "Curved Six-Inch Stone Curbing," or "Curved Eight-Inch Stone Curbing", as the case may be, which price shall be full compensation for furnishing and placing all stone, all quarrying, labor, equipment, tools, and incidentals necessary to complete the work.

100-120-1623-19

114. RESETTING CURBING

Description. This item shall consist of readjusting and resetting existing curbing and cementing the joints, and shall be done in accordance with these specifications and in conformity with the lines and grades required.

Materials. All existing curbing shall be used except no curbing less than 4 feet in length shall be used. The mortar for cementing the joints shall fulfill the requirements for the mortar of Class A concrete, proportions one of cement to two of sand.

Construction Methods. The existing curbing shall be readjusted in a satisfactory manner, suitable material being tamped thoroughly under and around it. Where necessary, the curbing shall be removed, all inacceptable material being disposed of as directed, the subgrade shaped to the required elevation and the acceptable curbing reset on a firm, compacted foundation.

Joints shall be cemented and refilling shall be done in accordance with the requirements for new curbing.

Basis of Payment. This item shall be paid for at the contract price bid per linear foot for "Resetting Curbing" complete in place, which price shall be full compensation for all excavation, disposal of surplus material, all material except stone, for all labor, equipment, tools, and incidentals necessary to complete the work.

100-120-1623-20

115. WIRE CABLE GUARD RAILING

Description. This item shall consist of two lines of wire cable supported on wood posts and 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.

Materials. The cable shall be manufactured of standard galvanized steel or iron wire and shall be not less than three-quarters of an inch in diameter. Precaution must be taken by the Contractor in handling the wire cable to prevent the displacement of the galvanizing. The minimum tensile strength of the cable shall be 13,000 pounds.

Posts: The posts shall be as required for wood guard rail, treated, set and painted as therein required.

Fittings: Anchors for all posts shall consist of a concrete "Dead-man" of the design and dimensions shown on the plans, and an eyebolt 4 feet in length. No. 8 soft wire shall be furnished for securing the end post to the anchors.

For each section of fence more than 200 feet in length, there shall be furnished 4 eyebolts, 24 inches in length, threaded 18 inches.

For each section of fence not more than 200 feet in length, there shall be furnished 2 eyebolts 8 inches in length, threaded for 3 inches, and 2 eyebolts 12 inches in length, threaded for 6 inches.

All eye bolts shall be 1 inch in diameter, shall be galvanized, and shall have galvanized washers and nuts attached.

Construction Methods. The posts shall be set plumb and firm, spaced 10 feet apart on center, $3\frac{1}{2}$ feet in the ground, and $3\frac{1}{2}$ feet above the ground, and to lines and grades given. Posts shall be located $3\frac{1}{2}$ feet from the nearest edge of the pavement to the near face of the post unless otherwise directed by the Engineer. The tops shall be bevelled at an angle of thirty degrees, the bevelled section to slope away from the road with a 1 inch bevel around the top of the posts, and holes bored 6 and 20 inches below the top of post, after the post is placed. The wire cable shall pass through these holes. The cable shall be drawn taut, and fastened securely on both ends in the following manner, as shown on plans:- the end posts shall be anchored by means of the 4 foot eye-bolts, which shall have been embedded in a "dead man" buried securely in the ground. Not less than 8 strands of twisted No. 8 soft wire shall pass through this eye-bolt and around the post above the upper cable and shall be drawn taut and fastened securely in place. The 24 inch eye-bolt shall pass through the end of post, 6 inches and 20 inches, respectively, below the top thereof, the ends of the cable shall pass through the eye of the bolt and shall be fastened securely in place by means of 2 wire clips each on sections of fence not more than 200 feet in length, the 24 inch eye-bolts may be omitted and the 12 inch eye-bolts used on one end and the 8 inch eye-bolts on the other. The cables then shall be drawn taut by means of the nuts on the ends of the bolts, iron washers being interposed between the nut and the post.

After erection is completed, the posts and all parts not galvanized shall be painted with 3 coats of the specified material, which shall be brushed in thoroughly.

Method of Measurement. The measurement shall be from outer post to outer post and shall not include the distance from the end posts to "dead man."

Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot for "Wire Cable Gaurd Railway" complete in place, which price shall be full compensation for furnishing all wire cable, posts, and fittings: for all preparation and erection of same, all labor, equipment, tools, and incidentals necessary to complete the work.

116. GALVANIZED PIPE GURAD RAILING

Description. This item shall consist of galvanized iron or steel pipe of the number of lines shown, 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.

Materials. All pipe shall be made from the best grade of galvanized wrought iron pipe that is equal in every respect to the best grade of "Byers Wrought Iron Galvanized Pipe." All such pipe must have an even smooth surface, be of full weight and thickness, well threaded and free from rust or cracks. All fittings used in pipe guard railing shall be galvanized and made from malleable iron that is free from flaws, cracks, etc. They shall be neatly threaded or bored to the required size needed for the proper installation of the pipe.

Construction Methods. The pipe posts and anchor bolts shall be set in concrete or masonry and shall be grouted in place securely with a grout composed of one part of Portland cement and two parts of approved clean sand. The posts shall be screwed into the fittings and the rails shall screw into the end fittings and slide through intermediate fittings. All threaded joints shall be erected satisfactorily and shall be straight and true after erection. All spots where the galvanizing has been damaged by tools in erecting and exposed threads shall be painted with aluminum paint.

Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot for "Galvanized Pipe Guard Railing" complete in place as required, which price shall be full compensation for furnishing and preparing and erecting material, all labor, equipment, tools, and incidentals necessary to complete the work. "Concrete" shall be paid for as provided under this item.

100-120-1623-22

117. WOOD GUARD RAILING

Description. This item shall consist of double guard rail supported on wood posts and 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.

Materials. The wood rails shall be made of well seasoned, straight grained, sound, yellow pine, or other approved wood, free from loose or unsound knots, or other defects and shall be surfaced on all sides. The top rails shall be 4 by 4 inches and the side rails shall be 2 by 6 inches, and both rails shall be in lengths of 16 feet or in multiples of 8 feet.

The posts shall be creosoted yellow pine, mountain cedar, or bois d'arc, and shall be not less, in any place, than $5\frac{1}{2}$ inches diameter or 6 inches square. They shall be not less than 6' -6" in length and the bottom shall be sawed off square. If round posts are used, they shall be peeled and trimmed of all knots and knobs and shall be straight and smooth. Both round and square posts shall not be used on the same contract, and they shall be of the same kind of material.

Pine posts must be bored or cut to dimensions shown on plans before being treated and shall be impregnated with at least 12 pounds of preservative oil, meeting the requirements for treated timber per cubic foot of material.

The material for painting the fence after erection shall be composed of from 65 to 70 per cent by weight of pigment in paste form and from 35 to 30 per cent of vehicle: or 60 to 65 per cent by weight of dry pigment.

The pigment shall be composed of not less than 65 per cent of pure white lead and not less than 20 per cent of pure zinc white, all finely ground. Not more than 15 per cent of inerts shall be permitted.

The vehicles shall be composed of not less than 90 per cent of pure raw linseed oil and sufficient first quality Japan or other approved drier to cause the applied paint to dry in approximately 3 days, but in no case shall the drier exceed ten per cent.

Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot of "Wood Guard Railing" complete in place as required, which price shall be full compensation for furnishing, preparing, and erecting all material, for all labor, equipment, tools and incidentals necessary to complete the work.

100-120-1623-23

118. CONCRETE RAILING FOR STRUCTURES

Description. This item shall consist of concrete railings constructed in accordance with these specifications and in conformity with the pertinent designated Plan and shall include that part of the structure above the top of curb, erected for the protection of traffic.

Materials. Unless otherwise provided, this item shall be constructed of Class D concrete, the coarse aggregate of which shall all pass the 3/4 inch screen.

Construction Methods. For "cast in place" railings, the forms shall be made of good quality tongued and grooved lumber and be of first class workmanship throughout. They shall be accurately built to the designs and dimensions shown on the plans, and all mouldings, panel work, and bevel strips shall be straight and true with neatly mitered joints. Forms shall be erected to exact line and grade and be so rigidly braced that they will maintain true aligment during the placing of concrete. Each section of the work shall be cast complete to 1½" below the top in a single operation. The top shall be finished with 1½" of mortar, of the same mix as used in the concrete, struck off with a templet moved on guides attached to the forms. This mortar shall be placed within 10 minutes after the concrete underneath is deposited. Railings shall be very carefully finished, the forms shall be carefully removed as soon as possible (in not less than 12 nor more than 48 hours) and all porous spots and places damaged in removing the forms repaired and the entire surface rubbed with clean water and a wooden float until all form marks are removed and the surface assumes a uniform sandy appearance.

Precast Railings shall be made in accordance with the designs and dimensions shown on the Plans or as directed, and shall be erected true to line and grade in a thoroughly workmanlike manner. The members shall be straight and true to form and free from imperfections or damaged places. They shall be set in place in full beds of 1:3 cement and sand mortar, and shall be thoroughly bonded together as shown on the plans or as directed.

Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot of "Concrete Railing for Structures" as required, which price shall be full compensation for furnishing, preparing, and erecting all material, including reinforcing steel, all labor, equipment, tools, and incidentals necessary to complete the work.

100-120-1623-24

119. PIPE RAILING FOR STRUCTURES

Description. This item shall consist of railing of the number of lines shown, constructed in accordance with these specifications, and in conformity with the pertinent designated Plan, and shall include that part of the structure above the top of curb erected for the protection of traffic.

Materials. Pipe and fittings for pipe railings shall consist of standard galvanized iron or steel pipe of the size designated.

Construction Methods. Railing shall be erected in a workmanlike manner, straight and true to line and grade. When used on steel work, the fastenings of rails and posts shall be as shown on the plans. In other locations, the posts or anchor bolts for same shall be set in concrete or masonry and grouted in place with 1 to 2 cement grout. The joining together of different pieces of pipes between posts by means of sleeves or couplings will not be permitted. Entire pieces must be used for this purpose.

Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot of "Pipe Railing for Structures" as required, which price shall be full compensation for furnishing, preparing, and erecting all material, all labor, equipment, tools and incidentals necessary to complete the work.

100-120-1623-25

120. IRON RAILING FOR STRUCTURES

Description. This item shall consist of any type of metal railing other than pipe rail, of the number of lines shown, constructed in accordance with these specifications, and in conformity with the pertinent designated Plan, and shall include that part of the structure above the top of curb erected for the protection of traffic .

Materials. Materials shall conform to the requirements for structural steel.

Construction Methods. The railings, posts, and fittings shall be manufactured in accordance with the pertinent Plans and Specifications and shall be erected true to line and grade.

Basis of Payment. This item shall be paid for at the contract unit price bid per linear foot of "Iron Railings for Structures" as required, which price shall be full compensation for furnishing, preparing, and erecting all material, and for all "anchor bolts" and "bracing", and for all labor, equipment, tools, and incidentals necessary to complete the work.

COMPLETE SCHEDULE OF PAY ITEMS
COVERED BY THESE STANDARD SPECIFICATIONS.

The foregoing approved standard specifications contain specifications for work and material, for which the following explicitly named unit items, when paid at the corresponding unit prices explicitly bid for each specific item, and in accordance with the Contract, are mutually understood and agreed to constitute full compensation for all the work and material specified or implied in the foregoing specifications except "Extra Work" and items covered by Special Provisions.

Light Clearing	per 100 foot station
Clearing	per acre
Light Grubbing	per 100 foot station
Grubbing	per acre
Unclassified excavation) per cubic yard	or (Solid Rock excavation per cubic yard (Common excavation per cubic yard
Dry Channel excavation	per cubic yard
Wet Channel excavation	per cunic yard
Excavation for Culverts	per cubic yard
Excavation for Bridges	per cubic yard
Borrow	per cubic yard
Stripping Material Pits	per cubic yard
Overhaul	per cubic yard station
Road Grader Work	per 100 foot station
Sub-base	per cubic yard
Fine Grading Subgrade and Shoulders	per square yard
Extra Rolling Earthwork	per hour
Extra Rolling, Base and Surface Courses	per hour
Sprinkling	per 1000 gallons
Water Hauled Additional Mile	per 1000 gallons
Subgrade Treatment Material	per cubic yard
Subgrade Treatment	per cubic yard

Quarter

Material Hauled Additional Mile	per cubic yard
Screening	per cubic yard
Reconstructed Base Course	per square yard
Shell	per cubic yard
Shell Base Course	per cubic yard
Caliche	per cubic yard
Caliche Base Course	per cubic yard
Disintegrated Limestone	per cubic yard
Disintegrated Limestone Base Course	per cubic yard
Iron Ore Top Soil	per cubic yard
Iron Ore Top Soil Base Course	per cubic yard

Gravel for Base Course per cubic yard	or	Gravel base course per cubic yard
		Crushing and screening per cubic yard
Gravel Base Course per cubic yard		Screening per cubic yard

Local Base Course Limestone	per cubic yard
Soft Limestone Base Course	per cubic yard
Sledging Stone	per cubic yard
Sledged Stone Base Course	per cubic yard
Crusher Run Broken Stone	per cubic yard
Crusher Run Broken Stone Base Course	per cubic yard

The item,- "Material hauled additional quarter mile", per cubic yard, applies to subgrade treatment, reconstructed base course, shell base and shell surface course, caliche base and caliche surface course, disintegrated limestone base and disintegrated limestone surface course, Iron Ore top soil base and Iron Ore top soil surface course, gravel base course, standard gravel surface course, pea gravel surface course, soft limestone base course, sledged stone base course, crusher run broken stone base course, and sand clay surface course.

Water Bound Gravel or Broken Stone Base Course	per square yard
Bituminous Concrete Base Course	per square yard
Concrete Base Course and Curb	per square yard

Sand Clay Surface Course	per cubic yard
Shell	per cubic yard
Shell Surface Course	per cubic yard
Caliche	per cubic yard
Caliche Surface Course	per cubic yard
Disintegrated Limestone	per cubic yard
Disintegrated Limestone Surface Course	per cubic yard
Iron Ore Top Sod	per cubic yard
Iron Ore Top Soil Surface Course	per cubic yard

Pea Gravel per cubic yard	or	Pea Gravel Surface Course per cubic yard
Pea Gravel Surface Course per cubic yard		Screening per cubic yard

Gravel for Surface Course per cubic yard	or	Standard Gravel Surface Course per cubic yard
Standard Gravel Surface Course per cubic yard		Crushing and Screening per cubic yard Screening per cubic yard

Waterbound Macadam Surface Course	per square yard
Single Bituminous Surface Treatment	per square yard
Double Bituminous Surface Treatment	per square yard
Triple Bituminous Surface Treatment	per square yard
Limestone Rock Asphalt Surface Treatment	per square yard
Bituminous Macadam Surface Course	per square yard
Two Course Limestone Rock Asphalt Surface Course	per square yard
Hot Mixed Limestone Rock Asphalt Pavement	per square yard
Coarse Aggregate Bituminous Concrete Pavement	per square yard
Bituminous Concrete Pavement (modified Topeka Type)	per square yard
Sheet Asphalt Pavement	per square yard

Concrete Pavement	per square yard
Reinforcing Steel for Pavement	per pound
Bituminous Filled Brick Pavement	per square yard
Untreated Timber	per 1000 feet board measured
Treated Timber	per 1000 feet board measured
Class "A" Concrete	per cubic yard
Class "B" Concrete	per cubic yard
Class "C" Concrete	per cubic yard
Class "D" Concrete	per cubic yard
Reinforcing Steel	per pound
Structural Steel	per pound
Dry Rubble Masonry	per cubic yard
Mortar Rubble Masonry	per cubic yard
Reinforced Concrete Pipe	per linear foot for the sizes prescribed
Cast Iron Pipe	per linear foot for the sizes prescribed
Corrugated Galvanized Metal Pipe	per linear foot for the sizes prescribed
Vitrified Clay Pipe	per linear foot for the sizes prescribed
Relaying Culvert Pipe ~~under~~ 18" diameter and under	per linear foot
~~Relaying Pipe~~	~~per linear foot for the sizes prescribed~~
Relaying C. P. over 18" diameter	" " "
Sodding	per 100 foot of roadway
Seeding	per 100 foot of roadway
Untreated Timber Piling	per linear foot
Treated Timber Piling	per linear foot
Precast Concrete Piling	per linear foot
Cast in Place Concrete Piling	per linear foot
Plain Rip Rap	per square yard
Grouted Rip Rap	per square yard
Stone Underdrain	per linear foot
Vitrified Tile Underdrain	per linear foot

Vitrified Tile Foundation Underdrain	per linear foot
Vitrified Tile Outlets for Underdrains	per linear foot
Concrete Curbing	per linear foot
Stone Curbing	per linear foot
Resetting Curbing	per linear foot
Wire Cable Guard Railing	per linear foot
Galvanized Iron Pipe Guard Railing	per linear foot
Wood Guard Railing	per linear foot
Concrete Railing for Structure	per linear foot
Pipe Railing for Structures	per linear foot
Iron Railing for Structures	per linear foot