

BRIDGE SECTION LIBRARY

SPECIFICATIONS AND CONTRACT

Edition 1918



TEXAS DEPARTMENT OF TRANSPORTATION

**STATE OF TEXAS
STATE HIGHWAY DEPARTMENT
SPECIFICATIONS AND
CONTRACT**

Edition 1918

**STATE HIGHWAY COMMISSION
STATE HIGHWAY ENGINEERING DEPARTMENT**

STATE OF TEXAS
STATE HIGHWAY DEPARTMENT

SPECIFICATIONS AND
CONTRACT

Edition of 1918



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Henry

Henry

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Henry Henry

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STATE OF TEXAS
STATE HIGHWAY DEPARTMENT

NOTICE TO CONTRACTORS
FOR
STATE ROAD AND BRIDGE CONSTRUCTION

Notice is hereby given that sealed proposals for the construction of highway improve-
ment in.....County, will be received at the office of
....., at....., Texas,
untilo'clock,.....M.,....., 19.....,
and then publicly opened.

DESCRIPTION OF WORK TO BE DONE.

.....
.....
.....
.....
.....
.....
.....
.....

County.....

Detailed plans of the work may be seen for examination, and information may be ob-
tained, at the office of.....
at....., Texas, and at the office of the State Highway Department,
Capitol Building, Austin, Texas.

A certified check for..... Dollars
(\$.....), made payable to the order of.....
of.....County, must accompany each proposal.

The right is reserved by the party of the first part to reject any and all proposals and
to waive all technicalities.

Proposals shall be submitted in sealed envelopes and marked, "Bids for the Construc-
tion of the..... Bridge in.....County."
Road

Proposals may be sent by mail, and when sent by mail shall be enclosed in an addi-
tional sealed envelope properly marked as indicated above.

All proposals otherwise submitted will be rejected as irregular. Only sealed bids will
be considered.

All bids received will be retained by the Department and will not be returned to the
bidders.

SPECIFICATIONS

ITEM 1. DEFINITION OF TERMS.

1.1. Information for Contractors. All things herein contained, also the proposal plans and advertisement for proposal, are hereby made a part of these specifications and contract, and are to be considered as one instrument.

The intent is to make them explanatory one of the other. Should any conflicting statements be found, the bidder, or contractor, shall accept the interpretation of the State Highway Engineer, whose decision shall be final and conclusive.

1.2. Definition of Terms. Whenever in the specifications or contract the following terms, or pronouns in place of them, are used, the intention and meaning shall be interpreted as follows:

State	State of Texas.
Commission	State Highway Commission of Texas.
State Highway Department.....	Party of the first part to this agreement.
State Highway Engineer.....	State Highway Engineer of Texas.
Engineer	State Highway Engineer of Texas, acting directly or through an assistant duly authorized by the State Highway Engineer.
Contractor	Party of the second part to this agreement.
Inspector	An authorized representative of the Engineer assigned to make any or all necessary inspection of the work contracted for.
Bidder	Any individual, firm or corporation submitting a proposal.
Plans	All drawings, or reproductions of drawing, profiles, etc., pertaining to the work, or to any structure connected with the work, which have been approved by the Engineer.
Proposal	The approved prepared form on which the bidder is to submit his, their, or its bid for the work to be contracted for.
Specifications	The directions, requirements, etc., contained herein, together with all written agreements made or to be made pertaining to the method or manner of performing the work or to quantities or qualities of materials to be furnished under the contract. The specifications shall include "Notice to Bidders," and proposal requirements, general provisions, payments, miscellaneous provisions, construction details, plans, etc.
Contract	The agreement covering the performance of the work. It shall include the plans and specifications and shall be held to cover any or all work, labor, implements, machinery, equipment and materials that are required to complete the work indicated in a proper and satisfactory manner. Work shown on the plans and not mentioned in the specifications, or vice versa, shall be done the same as if shown by both, and in case of conflict the decision of the Engineer shall be final and conclusive.

ITEM 2. INSTRUCTIONS TO BIDDERS.

2.1. Estimate of Quantities. The quantities listed in the estimate are the results of careful calculation, but are to be considered as approximate.

Payment to the Contractor will be made only for the actual amount of work of each class performed (which amount shall be determined after the completion of the contract) subject to the limitations hereinafter noted, and at the prices fixed for the same. The party of the first part reserves the right to increase or decrease subsequently any or all of the amounts given in the estimate of approximate quantities as shown in the Form of Proposal, or altogether to omit any of them, as may be deemed necessary by the Engineer.

2.2 Examination of Plans. Bidders shall examine carefully the plans, specifications and contracts, and proposal forms before submitting proposals, and shall carefully examine the conditions of the work and location of the same.

2.3. Laws and Ordinances. The Contractor and those under him shall conduct the work in such manner as to fulfill all the requirements of the Federal, State, county, and municipal laws and ordinances applying to the work in hand, and shall take such necessary precautions as will guard against accident or loss of life.

2.4. Proposal Form. Proposals must be made upon forms which may be obtained at the office of the State Highway Department, Austin, Texas. These proposal forms will state the location and will show the estimated quantities of the work to be performed, the time in which the work must be completed and the amount of certified check which must accompany the proposal.

2.5. Method of Submitting Proposals and Time to Complete. Sealed proposals must be signed properly and submitted as set forth in the "Notice to Contractors." Proposals will be received until the time and date indicated in the "Notice to Contractors," at which time they will be publicly opened and read. Each bidder must state in his proposal (in writing and in figures, without interlineations, alterations or erasures) the sum of money for which he will supply the materials and perform the work required by the general instructions, conditions and specifications, and state the time by which he will complete the work, should his proposal be accepted; and must sign his proposal with his full name and give his address.

In case where a firm or corporation submits a proposal, the proposal must be signed with the full name of each member of the firm, or the full name of each officer of the corporation, in addition to the firm or corporation signature, with official corporate seal thereto, and their addresses must be given.

2.6. Irregular Proposals. Proposals may be rejected as being informal if they show any omissions, alterations, additions not called for, conditional bids or irregularities of any kind.

2.7. Certified Check to Accompany Proposal. No proposals will be considered unless accompanied by a certified check payable to the order of party named and to an amount stated in "Notice to Contractors." All certified checks will be cashed as soon as received and deposited to the account of the State Highway Department. The amount of the checks deposited by the unsuccessful bidders will be paid by a State Warrant and returned to them within a reasonable time after contract is awarded. The amount of the successful bidder will be kept until the proper execution of the contract, after which a similar return of the amount of check will be made to him. If no award is made, all proposals will be rejected and the amount of all checks returned.

2.8. Delivery of Proposals. Proposals may be delivered in person by the Contractor or representative, or may be sent by mail, and when sent by mail must be enclosed in an additional envelope marked as indicated under "Notice to Contractors."

2.9 Withdrawal of Proposals. No bid shall be withdrawn after having been filed.

2.10. Opening of Proposals. Bids will be opened at the time and place indicated in "Notice to Contractors." Bidders or their authorized agents are invited to be present at the opening of the proposals.

2.11. Disqualification of Bidders. No bidder shall submit more than one proposal for any one piece of work outlined in the specifications and contract. All proposals unless submitted in regular form will be rejected, also unbalanced proposals, and proposals in which the gross sum as submitted does not agree with one obtained from several unit prices. Only sealed bids will be accepted.

2.12. Execution of Contract and Surety Bonds. The successful bidder must deposit and execute in conjunction with the contract, the bond hereto attached.

ITEM 3. AWARD AND EXECUTION OF CONTRACTS.

3.1. Right to Reject Bids. The right is reserved to reject any or all bids or proposals for nonconformance to the requirements under "Instructions to Bidders."

3.2. Award of Contract. Contracts will be awarded by the party of the first part at the time and place indicated in "Notice to Contractors," or if deemed advisable, at a time and place fixed by the party of the first part at the time of opening of bids.

3.3. Return of Guaranty. Certified checks or other guaranty will be returned to the bidder after a reasonable time after contracts have been awarded.

3.4. Contractor's Bond. The Contractor must execute a bond on the form hereto attached.

3.5. Execution of Contracts. The Contractor shall execute and file the contract with the State Highway Engineer within 10 days after the date of letting.

3.6. Failure to Execute Contract. It is hereby understood and stated that, should the successful bidder refuse or neglect to execute the contract within ten days after being notified to do so, the amount of the certified check shall become the property of the State, not as a penalty, but as liquidated damages for such neglect or refusal.

3.7. Subletting or Assignments. No work is to be sublet or assigned by a contractor without the written consent of the State Highway Engineer or his duly authorized agent.

3.8. Patented Products or Processes. If the Contractor uses any material, device or method covered by letter of patent without the written consent of the patentee or owner, he shall file bond satisfactory to the Commission indemnifying the State against any or all damages from the use thereof.

ITEM 4. GENERAL PROVISIONS.

4.1. Scope of Work. The Contractor shall furnish all labor, tools, equipment and materials necessary to complete the work to the finished lines, grades and cross-sections, and shall do such additional or incidental work as may be considered necessary in the opinion of the Engineer to complete the work in a substantial and satisfactory manner, and shall clean and remove from the right-of-way, footways, lawns or adjacent property all surplus or discarded material and temporary structures except as provided in special provisions in accordance with the plans, specifications and contract hereto attached.

4.2. Permits and Licenses. The Contractor shall procure and pay for all State and local licenses or permits required, and shall give all notices and pay all charges and fees incident to the lawful prosecution of the work.

4.3. Changes in Plans and Specifications. The Contractor shall make no changes in the plans or specifications or perform any work in any manner except as herein specified, except upon written notice of the Engineer or his authorized agent.

4.4. Interpretation of Plans. Where there is any discrepancy between the figures shown on the plans and those written in the specifications, the figure dimensions on the plans shall govern.

4.5. Special Work. Provisions for special work will be made in the form of special specifications, which will be attached to the form of proposal.

4.6. Alteration of Work. The right to be reserved by the Engineer to make such changes in the plans and specifications as may be considered necessary or desirable from time to time to complete more fully and perfectly the work agreed to be done.

4.7. Additional Work. The Contractor shall do such additional work, other than that designated in the estimate of quantities, as may be considered necessary in the opinion of the Engineer to complete the work fully as planned and contemplated, and will receive full payment for such additional work at the unit price shown in the proposal, and in the same manner as if such work had been included in the original estimate of quantities.

4.8. Extra Work, or Force Accounts. ~~Should~~ it be necessary in the opinion of the Engineer to do any work that is not covered by the plans and specifications other than that provided for in these plans and specifications, the Contractor hereby agrees to do any such work for the actual cost of the same plus ten per cent., actual cost being understood and agreed to as meaning all necessary labor at the regular prices paid therefor, and the actual cost to the Contractor of all materials as shown by properly authenticated bills. No charge shall be made by the Contractor for organization or overhead, but shall be limited to forces on the job.

4.9. Unauthorized Work. No work done by the Contractor not authorized under the plans or specifications or by the Engineer in charge will be paid for under the provisions of this contract.

4.10. Prosecution of the Work. The Contractor shall give his constant personal attention to the work while it is in progress, or shall place it in charge of a competent and reliable superintendent who shall have full authority to act for him, and who shall be acceptable to the Engineer, and shall prosecute the work at such points and in such order as the Engineer may from time to time direct. If at any time during the work progress ~~not~~ satisfactory to the Engineer shall not have been made, the Contractor shall increase the force, tools, and equipment as directed by the Engineer, but the failure of the Engineer to give such directions shall not relieve the Contractor of his obligations to complete the work at the time specified in this Contract.

4.11. Character of Workmen and Equipment. Whenever the Engineer shall determine that any person employed by the Contractor is, in his opinion, incompetent, unfaithful, disorderly or otherwise unsatisfactory, such person shall upon notice be discharged from the work and shall not again be employed on it except with the written consent of the Engineer. Any machinery furnished by the Contractor which shall be deemed by the Engineer as being unfit for use on the work, shall be removed at once upon due notice to the Contractor by the Engineer.

4.12. Co-operation of Contractor. The Contractor shall have in his possession a copy of all plans and specifications and shall familiarize himself with the same. In the absence of the Contractor there shall be placed in charge a competent and reliable Superintendent, as the Contractor's authorized representative to receive and obey orders from the Engineer.

4.13. Laws and Ordinances. The Contractor and those under him shall conduct the work in such manner as to fulfill the requirements of the Federal, State, County and municipal laws and ordinances applying to the work in hand, and shall take such necessary precautions as will guard against accident or loss of life. He shall maintain all camps and quarters for men according to the special rules and regulations of the State, county and town boards of health.

4.14. Public Convenience and Safety. During the performance of the work the Contractor shall so carry on the work that there shall be no undue interference with or hindrance to travel over the road, and the road shall be kept open to the traveling public at all times, unless otherwise directed by the Engineer in charge until the work is accepted. The Contractor shall take all necessary precautions to place proper guards for the prevention of accidents and shall between sundown and sunrise put up and keep suitable lights as warning signals. Whenever the road is not closed, and it is necessary to divert traffic around any portion of the work, the Contractor shall maintain safe and suitable passageway for the traveling public. If, in the opinion of the Engineer, it is not possible to maintain such passageway, then the Contractor shall erect barriers and direct the traveling public around the work by suitable signs in a manner satisfactory to the Engineer. The Contractor shall also be careful not to cover any hydrants or place any obstructions to sidewalks or cross-roads in such manner as to cause undue inconvenience to the traveling public, and shall within fire limits place no materials on or near hydrants as outlined under the specific regulations of the fire or police authorities. Where blasting is necessary the Contractor shall use the utmost care so as not to endanger life or property and shall be responsible for all damages and loss of life or property caused by carelessness due to the handling of explosives, and when directed, the number and sizes of charges shall be reduced. All explosives shall be kept in a secure and proper manner approved by the Engineer.

4.15. Property Damage and Replacements. In case of any direct or indirect injury or damages being done to public or private property by or because of the work or in consequence of any accident or omission on the part of the Contractor, his employees or agents, the Contractor shall at his own expense restore such property to a condition similar and equal to that existing before such damage was done, by repairing, rebuilding or otherwise restoring as may be directed, or he shall make good such damage or injury in a satisfactory manner, and in case of failure on the part of the Contractor to restore such property or make good such damage or injury, all payments will be withheld until such work shall be completed to the satisfaction of the Engineer.

4.16. Damage to Underground Structures. The Contractor shall be responsible for any damage to pipes, connections, conduits, tubing or other underground structures of any character that may be caused by negligence or carelessness on the part of his employees or agents.

4.17. Responsibility Before Acceptance. All depressions, defects and imperfections which may become evident in any portion of the roadway before final acceptance of the work by the Engineer, whether due to poor workmanship or material, public travel, rain, snow, ice, frost, or other causes, shall be repaired and made good by the Contractor at his own expense. Issuance of any estimate on any part of the work done shall not be considered as a final acceptance of any work completed up to that time. The Contractor will be required to replace any portion of any pavements adjoining the work which may have suffered through his operation, and it shall be left in a neat, workmanlike manner in a condition equal to that obtaining before the Contractor started the work.

4.18. Restoration of Surfaces. All surfaces opened by the Contractor, except those therein specified shall be replaced by him in a neat, workmanship manner. No additional allowance will be made for such work except when same has been ordered by the Engineer.

4.19. Tests of Materials. The Contractor shall allow the Engineer to check or assemble samples for testing purposes from any and all materials used. The result of any tests upon any of the materials shall govern the question of acceptance or rejection of such materials by the Engineer. All materials will be tested by the party of the first part in accordance with the standard practice as hereinafter stated.

4.20. Quality of Materials. No materials shall be used in this work unless conforming to the requirements of these specifications, and all materials proposed to be used will be inspected and approved by the Engineer before being incorporated into the work.

4.21. Storage of Materials. The Contractor shall provide facilities on the job for properly protecting and keeping in good condition all materials subject to deterioration on account of climatic or other conditions.

4.22. Use of Materials Found on Work. The Contractor, with the approval of the Engineer, may use in the construction of the work any sand, gravel, or stone found in the excavations, but whenever deemed necessary shall replace any material so removed with the other satisfactory material.

4.23. Disposition of Old Material. The Contractor shall dispose of, as directed by the Engineer, all structures and materials found on the work and not specified to be used to complete the work contemplated or found necessary under the contract.

4.24. Lines and Grades. The Contractor will be furnished by the Engineer with all lines, grades and measurements necessary to the proper prosecution of the work contracted for under these specifications. The Contractor will be held responsible for the proper preservation of all marks and stakes. If in the opinion of the Engineer any marks or stakes should be wilfully or carelessly disturbed or destroyed by the Contractor or his employees, the cost of replacing them at a rate of 50c a stake will be charged against the Contractor, to be deducted from any moneys due him.

4.25. Cross-Section of Roadway. The cross section of the finished roadway shall be shown on the plans, and shall be changed only at intersection or to insure proper surface drainage, or for other reasons as set forth by the Engineer.

4.26. Inspection. The Contractor and his employees shall obey the directions and orders given by the Inspector or Engineer, and in case of disputes shall refer the matter in writing to the State Highway Engineer, whose decision shall be final and binding.

The work shall be done under the direct supervision and to the complete satisfaction of the State Highway Engineer, and if it is Federal Aid work it shall be subject to inspection at all times, and approval by the United States Secretary of Agriculture, or his agents, and in accordance with the laws of the State of Texas and the rules and regulations of the said Secretary of Agriculture made pursuant to that certain Act of Congress approved July 11, 1916, (39 U. S. Statutes at Large, 355) entitled "An Act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes."

4.27. Examination of Work. The Engineer shall be furnished with every reasonable facility for ascertaining whether or not the work is being done in accordance with the requirements and intention of this contract, even to the extent of uncovering or

removing portions of finished work. Should the work thus exposed or examined prove satisfactory, the uncovering or removing and the replacing of the covering or the making good of the parts removed shall be paid for as additional work, but should the work exposed or examined prove unsatisfactory, the uncovering, removing and the replacing of the covering or the making good shall be at the expense of the Contractor.

4.28. Defective Materials and Work. If after trial it is found that partially developed quarries, ledges, banks or other sources of supply which had been approved upon sampling or otherwise do not furnish a uniform product, or if for any reason the product from any source at any time before commencing or during the progress of the work proves to be unsatisfactory, the Contractor shall furnish approved material from other sources. All defective work which has been condemned shall be removed immediately by the Contractor at his expense. All crushing plants installed on the work shall be fitted with tailing chutes, so that no stone will reach the bins other than that passing through the proper screens. All stone must be of the required size when placed in the roadway, and no breaking up of stone by hammer or otherwise will be permitted.

4.29. Failure to Remove Defective Material. Should the Contractor fail to remove any rejected materials or renew any defective work indicated by the Engineer, the work shall be closed down upon written notice from the Engineer, setting forth reasons for such action.

4.30. Final Cleaning Up. Before the work is accepted as fully complete, the Contractor shall neatly trim the slopes of cuts and fills to the dimensions indicated on the cross-section, remove all rubbish and surplus material from the roadway, shoulders, culverts, inlets, outlets and ditches, and leave the roadway in a neat and presentable condition from end to end.

4.31. Suspension of Work. The Engineer may stop any portion of the work if in his judgment the weather or other conditions, such as labor troubles, poor materials, etc., are such as to prevent the same being done properly. Such notice shall be in writing to the Contractor.

4.32. Method of Computing Time Allowance. The computation of the number of consecutive working days shall start from the date the Engineer notifies the Contractor to begin the work. If, on account of bad weather, or for other reasons not controlled by the Contractor, or through no act or fault of the Contractor, the work should be delayed or impeded, then the total number of days resulting from such delay shall be excluded from the above mentioned computation. In all cases the Engineer shall determine the number of days that the Contractor has been unavoidably delayed which shall be certified to in writing and shall be binding and conclusive upon the Contractor. When the execution or completion of the contract requires work or material in greater amounts or quantities than those mentioned and set forth in the estimates, the time may be increased as the Engineer may deem just and reasonable.

4.33. Failure to Complete Work on Time. For each working day that any work shall remain uncompleted after the time specified in the proposal and contract, and allowed by the Engineer for the completion of the work provided for in these plans, specifications and contract, the sum per day given in the following schedule, unless otherwise specified in the proposal, shall be deducted from the moneys due the Contractor, not as penalty, but as liquidated damages:

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 and less than \$20,000.....	\$15.00
\$20,000 and less than \$50,000.....	\$20.00
\$50,000 or more	\$25.00

4.34. Annulment of Contract. If at any time the work under contract should be abandoned, or if at any time the Engineer should judge that said work or any part thereof, is unnecessarily delayed, or that the Contractor is wilfully violating any of the contract or covenants of this contract, or is executing the same in bad faith, or shall

neglect or refuse to remove such material or to perform anew such work as shall be rejected as defective and unsuitable, then in such case, the Engineer shall notify said Contractor in writing to that effect. If the Contractor should not within three days thereafter take such measures as will, in the judgment of the Engineer, insure the satisfactory progress of the work, the party of the first part may then notify the said Contractor in writing to discontinue all work under this contract and declare said contract null and void, and the Engineer may employ other parties or labor to complete the work in such manner as he may decide, and use such materials and machinery as may have been delivered upon aforesaid work, and if necessary procure other labor, machinery or materials for its completion and charge the expense of said labor, machinery or materials to the Contractor, which expense shall be deducted from any moneys due him under this contract. In case the expense shall exceed the sum which would have been payable under this contract if the same had been completed by the Contractor, he or his sureties shall pay the amount of the excess to the party of the first part on notice from the Engineer, and in case the expense is less than the sum which would have been payable under the contract, then the Contractor shall be entitled to receive the difference.

4.35. Measurement of Quantities. All work done under these specifications will be measured in "U. S. Standard Measure." All linear surface measurements will be made along the actual surface of the highway or structure and not horizontally. The area of the surfacing to be paid for will be only the actual area covered by the entire surfacing material except that no deduction will be made for fixtures in the street or roads with an area of nine square feet or less. The amount of work done by the Contractor will be measured by the Engineer. The line measurements of any road will be made along the center line of said road or parallel thereto.

4.36. Scope of Payments. The Contractor shall receive and accept the compensation as herein specified in full payment for furnishing all materials, labor, tools, and equipment and for doing all the work contemplated and embraced in these specifications, also for all loss or damage arising out of the nature of the work aforesaid or from the action of elements or from any unforeseen difficulties or obstructions which may arise or be encountered in the prosecution of the work until its approval by the Engineer and its acceptance, and for all risks of every description connected with the work, also for all expenses incurred by or in consequence of the suspension or discontinuance of said work as herein specified, and for any infringement of patent, trademark, or copyright, and for completing the work and the whole thereof in a manner and according to the plans, specifications, and contract. All such payments do not constitute acceptance of said work.

4.37. Partial Payments. On the first Monday of the month for Division No. 1, the first Tuesday for Division No. 2, the first Wednesday for Division No. 3, the first Thursday for Division No. 4, the first Friday for Division No. 5, and the first Saturday for Division No. 6, 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 price contracted for. From the amount 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. No estimate, other than a final estimate, shall be made where the amount earned since the last preceding payment is less than \$500.00, unless a written order to do so is given by the Commissioners' Court.

4.38. Final Payments. The action of the Engineer by which the Contractor is to be bound and concluded according to the terms of the contract shall be evidenced by the final estimate, all prior estimates upon which ninety per cent. payments may have been made being really partial estimates and subject to corrections in such final estimate. The Engineer, when satisfied that the Contractor shall have completed the work in accordance with the terms of the contract, shall certify the aforesaid final estimate for payment. The Contractor shall check the final estimate for errors, and unless the Engineer is notified within thirty days of any change that the Contractor believes should be made, then the final estimate as rendered shall be considered as the proper and final payment of all moneys due the Contractor; and the Contractor's acceptance of the final estimate shall constitute a conclusion of the contract in so far as payments due him are concerned, and the said acceptance shall be taken as his acquiescence in the correctness of the final estimate.

4.39. Waiver of Legal Right. No decision or discovery of error in plans, estimates, or specifications, or contract shall in any way invalidate the contract.

4.40. Contractor's Bond. The Contractor shall file as a guaranty of his faithful performance of said contract, a good and sufficient bond in an amount of the total sum intended to be paid to said Contractor under this contract. Said bond shall be furnished by the surety company authorized to do business in the State of Texas, or responsible persons acceptable to party of first part.

4.41. Contractor's Cost Record. The Contractor shall keep and submit to the Engineer a detailed cost record of the work on forms prescribed by the Engineer. The Contractor shall be required to certify as to the correctness of all cost records thus submitted by him to the Engineer.

4.42. Work Limited to Amount of Money Available. Before starting the work there shall be appropriated by the Commissioner's Court, out of the proper funds, an amount of money 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, the Commissioners' Court, and the Contractor. If reduction is made in a manner other than herein above mentioned, the Contractor shall have cause for court proceedings against the Commissioners for misappropriation of funds, and the said Commissioners shall be subject to all penalties covering misappropriation of funds. The Contractor is hereby cautioned and warned that he will receive no greater amount for work done than the appropriated amount, and all work done beyond that quantity that can be paid for from appropriated moneys, 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 appropriation 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.

CONSTRUCTION DETAILS

ITEM 5. EXCAVATION AND EMBANKMENT.

5.1. Excavation. Excavation shall include the removal and satisfactory disposal of all material taken from within the limits of the work contracted for and usually designated by the term grading, necessary for the preparation and construction of the roadbed, embankment, subgrade, berms, slopes, side ditches, approaches, public and private entrances, etc., as directed. This excavation will be measured in the original position and paid for at the contract price per cubic yard for excavation, which price will also include all clearing and grubbing, except that classified separately as clearing and grubbing, and shall include the shaping and preparation of the flat subgrade. All rock and other materials excavated shall be included and classified as plain "Excavation," except face rock or quarry work, which will be listed and paid for as rock excavation.

5.2. Clearing and Grubbing. The ground shall be cleared of all trees, stumps, brush, roots, fences, walls, buildings, or other incumbrances upon or within the outer limits of the roadway before grading is commenced. The Contractor shall burn or otherwise dispose of all such trees, stumps, roots, etc., in a satisfactory manner, and shall remove all rubbish or refuse to such point or points beyond the limits of the work as may be directed. When it is necessary to remove a fence or fences for the prosecution of the work, the Contractor shall do such work with proper care, and shall place the material so removed on the abutting property in a manner satisfactory to the Engineer. Clearing and grubbing shall be paid for and included in the contract price for Excavation, unless classified separately as clearing and grubbing of new right-of-way, soil, sand-clay, and gravel pits, which will be paid for at a unit price as listed in the Proposal.

5.3. Removal of Obstructions. Removal of obstructions or incumbrances, etc., shall be classified as clearing and grubbing unless otherwise specified.

5.4. Roadway Excavation. The roadbed shall be graded to the lines, and grades given by the Engineer and in conformity with the plans, profile, and cross-sections.

5.5. Excavation for Structures. Excavation for all structures shall consist of the removal and back-fill of all materials necessary to place the structure or any part thereof and the cost therefor shall be included in the price contracted for the structure.

5.6. Embankments. Embankments shall be formed of successive horizontal layers of suitable material not more than (12) twelve inches in depth for the fullest width of the cross-section. When roadway is to be hard surfaced each layer of fill and the cuts shall be rolled thoroughly with a power roller weighing not less than ten tons when ordered by the Engineer. Stumps, trees, rubbish or other unsuitable material shall not be permitted in the embankment. When embankments are to be on a hillside, the slope of the original ground under the fill shall be plowed deeper or cut into steps before the filling or embankment is commenced. It is understood that the Contractor assumes the responsibility for the safety and stability of all embankments and shall replace any portion thereof which has become displaced or destroyed due to carelessness or negligence on the part of the Contractor or to damage resulting from natural causes, such as storms, cloudbursts, etc., and not attributable to the unavoidable slipping of the natural ground upon which the embankment is made, nor to the nature of the material itself when placing of such material has been ordered by the Engineer. All such work shall be done by the Contractor at his own expense. All embankment work shall be classified, included and paid for under Excavation, and when embankments are made with borrowed material, the measurements shall be made in the excavation and shall be paid for under Excavation.

5.7. Disposal of Surplus Material. All excavated material not required nor permitted in the embankment, shall be removed from within the lines of the roadway and deposited at such point or points as directed by the Engineer.

5.8. Borrow. Borrow shall include the removal and satisfactory disposal of material in addition to that found in the excavation within the limits of the work contracted for, necessary to form or complete the embankment, subgrade, berms, etc. It will be paid for at the contract price per cubic yard for excavation, which price will include clearing, grubbing, and any necessary incidental work thereto. When the amount of the embankment exceeds the amount of the excavation within the limits of the work contracted for, sufficient suitable material to form or complete the embankment, subgrade, berm, etc. shall be obtained by the Contractor from borrow pits as directed by the Engineer and included under the items of Excavation.

5.9. Overhaul. All excavated materials shall be placed as directed within one thousand feet haul. Contractor will be allowed one cent per cubic yard per one hundred feet for overhaul in excess of one thousand feet.

5.10. Subgrade. The bottom of the excavation and the top of the fill when completed shall be known as the graded section, and all places shall be true to the lines, grades, and cross-sections as shown on the plans. All work in connection with the section as graded flat will be included in the contract price for Excavation. The subgrade is the surface on which the road metal rests. When the roadbed is to be surfaced with a hard surfacing material, the subgrade shall be brought to the trench, or box section and the entire area rolled with a power roller weighing not less than ten tons, and all portions of the surface of the trenched subgrade which are inaccessible to the roller shall be tamped thoroughly with a hand tamper weighing not less than fifty pounds, the face of which shall not exceed one hundred square inches in area. All soft and yielding material and all vegetable substances or other unsuitable materials shall be removed and the space refilled with approved material, and it is essential under all conditions that the subgrade be firm and unyielding. In handling materials, tools, equipment, etc., the Contractor shall protect the finished subgrade from damage by laying planks thereon when directed and shall take such other precautions as may be deemed necessary. No foundation or surfacing material shall be placed on the subgrade until same has been checked and accepted by the Engineer. The trenching and finishing done just prior to placing the surfacing, and after the section has been graded flat, shall be considered as part of the work incidental to placing the surfacing and shall be classified as being under "Placing Surfacing."

5.11. Shoulders. All materials used for shoulders adjacent to any surfacing, that necessarily would be placed during the flat grading will be classified under Excavation.

The part of the shoulders that is built after the subgrade or trench is shaped, just prior to placing the surfacing, will be considered as part of the work incidental to the placing of the surfacing and shall be classified as being under "Placing Surfacing."

5.12. Quantities of Excavation. All measurement of excavated material shall be made in place in the original position.

5.13. Drainage Ditches. All material removed, excavated, or hauled for the purpose of draining the water from the roadway, other than the ditching as outlined in the cross-sections of the roadway design, shall be classified as Ditching, and shall be contracted and paid for at a rate per cubic yard stipulated in the Proposal and further classified as Hand or Machine Work.

5.14. Basis of Payments. Payments of all Excavation shall be made on the basis of a cubic yard and in accordance with the prices listed in the Proposal.

5.15. Sub-base. Any broken stone, gravel, or other material used to replace sub-grade material or to support the base course or bring the subgrade to proper grade shall be included and paid for as Excavation.

Stakes are to be set opposite the reference stakes at equal distance each side of the center line, the distance between these stakes to be the width of the new road. These stakes are to be used as a guide to plow out the trench. The plow shall be run inside the stakes, cutting as close to the stakes as possible without disturbing them, turning the furrow toward the center of the road, and the trench roughed out with a road machine.

6.4. Hand Work. After all possible road machine trenching has been done, the stakes shall be reset and driven firmly and a line drawn on their inside faces to guide the laborers in trimming the shoulders.

The edges of the trench shall be trimmed straight and the bottom shall have a uniform longitudinal grade and shall conform to the cross section shown on the plan.

6.5. Rolling Subgrade. After the trench or subgrade has been properly shaped as heretofore described, it shall be rolled until compact, and any hollows that develop shall be filled with suitable material.

In deep, mealy sand where rolling is impracticable, the shaped subgrade shall be thoroughly soaked with water to prevent the sand from mixing with the stone. Where soft places occur in the subgrade, they shall be dug out and the soft material replaced with good dirt or other material which will compact under the roller.

6.6. Side Drains. In clay soils, or at any place as directed by the Engineer, side drain trenches, or bleeders, shall be cut through the shoulders at right angles to the center line, every fifty feet, and every twenty-five feet in low places or between hills. The trenches shall be cut three inches lower than the bottom of the subgrade at the shoulders and shall have a good fall all the way to the ditch. They shall be filled to a depth of four inches for their whole length with first course material and covered with sod, grass side down, or with hay or straw. The remaining depth of trench shall then be filled with earth until flush with the shoulders, the ditch end of the drain being left open. On hills over four per cent. in grade, side drain trenches shall be cut seventy degrees with the center line down hill and shall be cut through to the center of the roadbed.

6.7. First Course. First course material shall be dumped on the subgrade and spread to a uniform loose depth of..... (.....) inches and to a width of..... (.....) feet, after which it shall be rolled until it forms a compact, firm, smooth, surface. Rolling shall commence at the sides and work toward the center, and the rear wheels of the roller must cover this space thoroughly, or as close thereto as the width of roller and road permit. Should any unevenness or depressions occur upon rolling the first course, they shall be filled and levelled immediately with first course material and rerolled until a firm, even surface is obtained. In no case shall first course material be placed upon a muddy subgrade.

6.8. Reshaping Shoulders. After spreading and rolling the first course as above, if necessary, the shoulders are to be rebuilt, true to line and to such a height that the second course material can be spread between them without overlapping the earth at the sides.

6.9. Second Course. Second course material shall be dumped on top of the first course and spread evenly to a uniform loose depth of..... (.....) inches, and to a width of..... (.....) feet, after which it shall be rolled commencing on each outer edge, with the rear wheel half on the stone and half on the shoulder, working from the outside toward the center. The roller shall be run over this course a number of times until the stone is brought to shape and well compacted before any third course material is applied. All low places shall be filled with second course material and all high spots shall be raked down and rerolled so that the surface presents a smooth, even appearance and has the cross section shown on plans.

6.10. Third Course. Third course material, commonly called screenings, shall be dumped in piles on the side of the grade with the inner edge of the piles about two feet from the trench or subgrade. **IN NO CASE SHALL THE SCREENINGS BE DUMPED DIRECTLY ON THE SECOND COURSE MATERIAL.** Screenings shall be applied with a square point dirt shovel, putting them on very thinly and with a quick sweeping motion, working from one end of the road to the other. The roller shall be kept running

continuously over the part of the road being screened while the screenings are being applied. This process shall be repeated until all the voids, or holes, are filled and the stone is entirely covered with screenings to a depth not exceeding one-quarter inch.

6.11. Flushing. After the stones have been covered with screenings, as heretofore described, the surface shall be thoroughly soaked with water, applied with a sprinkler until the tires run clean. The sprinkler shall be followed closely by the roller and the road shall be sprinkled and rolled until water is carried along continually in front of the roller wheels.

If bare spots appear more screenings shall be added and the sprinkling and rolling continued until a smooth, compact surface is obtained, showing no perceptible tracks of the rear roller wheels. If any unevenness or depressions appear upon rolling the screenings, second course material shall be used until they are removed and the disturbed surface shall be screened, flushed, and completed until it presents a smooth, even appearance.

6.12. Closing the Road. The newly finished portion of the road shall be blocked up so travel will be kept off until the surface is, in the opinion of the Engineer, dry enough to use.

6.13. Trimming Shoulders. After the road is flushed as above, any screenings or other material not used shall be removed from the side of the road, and as soon as the flushed portion is dry enough, the shoulders shall be brought to the specified slope and width and rolled as far out from the center as is practicable and safe. No portion of the shoulders shall be left higher than the finished surface of the stone at the outer edge. After trimming, rolling, and removing surplus material, the finished road shall have the dimensions called for on the cross-section drawings for this work, and shall be left in a neat and presentable condition.

6.14. Defects Before Acceptance. All depressions, defects, and imperfections which may appear in any portion of the macadam surface before final acceptance by the Engineer, whether due to poor workmanship or material, public travel, or other cause, shall be repaired and made good by the Contractor at his own expense. The right is reserved by the party of the first part to defer final acceptance and final payment for any part of the work until it has been open to public travel for at least thirty days.

Before any portion of the work is accepted as completed, the Contractor must neatly trim the slopes in cuts and fills, remove all surplus material and present the portion of the road desired to be accepted in a neat and presentable condition from end to end.

6.15. Bituminous Macadam. Whenever a bituminous macadam shall be specified the stone and bitumen shall be applied as hereinafter described. All clauses of the specifications for "Waterbound Macadam" preceding shall be in full force and effect except when contrary to or modified by the specifications following.

6.16. Basis of Payments. The surfacing material will be paid for by the cubic yard at the nearest delivery point. Hauling surfacing will be paid for at the unit price per cubic yard per one-fourth mile haul. All preparation of subgrade, placing, handling, mixing, sprinkling, rolling, and other work incidental to the placing of the surfacing are to be included in the unit price for "Placing Surfacing." Where side drains are necessary, the excavation will be paid for at the unit price per cubic yard for ditching. The filling of the drain ditches with gravel, sod, and earth shall be considered as work incidental to the placing of the surfacing and shall be included in the unit price for "Placing Surfacing."

ITEM 7. BITUMINOUS MACADAM.

(PENETRATION METHOD)

7.1. Description. This pavement shall consist of a three (3) inch wearing surface, composed of broken stone and bituminous binder, with a bituminous seal coat and stone chip covering, constructed on a five inch base course, unless otherwise specified, by the penetration method, in accordance with these specifications.

7.2. Bituminous Material. The bituminous material to be used in this work shall be a hydrocarbon product refined and prepared from asphaltic petroleum, or crude, natural, solid asphalt, with the use of a proper flux; or from tar, and shall meet with one of the following sets of requirements:

PETROLEUM AND ASPHALTIC DERIVATIVES.

(a) *Refined Asphalt.* The refined asphalt, to be used for the paving mixtures herein required, shall be derived by one of the following methods:

1. By heating, if requiring refinement, crude, natural, solid asphalt to a temperature of not more than four hundred (400) degrees F., until all the water has been driven off. The term "crude, natural, solid asphalt" shall be construed to mean any natural mineral bitumen, either pure or mixed with foreign substances, from which, through natural causes in the process of time, the light oils have been driven off until it has a consistency harder than one hundred (100) penetration at seventy-seven (77) degrees F. At least ninety-eight and one-half (98½) percent of the contained bitumen in the refined asphalt, which is soluble in cold carbon bisulphide (CS₂), shall be soluble in cold carbon tetrachloride (CCl₄). In no case shall any asphalt be prepared at the refinery with any product not hereinafter provided for.

2. By careful distillation of asphaltic petroleum with continuous agitation until the resulting bitumen has a consistency not harder than twenty-five (25) penetration at seventy-seven (77) degrees F.

Specific Gravity. The specific gravity 25°C/25°C. shall not be less than 1.02.

Penetration. The penetration at seventy-seven (77) degrees F. shall be between ninety (90) and one hundred and sixty (160).

Volatility. The loss by volatilization, fifty (50) grams, five (5) hours, three hundred and twenty-five (325) degrees F., shall not exceed five (5) percent, by weight, of the bitumen present.

Solubility. Materials prepared from asphaltic petroleum shall be soluble in cold carbon bisulphide (CS₂) to the extent of not less than ninety-nine (99) percent. Of the bitumen soluble in cold carbon bisulphide (CS₂) for both asphaltic petroleum and natural asphaltic pitch derivatives, not less than ninety-eight and one-half (98½) percent shall be soluble in cold carbon tetrachloride (CCl₄).

Ductility. The asphaltic cement at the penetration used, shall have a ductility of not less than fifty (50) centimeters, at seventy-seven (77) degrees F.

3. Refined asphalt produced by combining crude natural asphalt with either of the following:

(1) Residuums obtained by the distillation of petroleum oils as specified under fluxes.

(2) Alphas obtained by the distillation of petroleum oils as specified.

(b) *Flux.* The fluxing material may be a paraffine, a semi-asphaltic or asphaltic residue, which shall be tested with and found suitable to the asphalt to be used. Paraffine and semi-asphaltic residuums must have a penetration greater than three hundred and fifty (350) at seventy-seven (77) degrees F. under fifty (50) grams weight for one (1) second. All residuums shall be soluble in cold carbon tetrachloride (CCl_4) to the extent of at least ninety-nine (99) percent and must remain soft after heating for five (5) hours at four hundred (400) degrees F.

(1) *Paraffine Residuum.* Paraffine residuum shall have a specific gravity of ninety-two one-hundredths (0.92) to ninety-four one-hundredths (0.94) at seventy-seven (77) degrees F. It shall not flash below three hundred and fifty (350) degrees F., open cup method, and shall show a loss of not more than five (5) percent, by weight, in the volatilization test, as herein described. The residue after heating shall flow at seventy-seven (77) degrees F., and shall be homogeneous and shall show no coarse crystals.

(2) *Semi-Asphaltic Residuum.* Semi-asphaltic residuum shall have the same general characteristics as paraffine residuum, except that it shall have a specific gravity of ninety-four one-hundredths (0.94) to ninety-eight one-hundredths (0.98) at seventy-seven (77) degrees F.

(3) *Asphaltic Residuum.* Asphaltic residuum shall have the same general characteristics as paraffine residuum, except that the specific gravity shall not be less than ninety-eight one-hundredths (0.98) nor more than one and one one-hundredths (1.01) at seventy-seven (77) degrees F.

(c) *Asphaltic Cement.* The asphaltic cement prepared from materials designated previously shall be composed of the refined asphalt, or asphalts and flux (where flux must be used), in such proportions as to produce an asphaltic cement of a suitable degree of penetration. The proportion of the refined asphalt comprising the cement in no case shall be less than forty (40) percent, by weight. When the weight of the flux in the asphaltic cement, prepared from solid natural asphalt, exceeds twenty-five (25) percent thereof, asphaltic or semi-asphaltic flux shall be used. Refined asphalts and flux comprising the asphaltic cement, when required, shall be weighed separately in the presence of the Engineer. In the use of the mixture of refined asphalts, described in Paragraph 7.2-a, for asphaltic cements, only asphaltic or semi-asphaltic fluxes shall be used, except in those cases where the solid natural asphalt is of such character that when mixed with paraffine flux, without the addition of any other material, it will produce an asphaltic cement complying with the requirements set forth in these specifications. In such cases, any of the fluxes elsewhere specified may be used.

(1) *Preparation and Properties.* The refined asphalt and flux used in the preparation of the cement shall be melted together in a kettle at a temperature ranging from two hundred and fifty (250) to not more than three hundred and seventy-five (375) degrees F., and shall be agitated thoroughly, when hot, by air, dry steam, or mechanical appliances, until the resulting cement has become mixed thoroughly into a homogeneous mass. The agitation must be continuous during the entire period of preparing the mixture. Asphaltic cement always shall be of uniform consistency and if any portion should settle in the kettle between the intervals of using, it must be agitated thoroughly before being drawn for use.

Penetration. The asphaltic cement shall have a penetration of from thirty-five (35) to seventy (70) which shall be varied by the Engineer within these limits to adapt it to the particular kind of asphalt used in the paving mixture, and to the traffic and other conditions.

Volatility. The asphaltic cement of the penetration to be used in the mixture shall show a loss by volatilization of not more than three (3) percent, by weight, of the bitumen present, nor shall the penetration at seventy-seven (77) degrees F. after such heating be less than one-half ($\frac{1}{2}$) of the original penetration.

Ductility. The asphaltic cement, at fifty (50) penetration shall have a ductility of not less than thirty (30) centimeters at seventy-seven (77) degrees F. If the asphaltic cement, as used in the paving mixture, varies from fifty (50) penetration, an increase of at least two (2) centimeters in ductility will be required for each five (5) points in penetration above fifty (50) and a corresponding allowance will be made below fifty (50) penetration.

(d) *Bituminous Tests.* All penetrations indicated herein, unless otherwise specified, refer to the depth in penetration in hundredths of a centimeter of a No. 2 cambric needle, weighted to one hundred (100) grams, acting for five (5) seconds on a sample maintained at seventy-seven (77) degrees F., the test to be conducted as described in the "1916 Standards of the American Society for Testing Materials."

The loss by volatilization as herein specified shall be determined on a sample of fifty (50) grams weight in a container two and three-sixteenths ($2\frac{3}{16}$) inches in diameter and one and three-eighths ($1\frac{3}{8}$) inches deep, maintained in an oven at a temperature of three hundred and twenty-five (325) degrees F. for five (5) hours, the test to be conducted as described in the "A. S. T. M. Standards, 1916."

The ductility shall be determined as the total elongation in centimeters, of a briquette having a minimum cross sectional area of one (1) square centimeter (Dow mould) elongated at the rate of five (5) centimeters per minute when maintained at a temperature of seventy-seven (77) degrees F.

TAR DERIVATIVES.

If the material to be used is made from tar, it shall be uniform in character, free from water, dirt or other adventitious materials, and shall contain not more than two-tenths (0.2) percent of mineral substance and not more than five-tenths (0.5) percent of water-soluble materials, and shall meet either of the following test requirements:

(a) *High Carbon Tar.* If made from a high carbon tar, it shall meet the following requirements:

Specific Gravity. The specific gravity shall be not less than one and twenty-two one-hundredths (1.22) nor more than one and twenty-eight one-hundredths (1.28) at seventy-seven (77) degrees F.

Distillation. When one hundred (100) cubic centimeters are distilled in a two hundred and fifty (250) cubic centimeter "Engler" flask, according to the method adopted by the American Society for Testing Materials (1917), it shall show the following fractions by weight:

0°—170°C	0.0 percent.
170°—300°C	not to exceed 15.0 percent.

The specific gravity of the entire distillate shall be not less than one and three one-hundredths (1.03) at seventy-seven (77) degrees F. The residue from the distillation shall have a melting point not greater than one hundred and sixty-five (165) degrees F.

Melting Point. The material shall have a melting point determined by the one-half ($\frac{1}{2}$) cube method, in water jacket of not less than one hundred (100) degrees F. nor more than one hundred and ten (110) degrees F.

Free Carbon. The free carbon shall be not less than twelve (12) nor more than twenty-two (22) percent.

(b) *Low Carbon Tar.* If made from a low carbon tar it shall meet the following requirements:

Specific Gravity. The specific gravity at twenty-five (25) degrees C. shall be between one and fifteen one-hundredths (1.15) and one and one-hundred and seventy-five one-thousandths (1.175).

Solubility. On extraction with carbon bisulphide (CS_2) at room temperature, not less than ninety-seven (97) per cent shall be soluble.

Consistency. When subjected to the "New York Testing Laboratory Float Test" at one hundred (100) degrees C. the float shall sink in not less than twenty (20) nor more than twenty-four (24) seconds.

Distillation. When one hundred (100) cubic centimeters are distilled in a two hundred and fifty (250) cubic centimeter Engler flask according to the method adopted by the American Society for Testing Materials (1917), it shall show the following fractions by weight:

	Percentage.
Start to 170 degrees C.....	Not more than 0.5
Up to 235 degrees C.....	Not more than 3.0
Up to 270 degrees C.....	Not more than 12.0
Up to 300 degrees C.....	Not more than 25.0

The melting point (ring and ball method) of the residue shall be not more than sixty-five (65) degrees C.

7.3. Coarse Stone for Top Course. The stone for this work shall consist of clean, tough, durable, crushed rock, which will not disintegrate when exposed to atmosphere, and having a French coefficient of wear not less than ten (10) unless otherwise specified. It shall be uniformly graded and of such size that all will not pass a laboratory screen having circular openings of less than one and one-half ($1\frac{1}{2}$) inches nor more than two (2) inches in diameter and through a screen having circular openings three and one-quarter ($3\frac{1}{4}$) inches in diameter. This material shall be free from dust, foreign materials and coatings of any character and from an excess of flat and elongated pieces.

7.4. Small Stone for Top Course. The stone for filling the surface voids in the coarse stone shall conform to the requirements for the coarse stone in the preceding Paragraph 7.3, except that it shall be of such size as will not pass a laboratory screen having circular openings of less than one-half ($\frac{1}{2}$) nor more than three-quarters ($\frac{3}{4}$) of an inch in diameter and through a screen having circular openings not larger than one and one-half ($1\frac{1}{2}$) inches in diameter.

7.5. Stone Chips. The stone chips to be used on the seal coat shall conform to the requirements for coarse stone, Paragraph 7.3, except that they shall be of such size that all will pass through a laboratory screen having circular openings not less than one-fourth ($\frac{1}{4}$) nor more than three-quarters ($\frac{3}{4}$) of an inch in diameter, free from excessive dust and with the larger sizes predominating.

7.6. Approval of Material Sources of Supply. Sources of supply for the bituminous binder and aggregates shall be approved by the Engineer before the delivery of materials is started.

Samples of bituminous binder shall be submitted when directed. Samples of aggregates shall be forwarded to the State Highway Department, Testing Laboratory, Austin, Texas. Aggregate samples shall be accompanied by a statement giving the type of material, name of the producer, location of the plant and diameter of openings in screens used in their preparation.

(a) *Stone Chip Samples.* Samples representative of the stone chips intended for use in the seal coat shall weigh approximately ten (10) pounds, and shall be shipped in dust proof containers.

(b) *Coarse Aggregate Samples.* Samples of coarse aggregate for the bituminous macadam surface course shall be of the character described in Paragraph 9.7.

7.7. Base Course. The base course for the Bituminous Macadam surface course shall be as specified in Item 6, for the "First Course" of "Waterbound Macadam." As outlined in Paragraph 6.15, all clauses of the specifications for "Waterbound Macadam" shall be in full force and effect, except when contrary to or modified by the specifications for "Bituminous Macadam."

7.8. Spreading and Compacting Coarse Stone. The prepared base course shall be cleaned of all foreign substances and the coarse stone spread upon it with shovels from piles along the side of the roadway or from a dumping board. This stone shall be spread so that the surface course will be three (3) inches in depth after final compression. It shall then be rolled with a power roller, weighing not less than ten (10) tons, until the stone is compressed to form a firm, even surface, true to grades and cross-sections given. If any irregularities appear during or after rolling of this course, they shall be remedied by loosening the surface and removing or adding coarse stone, as may be required, after which the entire area including the surrounding surface shall be rolled until it is compacted satisfactorily to a uniform surface.

7.9. Application of Bituminous Binder. No bituminous material shall be applied unless the entire depth of the stone surface course is thoroughly dry and the air temperature is at sixty (60) degrees F. or above. Any of the surface course stone which has become coated or mixed with dirt or foreign substances shall be removed and replaced with clean stone.

After the coarse stone has been rolled as above, there shall be spread over the surface from one and one-half ($1\frac{1}{2}$) to one and three-quarters ($1\frac{3}{4}$) gallons, as directed, of the bituminous binder to each square yard of surface area. The bituminous material shall be heated to and applied at a temperature of not less than two hundred and twenty-five (225) degrees F. nor more than three hundred and twenty-five (325) degrees F. if an asphalt, and not less than one hundred and seventy-five (175) degrees F. nor more than two hundred and fifty (250) degrees F. if a tar product, as may be directed.

The bituminous binder shall be evenly spread over the surface by approved pressure distributors, unless otherwise specified or permitted, operating under a pressure of fifty (50) pounds per square inch or more, as may be directed. In order to ensure uniformity at junctions of two applications, when the last of the application starts to thin the distributor shall be shut off, and upon starting the next application, building paper or its equal 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 stone surface is reached. This building paper shall then be removed and destroyed.

When hand pouring is permitted, the bituminous material shall be spread uniformly over the surface with pouring pots of approved design.

7.10. Spreading Small Stone. After the bituminous binder has been applied and while it is still warm, a layer of the small stone shall be spread in such quantity as will just fill the surface voids and cover the entire surface of the coarse stone. Rolling shall then be continued until the material is compacted and the surface is bonded thoroughly.

7.11. Application of Seal Coat. After the surface has been compacted as above, it shall be swept clean of all loose stone and a seal coat of approximately one-half ($\frac{1}{2}$) of a gallon of bituminous binder to the square yard of surface area shall be applied evenly. This application shall be made with pressure distributors, if such are used for the binder application.

Immediately after the bituminous material has been applied, it shall be covered entirely with a thin layer of stone chips which shall then be rolled lightly. When required, additional chips shall be used to take up all excess bituminous material. The finished surface shall be uniform and shall conform to the grades and cross-sections given.

7.12. Basis of Payment. The work will be paid for as noted under (1) or (2). The method used shall be specified in the Proposal.

(1) This work will be paid for at the contract unit price per square yard for "Bituminous Macadam Surface Course, (Penetration Method)" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto.

(2) The stone material for Bituminous Surfacing (Penetration Method) will be paid for at the contract unit price per cubic yard for "Stone Material for Bituminous Surfacing" at the nearest delivery point, and may be further specified as "Coarse," "Small" or "Chips."

Hauling stone material will be paid for at the contract unit price per cubic yard per $\frac{1}{4}$ mile haul. For the first $\frac{1}{4}$ mile the price will include loading and unloading. Each additional $\frac{1}{4}$ mile will be paid for at the contract unit price for "Additional cubic yard $\frac{1}{4}$ mile haul."

Placing Surfacing will be paid for at the contract unit price for "Placing Surfacing" and will include all harrowing, placing, rolling, sprinkling, and all equipment, tools, labor and work incidental thereto.

The Bituminous material will be paid for at the contract unit price per gallon, furnished and applied, and will include all heating, mixing, teaming, distributing, and all material, labor, tools, and machinery incidental to the application of same.

ITEM 8. BITUMINOUS SURFACE TREATMENT.

8.1. **Description.** Bituminous Surface Treatment shall consist of treating shell, gravel, waterbound macadam, and other types of road surfacing with approved bituminous material in accordance with these plans and specifications.

8.2. **Bituminous Material.** The bituminous material to be used in this work shall be of approved quality and shall meet the requirements specified below.

(a) *Refined Coal Tar Products.*
(Hot Application.)

1. The tar shall be homogeneous and free from water.
2. Specific Gravity 25°C/25°C from 1.20 to 1.27.
3. Consistency—Float test 50°C., 35 seconds to 80 seconds.
4. Total bitumen (Soluble in CS₂) 78 to 88%.
5. Free Carbon—not less than 12 nor more than 22%.
6. Total distillates, by weight:
 - To 170°C not to exceed 0.5%
 - To 270°C not to exceed 15%
 - To 300°C not to exceed 20%

(b) *Refined Coal Tar Products.*
(Cold Application.)

1. The tar shall be homogeneous.
2. Specific Gravity 25°C/25°C., 1.14 to 1.18.
3. Specific Viscosity (Engler) 50°C., 5 to 15.
4. Free Carbon, from 4 to 12%.
5. Total bitumen (soluble in CS₂) 88 to 96%.
6. Total distillates by weight:
 - Up to 110°C. not to exceed 1.0%.
 - Up to 170°C. not to exceed 5.0%.
 - Up to 300°C. not to exceed 30%.

(c) *Asphaltic Oils—Class AA.*

1. The oil shall be free from water.
2. Specific Gravity 25°C./25°C., not less than 1.01.
3. Flash point not less than 149°C.
4. Inorganic Matter (Ash), not over 0.5%.
5. Total Bitumen (Soluble in CS₂), 99.5%.
6. Total Bitumen insoluble in 86°B. Naphtha 20 to 30%.
7. Penetration, 25°C., 100 Gram. 5 Sec., 60 to 110.
8. Loss at 163°C - 5 hours, not more than 2%.
9. Ductility after volatilization to 100 penetration, not less than 75.

(d) *Asphaltic Oils—Class A.*

1. The oil shall be a fluid product free from water.
2. Specific Gravity 25°C/25°C., not less than 0.98.

3. Flash point not less than 100°C.
4. Specific Viscosity at 100°C., 15 to 45.
5. Float test, 50°C, 35 to 120 seconds.
6. Loss at 163°C -5 hours, not more than 15%.
7. Total Bitumen (soluble in CS₂), 99.5%.
8. Total Bitumen insoluble in 86°B. Naphtha 15 to 25%.
9. Ductility after volatilization to 100 penetration, not less than 75.

(e) *Asphaltic Oils—Class B.*

1. The oil shall be a fluid product free from water.
2. Specific Gravity 25°C/25°C., not less than .95.
3. Flash point not less than 45°C.
4. Specific Viscosity at 50°C., 10 to 75.
5. Loss at 163°C -5 hours, not over 30%.
6. Total Bitumen (soluble in CS₂), 99.5%.
7. Bitumen insoluble in 86°B. Naphtha, 10 to 20%.
8. Ductility after volatilization to 100 penetration, not less than 75.

(f) *Rock Asphalt—Class C.*
(Cold Treatment.)

1. The material as laid shall be composed of uniform, well-graded, pulverized rock asphalt, fluxed to a uniform consistency, and rolled to a uniform density, and to the satisfaction of the Engineer.
2. The rock asphalt shall consist of limestone rock impregnated with the natural asphalt.
3. Mesh of pulverizer grating, not more than one-fourth inch.
4. The natural asphaltic content shall not vary more than one per cent from an average of 10%.

8.3. **Cover Material.** The grit to be used in the bituminous surface treatment shall consist of approved coarse sand, pea gravel, or broken stone, having a French co-efficient of at least 10, clean and free from dust or other foreign material.

8.4. **Scarifying and Re-Shaping Old Surfacing.** The contractor shall thoroughly scarify the old surfacing by means of a mechanical scarifier of approved type, or by hand picking. When a roller with spiked wheels is used the surfacing must be further broken by hand picking, or plowing and harrowing. In all cases the method to be used must be approved by the Engineer.

New material of a quality at least as good as that specified for the top course of the surfacing, and having all stone over two inches in size removed, shall be added in quantity sufficient to bring the road to the crown and cross-section shown on the plans. The new material shall be added at the places and in the manner as directed by the Engineer.

The scarified material after having the necessary new material added to it shall be raked over or harrowed, as directed by the Engineer; after which the surfacing material shall be compacted by rolling with a self-propelled roller weighing not less than ten tons, and in the manner as outlined in paragraph 14.5. If necessary, in order to compact the surfacing satisfactorily, it shall be sprinkled during the process of rolling, as directed by the Engineer.

8.5. **Cleaning Surface.** On new roads traffic must be permitted over the road for at least.....months, and longer if necessary, in the opinion of the Engineer, before applying surface treatment of Bituminous Material.

All surfacing to be treated shall be swept clean of all dust, dirt, or other loose material. If the bituminous treatment is to be a hot application, the sweeping shall be con-

tinued until the voids in the surface are slightly exposed; for a cold application, all dirt, dust or other foreign matter shall be removed, but the sweeping shall not be continued until the voids in the surface are exposed.

The sweeping shall be done with a rotary street sweeper of approved type and with street hand brooms as finishers, or some other method, which will, in the opinion of the Engineer, give as good results. When, in the opinion of the Engineer, the dust cannot be sufficiently removed by the above method, he shall cause the surface to be sprinkled lightly, just prior to the application of the bituminous material, at the time and in the manner as directed by him; or else the dust shall be removed to the satisfaction of the Engineer by air pressure.

8.6. Application of Bituminous Material.

(a) *Tars and Asphaltic Oils.* After the surfacing to be treated shall have been cleaned to the satisfaction of the Engineer, the bituminous material shall be uniformly sprayed over the surface by means of an approved mechanical pressure distributor. Each machine used for applying the bituminous material shall be required to operate under and maintain a pressure of at least twenty pounds per square inch. The machine must be so constructed that at all times under any condition, it will distribute the material evenly and uniformly.

The amount of bituminous material to be used in any one application shall not be less than 1/6 nor more than 5/10 gallon per square yard, the exact quantity depending upon the character of the surfacing, the bituminous material, and local conditions.

Unless otherwise specified, the bituminous material shall be put on in two different applications, the first application shall consist of.....gallon per square yard, and the second application shall consist of.....gallon per square yard.

When a hot application is to be made, it shall be at a temperature of not less than 175°F. for Tar products specified in paragraph 8.2 a, 250° F. for asphaltic oils specified in paragraph 8.2c, not less than 215°F. for the oil specified in paragraph 8.2d, not less than 100° F. for the oil specified in paragraph 8.2e. If specified on the plans, cover material shall be added to each application. If so noted, pea gravel, or clean stone chips, having a French co-efficient of wear of at least 10 shall be used to cover the first application, and approved coarse sand, or finer graded stone chips of at least as good quality as above noted, for the second application.

Each application shall be rolled with a six ton roller as directed by the Engineer. In general, rolling will not be required unless specified on the plans.

(b) *Rock Asphalt.* After the surfacing to be treated shall have been cleaned to the satisfaction of the Engineer, there shall be applied, as specified above, a treatment of hot asphaltic oil, not to exceed.....gallon per square yard. After this oil has been allowed to penetrate a few hours, the exact time to be determined by the Engineer, a second application not to exceed 1/10 gallon per square yard shall be applied, if considered necessary by the Engineer. Following the asphaltic oil treatment just described, the pulverized rock asphalt shall be applied and spread to such a depth that it will be..... inch thick after being compacted by rolling. A suitable flux, in predetermined quantity to meet the traffic and climatic conditions, shall be used. The amount of flux used shall not vary more than 0.5% on any square yard of compacted pavement, and the method of application shall be approved by the Engineer.

The rock asphalt shall be rolled with a self-propelled roller weighing not less than 8 tons until the material is thoroughly compacted, and to the satisfaction of the Engineer. All voids or depressions appearing in the surface after rolling shall be filled by sweeping with pulverized rock asphalt, and if considered necessary by the Engineer, they shall be rolled again.

8.7. Application of Cover Material. After the bituminous material shall have been applied, it shall be covered with material as specified under paragraph 8.3 at the rate

of 1 cubic yard to every 70 to 125 square yards of surfacing, depending upon the kind of bituminous and cover materials. In every case it shall be applied in sufficient quantity to prevent tracking. Traffic shall be kept off the newly treated road for twenty-four hours after being treated.

The cover coat must be evenly and accurately distributed over the entire road by a mechanical spreader or otherwise; if spread by hand the work must be done by experienced workmen to the end that an even and smooth surface is obtained.

8.8. Maintenance During and After Treatment. The application of the bituminous material shall be confined to one side of the road for any continuous length treated under this contract, to as great an extent as the economical distribution of material from one delivery point will permit, leaving the opposite side of the road free for traffic, unless permission to do otherwise is given by the Engineer. For a period of.....months after the acceptance of the road, the Contractor shall maintain the surface of the road which has received bituminous treatment under this contract, and shall keep it free from pickups, pits, or other breaks in the surface not caused by defective foundation, hidden springs, leaking pipes, cracking of the ground or other appreciable sinkings from natural causes, from floods, or the breaking down of the treated surface due to the washing away of the base.

8.9. Basis of Payment. The surfacing material used for reshaping old surfacing, will be paid for at the unit price per cubic yard at the nearest delivery point. Haul for the surfacing material will be paid for at the unit price per cubic yard per $\frac{1}{4}$ mile hauled. The price for the first $\frac{1}{4}$ mile haul will include loading and unloading. Each additional $\frac{1}{4}$ mile will be paid for at the contract unit price for "Additional cubic yard $\frac{1}{4}$ mile."

Scarifying and Re-shaping Old Surfacing will be paid for at the unit price per square yard, and will include all scarifying, hand-picking, plowing, placing new material, harrowing, sprinkling, rolling, and all the labor, and material incidental to "Scarifying and Re-Shaping Old Surfacing."

The Bituminous Material, with the exception of the rock asphalt, will be paid for at the unit price per gallon furnished and applied, and will include all heating, mixing, teaming, distributing, rolling, and all material, labor, tools, and machinery incidental to the application of same.

The Rock Asphalt will be paid for at the contract unit price per square yard of surface treated, unless otherwise stated, for "Rock Asphalt Surface Treatment," and will include all heating, mixing, pulverizing, teaming, distributing, rolling, all material, labor, tools, and machinery incidental to the application of same.

The Cover Material will be paid for at the unit price per square yard of bituminous treated surfacing covered, unless otherwise stated, and will include all sand, gravel, or stone chips, furnished and applied, all teaming, distributing, rolling, and all material, labor, tools, and machinery incidental to the application of same, and will be further classified as "Single" or "Double Layer of Cover Material."

ITEM 9. ONE COURSE PLAIN AND REINFORCED CEMENT CONCRETE PAVEMENT.

9.1. Description. This pavement shall consist of concrete, composed of one part of Portland cement and not more than five (5) parts of fine and coarse aggregates, constructed on the prepared sub-grade, in one (1) course of the depth shown on the plans, in accordance with these specifications.

The standard pavement shall be sixteen (16) feet in width, seven (7) inches in depth at the center and five (5) inches in depth at the sides, constructed in slabs, approximately forty (40) feet in length, separated by transverse joints. The bottom of the pavement shall be flat and the top surface shall conform to the arc of a circle. The width, depth and crown may be varied, as will be indicated on the plans.

When reinforcement is required it shall consist of steel fabric, unless otherwise noted on the plans, in accordance with these specifications.

9.2. Portland Cement. All cement used in this work shall be Portland cement, which shall be tested according to methods prescribed by and shall conform to the requirements of the report of a Joint Conference representing the United States Government, American Society of Civil Engineers and the American Society for Testing Materials, published in the "1916 Standards of the American Society for Testing Materials, Page No. 429, Serial Designation C 9-17," etc.

(a) *Definition.* Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimately and correctly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

(b) *Chemical Properties.* The following limits for the chemical properties of the cement shall not exceed:

Properties	Percentage
Loss of Ignition.....	4.00
Insoluble Residue.....	0.85
Sulfuric Anhydride (SO ₃).....	2.00
Magnesia (MgO).....	5.00

(c) *Physical Properties.* The physical properties of the cement shall meet the following requirements:

Specific Gravity. The specific gravity of cement shall be not less than three and ten one-hundredth (3.10). Should the test of cements as received fall below this requirement, a second test may be made upon an ignited sample. The specific gravity test will not be made unless specifically ordered.

Fineness. The residue on a standard No. 200 laboratory sieve shall not exceed twenty-two (22) percent by weight.

Soundness. A pat of neat cement shall remain firm and hard, and show no signs of distortion, cracking, checking, or disintegration, in the steam test for soundness.

Time of Setting. The cement shall not develop initial set in less than forty-five (45) minutes when the Vicat needle is used, or sixty (60) minutes, when the Gilmore needle is used. Final set shall be attained within ten (10) hours.

Tensile Strength. The average tensile strength in pounds per square inch of not less than three (3) standard mortar briquettes composed of one (1) part cement and three (3) parts standard sand, by weight, shall be equal to or be higher than the following:

Age of Test, days	Storage of Briquettes	Tensile Strength, Pounds per sq. in.
7.	1 day in moist air, 6 days in water.....	200
28	1 day in moist air, 27 days in water.....	300

The average tensile strength of standard mortar at twenty-eight (28) days shall be higher than the strength at seven (7) days.

(d) *Packages and Marking.* The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer clearly marked thereon, unless shipped in bulk. A bag shall contain ninety-four (94) pounds net. A barrel shall contain three hundred and seventy-six (376) pounds net.

(e) *Storage.* The cement shall be stored in such manner as to permit easy access for suitable inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness. When permission is given to store in the open, a platform and ample water-proof covering shall be provided, as directed.

(f) *Inspection.* Every facility shall be provided for careful sampling and inspection at either the mill or at the site of the work, as may be directed by the Engineer. At least ten (10) days from the time of sampling shall be allowed for the completion of the seven (7) day test, and when directed at least thirty-one (31) days shall be allowed for the completion of the twenty-eight (28) day test. The cement shall be tested in accordance with the methods referred to herein.

(g) *Rejection.* The cement may be rejected if it fails to meet any of the requirements of these specifications:

Fineness Test. Cement shall not be rejected on account of failure to meet the fineness requirement if upon retest, after drying at one hundred (100) degrees C. for one (1) hour, it meets this requirement.

Soundness Test. Cement failing to meet the test for soundness in steam may be accepted if it passes a retest, using a new sample at any time within twenty-eight (28) days thereafter.

Weight. Packages varying more than five (5) percent from the specified weight may be rejected, and if the average weight of packages in any shipment as shown by weighing fifty (50) packages taken at random, is less than that specified, the entire shipment may be rejected.

9.3. Fine Aggregates. The fine aggregate shall consist of sand, or a combination of stone grit and sand, conforming to the following requirements:

(a) *Sand.* The sand shall consist of clean, hard durable grains graded from coarse to fine with the coarse particles predominating and shall be free from lumps of clay and all vegetable or other deleterious substances. When dry it shall pass a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) of an inch in diameter, nor more than twenty-eight (28) percent, by weight, shall pass a standard No. 50 laboratory sieve, nor more than ten (10) percent, by weight, shall pass a No. 100 sieve. It shall contain not more than three (3) percent, by weight, of loam or other foreign substances.

Strength. Mortar composed of one (1) part, by weight, of Portland cement and three (3) parts, by weight, of sand mixed in accordance with the methods referred to in Paragraph 9.2, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) percent of that developed by mortar of the same proportions and consistency made of the same cement and standard Ottawa sand.

(b) *Stone Grit.* Stone grit shall consist of clean dustless stone screenings, resulting from the crushing of tough, durable rock equal in quality to that specified for coarse aggregate, Paragraph 9.4, and prepared by screening through a revolving screen having circular openings not larger than three-eighths ($\frac{3}{8}$) of an inch in diameter and by passing over a dust jacket to remove the dust of fracture. Not more than twenty-five (25) percent, by weight, shall pass a standard No. 50 laboratory sieve. This stone grit shall be used only in combination with sand, each measured separately and accurately by volume, and in such proportions as may be directed by the Engineer.

(c) *Combination of Stone Grit and Sand.* This stone grit shall conform to the requirements of Paragraph 9.3-a, and the sand shall conform to the requirements of Paragraph 9.3-b, except as to strength in mortar briquettes and grading requirements.

Combinations of stone grit and sand in the same proportions as directed for use on the work, shall contain not more than twenty-five (25) percent, by weight, of particles passing a standard No. 50 laboratory sieve and not more than seven (7) percent, by weight, passing a No. 100 sieve.

Strength. Mortar composed of one (1) part, by weight, of Portland cement and three (3) parts, by weight, of the combination of stone grit and sand, mixed in accordance with the methods referred to in Paragraph 9.2, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) percent of that developed by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand.

9.4. Coarse Aggregate. This coarse aggregate shall consist of clean, tough, durable, crushed rock having a French coefficient of wear of not less than ten (10) and a crushing strength of not less than twenty thousand (20,000) pounds per square inch unless otherwise specified. This material shall be free from dust and excess of flat and elongated pieces. It shall be graded uniformly from the maximum size to pieces one-quarter of an inch in diameter. The maximum size shall be such that all will pass through a revolving screen having circular openings not less than one and one-half ($1\frac{1}{2}$) nor more than two (2) inches in diameter. Not more than five (5) percent, by weight, shall pass a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) of an inch in diameter.

9.5. Water. Water used for this work shall be clean, free from oil, acid, alkali or vegetable substances.

9.6. Joint Filler. The filler to be used in the transverse joints in the pavement shall consist of approved, prepared tar or asphalt filler having a thickness of not less than one-quarter ($\frac{1}{4}$) nor more than one-half ($\frac{1}{2}$) of an inch as specified, and a depth of not less than one (1) inch more than the depth of the pavement.

9.7. Approval of Material Sources of Supply. Sources of supply for Portland cement, fine and coarse aggregates, and joint filler shall be approved by the Engineer before the delivery of materials is started. Samples of fine and coarse aggregate shall be as follows:

(a) *Fine Aggregate Samples.* A fine aggregate sample shall weigh approximately twenty (20) pounds.

(b) *Coarse Aggregate Samples.* The quality of the stone will be determined by tests made on a sample consisting of approximately twenty-five pounds of pieces not less than one and one-half ($1\frac{1}{2}$) inches nor more than three (3) inches in diameter, and of two small slabs preferably four (4) to six (6) inches in depth. Acceptability of the coarse aggregate in other respects will be determined by tests upon a sample of the crushed stone of the same sizes as intended for use in the work, having a weight of not less than twenty-five (25) nor more than fifty (50) pounds.

Representative samples of both fine and coarse aggregates shall be forwarded to the State Highway Department, Testing Laboratory, Austin, Texas, unless materials from the same sources of supply have been tested and approved during the year preceding the award of the contract. Aggregate samples shall be accompanied by a statement giving the type of material, name of the producer, the location of the plant and diameter of openings in screens used in their preparation.

9.8. Forms. Outside forms for this work shall be of wood or metal, of the depth of the concrete, straight, free from warp and of sufficient strength, when staked, to resist the pressure of the concrete without springing. If of wood, they shall be of two (2) inch surfaced plank, or if of metal they shall be of approved section and shall have a flat surface on top of not less than one and three-quarters ($1\frac{3}{4}$) inches. The forms shall be joined neatly and tightly and staked securely to line and grade at least two hundred (200) feet in advance of the point of placing concrete, and shall be cleaned thoroughly and greased or soaped before any concrete is placed against them.

9.9. Devices for Measuring Materials. The accurate measurement of each of the materials composing and the production of a uniform mixture of the concrete are essential. The Contractor shall furnish and use approved timing devices, a water measur-

ing and discharging device, also boxes or pans of such dimensions as will give, when filled and struck, the exact volumes of aggregate required by the Engineer.

9.10. Composition. The concrete shall be composed of one (1) part of Portland cement, not more than two (2) parts of fine aggregate and not less than three (3) parts of coarse aggregate, totalling not more than five (5) parts aggregates. The aggregates shall be measured separately and accurately by volume in such proportions as the Engineer shall direct, so as to give the greatest density and strength.

9.11. Consistency. Sufficient water shall be used, in mixing, to produce a concrete which will flatten out and quake when deposited, in place, but not enough to cause it to flow or the mortar and coarse aggregate to separate. The water shall be accurately measured and gauged and shall be automatically discharged into the drum with the aggregates. The quantity of water shall be determined by the Engineer and not varied without his consent.

9.12. Mixing Conditions. No concrete shall be mixed while the air temperature is at or lower than thirty-five (35) degrees F., and no materials containing frost shall be used. Bags of cement or fine aggregate containing lumps or crusts of hardened material shall not be used. The concrete shall be mixed only in such quantity as is required for immediate use and any which has developed initial set or has been mixed longer than thirty (30) minutes shall not be used.

9.13. Mixing Concrete. Concrete shall be mixed thoroughly in a batch mixer of approved type for a period of not less than one and one-half ($1\frac{1}{2}$) minutes after all the materials are in the drum, and during this period the drum shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute. The entire contents shall be removed from the drum before materials are placed therein for the succeeding batch.

When permitted, hand mixing shall be done on a water-tight wood or metal surface of suitable size. The cement and fine aggregate shall be mixed without the addition of water until a mixture of uniform color is produced. The coarse aggregate shall be spread to a depth of approximately eight (8) inches and wetted, the mixture of cement and fine aggregate spread over it, and the whole turned once, then water shall be added in sufficient quantity to produce the desired consistency and the whole mass turned not less than six (6) times. Hand mixed batches shall not exceed one-half ($\frac{1}{2}$) of a cubic yard.

9.14. Placing Concrete. The placing of concrete shall generally proceed up grade. 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 not be constructed within three (3) feet of the outside edge of any structure, nor adjacent to a railway track until it has been reset to the established line and grade nor shall a concrete pavement be constructed before all structures and railway tracks have been brought to line and grade in advance of placing concrete. The contractor shall give notice to the Public Service Companies or other persons whose structures or tracks require resetting or attention, which notice shall be given at least forty-eight (48) hours in advance of the laying of the pavement at those points. Cast iron manholes and valve box frames shall be set by owners, fully and firmly on brick masonry laid in mortar composed of one (1) part Portland cement and three (3) parts approved sand. Where the masonry needs to be raised one (1) inch or less, cast iron distant pieces and wedges one-half ($\frac{1}{2}$) inch by two (2) inches by four (4) inches in size shall be inserted in at least four (4) equidistant points and the remaining voids filled with mortar. Wooden valve boxes shall be shortened by sawing away the excess material and shall be lengthened either by raising and resetting the box on a firm broken stone foundation, or by nailing securely to the top of the box a stout wooden frame of sufficient depth to give the desired additional length. The cast iron frame in all cases, shall be set evenly upon the sub-structure. No chipping of cast iron structures will be permitted. Any structure or substructure damaged by the Contractor during the prosecution of the work shall be replaced by him. All materials and debris falling into the interior of any structure shall be removed. Any structure displaced by the Contractor after it has been reset by the owners or lessee shall be again reset by the Contractor without compensation.

Railway tracks shall be brought to the established line or grade by their owners or lessee. All structures and tracks shall be checked by the Engineer before any pavement materials are placed around or against them.

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 for handling concrete. This operation shall be continuous between transverse joints without the use of intermediate forms or bulkheads. In case of an unavoidable interruption, a transverse joint shall be placed as herein specified at the point of stopping work, provided that the section on which work has been suspended shall not be less than ten (10) feet in length. Sections less than ten (10) feet in length shall be removed.

9.15. Placing Transverse Joints. Transverse joints shall be formed at right angles to the center line, at intervals of approximately forty (40) feet unless otherwise required, to the full depth and width of the pavement. They shall not be less than one-quarter ($\frac{1}{4}$) nor more than one-half ($\frac{1}{2}$) of an inch in width as specified. All joints shall be formed during the placing of the concrete by securely staking an iron bulk-head at right angles to the center line and perpendicular to the surface of the pavement, against which the joint filler shall be placed. The iron bulk-head shall be at least three-eighths ($\frac{3}{8}$) of an inch in thickness, of a width at least one (1) inch more than the greatest depth of the pavement and of a length one-half ($\frac{1}{2}$) of an inch less than the width of the pavement. When the concrete has been placed on both sides of the joint, the iron bulk-head shall be removed carefully so that the expansion joint filler shall extend to the bottom of the pavement. After the pavement is completed, the filler shall be cut above the surface of the road to the height designated.

9.16. Finishing Concrete. The surface of the concrete shall be struck off by means of a steel templet of approved section weighing not less than two hundred (200) pounds for a length of eighteen (18) feet. The templet shall be rolled to the desired cross-section and have sufficient strength to retain its shape under all working conditions. This templet shall be moved with a longitudinal and cross-wise motion, moving always in the direction in which the work is progressing. When the templet reaches within three (3) feet of a transverse joint it shall be lifted to the joint and the pavement struck by moving the templet away from the joint, and all excess concrete shall then be removed.

Immediately after the concrete has been struck off it shall be rolled with an approved metal hand roller having a smooth, even surface, approximately six (6) feet in length, not less than eight (8) nor more than twelve (12) inches in diameter and weighing not more than one hundred (100) pounds. This roller shall have a handle at least two (2) feet longer than the width of the pavement, and all the rolling shall be done from one side of the pavement. The roller shall pass from one edge of the pavement to the other in one operation, and the rolling shall continue until free water ceases to come to the surface.

After the rolling has been completed the concrete shall be finished by using a belt made of canvas or rubber belting not less than twelve (12) inches in width nor less than two (2) feet longer than the width of the pavement. This belt shall be worked with a longitudinal and crosswise motion as described for the steel templet. Care shall be observed in the use of the belt not to permit the edges to dig into the surface of the concrete or to work the crown out of the pavement.

The concrete adjacent to the transverse joint shall be finished with a split wood float which will ensure 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 ($\frac{3}{16}$) of an inch and the sides of the slabs to a radius of approximately three-quarters ($\frac{3}{4}$) of an inch. The finishing of the joint shall be done from a bridge which shall not rest on the concrete at any point.

9.17. Protection of Concrete. As soon as finished, the concrete shall be protected by a canvas covering, suspended not less than twelve (12) inches above the surface, and, if directed, the surface of the pavement shall be sprinkled with water. When the concrete has hardened sufficiently the canvas covering shall be removed and the entire surface

of the pavement wetted thoroughly and covered with earth or other approved material to a depth of not less than one and one-quarter ($1\frac{1}{4}$) inches. This material shall be kept moist by sprinkling with water, if directed, and shall remain on the concrete for a period of not less than eighteen (18) days under the most favorable conditions or for a longer period if directed by the Engineer, during which time traffic shall be excluded from the concrete by the erection and maintenance of suitable barricades, and satisfactory precautions shall be taken to exclude foot traffic for a period of not less than three (3) days.

When required or approved, other methods of curing and protecting the concrete may be used.

After the foregoing period has elapsed, the covering on the concrete shall be removed, the surface of the pavement swept clean and the concrete allowed to cure for a period of three (3) days, after which the roadway may be opened to traffic.

9.18. Sealing Transverse Joints. All transverse joints shall be sealed by pouring hot tar, of an approved quality and consistency, into and over the joints when they are dry. Care shall be observed to prevent the tar from spreading over the surface of the pavement for a width of more than one (1) inch on either side of the joint. This work shall be done after the entire pavement has been completed, or just prior to discontinuing operations when the work is to be suspended during the winter.

9.19. Reinforcing Material. The reinforcement for the concrete pavement shall consist of steel fabric unless otherwise indicated on the plans, having an effective weight of not less than twenty-five (25) pounds for each one hundred (100) square feet. A standard "A. S. T. M." test bar shall develop an ultimate tensile strength of not less than seventy thousand (70,000) pounds per square inch and shall bend one hundred and eighty (180) degrees around one (1) diameter and straighten without fracture. The main members shall be spaced not more than six inches apart and shall have an effective cross-sectional area of not less than six one-hundredths (0.06) of an inch per linear foot of pavement length, and the cross members shall be spaced not more than eight (8) inches apart. The material shall be furnished on the work in flat sheets, of a length equal to four (4) inches less than the width of the pavement unless otherwise permitted, so constructed that they shall retain their original shape during the necessary handling. These sheets shall be free from excess rust, scale, paint, or coatings of any character which will tend to destroy their bond with the concrete.

9.20. Placing Reinforcement. The reinforcement shall be placed two (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 two (2) inches of both the ends and sides of the slabs, or sections. Adjacent sheets of fabric shall be lapped not less than four (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 twelve (12) inches.

9.21. Basis of Payment. One Course Plain Cement Concrete Pavement will be paid for at the contract unit price per square yard unless otherwise noted in the Proposal, for "One Course Plain Cement Concrete Pavement" complete in place, which price will include all concrete and transverse joint materials, all forms, equipment, tools, labor and work incidental thereto.

One Course Reinforced Concrete Pavement will be paid for at the contract unit price per square yard, unless otherwise noted in the Proposal, for "One Course Reinforced Concrete Pavement" complete in place, which price will include all concrete, reinforcement and transverse joint materials, all forms, equipments, tools, labor and work incidental thereto.

ITEM 10. TWO COURSE PLAIN AND REINFORCED CONCRETE PAVEMENT.

10.1. Description. This pavement shall consist of concrete constructed on the prepared subgrade, in two (2) courses of the depth shown on the plans, in accordance with these specifications.

The standard pavement shall be sixteen (16) feet in width, eight (8) inches in depth at the center and six (6) inches in depth at the sides constructed in slabs approximately forty (40) feet in length separated by transverse joints. The bottom of the pavement shall be flat and the top surface shall conform to the arc of a circle. The bottom course shall be composed of one (1) part of Portland cement and seven and one-half ($7\frac{1}{2}$) parts of fine and coarse aggregates and shall be constructed to within two (2) inches of the finished surface of the pavement at all points. The top course shall be composed of one (1) part of Portland cement and not more than three and one-half ($3\frac{1}{2}$) parts of fine and coarse aggregates and shall be uniformly two (2) inches in depth.

Where reinforcement is required it shall consist of steel fabric, unless otherwise noted on the plans placed between the bottom and top courses, in accordance with these specifications.

10.2. Portland Cement. The cement used for this work shall conform to the requirements of Paragraph 9.2 for "Plain Cement Concrete Base Course."

10.3. Fine Aggregate for Bottom Course. This fine aggregate shall consist of sand, or a combination of sand and stone screenings, conforming to the following requirements:

(a) *Sand.* This sand shall consist of clean, hard, durable grains. When dry, it shall pass a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) of an inch in diameter, and shall be graded from coarse to fine. It shall contain not more than five (5) percent, by weight, of loam or other foreign substances. "Run-of-bank" sand shall not be used except upon approval of the Engineer.

Strength. Mortar composed of one (1) part by weight, of Portland cement, and three (3) parts, by weight, of sand, mixed in accordance with the methods referred to in Paragraph 9.2, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than seventy-five (75) percent of that developed by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand; except that, sands conforming to the requirements of Paragraph 10.3-a, but giving a strength ratio at seven (7) and twenty-eight (28) days of less than seventy-five (75) percent but not less than fifty (50) percent, will be accepted for use in concrete subject to the addition of cement to the proportion specified in Paragraph 10.12-a. The additional proportion of cement required will be determined by Laboratory test, and shall be that amount necessary to increase the tensile strength ratio of the mortar to not less than seventy-five (75) percent at seven (7) and twenty-eight (28) days.

(b) *Stone Screenings.* These screenings shall consist of material resulting from the crushing of clean, tough, durable rock having a French co-efficient of wear of not less than ten (10). For purposes of proportioning on the work, and in laboratory tests for grading and strength, only that portion of the entire product which passes a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) of an inch in diameter will be regarded as fine aggregate. This material shall be graded from coarse to fine, containing not more than thirty (30) percent, by weight, of particles passing a standard No. 50 laboratory sieve, nor more than eighteen (18) percent, by weight, passing a No. 100 sieve. It shall contain not more than three (3) percent, by weight, of loam or other foreign substances.

(c) *Combination of Sand and Stone Screenings.* Combinations of sand and stone screenings, each measured separately and accurately by volume, shall be used in such

proportions as may be directed by the Engineer. Sand for this purpose shall consist of clean, hard, durable grains, containing not more than five (5) percent, by weight, of loam, and stone screenings shall conform to the requirements of Paragraph 10.3-b; except that screenings which do not conform to the grading requirements specified may be used with sand in combinations which shall contain not more than thirty-five (35) percent, by weight, of particles passing a No. 50 sieve, nor more than twelve (12) percent, by weight, passing a No. 100 sieve.

Strength. Mortar composed of one (1) part, by weight, of Portland cement and three (3) parts, by weight, of the combination of sand and stone screenings, mixed in accordance with the methods referred to in Paragraph 9.2 shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than ninety (90) percent of that developed by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand.

10.4. Coarse Aggregate for Bottom Course. This coarse aggregate shall consist of crushed stone or slag, or gravel graded uniformly from the maximum size to pieces one-quarter ($\frac{1}{4}$) of an inch in diameter. The maximum size shall be such that all will pass through a revolving screen having circular openings not less than one and one-half ($1\frac{1}{2}$) nor more than two and one-half ($2\frac{1}{2}$) inches in diameter. Not more than five (5) percent, by weight, shall pass a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) of an inch in diameter.

(a) *Crushed Stone.* Crushed stone shall be obtained from clean, tough, durable rock, having a French co-efficient of wear of not less than six (6). This material shall be free from dust and excess of flat and elongated pieces.

(b) *Crushed Slag.* Crushed slag shall consist of tough, durable pieces of reasonably uniform and non-glassy character. It shall be air cooled and shall have been exposed to the weather for a suitable time prior to use. The dried slag, when shaken to refusal, shall have a weight per cubic foot of not less than seventy-eight (78) pounds.

(c) *Gravel.* Gravel shall consist of clean, tough, durable stone of high resistance to abrasion, washed free of clay or coatings of any character.

(d) *Unscreened Gravel.* Unscreened gravel may be used for concrete in the place of broken stone and sand. When so used, frequent tests will be made to determine the relative proportions of sand and stone, in case the relative proportions of sand and stone are excessively irregular so as to make it practically impossible to proportion the concrete properly, the Engineer may reject the material or require that it be screened and re-proportioned.

The fine aggregate shall be considered as that portion of the gravel which passes a one-fourth inch screen, and shall conform to the requirements herein specified for fine aggregate.

The coarse aggregate shall be considered as that portion of the gravel retained on a one-fourth inch screen and shall conform to the requirements herein specified for coarse aggregate.

In all cases where unscreened gravel is used, one part by volume of cement shall be used to each two and one-half ($2\frac{1}{2}$) parts of fine aggregate.

The ratio by volume of the fine to the coarse aggregate shall not be less than one to two nor more than one to one.

10.5. Fine Aggregate for Top Course. The fine aggregate for the top or wearing course shall be of the quality and size specified in Paragraph 9.3 for "One Course Plain Cement Concrete Pavement."

10.6. Coarse Aggregate for Top Course. The coarse aggregate for the top or wearing course shall be prepared from stone of the quality specified in Paragraph 9.4 for "One Course Plain Cement Concrete Pavement." This material shall be free from dust

and excess of flat and elongated pieces. It shall be graded uniformly from the maximum size to pieces one-quarter ($\frac{1}{4}$) of an inch in size. The maximum size shall be such that all will pass through a revolving screen having circular openings not less than one (1) nor more than one and one-quarter ($1\frac{1}{4}$) inches in diameter. Not more than ten (10) percent, by weight, shall pass a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) of an inch in diameter.

10.7. **Water.** Water used for this work shall be clean, free from oil, acid, alkali, or vegetable substances.

10.8. **Joint Filler.** The filler for transverse joints shall be furnished as specified in Paragraph 9.6 for "One Course Plain Cement Concrete Pavement."

10.9. **Approval of Material Sources of Supply.** Sources of supply for fine and coarse aggregates shall be approved by the Engineer before delivery of materials is started. Samples of the aggregates for the bottom course shall be submitted as directed in Paragraph 9.7, and samples of the aggregates for the top course shall be submitted as directed in Paragraph 9.7.

10.10. **Forms.** Forms shall be furnished and set securely as specified in Paragraph 9.8.

10.11. **Devices for Measuring Material.** Materials for the concrete for both courses shall be measured with devices as described in Paragraph 9.9 for "One Course Plain Cement Concrete Pavement."

10.12. **Composition.** The composition of the two courses shall be as follows:

(a) *Bottom Course.* The concrete in the bottom course shall be composed of one (1) part of Portland cement to seven and one-half ($7\frac{1}{2}$) parts of fine and coarse aggregates, each measured separately and accurately by volume. The concrete shall approximate a 1:2 $\frac{1}{2}$:5 mixture, but the Engineer may vary the relative proportions of fine and coarse aggregates to obtain concrete of the greatest density and strength.

(b) *Top Course.* The concrete in the top or wearing course shall be composed of one (1) part of Portland cement and three and one-half ($3\frac{1}{2}$) parts of fine and coarse aggregates, each measured separately and accurately by volume. The concrete shall approximate a 1:1 $\frac{1}{2}$:2 mixture, but the Engineer may vary the relative proportions of fine and coarse aggregates to obtain concrete of the greatest density and strength.

10.13. **Mixing and Placing Concrete.** (a) *Bottom Course.* Consistency. Sufficient water shall be used, in mixing, to produce a concrete which will flatten out and quake when deposited in place, but not enough to cause it to flow or the mortar and coarse aggregate to separate. The water shall be accurately measured and gauged, and shall be automatically discharged into the drum with the aggregates. The quantity of water shall be determined by the Engineer and not varied without his consent.

Mixing Condition. No concrete for the bottom course shall be mixed while the air temperature is at or lower than thirty-two (32) degrees F., and no materials containing frost shall be used. Bags of cement, or fine aggregate containing lumps or crusts of hardened material shall not be used. The concrete shall be mixed only in such quantities as are required for immediate use, and any which has developed initial set or has been mixed longer than thirty (30) minutes shall not be used.

Mixing Concrete. Concrete for the bottom course shall be mixed thoroughly in a batch mixer of approved type for a period of not less than one (1) minute after all materials are in the drum, and during this period the drum shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute. The entire contents shall be removed from the drum before materials are placed therein for the succeeding batch.

When permitted, hand mixing shall be done on a water-tight wood or metal surface of suitable size. The cement and fine aggregate shall be mixed without the addition of water

until a mixture of uniform color is produced. The coarse aggregate shall be spread to a depth of approximately eight (8) inches and wetted, the mixture of cement and fine aggregate spread over it, and the whole turned once, then water shall be added in sufficient quantity to produce the desired consistency and the whole mass turned not less than six times. Hand mixed batches shall not exceed one-half ($\frac{1}{2}$) of a cubic yard.

Placing Concrete. Concrete shall be placed only on a moist sub-grade. If the sub-grade is dry it shall be sprinkled with as much water as will be absorbed readily. No concrete shall be placed adjacent to railway tracks, nor around manholes, inlets, or other structures until they have been brought to the required grade and alignment, as specified in Paragraph 9.14, "Excavation and Embankment," and all structures which project through the base course shall be cleaned thoroughly to permit adhesion of the concrete. Block paving shall be placed directly on the concrete base course before it has developed initial set, where indicated on the plans, as specified.

The concrete shall be deposited upon the subgrade by means of a suitable discharging device which does not cause a segregation of the mortar and coarse aggregates and shall be spread to the full depth required by shoveling or other approved methods. Rakes shall not be used in handling concrete. The concrete shall be compacted thoroughly and made to conform to the required cross-section, by means of approved trowels. The sides of the base course shall be well spaded. The top surface for all block pavements shall be brought to a smooth finish. The surface for bituminous pavements shall be moderately rough with the coarse aggregate well embedded, but not covered with a coating of mortar, and with the entire surface free from all depressions or other irregularities.

When combination curbing and base is to be constructed the concrete for the curbing shall be placed immediately and in no case more than thirty (30) minutes after the base course concrete is placed. The concrete for the curbing shall be tamped and spaded and the top surface floated to a smooth, even surface. The outside edge of the surface of the curbing shall be rounded as shown on the plan.

At the end of any working period a bulk-head shall be placed at right angles to the center line and perpendicular to the surface, and the base course finished to it. When work is resumed the bulkhead shall be removed and the joint wetted before placing concrete against it.

(b) *Top Course.* Concrete for the top course shall be mixed and placed, as specified in Paragraphs 9.11 to 9.14 inclusive, and 9.16 for "One Course Plain Cement Concrete Pavement," upon the bottom course as soon as possible after it has been struck off, and in all cases within thirty (30) minutes after the bottom course has been placed, so that both courses will set up together and form a monolithic slab. Any part of the bottom course upon which the top course has not been placed within thirty (30) minutes shall be removed.

10.14. Protection of Concrete. This concrete shall be protected during the period of setting and from traffic as specified in Paragraph 9.17.

10.15. Sealing Transverse Joints. All transverse joints shall be sealed as specified in Paragraph 9.18.

10.16. Reinforcing Materials. The reinforcement to be used for the work shall be as specified in Paragraph 9.19 for "One Course Reinforced Cement Concrete Pavement."

10.17. Placing Reinforcement. The reinforcement shall be placed, as specified in Paragraph 9.20 for "One Course Reinforced Cement Concrete Pavement," on the bottom course immediately after it has been shaped and just prior to the placing of the top course.

10.18. Basis of Payment. Two Course Plain Cement Concrete Pavement will be paid for at the contract unit price per square yard, unless otherwise noted in the Proposal for "Two Course Plain Cement Concrete Pavement" complete in place, which price will include all concrete and transverse joint materials, all forms, equipment, tools, labor and work incidental thereto.

Two Course Reinforced Concrete Pavement will be paid for at the contract price per square yard, unless otherwise noted in the Proposal, for "Two Course Reinforced Cement Concrete Pavement," which price will include all concrete reinforcement and transverse joint materials, all forms, equipment, tools, labor and work incidental thereto.

ITEM 11. VITRIFIED BRICK PAVEMENT.

SAND-CEMENT BED.

11.1. Description. This pavement shall consist of a vitrified brick wearing surface laid on a cement-sand bed three-quarters ($\frac{3}{4}$) of an inch in depth, with a cement grout filler and expansion joints, or a bituminous-mastic filler, constructed on a concrete base course 5 inches in depth unless otherwise specified, and in accordance with these specifications.

11.2. Vitrified Bricks. (a) *Quality.* All bricks must be No. 1 pavers of the sizes or types commercially known as vertical fibre, repressed, wire cut lug, or other vitrified paving brick. They must be thoroughly annealed, tough, durable, regular in size and evenly burned. When broken they shall show a dense stone-like body, free from lime, large air pockets, marked laminations, or cracks which would tend to weaken the structure. Kiln marks shall not exceed $\frac{1}{4}$ inch in depth, and at least one edge shall show but slight kiln marks.

(b) *Size.* All brick shall not be less than 8 nor more than 9 inches in length. The width shall not vary more than $\frac{1}{8}$ inch from the average or standard size from any one plant. The depth of the brick shall be.....inches and shall not vary from this specified depth more than $\frac{1}{8}$ inch. If the edges of the brick are rounded, the radius shall not exceed $\frac{3}{16}$ of an inch. All repressed and wirecut lug brick shall have lugs on one side only, the lugs to be between $\frac{1}{8}$ and $\frac{1}{4}$ inch in height.

(c) *Resistance to Abrasion.* The brick shall be tested in the standard rattler recommended by the National Paving Brick Manufacturers Association. The method of testing shall be the latest that is recommended by the "American Society for Testing Materials." When so tested the abrasion loss shall be as follows:

4 in. vertical fiber or wirecut lug brick from 22 to 24%.

3 in. vertical fiber or wirecut lug brick from 24 to 28%.

2½ in. vertical fiber brick from 27 to 32%.

4 in. repressed brick from 25 to 30%.

(d) *Sampling and Testing.* If ordered by the Engineer, at least 12 brick from every 10,000 to be used in the pavement shall be submitted for the rattler test. Should a sample of brick fail to pass the test, then the portion of the lot represented by that test shall be resampled and 3 more tests performed. If any one of the three subsequent tests shows a variation either above or below the limits greater than 3½%, the rejection of a portion, or of the entire lot of brick represented by the samples shall be at the discretion of the Engineer.

(e) *Handling.* The brick at all times shall be handled carefully, piled neatly, and kept clean.

(f) *Visual Inspection.* All bricks shall be subjected to careful inspection before and after laying and rolling, and rejections will be made on the following conditions:

(1) Bricks which are broken through or chipped in such manner that the wearing surface remains substantially intact or in such manner that the lower or bearing surface is reduced in area by more than $\frac{1}{6}$.

(2) Bricks which are cracked to a depth greater than $\frac{1}{4}$ inch on any surface, or which are cracked in the wearing surface.

(3) Bricks which are so off-size or so misshapen, bent, twisted, or kiln marked that they will not form a uniform surface nor align correctly with other bricks.

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

11.3. Materials for Concrete Base. The concrete base shall be composed of 1 part Portland cement, 3 parts fine aggregate, and 6 parts coarse aggregate.

(a) *Portland Cement.* Cement for this work shall conform to the requirements of paragraph 9.2.

(b) *Fine Aggregate.* Fine aggregate for the bottom course shall conform to the requirements of paragraph 10.3.

(c) *Coarse Aggregate.* Coarse aggregate for the bottom course shall conform to the requirements of paragraph 10.4.

11.4. Materials for Cement-Sand Bed. The cement-sand bed shall be composed of 1 part Portland cement and 4 parts of sand, meeting the following requirements:

(a) *Portland Cement.* The cement shall be of the same quality as that specified in paragraph 11.3.

(b) *Sand.* The sand shall consist of clean, hard, durable grains free from vegetable and other deleterious substances. When dry it shall pass a laboratory screen having circular openings $\frac{1}{4}$ inch in diameter and shall be graded from coarse to fine. It shall not contain more than 5 percent, by weight, of loam or other foreign substances.

11.5. Materials for Grout Filler. The filler for grouting between the bricks, shall be composed of one (1) part of Portland cement and one (1) part of sand, meeting the following requirements:

(a) *Portland Cement.* Cement for this work shall conform to the requirements of paragraph 11.3.

(b) *Sand.* This sand shall consist of clean, hard, durable grains. When dry it shall pass a laboratory screen having circular openings one eighth ($\frac{1}{8}$) of an inch in diameter and not less than ninety (90) percent, by weight, shall pass a standard No. 10 laboratory sieve. It shall contain not more than five (5) percent of loam or other foreign substances.

Strength. Mortar composed of one (1) part, by weight, of Portland cement and three (3) parts, by weight, of sand, mixed in accordance with the methods referred to in paragraph 11.3, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than seventy (70) percent of that developed by mortar of the same proportions and consistency made of the same cement and standard Ottawa sand.

11.6. Materials for Bituminous-Mastic Filler. This filler shall be composed of sand and a bituminous material combined so as to form a pliable, waterproof mixture which will adhere firmly to the paving brick, and which, at extremes of climatic temperature shall neither flow nor become brittle.

(a) *Sand.* The sand shall consist of approved, clean, fine grains of such size as shall pass a standard No. 10 mesh sieve.

(b) *Bituminous Material.* The bituminous material shall meet either of the following specifications:

(1) Specification "A," Coal Tar Pitch. The coal tar pitch to be used in the filler shall be free from water, shall contain not more than five-tenths (0.5) percent of inorganic matter, and shall meet the following test requirements:

Specific Gravity. The specific gravity shall be not less than one and twenty-three one-hundredths (1.23) nor more than one and thirty-three one-hundredths (1.33) at sixty (60) degrees F.

Free Carbon. It shall contain not less than twenty (20) nor more than thirty-five (35) percent, by weight, of free carbon.

Melting Point. It shall have a melting point between 130 and 180 degrees F., as may be directed, with a permissible variation of five (5) degrees F. from the designated figures. This determination shall be made by the cube method in water.

(2) Specification "B," Asphalt. The asphalt to be used in the filler shall be an

asphaltic cement obtained by the distillation of asphaltic petroleum at a temperature not exceeding seven hundred (700) degrees F. It shall be homogeneous, free from water or decomposition products, and shall meet the following test requirements:

Penetration. The penetration at seventy-seven (77) degrees F. shall not be less than sixty (60) nor more than one hundred (100), (100 grams, 5 seconds, No. 2N), as may be directed by the Engineer, and the penetration at one hundred (100) degrees F. shall not exceed three (3) times the penetration at seventy-seven (77) degrees F., the conditions of time and load being as above.

Solubility. The solubility in cold carbon tetrachloride shall not be less than ninety-eight and one-half (98½) percent.

Ductility. The ductility at seventy-seven (77) degrees F. shall not be less than forty (40) centimeters, the rate of elongation being five (5) centimeters per minute.

Volatility. The loss by volatilization shall not be more than three (3) percent, by weight. (A. S. T. M. Standards, 1916.)

11.7. Expansion Joint Material. Where cement joint filler is used for the brick, the expansion joint material shall consist of a suitable high grade wool felt or bituminous fibre combined with either coal tar or asphalt. The felt shall be ½ inch in thickness, of such width as to be flush with the brick of the finished pavement, and in lengths of not less than 4 feet.

The contractor shall submit samples and receive the approval of the Engineer for the joint material to be used before it shall be incorporated in the work.

11.8. Water. Water used for this work shall be clean, free from oil, acid, alkali, or vegetable substances.

11.9. Approval of Material Sources of Supply. Sources of supplies for the bricks, the expansion joint filler, the concrete base, the cement-sand bed, the cement grout, and the bituminous-mastic filler shall be approved by the Engineer before delivery of the materials is started.

Samples of the materials specified herein shall be submitted when directed.

11.10 Side Forms. The concrete base shall be placed between side forms of steel or 2-inch plank as specified in paragraph 9.8. Before placing the sand-cement bed, the side forms shall be placed in conformity with the alignment of the finished pavement. These forms shall be such as to confine both the sand-cement bed and the grout filler, and shall not be removed within 24 hours of the grouting of the pavement.

11.11. Devices for Measuring Materials. Materials for the concrete base, the sand-cement bed, and the grout filler shall be measured with devices as described in paragraph 9.9.

11.12. Mixing and Placing Concrete Base. The concrete for the base shall be mixed and placed in accordance with paragraph 10.13-a.

11.13. Mixing and Placing Cement-Sand Bed. Upon the prepared base course, which shall be cleaned of all loose and foreign materials, and dampened thoroughly shall be spread a mixture of cement and sand to form the bed for the bricks. The cement and sand shall be mixed, dry to a uniform color, in an approved batch mixer, or, if by hand, on a clean, tight surface. It shall then be spread and shaped carefully by means of an approved trowel. The entire surface of the bed shall be rolled with a hand roller, which shall be not less than thirty-six (36) inches in diameter, twenty-four (24) inches in width, shall weigh not less than ten (10) pounds per inch width of tread and shall have a handle not less than twelve (12) feet in length. The bed shall be reshaped and rerolled until firm and true to the cross-section required, and shall have a uniform depth of three-quarters (¾) of an inch upon completion. No more cement-sand bed shall be mixed or prepared than can be used within any continuous working period, and any bed upon which the bricks are not laid and rolled, during any continuous working period, shall be removed and replaced with new materials when work is resumed. Cement-sand bed which is injured or displaced by a flow of water, rain, or any other cause, shall be re-

placed satisfactorily with new material. The workmen shall not walk upon the bed after it has been shaped by the templet.

11.14. Placing Expansion Joints. Where curbs are required, and when cement grout filler is used, expansion joints shall be placed parallel with and at each of the curb lines. Where the pavement joins car rails a joint from $\frac{1}{4}$ to $\frac{1}{2}$ inch may be required next to each side of each rail. The expansion joint strips of the proper thickness and width shall be set against the curb in advance of the laying of the brick and the brick laid against this, care being taken to have the strips close butted and set the full depth of the brick.

11.15. Laying Brick. In delivering the brick from the piles for placement in the pavement, no wheeling in barrows will be allowed on the brick surface, but they shall be carried on pallets. They shall be placed upon the pallets so that when delivered to the dropper they will lie in such order that each brick, in the regular operation of placing it upon the foundation as prepared, will bring the lugs in the same direction with the best side uppermost. All bricks shall be laid carefully with the best face up, lugs in the same direction, from one side of the pavement to the other side, in parallel straight courses at right angles to the center line, except at intersections and on curves where they shall be laid as directed. The bricks shall be laid with both ends and sides in contact, breaking joints not less than three (3) inches. The courses shall be straightened by striking lightly with a sledge on a four by four (4 x 4) inch timber three (3) feet long, placed against every fourth course, all thick bricks being removed. At the ends of, and where necessary, between courses, closures shall be made by carefully placing bricks cut accurately to give close joints. Cut or broken bricks shall be used only at the ends of courses, placed with the cut end turned towards the adjacent whole brick, and shall be not less than three (3) inches in length. While laying brick, 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 for rolling, and if any section contains more than ten (10) percent of culls, the bricks shall be removed and the bed replaced. When the pavement is laid adjacent to railway tracks and other miscellaneous structures, the bricks shall be laid so that when rolled or tamped they shall meet the rail surface or edge of structures, or be slightly below, as may be directed.

"Hillside" brick shall be laid as above specified with the grooves across the line of traffic and the square edge up grade.

11.16. Rolling Brick. Before rolling, the surface of the bricks shall be swept free of spalls. The pavement shall then be rolled with a hand or tandem self-propelled roller, weighing not less than three (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 from one side of the pavement to the other side, at an angle of forty-five (45) degrees, 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. When a cement-sand bed is used, the surface shall be rolled as soon as possible after laying, so as to complete it before the bed begins to set. The bricks 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 (2) inch board. If the bed is forced up between the blocks more than one-half ($\frac{1}{2}$) of an inch, the bricks shall be removed and the bed reshaped.

After final rolling the pavement shall be tested with a ten (10) foot straight edge, laid parallel with the side of the pavement, and any depressions exceeding one-quarter ($\frac{1}{4}$) of an inch shall be corrected, and if necessary, the entire surrounding surface again rolled.

11.17. Mixing and Applying Grout Filler. Equal parts of cement and sand shall be measured separately and accurately by volume and mixed thoroughly on a clean, dry surface to a uniform color, after which the mixture shall be transferred to a mixing box, preferably about four (4) feet eight (8) inches in length, thirty (30) inches in width

and fourteen (14) inches in depth, resting on legs of different lengths so that the mixture shall flow readily to the lower corner of the box, which corner shall be approximately three (3) inches above the pavement. To the dry mixture shall be added sufficient clean water to produce a grout thinner than thin cream, which will flow readily into the spaces between the bricks. It shall then be mixed thoroughly, and the mixture shall be kept in constant motion from the time the water is added until the last of the filler is removed from the box and floated between the bricks. Grout may be mixed in approved mechanical appliances.

After the bricks have been rolled thoroughly, inspected and approved they shall be wetted by spraying lightly with clean water. More than three hundred (300) feet of pavement shall not be laid before grouting begins, and it shall follow the paving as closely as possible. Where a cement-sand bed is used the grouting shall be completed to within not more than twenty (20) feet of the end of the bricks laid before work is stopped. The grout shall be removed from the box with scoop shovels and poured in front of the sweepers, who shall sweep it rapidly lengthwise of the bricks into the spaces between them, working from each side toward the center until the spaces are filled. After the grout has settled and before initial set develops, the unfilled portions of the spaces shall be filled successively with a slightly thicker grout until it remains flush with the top of the bricks. After this application has had time to settle, and before the initial set takes place, the pavement shall be finished to a smooth surface with a squeegee, or wooden scraper having a rubber edge, which shall be worked over the bricks parallel to the courses. Metal strips one-sixteenth ($1/16$) of an inch thick, six (6) inches wide and not less than three (3) feet long shall be provided and inserted between the bricks, across the pavement, to close a stretch of grouting, at the end of each working period, with a straight joint. These strips shall be taken out when the grout becomes stiff and before final set.

The grooves of "Hillside" brick shall be cleaned out after the grout takes its initial set but while it is still soft and the pavement shall be swept clean.

11.18. Mixing and Applying Bituminous-Mastic Filler. After the bricks have been rolled thoroughly, inspected and approved, the spaces between them shall be filled with the mixture of sand and bitumen. Before being mixed the sand shall be heated to a temperature of not less than three hundred (300) nor more than four hundred (400) degrees F., and shall be between these limits when mixed with the bitumen. The bitumen shall be heated in kettles equipped with an approved thermometer which will register its temperature. The bituminous material shall be mixed with as much hot, dry sand as the bitumen will carry, but in no case shall the volume of the sand exceed the volume of the bituminous materials. This hot mixture shall be flushed on the surface of the bricks and pushed into the spaces between them with suitable tools, refushing or repouring being continued until the joints are filled permanently, flush with the top of the bricks. As little of the material as possible shall be left on the surface.

When tar is used in the mixture it shall be at a temperature of not less than two hundred and fifty (250) degrees F., and at no time shall be heated to more than three hundred and twenty-five (325) degrees F.

When asphalt is used it shall be heated to a temperature of two hundred and seventy-five (275) degrees F.

In applying the filler, care shall be observed that the pavers are closely followed by the filler gang, and in no case shall the paving be left over night, or work stopped, unless all joints are filled completely. In case rain stops the filler gang before its work is completed, the joints shall be protected by tarpaulins or other approved means. Fillers shall not be poured into joints unless they are dry.

11.19. Protection. After the surface has been inspected and approved and sufficient time for setting has elapsed so that the covering material shall not injure the grout filler in any way, the surface shall be covered with one-half ($1/2$) inch or more of approved, clean sand or other acceptable material to prevent too rapid drying of the filler, and this covering shall be sprinkled three (3) times each day for four (4) days. Traffic shall not be permitted on the pavement for a period of at least ten (10) days after the grouting, or longer as may be directed. Before opening the road to traffic the covering shall be removed from the finished pavement satisfactorily.

When a bituminous-mastic filler is used, immediately after the spaces between the bricks have been filled and while the filler is still soft and pliable, the pavement shall be covered with a thin layer of approved, clean sand, which shall be heated if directed. Traffic shall not be permitted on the pavement until the filler has cooled to the air temperature. This covering shall remain on the pavement for such time as may be directed, after which it shall be removed in a satisfactory manner.

11.20. Basis of Payment. This work will be paid for at the contract unit price per square yard for "Vitrified Brick Pavement with Sand-Cement Bed," complete in place, which price will include all brick, concrete, filler, expansion joint, bed and protection materials, all equipment, tools, labor and work incidental thereto.

ITEM 12. VITRIFIED BRICK PAVEMENT.

MONOLITHIC CONSTRUCTION.

12.1. Description. This pavement shall consist of a cement grouted, vitrified brick wearing surface imbedded directly on the fresh unset concrete base covered with a cement-sand coating, in accordance with these specifications.

Unless otherwise specified the concrete base shall be composed of 1:3:6 concrete, 4 in. thick, and the cement-sand coating shall be composed of 1 part cement, 3 parts sand, 3/16 in. thick.

12.2. Material. The vitrified brick, cement, fine and coarse aggregate for the concrete base, sand for the cement-sand bed and cement grout filler, and water shall meet the requirements of Item 11.

The vitrified brick shall be——inches long, —— inches wide, —— inches deep, and shall not vary from these dimensions more than 1/8 inch.

12.3. Side Forms. The side forms shall meet the requirements of paragraph 11.10.

12.4. Measuring, Mixing and Placing Concrete Base. The materials to be used in the concrete base shall be measured, mixed and placed in accordance with the requirements of paragraphs 11.11 and 11.12 in so far as they do not conflict with the following requirements as to placing the concrete:

In placing the concrete, it shall be placed to the entire thickness at one time. The concrete shall be placed also in successive batches for the entire width of the pavement and in a continuous operation. The workmen shall be guided by a light wood template resting on the side-forms, so made as to leave the concrete a little in excess of the depth required. The upper surface of the base shall be smooth, true, uniform, and parallel with the surface of the finished pavement.

12.5. Placing the Cement-Sand Coating. Over the concrete base shall be drawn a multiple steel template consisting of a 6 inch I-beam in front and a 6 inch channel beam in the rear with flanges turned back, bent true to the crown or cross-section of the pavement and placed in a frame so that they will be rigidly held about 2 feet apart. Two rollers at each end, resting on the side forms, and at least 3 feet apart, shall support the template. The I-beam shall be 3/16 inch lower than the channel beam, and shall strike off the concrete base practically to a true surface.

The space between the beams shall be kept filled with a dry cement-sand mixture composed of 1 part cement and 3 parts sand. A thin coating of dry mortar is distributed over the surface of the base, about 3/16 inch thick, by the rear beam of the template, leaving the surface entirely smooth.

This type of multiple template constructed of the I-beam, channel, rollers, etc., is essential to the construction of this type of brick pavement and no substitute will be accepted therefor unless approved in advance by the Engineer.

12.6. Laying Brick. Upon the foundation as prepared shall be laid the brick before the concrete has had time to set. The bricks shall be laid with the best side up, the lugs in the same direction, and with the courses straight and at right angles to the edging line. All joints shall be closed up and courses straightened by tapping lightly with a brick on a 4 x 4 inch timber, 3 feet in length, provided for that purpose. Only whole brick shall be used, except in starting or finishing courses, or in such cases as may be directed by the Engineer. The cutting and trimming of the brick shall be done by experienced men, and the fractured ends turned toward the center of the pavement. Nothing less than 3 inch bats shall be used for closures. Broken and chipped brick suitable for batting shall be used to the extent of obtaining the necessary half brick for breaking curves and making closures, instead of breaking otherwise whole and sound brick. All the work of bricklaying shall be done over the brick already laid, but wheeling in bar-

rows over the freshly laid brick will not be allowed. Walking upon the foundation also is prohibited.

Immediately after the brick has been laid, the chips shall be swept from the pavement and all soft brick removed. Bricks that are broken, misshapen, or badly spalled shall be turned over or removed by the Contractor. Rejected brick, suitable for batting in, shall be carried forward and used for that purpose. All other rejected brick shall be placed in separate piles along the road.

12.7. Rolling. After the brick in the pavement have been inspected and the surface swept clean, the pavement shall be rolled with a hand roller not less than thirty (30) inches long, made in sections and weighing not less than fifteen (15) nor more than twenty (20) pounds per inch of length. The rolling must be kept close to the laying and continued until the brick are uniformly bedded and the surface is smooth. Portions of the pavement inaccessible to the roller shall be tamped by use of hand tampers applied upon a short piece of plank two (2) inches thick. After the final rolling, the surface shall be tested with a ten (10) foot straight edge, laid parallel to the sides and any depressions or humps exceeding one-quarter ($\frac{1}{4}$) of an inch must be taken out.

The inspector shall keep the brick culled and the contractor shall make the necessary changes and replacements so that the work at all times shall be ready for grouting within twenty-five (25) feet of the brick laying.

12.8. Cement Grout Filler. As soon as the brick have been passed for filling, cement grout, consisting of 1 part cement and 1 part sand, shall be applied and the joints entirely filled as specified under paragraph 11.17.

12.9. Finishing Day's Work. The concreting work will be stopped so that all the foundation may be covered with brick and grouted by the end of the day's work. The concrete shall be finished against a vertical stop plank placed transversely to the roadway, and the brick laid, rolled and culled up to this plank. The grouting shall be stopped five (5) or six (6) rows back from this plank by inserting the metal strips previously described.

On beginning work again, the ungrouted rows of brick will be carefully removed, leaving the foundation bare so that the double steel template may be backed over it in position for the I-beam to start leveling the first of the fresh concrete placed.

The brick removed will then be carefully replaced in the same positions they formerly occupied, and the laying, rolling and grouting proceed as before.

12.10. Protection. The pavement shall be cured and protected as stated in paragraph 11.19.

12.11. Basis of Payment. This work will be paid for at the contract unit price per square yard for "Monolithic Vitrified Brick Pavement," which price will include all brick, concrete, filler, bed, protection materials, and all equipment, tools, labor, and work incidental thereto.

ITEM 13. SAND-CLAY SURFACING.

13.1. Description. Sand-Clay Surfacing shall consist of an intimate mixture, either natural or artificial, of properly proportioned sand and clay, applied in one or more layers and constructed in accordance with these specifications.

13.2. Materials. The material to be used for the surfacing shall be sand and clay of suitable character and thoroughly mixed either naturally or artificially, and in the proper proportions.

(a) *Natural Sand-Clay Surfacing.* The Engineer will designate suitable places for obtaining natural sand-clay mixtures for surfacing. Stones over 3 inches in diameter must be removed.

(b) *Sand.* For an artificial mixture of sand and clay, or where the clay must be added to a natural combination, the sand shall be sharp, clean, free from dirt or loam, and not too fine. It must be approved by the Engineer.

(c) *Clay.* For an artificial mixture of sand and clay, or where the clay must be added to a natural combination, it shall be of approved quality, and shall show resistance to slacking and shrinking satisfactory to the Engineer.

13.3. Preparing Material Pits. When necessary, clearing and grubbing shall be stripped off and removed, and this work will be paid for at the unit price bid for "Excavation."

13.4. Preparation of Sub-Grade. The graded roadbed shall be shaped to the elevation, alignment, and cross section indicated for sub-grade on the plans, and shall be maintained free from ruts and other depressions until covered with the surfacing material.

No trenching 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.

Where it is necessary to bring the sand and clay on the road separately, and mix them in place, a trench shall be formed with the grading machine to receive the bottom layer, which may be either the sand or clay. A trench shall be formed with the grading machine to receive the bottom layer, which may be either the sand or clay. A trench also shall be formed where a natural mixture is to be used.

13.5. Method of Construction. Whether the construction shall consist of an admixture of clay with a sandy subsoil or an admixture of sand with a clay subsoil, the process is exactly similar.

(a) *Clay with Sandy Subsoil.* After the road bed has been shaped as specified in paragraph 13.4, the clay shall be spread over that part of the roadway as indicated on the plans, to such a depth, that when mixed with the sand, a compacted surfacing of _____ inches in thickness will be obtained, as shown on the plans. The proper amount of clay shall be added to fill the voids of the sand. After the clay has been spread, the contractor shall then plow up sand from beneath and add sand from the sides, so that the net proportion of sand to clay is about 2 to 1, or in sufficient quantity so that the clay will slightly more than fill the voids of the sand. It is better to have too little than too much sand, for it is easier to add sand from the roadbed than to haul additional clay. After plowing, 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.

(b) *Sand with Clay Subsoil.* This process is exactly similar to that in paragraph 13.5-(a), except that sand is spread over the graded road bed, and clay is plowed up from beneath, if of the approved quality, or hauled in when necessary, to mix with it. The sand shall be spread over the part of the roadway as shown on the plans, to such a depth that when mixed with clay, a compacted surfacing of _____ inches in thickness will be obtained, as shown on the plans. The depth to which the sand should be spread will depend upon the amount of sand contained originally in the clay of the road bed. It

should be borne in mind that in this case, it is better to have a surplus of sand than a surplus of clay, because the clay is more easily obtained. When building on a clay foundation, it is advisable to plow the clay before adding the sand in order to insure a thorough mixing.

(c) *Sand with Clay on a Different Subsoil.* 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 the sand or the clay) to such a depth, and then have the top layer spread upon it, to such a depth, so that when mixed together, the sand and clay will show a properly proportioned and uniformly mixed, compacted surfacing of _____ inches in thickness and _____ feet in width, as shown on the plans. Ordinarily, the best conditions are obtained when the clay just fills the voids of the sand. Where the road bed 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 the surfacing. The surplus sand which remains under the completed surface will serve to improve the drainage of the road. The plowing, harrowing, shaping, and other work shall be as specified in paragraph 13.5-(a).

(d) *Top Soil or Other Natural Sand-Clay Mixture.* After the road bed has been graded as specified above, and the portion to be surfaced has been trenched, as indicated on the plans, the surfacing material shall be immediately spread on the prepared subgrade to such a depth, that when compacted, it will be _____ inches thick, and _____ feet wide, as shown on the plans. The Contractor shall throw out all stones over 3 inches in diameter. The construction shall begin at the point nearest the source of material and be continued from such point. The plowing, harrowing, shaping, and other work shall be as specified in paragraph 13.5-(a).

In all cases, in order to obtain the best results, only sufficient clay to fill the voids of the sand should be used, the clay serving as a binder to prevent the sand grains from moving under traffic. On sections of road that are not exposed to the sun and wind, as in dense woods, or deep cuts, or on low boggy sections, a smaller percentage of clay is required, as water will partially fill the voids between the sand grains. On heavy grades, especially when exposed to the sun and wind, a greater percentage of clay is desired.

The construction of all surfacing shall begin at the point on the road nearest the source of material, and be continued from such point. In hauling over the sand and clay material, wagons will be required to use the entire width of surfacing. The teams will not be permitted to follow a single track or to form ruts.

13.6. Maintenance During Construction. All depressions, defects, and imperfections which may appear before acceptance shall be treated with a properly proportioned sand-clay mixture so that the finished surface will conform to the cross-section specified, and, when directed by the Engineer, the Contractor shall, at any time during the term of this contract, apply additional sand or clay, as the case may be, to the road surface, in order to obtain the proper mixture of sand and clay. The Contractor shall maintain the sand-clay surface true to the cross section specified, as herein provided, until final acceptance, by the use of a road machine, road drag, or other satisfactory means.

13.7. Basis of Payment. Where clearing and grubbing of material pits is necessary, it will be paid for at the contract unit price for "Clearing and Grubbing" as listed in the "Proposals."

Stripping of Material Pits will be paid for at the contract unit price per cubic yard for "Excavation."

Sand-Clay Surfacing material will be paid for at the contract unit price per cubic yard for "Sand-Clay Surfacing Material," at the pit, measured loose in the wagon, which will include the excavation of the material. If furnished free in the pit by the County, it will be so noted in the Proposal.

Hauling Surfacing Material will be paid for at the unit price per cubic yard per one-fourth mile haul. The price for the first one-fourth mile hauled will include the loading and unloading. Each additional one-fourth mile will be paid for at the contract unit price for "Additional cu. yd.—one-fourth mile Haul."

The mixing, shaping, and finishing of the surfacing material will be paid for at the contract price per square yard for "Mixing, Shaping, and Finishing Sand-Clay Surfacing." This will also include the preparation of the trench subgrade when the type of surfacing is of a nature to require the trenching.

ITEM 14. GRAVEL.

14.1 Description. Gravel roads shall be construed to mean all surfacing of gravel, or of earthy material in the composition of which gravel predominates, not included under "Waterbound Macadam" surfacing. The surfacing may be built in one or more layers. The gravel should contain or have added to it, clay or other binding material which, with harrowing, sprinkling, and rolling, will bond the material into a uniform and compact road surfacing.

14.2. Thickness. The Contractor is to load, haul and spread upon the subgrade, prepared as hereinbefore described, gravel which shall have a loose depth of..... inches and which, after compacting, shall be.....inches deep. It shall be..... feet in width from station.....to station

Where the depth of compacted gravel exceeds six inches, it shall be placed upon the road in two separate layers. The Contractor shall place loose gravel on the road to the thickness of loose gravel shown on the plans, and this loose gravel shall be compacted to the thickness shown. If the loose thickness should compact at any place to a depth less than the compacted depth required, then the Contractor shall add gravel as directed by the Engineer until the required compacted depth is obtained.

14.3. Gravel. The gravel shall consist of hard, durable particles of stone mixed with sand and clay or other binding material, all of which will pass through a three inch mesh screen. Not less than 50% nor more than 75%, by weight, of the gravel shall consist of stone particles sufficiently large to be retained on a 1/4 inch mesh screen.

The material passing a 1/4 inch mesh screen shall consist of sand and clay or other binding material which when tested in the manner described in Bulletin No. 347 of the U. S. Department of Agriculture shall have a cementing value of not less than 50.

The material retained on a 1/4 inch mesh screen shall be graded from fine to coarse so that not more than 75% and not less than 25% will pass a 3/4 inch mesh screen.

The Contractor shall, at his own cost, throw out all stones over three inches in diameter.

Gravel obtained from the pit located at.....

.....
will be acceptable under this specification, provided that, if necessary, the gravel shall be screened to remove any excess of either fine or coarse material which it may contain above the limits specified.

14.4. Per Cent of Clay in Gravel. If clay gravel is used it should contain only enough clay to coat the pebbles, with no free lumps. In no case shall the clay exceed 15 per cent of the mass. If the gravel, as taken from the pit, contains an excess of clay, the Contractor shall add sufficient sandy gravel or sand filler, whichever is required for the proper grading of sizes, to secure a proper binding material as hereinbefore specified.

If the gravel is lacking in binding material, and is of such a nature that it cannot be properly bonded, then sufficient clay shall be added to secure a proper bond, the material so added to form a part of the required thickness of the gravel surfacing as hereinbefore provided for, and which shall be measured and paid for as gravel.

14.5. First Course. The gravel for the first course, hereafter designated as "No. 1 Gravel," shall not contain any particles which would be retained on a 3 inch mesh screen. This gravel shall be spread uniformly to such a depth that when compacted it will have the thickness shown on the cross-section drawings. In order to secure the required thickness for the course, the Contractor shall, if required by the Engineer, set

wooden guide blocks upon the subgrade at frequent intervals. These blocks shall be about 6 inches square and of a height equal to the required depth of the loose layer, and the gravel shall be spread flush with the tops of the blocks. After the gravel has been spread, as above specified, it shall be harrowed with a tooth harrow until the different sized particles and the cementing material are evenly distributed through the mass. It shall then be floated and rolled until no further compacting is possible. The rolling must be done only after the road has been wetted by sprinkling or after rains. All irregularities and depressions that may develop shall be corrected immediately and No. 1 gravel added or removed as may be necessary, and the rolling continued until the surface is uniformly smooth and hard and everywhere parallel to the surface of the finished road. The crown shall be maintained during construction by the occasional use of the grader or other suitable tools. Ruts formed by hauling over the gravel shall be kept filled by using the harrow twice or more every day, preferably just before quitting time both noon and night. The bottom course of gravel shall be completed a sufficient time in advance of the second course to be thoroughly compacted.

14.6. Reshaping Shoulders. After spreading and rolling the first course as above, the shoulders shall be rebuilt, if necessary, true to line and to such height that the second course can be spread between them without overlapping the earth at the sides.

14.7. Second Course of Gravel. The gravel for the second course, hereafter designated as "No. 2 Gravel," shall not contain any particles which would be retained on a screen having circular openings $1\frac{1}{2}$ inches in diameter. No. 2 gravel shall be spread uniformly to such a depth that a shrinkage of $33\frac{1}{3}$ per cent. will be obtained when compacted to the thickness shown on the cross-section drawings. This gravel shall be harrowed and rolled in the same manner prescribed for the first course. Any irregularities or depressions that may be formed during the rolling shall be filled with No. 2 gravel and the road re-rolled until the surface is uniformly smooth and hard and everywhere conforms to the proposed grade and cross-section of the road.

14.8. Side Drains. In clay soils, or at any place as directed by the Engineer, side drain trenches, or bleeders, shall be cut through the shoulders at right angles to the center line and not more than 100 feet apart. The trenches shall be cut three inches lower than the bottom of the subgrade at the shoulders and shall have a good fall all the way to the ditch. They shall be filled to a depth of four inches for their whole length with first course material and covered with sod, grass side down, or with hay or straw. The remaining depth of trench shall then be filled with earth until flush with the shoulders, the ditch end of the drain being left open. On hills over four per cent. in grade, side drain trenches shall be cut seventy degrees with the center line down hill and shall be cut through to the center of the road bed.

14.9. Manner of Rolling. Rolling shall be done when the gravel has been thoroughly wetted by sprinkling or recent rains, and shall at all times begin at the sides, rolling lengthwise of the road, but gradually working toward the center. In the final rolling, the whole surface of the roadway, including the shoulders, shall be rolled from ditch to ditch and the whole road grade left in such perfect condition that water will flow without obstruction to the side ditches. If the gravel contains clay of such quality that it causes the surface material to adhere to the wheels of the roller after the gravel has been sprinkled, the surface shall be sanded with coarse sand. It is advisable also to finish the surface of a gravel road, built of gravel containing clay, with a coat of sand about $\frac{1}{2}$ inch in thickness before traffic is allowed upon it. The roller shall not weigh less than 10 tons.

14.10. Defects Before Acceptance. Should any defects, holes, or depressions appear in the road surfacing before the work has been finally accepted, the Contractor shall, at his own expense, refill same with suitable material and restore the road to its proper shape. The right is reserved by party of the first part to defer final acceptance and final payment for any part of the work until it has been open to public travel for at least thirty days. Before any portion of the work is accepted as completed, the Contractor must neatly trim the slope in cut and fill, remove all surplus material, and present the portion of the road desired to be accepted in a neat and finished condition from end to end.

14.11. Crown. The finished road shall have a uniform crown of $\frac{2}{3}$ inch to the foot unless otherwise noted.

14.12. Basis of Payment. The Surfacing material will be paid for at the unit price per cubic yard at the nearest delivery point. Hauling Surfacing will be paid for at the unit price per cubic yard per one-fourth mile haul. The price for the first one-fourth mile haul will include the loading and unloading. Each additional one-fourth mile will be paid for at the contract unit price for "Additional Cu. Yds.—1/4 Mile Haul." All preparation of subgrade, placing, handling, mixing, harrowing, sprinkling, rolling and other work incidental to the placing of the surfacing shall be included in the price for "Placing Surfacing." Where side drains are necessary, the excavation will be paid for at the unit price per cubic yard for "Ditching." The filling of the drain ditches with gravel, sod, and earth shall be considered as work incidental to the placing of the surfacing, and shall be included in the unit price for "Placing Surfacing."

ITEM 15. SHELL SURFACING.

15.1. Description. Shell Surfacing shall consist of one or more layers of shells with a top coating of coarse sand, constructed in accordance with these specifications.

Where the proposed surfacing is to be over 6 inches in thickness the shells shall be placed in two layers, with a top coating of coarse sand.

Where the sub base is of a soft marshy nature, it shall be reinforced with a layer of sand before the shell surfacing is placed.

15.2. Material. (a) *Shell.* The shells shall consist of sound particles of oyster, clam, or other shells equally acceptable to the Engineer, and shall not contain more than 20 percent of mud, marl, clay, or loam.

(b) *Sand.* The sand used for the top coating shall be clean, sharp sand, no particles larger than one-fourth inch. The sand for the sub base, when required, may be as selected by the Engineer.

15.3. Preparation of Sub-Grade. The graded road bed shall be shaped to the elevation alignment and cross section shown on the plans. After this is done the sub base shall be shaped for receiving the surfacing material as shown on the plans, and then rolled until it is firm and unyielding. After rolling, the subgrade shall conform to the dimensions shown on the plans. The shoulders thrown up on either side of the sub base shall be at least as high as the shells will reach when loose, and if the shoulders are of a greater height than the proposed thickness of shells, greater stability will result after rolling.

At places where the sub base is of a soft marshy nature, a layer of sand about 3 inches in thickness, or of a thickness as specified by the Engineer, shall be placed. If sand is not available, other material approved by the Engineer may be used instead.

15.4. First Course. The first course of shells shall be — inches in thickness after being compacted. The shells shall be spread upon the road bed from piles placed along side the road, or from a dumping board, or as otherwise directed by the Engineer. They shall be rolled with a self-propelled roller weighing not less than 8 tons, beginning at the sides and rolling toward the center. During the process of rolling the shells shall be sprinkled lightly with water and bound with sand until the surface is firmly compacted.

15.5. Re-shaping Shoulders. After spreading and rolling the first course as above specified, the shoulders shall be rebuilt, true to line and of such height that the second course material can be spread between them without over-lapping the earth at the sides.

15.6. Second Course. The second course shall be — inches thick after being compacted, and shall be placed and rolled in the manner described for the first course.

15.7. Top Course. The Top Course shall be composed of clean, sharp sand, no particles larger than $\frac{1}{4}$ inch, spread just thick enough to cover the second course after the latter has been thoroughly compacted.

15.8. Maintenance During Construction. All depressions, defects, and imperfections which may appear in any portion of the shell surface before final acceptance by the Engineer, whether due to poor workmanship or material, public travel, or other cause, shall be repaired and made good by the Contractor at his own expense. The right is reserved by the party of the first part to defer final acceptance and final payment for any part of the work until it has been open to public travel for at least 30 days.

Before any portion of the work is accepted as completed, the Contractor must neatly trim the slopes in cuts and fills, remove all surplus material, and present the portion of the road desired to be accepted in a neat and suitable condition from end to end.

15.9. **Basis of Payment.** The Shell Surfacing Material will be paid for at the contract unit price per cubic yard, measured loose in the wagon, for "Shell Surfacing Material," at the beds, or nearest delivery point, which price will include all excavation necessary.

Hauling Surfacing Material will be paid for at the contract unit price per cubic yard per $\frac{1}{4}$ mile haul. The price for the first $\frac{1}{4}$ mile haul will include the loading and unloading. Each additional $\frac{1}{4}$ mile will be paid for at the contract unit price for "Additional cu. yds. $\frac{1}{4}$ mi. Haul."

Placing Surfacing will be paid for at the contract unit price for "Placing Surfacing," which price will include all preparation of trench and shoulders not included in the grading of the flat section, all placing, handling, mixing, sprinkling, rolling, and all equipment, tools, labor and work incidental thereto.

ITEM 16. CEMENT CONCRETE STRUCTURES.

16.1. Description. Cement concrete for structures shall be composed of Portland cement, fine aggregate and coarse aggregate. The concrete shall be of three classes, Class "A," Class "B," and Class "C" respectively, and the materials shall be mixed in such proportions and of such consistency as specified, and deposited in such places and of such form and dimensions as shown on the plans or as directed. Each class of concrete shall be used in that part of the structure in which it is called for on the plan or where directed, and shall be constructed in accordance with these specifications.

16.2. Class "A" Concrete. Class "A" concrete shall be composed of one (1) part of Portland cement, two (2) parts of fine aggregate, and four (4) parts of coarse aggregate.

16.3. Class "B" Concrete. Class "B" concrete shall be composed of one (1) part of Portland cement, two and one-half ($2\frac{1}{2}$) parts of fine aggregate, and five (5) parts of coarse aggregate.

16.4 Class "C" Concrete. Class "C" concrete shall be composed of one (1) part of Portland cement, three (3) parts of fine aggregate, and six (6) parts of coarse aggregate.

16.5. Portland Cement. All cement used in this work shall be Portland cement, which shall be tested according to methods prescribed by and shall conform to the requirements of the report of a Joint Conference representing the United States Government, American Society of Civil Engineers, and the American Society for Testing Materials, published in the "1916 Standards of the American Society for Testing Materials, Page No. 429, Serial Designation C 9-17," etc.

a, *Definition.* Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimately and correctly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

b. *Chemical Properties.* The following limits for the chemical properties of the cement shall not be exceeded:

Properties.	Percentage.
Loss on ignition.....	4.00
Insoluble residue	0.85
Sulfuric anhydride (SO ₃).....	2.00
Magnesia (MgO)	5.00

c. *Physical Properties.* The physical properties of the cement shall meet the following requirements:

Specific Gravity. The specific gravity of cement shall not be less than three and ten one-hundredths (3.10). Should the test of cement as received fall below this requirement, a second test may be made upon an ignited sample. The specific gravity test will not be made unless specifically ordered.

Fineness. The residue on a standard No. 200 laboratory sieve shall not exceed twenty-two (22) per cent by weight.

Soundness. A pat of neat cement shall remain firm and hard, and show no signs of distortion, cracking, checking, or disintegration, in the steam test for soundness.

Time of Setting. The cement shall not develop initial set in less than forty-five (45) minutes when the Vicat needle is used, or sixty (60) minutes when the Gillmore needle is used. Final set shall be attained within ten (10) hours.

Tensile Strength. The average tensile strength in pounds per square inch of not less than three (3) standard mortar briquettes composed of one (1) part cement and three (3) parts standard sand, by weight, shall be equal to or be higher than the following:

Age of Test, days.	Storage of Briquettes	Tensile strength, pounds per sq. in.
7	1 day in moist air, 6 days in water	200
28	1 day in moist air, 27 days in water	300

The average tensile strength of standard mortar at twenty-eight (28) days shall be higher than the strength at seven (7) days.

d. *Packages and Marking.* The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer clearly marked thereon, unless shipped in bulk. A bag shall contain ninety-four (94) pounds net. A barrel shall contain three hundred and seventy-six (376) pounds net.

e. *Storage.* The cement shall be stored in such manner as to permit easy access for suitable inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness. When permission is given to store in the open, a platform and ample water-proof covering shall be provided, as directed.

f. *Inspection.* Every facility shall be provided for careful sampling and inspection at either the mill or at the site of the work, as may be directed by the Engineer. At least ten (10) days from the time of sampling shall be allowed for the completion of the seven (7) day test, and when directed at least thirty-one (31) days shall be allowed for the completion of the twenty-eight (28) day test. The cement shall be tested in accordance with the methods referred to herein.

g. *Rejection.* The cement may be rejected if it fails to meet any of the requirements of these specifications:

Fineness Test. Cement shall not be rejected on account of failure to meet the fineness requirement if upon retest, after drying at one hundred (100) degrees C. for one (1) hour, it meets this requirement.

Soundness Test. Cement failing to meet the test for soundness in steam may be accepted if it passes a retest, using a new sample at any time within twenty-eight (28) days thereafter.

Weight. Packages varying more than five (5) percent from the specified weight may be rejected, and if the average weight of packages in any shipment, as shown by weighing fifty (50) packages taken at random, is less than that specified, the entire shipment may be rejected.

16.6. **Water.** All water used in the concrete shall be clean, free from oil, acid, alkali, or vegetable substances.

16.7. **Fine Aggregate for Class "A" Concrete.** The fine aggregate for Class "A" concrete shall consist of sand, stone grit, or a combination of sand and stone grit, conforming to the following requirements:

a. *Sand.* This sand shall consist of clean, hard, durable grains, uniformly graded from coarse to fine, free from lumps of clay and all vegetable or other deleterious substances. When dry, it shall all pass a laboratory screen having circular openings one-quarter (1/4) inch in diameter, not more than thirty (30) percent, by weight, of which shall pass a standard No. 50 laboratory sieve.

Strength. Mortar composed of one part, by weight, of Portland cement and three (3) parts, by weight, of sand, mixed in accordance with methods referred to in Paragraph 16.5, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) percent of that developed by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand; except that sands conforming to the requirement of Paragraph 16.7-a, but giving a strength ratio at seven (7) and twenty-eight (28) days of less than one hundred (100), but not less than seventy-five (75) percent will be accepted for use in concrete subject to

the addition of cement to the proportion specified in Paragraph 16.2. The additional proportion of cement required will be determined by laboratory test, and shall be that amount necessary to increase the tensile strength ratio of the mortar to not less than one hundred (100) percent at seven (7) and twenty-eight (28) days.

b. *Stone Grit.* This stone grit shall consist of clean, dustless screenings, resulting from the crushing of tough, durable rock, having a French coefficient of wear of not less than eight (8), at least equal in quality to stone specified for coarse aggregate, Paragraph 16.8-a, which shall be prepared by screening through a revolving screen having circular openings not larger than three-eighths ($\frac{3}{8}$) inch in diameter and by passing over a dust jacket. Not more than twenty-five (25) percent, by weight, shall pass a standard No. 50 laboratory sieve, nor more than five (5) percent shall pass a No. 100 sieve.

Strength. Mortar, composed of one part, by weight, of Portland cement and three (3) parts, by weight, of stone grit, mixed in accordance with the methods referred to in Paragraph 16.5, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) percent of that developed by mortar of the same proportions and consistency, made of the same cement and a standard Ottawa sand.

c. *Combination of Sand and Stone Grit.* Sand conforming to the requirements of Paragraph 16.7-a, and stone grit conforming to the requirements of Paragraph 16.7-b, may be used in combination, in such proportions as shall be approved by the Engineer.

Strength. Mortar composed of one (1) part, by weight, of Portland cement and three (3) parts, by weight, of fine aggregate consisting of a combination of sand and stone grit, mixed in accordance with the methods referred to in Paragraph 16.5, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) percent of that developed by mortar of the same consistency, made of the same cement and standard Ottawa sand.

16.8. *Coarse Aggregate for Class "A" Concrete.* The coarse aggregate for Class "A" concrete shall consist of crushed stone or slag, or gravel graded uniformly from the maximum size to pieces one-quarter ($\frac{1}{4}$) inch in diameter. The maximum size shall be such that all will pass through a revolving screen having circular openings not less than one and one-quarter ($1\frac{1}{4}$) nor more than one and one-half ($1\frac{1}{2}$) inches in diameter. Not more than five (5) percent, by weight, shall pass a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) inch in diameter. All reinforced concrete shall be Class "A" unless otherwise noted.

For walls and slabs less than six (6) inches thick, the maximum size screen openings shall be not more than one and one-quarter ($1\frac{1}{4}$) inches in diameter.

a. *Crushed Stone.* Crushed stone shall be obtained from clean, tough, durable rock, having a French coefficient of wear of not less than eight (8). This material shall be free from dust and an excess of flat and elongated pieces.

b. *Crushed Slag.* Crushed slag shall consist of tough, durable pieces of reasonably uniform and non-glassy character. It shall be air-cooled and shall have been exposed to the weather for a suitable time prior to use. The dried slag when shaken to refusal shall have a weight per cubic foot of not less than seventy-eight (78) pounds.

c. *Gravel.* Gravel shall consist of clean, tough, durable stone of high resistance to abrasion, washed free of clay or coatings of any character. "Run-of-bank" gravel or gravel which contains disintegrated or soft stone, or shale, or an excess of flat pieces, shall not be used.

16.9. *Fine Aggregate for Class "B" and Class "C" Concrete.* The fine aggregate for Class "B" and Class "C" concrete shall consist of sand, stone screenings, or a combination of sand and stone screenings, conforming to the following requirements:

a. *Sand.* This sand shall meet the requirements specified in Paragraph 16.7-a for Class "A" concrete.

b. *Stone Screenings.* The screenings shall consist of material resulting from the crushing of clean, tough, durable rock having a French coefficient of wear of not less

than ten (10). For purposes of proportioning on the work, and in laboratory tests for grading and strength, only that portion of the entire product which passes a laboratory screen having circular openings one-quarter ($\frac{1}{4}$) inch in diameter will be regarded as fine aggregate. This material shall be graded from the coarse to fine, containing not more than thirty (30) percent, by weight, of particles passing a standard No. 50 laboratory sieve, nor more than eighteen (18) percent, by weight, passing a No. 100 sieve. It shall contain not more than three (3) percent, by weight, of loam or other foreign substances.

Strength. Mortar composed of one part, by weight, of Portland cement and three (3) parts, by weight, of screenings, mixed in accordance with the methods referred to in Paragraph 16.5, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) percent of that developed by mortar of the same proportions, made of the same cement and standard Ottawa sand.

c. Combination of Sand and Stone Screenings. A combination of sand and stone screenings, each measured separately and accurately by volume, may be used in such proportions as shall be directed by the Engineer. Sand for this purpose shall conform to the requirements of Paragraph 16.7-a, and stone screenings shall conform to the requirements of Paragraph 16.9-b, except as to amounts passing the Standard No. 50 and No. 100 laboratory sieves. The combination used shall contain not more than thirty-five (35) percent, by weight, of particles passing a No. 50 sieve, nor more than twelve (12) percent, by weight, passing a No. 100 sieve.

Strength. Mortar composed of one (1) part, by weight, of Portland cement and three (3) parts, by weight, of the combination of sand and stone screenings, mixed in accordance with the methods referred to in Paragraph 16.5, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) percent of that developed by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand.

16.10. Coarse Aggregate for Class "B" and Class "C" Concrete. The coarse aggregate for Class "B" and Class "C" concrete shall consist of crushed stone or slag, or gravel, similar in character to that specified in Paragraph 16.8 for Class "A" concrete, except that the maximum size of this material shall be such that all will pass a revolving screen having circular openings two and one-half ($2\frac{1}{2}$) inches in diameter, and that unscreened gravel may be used when meeting the specifications stated below. This material shall be graded uniformly from the maximum size to pieces one-quarter ($\frac{1}{4}$) inch in diameter.

Unscreened Gravel. Unscreened gravel may be used for concrete in the place of broken stone and sand. When so used, frequent tests will be made to determine the relative proportions of sand and stone. In case the relative proportions of sand and stone are excessively irregular so as to make it practically impossible to proportion the concrete properly, the engineer may reject the material or require that it be screened and re-proportioned.

The fine aggregate shall be considered as that portion of the gravel which passes a one-fourth ($\frac{1}{4}$) inch screen, and shall conform to the requirements herein specified for fine aggregate.

The coarse aggregate shall be considered as that portion of the gravel retained on a one-fourth ($\frac{1}{4}$) inch screen and shall conform to the requirements herein specified for coarse aggregate.

In all cases where unscreened gravel is used, one (1) part by volume of cement shall be used to each two and one-half ($2\frac{1}{2}$) parts of fine aggregate for Class "B" concrete; and one (1) part of cement to each three (3) parts of fine aggregate for Class "C" concrete.

The ratio by volume of the fine to the coarse aggregate shall not be less than one (1) to two (2) nor more than one (1) to one (1).

16.11. Rubble Cement Concrete. Rubble "one-man stone" may be embedded in plain mass concrete more than two (2) feet in thickness, or where shown on the plans. They shall not be placed within three (3) inches of any finished surface of the concrete and

shall be placed at least three (3) inches apart. The stone for this purpose shall consist of clean, sound, rubble stone, free from structural defects, foreign substances and coating of any character, and shall be of a quality satisfactory to the Engineer.

16.12. Approval of Material Sources of Supply. Sources of supply of Portland cement and fine and coarse aggregate shall be approved by the Engineer before delivery of materials is started.

A representative sample of fine aggregate shall be forwarded to the State Highway Department Testing Laboratory, Austin, Texas, unless material from the same source of supply has been tested and approved during the year preceding the award of the contract. Samples of coarse aggregate shall be submitted when directed. Aggregate samples shall be accompanied by a statement giving the type of material, name of the producer, location of the plant and diameter of openings in screens used in their preparation.

a. *Fine Aggregate Samples.* A fine aggregate sample shall weigh approximately twenty (20) pounds.

b. *Coarse Aggregate Samples.* The quality of the stone will be determined by tests made on a sample consisting of approximately twenty-five (25) pounds of pieces not less than one and one-half (1½) inches nor more than three (3) inches in diameter, and of two small slabs, preferably four (4) to six (6) inches in depth. Acceptability of the coarse aggregate in other respects will be determined by tests upon a sample of the crushed stone of the same sizes as intended for use in the work, having a weight of not less than twenty-five (25) or more than fifty (50) pounds.

16.13. Forms. The materials to be used in the forms for exposed surfaces shall be surfaced lumber, sound and free from loose knots, secured to studs or uprights, or shall be metal which presents a smooth surface of the desired contour. Undressed lumber may be used for backing or other unexposed surfaces. Forms shall be well built, substantial and unyielding, securely braced or tied together by means of wire or rods to conform to the contour of the desired structure and sufficiently tight to prevent the leakage of mortar. All edges shall be chamfered unless otherwise described. No wood devices of any kind used to separate forms shall be permitted to remain in the finished work. Forms on the sides of beams or girders shall be splayed slightly in order that they may be removed more readily. Forms shall be cleaned thoroughly and oiled or soaped before being used.

16.14. Devices for Measuring Materials. The accurate measurement of each of the materials composing and the production of a uniform mixture of the concrete are essential. The Contractor shall furnish and use an approved timing device, a water measuring and discharging device, also boxes or pans of such dimensions as will give, when filled and struck, the exact volume of aggregates required by the Engineer.

16.15. Consistency. Sufficient water shall be used, in mixing plain concrete to produce a mixture which will flatten out and quake when deposited in place, but not enough to cause it to flow, and in mixing concrete in which reinforcement is to be embedded, to produce a mixture which will flow sluggishly. In no case shall the quantity of water be enough to cause the mortar and coarse aggregate to separate. The water shall be accurately measured and gauged, and shall be automatically discharged into the drum with the aggregates. The quantity of water to be used shall be determined by the Engineer and not varied without his consent.

16.16. Mixing Conditions. The concrete shall be mixed only in such quantities as are required for immediate use and any which has developed initial set, or has been mixed longer than thirty (30) minutes, shall not be used. Bags of cement or fine aggregate containing lumps or crusts of hardened material shall not be used. No concrete shall be mixed while the air temperature is at or below thirty-five (35) degrees F.

To all concrete placed in water shall be added twenty-five (25) per cent of cement over and above the amount specified for the particular class being used, for which no additional compensation will be allowed.

16.17. Mixing Concrete. Concrete shall be mixed thoroughly in a batch mixer of approved type. Class "A" concrete shall be mixed for a period of not less than one and one-half (1½) minutes, and Class "B" and Class "C" concrete for a period of not less than one (1) minute, after all the materials are in the drum. During this period the

drum shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute. The entire contents shall be removed from the drum before materials are placed therein for the succeeding batch.

When permitted, hand mixing shall be done on a water-tight wood or metal surface of suitable size. The cement and fine aggregate shall be mixed without the addition of water until a mixture of uniform color is produced. The coarse aggregate shall be spread to a depth of approximately eight (8) inches and wetted, the mixture of cement and fine aggregate spread over it and the whole turned once; then water shall be added in sufficient quantity to produce the desired consistency and the whole mass turned not less than six (6) times. No hand mixed batch shall exceed one-half ($\frac{1}{2}$) cubic yard.

16.18. Placing Concrete. Concrete shall be placed in the forms immediately after mixing. All concrete shall be deposited so as to maintain the top surface level and avoid flowing along the forms. It shall be tamped and joggled continuously and sufficiently to expel the air. The concrete next to the centers or forms shall be spaded so that sufficient mortar will exude from the mass to form a smooth surface. The Contractor shall use suitable means for placing concrete in a satisfactory manner.

In placing concrete under water, it shall be deposited carefully, in the space in which it is to remain, in a compact mass by means of a tremie, a bottom dumping bucket, or other approved method, so as not to permit the concrete to fall through the water. The concrete must not be disturbed after being deposited. No concrete shall be laid in running water, and forms which are not reasonably water-tight shall not be used for holding concrete placed under water.

16.19. Connections of New and Old Concrete. In connecting fresh concrete with concrete which has set, the surface shall be cleaned thoroughly of all laitance and foreign materials, roughened and covered with a thin grout composed of one (1) part of Portland cement and one (1) part of fine aggregate, after which the fresh concrete shall be deposited.

16.20. Warm and Dry Weather Protection. During warm and dry weather all concrete shall be protected from the sun and kept moist for a period of at least forty-eight (48) hours, and in addition shall be moistened thoroughly at least twice each day for a period of seven (7) days thereafter.

16.21. Removal of Forms. No horizontal forms carrying loads shall be removed or centers struck for two (2) weeks, or longer if directed, after placing the last concrete unless otherwise directed by the Engineer, and no load shall be allowed on the concrete for a period of thirty (30) days. Forms on vertical surfaces shall be removed within not less than twenty-four (24) nor more than forty-eight (48) hours after placing of concrete, unless otherwise directed. In cold, damp, or freezing weather, all forms shall remain in place until the concrete has set thoroughly. Forms for columns shall be removed before the shores are taken from beneath the beams or girders. Projecting wire or other metal devices used for holding forms in place, and which pass through the body of the concrete, shall be cut at least one-half ($\frac{1}{2}$) inch beneath the finished surface of the concrete and the holes or depressions thus made, and all other holes, depressions and voids which show upon removal of the forms, shall be filled with cement mortar mixed in the same proportion as that which was used in the body of the concrete which is being repaired.

16.22. 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 joint marks, which, in the opinion of the Engineer, cannot be repaired satisfactorily, the entire section shall be removed and renewed. No compensation will be allowed for the work described above.

16.23. Finishing Concrete. All exposed concrete surfaces shall be true and even, free from open or rough spaces, depressions, or projections. The concrete in all bridge seats and walks shall be brought flush with the finished top surface and generally shall be struck off with a straight edge and floated, and mortar finishing shall not be permitted. The surface finish of all exposed concrete shall be "spade," "rubbed," or "tooled" as indicated on the plans, but when not so specifically indicated the Contractor shall make a spade finish on unexposed surfaces and rubbed finish on all exposed surfaces.

The spade finish shall be obtained by forcing a flat blade spade vertically down between the concrete and the form and then by pulling the top of the spade away from the forms so that the mortar will, in all cases, be on the finished surface.

Rubbed finish shall be made by rubbing the surface, previously spaded, with a soft brick or a block of wood while the concrete is still green or by rubbing with a block of carborundum after the concrete has set. Care should be observed to use plenty of water, either by dipping the brick or block in water, or by throwing water on the concrete with a brush or broom. After the concrete has been rubbed smooth, it shall be again rubbed as before, using in place of the water a thin grout, composed of one (1) part of Portland cement and one (1) part of approved sand, until a uniform color is secured.

Tooled finish shall be made on the surface, previously spaded, by cutting into the body of the concrete with a pointed tool or bush hammer, as indicated.

16.24. Side Walks and Curbing. When a granolithic finish is called for on the plans for a side walk, this finish shall be one (1) inch in depth and composed of one (1) part of Portland cement and one (1) part of stone grit as specified in Paragraph 16.7-b for Class "A" concrete. The surface shall be screeded and floated, then dotted and grooved and divided into blocks approximately four (4) feet square. Suitable provisions shall be made for expansions. The granolithic mixture shall be placed within thirty (30) minutes after the concrete base has been placed. The curbing shall be of the dimensions and construction indicated on the plans, and the expansion joints shall be constructed where indicated. This side walk and curbing will be paid for as indicated herein.

16.25. Drainage and Weep Holes. Drainage openings and weep holes shall be constructed in the manner and where indicated on the plans, or directed, and no additional allowance will be made for such work, except that no deduction will be made for such openings in payment for this concrete.

16.26. Placing Pipes and Conduits. Pipes and conduits which are to be encased in the concrete as shown on the plans, shall be placed by the Contractor during construction. Such pipes and conduits will be delivered to the Contractor, unless otherwise stated, at the site of the structure by the Department, or by other departments or persons for whose use they are intended. No compensation will be made for placing such pipes, conduits, etc., except that no deductions will be made for the volume occupied by them.

16.27. Placing Anchors, Bolts, Grillages, Etc. The Contractor shall place all anchors, bolts, grillages, etc., securely and accurately in the locations shown on the plans or as otherwise required. No compensation will be made for placing such anchors, bolts, grillages, etc., as may be furnished at the bridge site by the Department. The cost of placing those included in the approximate estimate for the "Structural Steel and Iron" items will be included in the contract prices for those items. No deduction will be made for the volume of concrete occupied by any of the materials specified above.

16.28. Waterproofing. Reinforced retaining walls, abutments, earth filled arches, etc., shall be waterproof wherever shown on the plans or directed. This waterproofing shall consist of two (2) coats of hot bituminous material of approved quality applied to the surface when it is clean and thoroughly dry. Compensation will be made for this waterproofing as indicated herein.

16.29. Refilling. All areas which have been excavated as specified in Paragraph 5.5 for "Excavation and Embankment," the volume of which is not occupied by the concrete structure, shall be refilled with acceptable material in layers of not more than six (6) inches in depth, each layer being tamped thoroughly before the succeeding layer is placed.

16.30. Measurement of Concrete. All concrete shall be classified as shown on the plans unless changes are ordered during construction. All plain concrete in piers, abutments and wings and other walls shall be measured in accordance with the dimensions shown on the plans, unless changes are ordered during construction, except that no deductions shall be made for panelling in this class of work. All reinforced concrete,

such as beams and girders, spandrel walls, water tables, parapets, copings, etc., shall be measured as described above for plain concrete and if panelling is not more than six (6) inches in width, no deduction will be made. In hand railing, if the rail is of an open type, that is, alternate solid and open spaces, it will be measured as if no openings existed.

16.31. Basis of Payment. This work will be paid for as follows:

a. *Concrete.* The concrete will be paid for at the contract unit price per cubic yard, unless otherwise specified, for "Class 'A' Concrete," "Class 'B' Concrete," or "Class 'C' Concrete," as the case may be, complete in place, which price will include all excavation and back fill, materials, forms, equipment, tools, labor and work incidental thereto, and will also include the construction of drainage and weep holes and the placing of all pipes, conduits, anchors, bolts, grillages and other similar material. Where reinforcement is used, it shall be included in the contract unit price for "Reinforced Concrete Class 'A'", unless otherwise noted.

No extra compensation will be made for the construction of granolithic sidewalks and curbs in conjunction with structures or for expansion joints in the concrete, but all will be measured and paid for at the contract price for the adjacent concrete.

The placing of the reinforcing materials will be included in the contract unit price for "Reinforced Concrete" unless otherwise noted.

b. *Waterproofing.* The waterproofing of the concrete will be paid for at the contract price per square yard for "Waterproofing" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto. This payment will be for the actual area of surface covered.

ITEM 17. REINFORCEMENT.

17.1. Description. All reinforcement for concrete structures shall consist of deformed or plain bars, expanded metal or wire cloth, or structural steel shapes, unless otherwise specified.

17.2. Deformed and Plain Bars. All deformed and plain bars shall be made of mild or medium open hearth steel and shall be free from dirt, oil, paint, grease, mill-scale or loose or thick rust. High carbon or rerolled rail steel shall not be used. All bars shall be capable of bending cold through one hundred and eighty (180) degrees around their own diameter without fracture, and must have a yield point of not less than thirty-three thousand (33,000) pounds per square inch. When the length of reinforcing bars is such as to require splicing, they shall be lapped for a distance of forty (40) diameters for deformed, and fifty (50) diameters for plain bars. They may be securely fastened together by means of metal clips, bolted around the bars, and if not so clipped they shall be placed one (1) inch apart. The sizes shown on the plans are in all cases for the side of a square bar. If other sections are used the area shall be equivalent to that indicated. On all deformed bars the minimum sectional area of the bar will be counted, not the average. Square twisted bars will not be considered as deformed bars.

17.3. Expanded Metal and Wire Cloth. Expanded metal or wire cloth shall be in accordance with Standard Commercial Specifications, and shall be free from dirt, oil, grease, scale or rust.

17.4. Structural Steel Shapes. Structural shapes used for reinforcement shall be in accordance with Standard Commercial Specifications, and shall be free from dirt, oil, grease, scale or rust.

17.5. Placing Reinforcement. All reinforcement shall be placed accurately as shown on the plan, and at each intersection rods shall be securely fastened together with wire or metal clips. All the reinforcement necessary for a section of concrete shall be placed and approved before any concrete is deposited in the section, and care shall be observed not to disturb it during the placing of the concrete.

17.6. Basis of Payment. This material will be paid for and included in the contract unit price for "Reinforced Concrete" or per pound or per square foot, for "Deformed Steel Bars," "Plain Steel Bars," "Expanded Metal" or "Wire Cloth," or "Structural Steel Shapes," complete in place, which price will include furnishing and placing the material and all equipment, tools, labor and work incidental thereto. No allowance will be made for the clips, wire or other mechanical means used for fastening reinforcement in place.

ITEM 18. BRICK MASONRY.

18.1. Description. Brick Masonry shall be composed of brick laid in full beds of mortar and constructed in such shapes and at such places as indicated on the plans or where directed, in accordance with these specifications.

18.2. Brick. The brick shall be new, whole brick of the best quality, of uniform standard commercial size, with straight parallel edges and square corners. They shall be of compact texture, burned hard and entirely true, free from injurious cracks and flaws, tough and strong, full weight, and shall have a clear ring when struck together. The sides, ends and faces of all bricks shall be plane surfaces at right angles and parallel one to the other. Brick of the same manufacturer shall not vary more than one-sixteenth ($1/16$) of an inch in thickness, nor more than one-eighth ($1/8$) of an inch in width or length. If deemed necessary the brick shall be culled and the truest brick shall be used in the faces of the masonry.

a. *Absorption.* The amount of water absorbed by the bricks, after being dried thoroughly and soaked in water, for a period of twenty-four (24) hours, shall not exceed four and one-half ($4\frac{1}{2}$) percent of the weight of the dry brick. All brick shall be uniform in quality and in percentage of absorption.

18.3. Mortar. This mortar shall be composed of one (1) part of a combination of Portland cement and hydrated lime and three (3) parts of approved sand. The combination shall be made of ninety (90) percent, by volume, of Portland cement, as specified in Paragraph 16.5, and ten (10) percent, by volume, of approved hydrated lime. The sand shall consist of clean, hard, durable grains, which shall contain not more than five (5) percent, by weight, of loam or other foreign substances. It shall be of such size that all will pass through a laboratory screen having circular openings one-eighth ($1/8$) of an inch in diameter.

The sand and combination of cement and lime shall be mixed dry, in a clean tight box, until a mixture of uniform color is produced, after which water shall be added in such quantity as to form a mortar of the consistency of stiff paste. Mortar which has been mixed for more than thirty (30) minutes shall not be used. Retempering of mortar shall not be permitted. Mortar for pointing shall be mixed in the proportion of one (1) part of cement to one (1) part of sand.

18.4. Construction Methods. The brick shall be laid in courses, in full and close joints of mortar. Adjoining courses shall break joints one-half ($1/2$) a brick, as nearly as practicable. The courses shall be level in all places, except where otherwise necessary. At least one course in every seven shall be composed of headers. All exposed surfaces shall be smooth and no joints shall exceed one-quarter ($1/4$) of an inch in width. All bricks shall be wetted thoroughly by immersion or otherwise immediately before being laid and no broken or chipped bricks will be allowed in the faces of the structure. In making closures no piece of brick less than the width of a whole brick shall be used, and wherever practicable in making such closures, whole brick shall be laid with the long side at right angles to the face of the structure. All joints shall be cleaned out and pointed satisfactorily.

18.5. Refilling. The excavated areas which are not occupied by the masonry structure shall be refilled with acceptable material in layers of not more than six (6) inches in depth. Each layer shall be tamped thoroughly and until the refilling is level with the original ground.

18.6. Basis of Payment. This work will be measured in accordance with the dimensions shown on the plans, except where changes are ordered during construction, and will be paid for at the contract unit price per cubic yard, unless otherwise noted, for "Brick Masonry" complete in place, which price will include all excavation and backfill, equipment, tools, labor and work incidental thereto.

ITEM 19. CEMENT RUBBLE MASONRY.

19.1. Description. Cement Rubble Masonry shall be composed of approved stones laid in full mortar beds, and constructed in such shapes and at such places indicated on the plans or where directed, in accordance with these specifications.

19.2. Stone. All stone for this work shall be rubble stone of approved quality, sound, free from structural defects, earth, clay or other foreign substances, and from which all weak points and angles have been removed. Selected stones, roughly squared and pitched to line, shall be used at all angles and ends of walls. The stones for the faces of the wall shall be not less than six (6) inches thick nor less than twelve (12) inches in length; the width shall not be less than the thickness, and the length shall not exceed three (3) times the thickness. Small stones of similar quality may be used for pinning and for the interstices in the heart of the wall.

19.3. Mortar. This mortar shall be composed of one (1) part of a combination of Portland cement and hydrated lime and three (3) parts of approved fine aggregate. The combination shall be made of ninety (90) percent, by volume, of Portland cement, conforming to the requirements of Paragraph 16.5, and ten (10) percent, by volume, of approved hydrated lime. The fine aggregate shall consist of material conforming to the requirements of Paragraph 16.9 for "Cement Concrete Structures, Class 'B' and 'C' Concrete."

The fine aggregate and combination of cement and lime shall be mixed dry, in a clean tight box, until a mixture of uniform color is produced, after which water shall be added in such quantity as to form a mortar of the consistency of stiff paste. Mortar which has been mixed for more than thirty (30) minutes shall not be used. Retempering of mortar shall not be permitted.

Mortar for pointing shall be mixed in the proportions of one (1) part of cement to one (1) part of fine aggregate.

19.4. Placing Rubble Stones. All stones shall be laid in full mortar beds, and placed so as to bond firmly in all directions. Stratified stone shall be laid on their natural beds and not on their edges. The stones shall be laid so as to form good, substantial masonry of neat and finished appearance on the face. At least one-fourth ($\frac{1}{4}$) of the area of the face of the wall shall be headers which shall extend for a distance of twice their thickness into the backing, and for walls up to eighteen (18) inches in thickness the headers shall extend through the wall. All stones shall break joints at least six (6) inches on the face of the wall and no joints in the face shall be more than two (2) inches in width. Backing shall consist of large stone well shaped and laid so as to break joints. All spaces between the stones shall be flushed with mortar and then packed with spalls. No voids in any part of the wall shall be permitted. The rear face shall present an approximately plane surface. On all exposed faces the joints shall be raked clear of loose mortar and pointed neatly with the mortar specified. The wall shall be kept wet while the pointing is being done. No pointing will be permitted in freezing weather and any work which is damaged by frost shall be removed and replaced. In hot or dry weather the pointed masonry shall be protected from the sun and moistened satisfactorily for a period of three (3) days after completion.

19.5. Placing Copings. Copings of the dimensions given shall be placed on the tops of all walls and shall be constructed of cement concrete. This concrete shall be composed of materials of the same character and size as specified in Paragraph 16.5 to 16.8 inclusive for "Cement Concrete Structures, Class 'A' Concrete," and mixed in the proportions of 1:3:6 as specified in Paragraph 16.4 for Class "C" concrete. The coping may be cast in place, or may be moulded and set in place on a full mortar bed. In either case the top shall be screeded sufficiently to cause water to drain off. In no case shall sections of coping be permitted less than six (6) feet in length, nor more than ten (10) feet without a joint.

19.6. Refilling. The excavated areas which are not occupied by the masonry struc-

tures shall be refilled with acceptable material in layers of not more than six (6) inches in depth. Each layer shall be tamped thoroughly and until the refilling is level with the original ground.

19.7. Basis of Payment. This work will be measured in accordance with the dimensions shown on the plans, except where changes are ordered during construction, and will be paid for at the contract unit price per cubic yard, unless otherwise noted, for "Cement Rubble Masonry," complete in place, which price will include all excavation and backfill, materials, equipment, tools, labor and work incidental thereto.

ITEM 20. DRY RUBBLE MASONRY.

20.1. Description. Dry Rubble Masonry shall be composed of approved rubble stone laid without the aid of mortar so as to fit neatly and firmly, and shall be constructed in such shapes and at such place as indicated on the plans and where directed in accordance with these specifications.

20.2. Stone. All stones for this work shall be rubble stones of the quality and size specified in Paragraph 19.2 for "Cement Rubble Masonry," and have horizontal beds and approximately vertical joints. Small stones may be used for pinning and filling interstices in the heart of the wall.

20.3. Construction Methods. All stone shall be laid on their natural beds in courses, breaking vertical joints by at least six (6) inches. The foundation courses shall be of large stone not less than twelve (12) inches in thickness and containing not less than six (6) square feet area of bed, and the thinnest courses invariably shall be placed towards the top of the wall. The stones shall be laid so as to form a substantial wall and shall fit neatly. All interstices in the heart of the wall shall be filled with spalls and the upper six (6) inches shall be laid in mortar of the character and in the manner described in Paragraphs 19.3 and 19.4 for "Cement Rubble Masonry." The top of the wall shall be finished with a coping consisting of concrete composed of materials similar in character and size to that specified in Paragraphs 16.5 and 16.8 inclusive for "Cement Concrete Structures Class 'A' Concrete," and mixed in the proportion of 1:3:6 as specified in Paragraph 16.4 for Class "C" concrete. This concrete coping may be cast in place, or may be moulded or set in place on a full mortar bed. In either case the top shall be screeded sufficiently to drain water. If the Contractor prefers, he may substitute for the concrete coping a stone coping of roughly scapped stones eight (8) inches thick, twenty-four (24) inches wide and not less than twenty-four (24) inches in length, placed on a full mortar bed.

20.4. Refilling. The excavated areas which are not occupied by the masonry structure shall be refilled with acceptable material in layers of not more than six (6) inches in depth. Each layer shall be tamped thoroughly and until the refilling is level with the original ground.

20.5. Basis of Payment. This work will be measured in accordance with dimensions shown on the plans, except where changes are ordered during construction, and will be paid for at the contract unit price per cubic yard, unless otherwise noted, for "Dry Rubble Masonry" complete in place, which price will include all excavation and backfill, materials, equipment, tools, labor and work incidental thereto.

ITEM 21. REPOINTING MASONRY.

21.1. Description. This work shall consist of repointing old masonry walls where indicated on the plans, or directed, in accordance with these specifications.

21.2. Mortar. The mortar for the repointing shall be composed of one (1) part of a combination of Portland cement and hydrated lime and one (1) part of fine aggregate as specified in Paragraph 19.3 for "Cement Rubble Masonry."

21.3. Repointing. The joints in the old masonry shall be thoroughly cleaned of all loose mortar and dirt, and in no case for a depth less than twice the width of the joint, in from the face of the wall. The joints shall then be filled with the mortar, well driven in, and finished neatly and satisfactorily. Upon completion of the pointing the work shall be protected from the elements in a satisfactory manner for a period of three (3) days after completion.

21.4. Basis of Payment. This work will be paid for at the contract unit price per square yard for "Repointed Masonry," which price will include all materials, equipment, tools, labor and work incidental thereto, also all necessary protection. This payment will be for the actual surface area of masonry over which the pointing extends.

ITEM 22. DRAINAGE STRUCTURES.

CONCRETE AND MASONRY CULVERTS, END WALLS, RETAINING WALLS, CATCH BASINS, DROP INLETS, MANHOLES, ETC.

22.1. Description. Culverts, end walls for pipe culverts and drains, retaining walls, and other similar structures shall consist of cement concrete, and reinforcement if required, or of masonry constructed in accordance with the designs and dimensions shown on the plans and in conformity with these specifications.

Catch basins, drop inlets, and manholes shall consist of cement concrete, and reinforcement if required, or brick masonry and the necessary metal frames and covers or gratings, all constructed as shown on the plans and in accordance with these specifications.

22.2. Materials. The concrete, reinforcement and masonry materials shall meet the requirements contained herein for class of concrete or kind of masonry to be used.

Castings for frames, covers, gratings, etc., shall be composed of best quality, tough, gray iron, free from cold shuts, blow holes and other imperfections. The castings shall be sound, true to form and thickness, clean and neatly finished, and shall be coated with coal-tar pitch varnish.

Inlet and outlet pipes shall be of the same size and kind as the connecting pipe shown on the plans.

22.3. Construction Methods. These structures shall be constructed in accordance with the specifications contained herein for the kinds of work being done and conforming to the lines, grades, measurements and designs shown on the plans.

Castings for catch basins, drop inlets, and manholes shall be set in full mortar beds, or otherwise secured as shown on the plans.

Inlet and outlet pipes shall extend through the wall for a sufficient distance beyond the outside surface to allow for connections, and the concrete or masonry shall be constructed around them neatly, so as to prevent leakage along their outer surface. The pipes shall be cut flush with the inside of the wall.

22.4. Basis of Payment. These structures will be paid for as follows:

a. Concrete and masonry culverts, end walls, retaining walls and other similar structures will be paid for at the contract unit prices for the class of work performed.

b. Catch basins, drop inlets, and manholes will be paid for at the contract price each for "Catch Basins," "Drop Inlets," or "Manholes," as the case may be, complete in place, which price will include all materials, forms, equipment, tools, labor and work incidental thereto, also all excavation, the refilling around the structure and disposal of surplus material, the required frames and covers, or gratings, and other fittings.

The inlet and outlet pipes will be measured with the adjoining pipe and paid for at the contract price per linear foot.

ITEM 23. PIPE CULVERTS.

23.1. Description. These culverts shall consist of sections of cast iron, corrugated metal, reinforced concrete, or vitrified clay pipe, of the diameter shown on the plans, laid on a firm bed true to line and grade in accordance with these specifications.

23.2. Cast Iron Pipe. This pipe shall be made of cast iron of good quality and of such character as to make the metal strong, tough and of even grain, but soft enough to admit of satisfactory drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal and shall be remelted in a cupola or air furnace. The pipe shall be hub and spigot style, smooth, free of scales, lumps, blisters and other defects impairing its strength or durability. It shall be manufactured in lengths of not less than three (3) feet, the inner and outer surfaces shall be true, whole, concentric cylinders, and it may be either cast iron water pipe or cast iron culvert pipe.

If cast iron water pipe is furnished, it shall be Class "A," but may be of light weight and second quality, and shall conform to standard specifications.

If cast iron culvert pipe is furnished, the minimum thickness of pipe and the weights per linear foot shall be as follows:

Normal Inside Diameter, Inches.	Thickness, Inches.	Weight per Foot, Pounds.
12	7/16	50
14	7/16	60
16	1/2	80
18	1/2	90
20	1/2	120
24	9/16	160
30	11/16	220
36	13/16	300

No pipe will be accepted, the weight of which shall be over five (5) percent less than the 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.

23.3. Corrugated Metal Pipe. All corrugated metal pipe shall be of first quality, of true circular form and shall be of such lengths as are indicated on the plans. The pipe shall be true and straight throughout its entire length and free from all imperfections. It shall have tightly riveted lap joints, and the rivets shall be of a quality at least equal to the metal used in the body of the pipe. This pipe shall be manufactured to meet the following requirements:

a. *Composition of Material.* All corrugated metal pipe shall be manufactured from either a pure iron or a copper bearing steel. If iron is used the metal must contain not less than ninety-nine and seventy one-hundredths (99.70) percent (determined by difference) pure iron, allowing thirty one-hundredths (.30) percent for all impurities or foreign elements. If steel is used, ninety one-hundredths (.90) percent will be allowed for impurities. The impurities mentioned, include carbon, phosphorus, sulphur, silicon, managanese, copper and oxgen; however, copper bearing steel shall contain from eighteen one-hundredths (.18) to thirty one-hundredths (.30) percent of copper. The metal shall have a tensile strength of not less than forty thousand (40,000) pounds per square inch. All sheets shall be free from blisters, seams, slag or foreign materials.

b. *Galvanizing.* All materials entering into the manufacture of the pipe shall be coated with not less than two (2) ounces of spelter per square foot of exposed surface.

The spelter shall be pure zinc, and shall be applied in such a manner as to form a continuous, impervious coating of uniform thickness, free from imperfections of any kind and shall show no signs of cracking or blistering.

c. *Corrugations.* The corrugations shall not be more than three (3) inches in width and not less than one-half (1/2) of an inch in depth.

d. *Gauges of Metal.* Corrugated metal culverts shall be made of sheets of the following thickness (United States Standard Gauge Measure) :

Diameter.	Gauge.
Pipe from 12" to 15" shall not be lighter than	16
Pipe from 18" to 24" shall not be lighter than	14
Pipe from 30" to 48" shall not be lighter than	12

23.4. Reinforced Concrete Pipe. Reinforced concrete pipe shall be of the hub and spigot or other approved style. The ends shall be at least as strong as the body of the pipe, and all pipe shall be cured properly and aged at least two (2) weeks before being used. Each section of pipe shall be straight and of true circular form. It shall have a uniform thickness throughout and shall be free from porous and scaly spots and spalled edges. Pipes having defective spots patched or plastered over will not be accepted.

a. *Manufacture.* The materials and methods used in the manufacture of this pipe shall be approved, and specifications covering them shall be submitted by the Contractor before purchasing pipe.

b. *Strength.* The pipe when tested without lateral support (the contact points at support and application of load not to exceed a width of three (3) inches measured on the circumference) shall show a load supporting capacity per linear foot at least equal to that expressed by the formula:

$$W=1000 \times D,$$

in which "W" equals the breaking strength per linear foot of pipe and "D" the diameter of the pipe expressed in feet.

This test shall be made on a section of pipe from which the hub has been removed.

23.5. Vitrified Clay Pipe. Vitrified clay pipe shall be of the hub and spigot style, of first quality, sound, thoroughly and perfectly burned, without warps, cracks or other imperfections, and shall be fully and smoothly salt-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 (2/3) 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 three (3) parallel lines extending completely around the circumferences. 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 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 1/2
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

23.6. Cement Mortar. The mortar for cementing the joints in the pipe shall be composed of one (1) part of Portland cement, meeting the requirements of Paragraph 16.5, and two (2) parts of approved, clean sand, mixed with sufficient water to form a plastic mortar.

23.7. Forming Bed for Pipe. Where the pipe is to be laid below the ground line, a trench shall be excavated to the required depth, and the bottom of the trench shall be shaped to conform to the bottom of the pipe and shall afford a uniformly firm bed throughout its entire length, and recesses shall be excavated to receive the hubs. Where rock is encountered the trench shall be excavated four (4) inches below the bottom of the pipe and this excess depth shall be refilled with suitable material, which shall be tamped thoroughly. Any soft or yielding material shall be removed and replaced with other suitable material, which shall be tamped thoroughly in place.

Where pipe is not laid in a trench, a uniformly firm bed shall be made as herein specified for the bottom of the trench.

23.8. Laying Pipe. The pipe shall be laid carefully, hubs upgrade, spigot ends fully entered into the adjacent hub, and true to lines and grades given. All cast iron, reinforced concrete and vitrified clay pipe shall be laid with cemented joints. 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 flush and 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.

When corrugated metal pipe sections are joined on the work, the ends shall be butted together and the sections joined with a band, made of the same material as the pipe, of sufficient width to lap at least one (1) full corrugation on either side of the joint, which band shall be bolted firmly in place. The bolts shall be of the same material as that used in the manufacture of the pipe and shall be painted with red lead or other approved material.

Any pipe which is not in true alignment or which shows any settlement after laying, shall be taken up and relaid without extra compensation.

23.9. Refilling Around Pipe. The filling around the pipe shall be made in layers with approved material free from rock, and each layer shall be tamped thoroughly around and over the pipe.

23.10. Relaying Pipe. Where indicated or directed old pipe culverts shall be removed and relaid, extending or renewed in the same manner as specified for new pipe culverts.

23.11. Basis of Payment. This work will be paid for as follows:

a. New pipe culverts will be paid for at the contract unit price per linear foot indicated in the contract for "Cast Iron Pipe," "Corrugated Metal Pipe," "Reinforced Concrete Pipe," or "Vitrified Clay Pipe," as the case may be, complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also all excavation and refilling and the disposal of surplus material.

b. Where existing pipe culverts are relaid, they shall be paid for at the contract unit price per linear foot for "Relaid Pipe" complete in place, which price will include all materials, tools, equipment, labor and work incidental thereto, also all excavation, refilling and disposal of surplus materials.

ITEM 24. STONE UNDERDRAIN.

24.1. Description. This underdrain shall consist of a trench twelve (12) inches wide at the bottom with flaring sides, filled with large stones to a depth of fifteen (15) inches, so as to produce voids through which water will drain. It shall be constructed in accordance with the plans and in conformity with these specifications.

24.2. Materials. The bottom course shall consist of approved, sound, hard, durable, rough slabs of stone from eight (8) to ten (10) inches in depth, from one (1) to three (3) inches in width, and of a length greater than the depth. The top course shall consist of sound, hard, durable slabs of stone from one (1) to three (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, clean, hard, durable crushed or napped rock, crushed slag, or gravel of such size as will pass through a two and one-half ($2\frac{1}{2}$) inch circular opening and be retained on a three-quarters ($\frac{3}{4}$) of an inch opening.

24.3. Construction Methods. Where indicated or directed, the Contractor shall excavate a trench twelve (12) inches wide at the bottom and of the required depth, with sides battered outward one (1) inch to ten (10) inches. 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 be from eight (8) to ten (10) inches in depth.

The top course stones shall be placed over the bottom course to fill the trench to a total depth of fifteen (15) inches. The slabs shall be laid flat over the bottom course stone, to cover it as completely as practicable, and up to the fifteen (15) inch line, with joints close and staggered and necessary voids filled carefully with stone, slag or gravel, or the crushed or napped stone or slag, or gravel may be used to fill this upper part of the trench when the slabs are not available. The remainder of the trench above the fifteen (15) inch line shall be filled with suitable earth, which shall be compacted thoroughly by tamping in four (4) inch layers. Suitable outlets shall be provided and protected with headwalls or small dry stone box openings.

24.4. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Stone Underdrain" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also the excavation, from the bottom of the trench to the top of the stone fill, and the disposal of surplus material.

Where stone box outlets are used they will be paid for as "Stone Underdrain."

ITEM 25. VITRIFIED TILE UNDERDRAIN.

AND

VITRIFIED TILE FOUNDATION UNDERDRAIN.

25.1. Description. This underdrain shall consist of vitrified clay pipe, four (4) inches in diameter, laid on a two (2) inch layer of stone, in a trench twelve (12) inches in width at the bottom with flaring sides, with open joints covered with tar paper, and the trench filled with broken stone for an additional depth of twenty-two (22) inches. This underdrain shall be constructed in accordance with the plans and in conformity with these specifications.

Foundation underdrain shall be the same as the drain described above, except that the total stone fill shall be twelve (12) inches in depth instead of twenty-four (24) inches as specified.

25.2. Pipe. 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 shall be fully and smoothly salt-glazed. It shall be manufactured in lengths of not more than two (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 four (4) inches in inside diameter.

25.3. Stone. The stone for the bottom part of the trench shall be composed of clean, tough, durable, approved, crushed rock or slag, or gravel of such size as will pass over a revolving screen having circular openings not less than five-eighths ($\frac{5}{8}$) nor more than three-quarters ($\frac{3}{4}$) of an inch in diameter and through a revolving screen having circular openings not more than one and one-half ($1\frac{1}{2}$) inches in diameter.

Stone for filling the remainder of the trench shall be composed of material similar in quality to that described above, of such size as will pass over a revolving screen having circular openings not less than three-quarters ($\frac{3}{4}$) of an inch nor more than one and one-quarter ($1\frac{1}{4}$) inches in diameter and through a revolving screen having circular openings three (3) inches in diameter.

25.4 Construction Methods. 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 of the trench shall be twelve (12) inches in width and the sides shall have an outward batter of one (1) inch in ten (10) inches.

The bottom course of stone shall be placed and tamped to a uniform depth of two (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 up grade and the spigot end fully entered into the adjacent hub. The pipe joints shall then be covered with approved two (2) ply tar paper strips, not less than six (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 three (3) inches.

After the pipes have been laid and approved, stone filling shall be placed carefully, so as not to displace the pipe or joint covering, around and over the pipe to a depth of twenty-two (22) inches above the bottom of the pipe. The remainder of the trench shall be filled with suitable earth which shall be tamped in layers of four (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 ten (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.

25.5. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Vitrified Tile Underdrain" or "Vitrified Tile Foundation Underdrain," as the case may be, complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also all excavation, from the bottom of the trench to top of the stone fill, and the disposal of the surplus material.

ITEM 26. VITRIFIED TILE OUTLETS FOR UNDERDRAINS.

26.1. Description. Vitrified Tile Outlets for Underdrains shall consist of vitrified clay pipe, four (4) inches in diameter, laid with cemented joints in a trench refilled with earth. These outlets shall be constructed in accordance with the plans and in conformity with these specifications.

26.2. Pipe. This pipe shall meet the requirements of Paragraph 25.2 for "Vitrified Tile Underdrain."

26.3. Mortar. The mortar for cementing the joints shall be composed of one (1) part of Portland cement, meeting the requirements of Paragraph 16.5, and two (2) parts of approved, clean, hard, durable sand of such size as will pass a one-eighth ($\frac{1}{8}$) inch screen, mixed with a sufficient quantity of water to form a plastic mortar.

26.4. Construction Methods. The trench shall be excavated to the lines and grades given, and the bottom of the trench shall be not less than twelve (12) inches wide, 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 up grade 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.

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 four (4) inches.

Lateral connections shall be made with suitable "Specials." These outlets shall be protected with headwalls and screens as required.

26.5. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Vitrified Tile Outlets" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also the screens for the ends of the outlets and all excavation, refilling and disposal of surplus material.

Headwalls will be paid for at the unit price for the class of concrete or masonry used, which price will include the necessary excavation.

ITEM 27. PLAIN AND GROUTED RUBBLE GUTTER.

27.1. Description. This gutter shall consist of stones, six (6) to eight (8) inches in depth, and a broken stone foundation, approximately four (4) inches in depth, constructed on a prepared sub-grade, in accordance with the dimensions indicated on the plans and in conformity with these specifications.

27.2. Foundation Material. The material for the foundation shall consist of approved, clean, sound, durable crushed rock or slag, or gravel of such size that, when dry, it shall pass through a revolving screen having circular openings three-quarters ($\frac{3}{4}$) of an inch in diameter, well graded from coarse to fine, containing not more than ten (10) per cent of clay, loam or other foreign substances.

27.3. Gutter Stone. The gutter stones shall consist of approved, sound, durable rubble stone, shall be not less than six (6) nor more than eight (8) inches in depth and shall have an approximately flat top surface of a width of not less than two (2) inches and a length of not less than the depth. All gutter stones shall be inspected thoroughly before and after laying and all rejected material shall be removed immediately from the work.

27.4. Gravel Filler. The material for filling the spaces between gutter stones shall consist of approved, clean gravel, coarse sand or stone screenings of such size that when dry, will pass through a laboratory screen having circular openings not more than one-half ($\frac{1}{2}$) nor less than one-quarter ($\frac{1}{4}$) of an inch in diameter, well graded from the maximum size down. An exceedingly fine material will not be accepted.

27.5. Grout Filler. The cement grout for filling the spaces between gutter stones shall be composed of one (1) part Portland cement and one and one-half ($1\frac{1}{2}$) parts approved sand, the materials to meet the requirements of Item 16.

27.6. Laying Gutter. The subgrades shall be formed at the required depth below and parallel with the finished surface of the gutter. All soft and yielding or other unsuitable material shall be removed and the subgrade shall be compacted thoroughly and finished to a smooth, firm surface.

The approved foundation material shall be spread on the prepared subgrade to form a bed approximately four (4) inches in depth.

The gutter stones shall be bedded in the foundation perpendicular to the finished surface, with the flat surface up, in straight rows, with the longest dimension at right angles to the center line of the gutter and in close contact. They shall break joints satisfactorily and no interstices exceeding one (1) inch in width shall exist.

27.7. Filling Gutter. The stones shall be rammed thoroughly until the surface is firm and conforms to the finished grade and cross-sections.

When the gravel filler is to be used, while being rammed, the approved gravel, sand or screenings shall be swept into the spaces between the stones until they are filled. Any gutter having an irregular or uneven surface shall be taken up and reset satisfactorily. After ramming, one (1) inch of the approved paving gravel, sand or screenings shall be spread evenly over the surface.

When grout filler is to be used, while being rammed, the spaces shall be filled with the approved gravel, sand or screenings to within four (4) inches of the top and any irregularities in the gutter shall be corrected, after which the cement grout shall be poured and broomed into the spaces between and over the stones, this operation being continued until the grout remains flush with the tops of the stones.

27.8. Basis of Payment. This work will be paid for at the contract unit price per square yard for "Plain Rubble Gutter" or "Grouted Rubble Gutter," as the case may be, complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto.

The excavation for gutters will be paid for at the contract unit price per cubic yard for "Ditching," which price will include refilling and disposal of surplus material.

ITEM 28. PLAIN CEMENT CONCRETE GUTTER
AND
COMBINATION CEMENT CONCRETE CURBING AND GUTTER.

28.1. Description. This gutter, or curbing and gutter, shall consist of concrete, composed of one (1) part of Portland cement, two (2) parts of fine aggregate, and three (3) parts of coarse aggregate, constructed on the prepared subgrade, in one (1) course, of the dimensions shown on the plans, in accordance with these specifications.

The standard plain cement concrete gutter shall be six (6) inches in depth, of the width shown on the plans and in lengths of ten (10) feet.

For combination cement concrete curbing and gutter, the standard gutter shall be six (6) inches in depth, and of the width shown on the plans, and the curbing shall be six (6) inches in width, twelve (12) inches in depth, and in lengths of ten (10) feet.

28.2. Materials for Concrete. The Portland cement, fine aggregate, coarse aggregate and water for the concrete shall meet the requirements of Paragraphs 16.5, 16.7, and 16.8 respectively, except that slag will not be accepted for and the maximum size of the coarse aggregate shall not exceed one and one-half ($1\frac{1}{2}$) inches in diameter when used for the combination curbing and gutter; and the source of supply for materials shall be approved as specified in Paragraph 16.12.

28.3. Placing Concrete. The subgrade shall be formed at the required depth below the finished surface of the gutter, in accordance with the dimensions and design shown on the plans for the bottom of the gutter. All soft and yielding or other unsuitable material shall be removed and the subgrade shall be compacted thoroughly and finished to a firm, smooth surface.

Concrete shall be mixed in 1:2:3 proportions, of the same consistency and in the same manner as specified in Paragraphs 16.14 to 16.17 inclusive. The subgrade shall be moistened and the concrete shall be placed in forms meeting the requirements of Paragraph 30.4, and shall be tamped sufficiently to bring the mortar to the surface, after which it shall be finished smooth and even by means of a wooden float.

The plain cement concrete gutter shall be constructed in alternate sections having a uniform length of ten (10) feet. The length of these sections may be reduced slightly where necessary for closures, but no section less than four (4) feet will be permitted. During construction, the first alternate sections shall be allowed to set at least twenty-four (24) hours before the intermediate sections are placed. The edges of the gutters shall be finished with an approved edging tool having a radius of not more than one-eighth ($\frac{1}{8}$) of an inch.

Combination cement concrete curbing and gutter shall be constructed in all respects as specified above, the face and top of the curbing shall be floated smooth and the edge shall be rounded to a radius of one (1) inch while the concrete is still soft, and the face and top of the curbing shall be finished as specified in Paragraph 30.10 for "Plain Cement Concrete Curbing."

28.4. Protection. When completed, the concrete shall be kept moist for a period of not less than three (3) days or longer if directed, and shall be protected from the elements in a satisfactory manner.

28.5. Refilling. After the concrete has set sufficiently the spaces on both sides of gutter, or curbing and gutter, shall be refilled to the required elevation with suitable material, which shall be compacted in layers of not more than six (6) inches until firm and solid.

28.6. Basis of Payment. The plain gutter will be paid for at the contract unit price per square yard for "Plain Cement Concrete Gutter," complete in place, and the combined curb and gutter will be paid for at the contract unit price per linear foot for "Combination Cement Concrete Curbing and Gutter" complete in place, which price will include all materials, forms, equipment, tools, labor and work incidental thereto.

The excavation will be measured for the actual width of the gutter, or curbing and gutter, and will be paid for at the contract unit price per cubic yard for "Ditching," which price will include refilling and the disposal of surplus material.

ITEM 29. REPAVING GUTTER.

29.1 Description. Repaving gutters shall consist of the removal and cleaning of the existing blocks or stones, the adjusting of the subgrade or foundation if for a rubble or similar stone gutter, or the placing of a new bed if for a block gutter, and the placing of a new filler. This work shall be done in accordance with these specifications.

29.2. Materials. All existing blocks or stones which are acceptable shall be used. The materials for the foundation, bed and filler shall meet the requirements of similar materials specified for the same or similar kind of new gutter.

29.3. Construction Methods. The existing gutter shall be removed, the unacceptable material disposed of in a satisfactory manner and the acceptable material handled carefully and piled neatly. Block or stones from the existing gutter shall be cleaned thoroughly before being again used. The repaving shall be done in accordance with the specifications contained herein for new gutters of the same or similar kind being relaid.

29.4. Basis of Payment. This work will be paid for at the contract unit price per square yard for "Repaved Stone Gutter" or "Repaved Block Gutter," as the case may be, complete in place, which price will include all materials necessary to complete the work in a satisfactory manner and all equipment, tools, labor and work incidental thereto, also the disposal of surplus materials.

Any whole section of new gutter in excess of one (1) square yard will be paid for at the contract unit price for the kind of gutter laid.

ITEM 30. PLAIN CEMENT CONCRETE CURBING
AND
ARMORED CEMENT CONCRETE CURBING.

30.1. Description. This curbing shall consist of concrete, composed of one (1) part of Portland cement, two (2) parts of fine aggregate, and four (4) parts of coarse aggregate, constructed in accordance with the plans and in conformity with these specifications. The standard curbing shall be six (6) inches in width, twenty (20) inches in depth, and in lengths of ten (10) feet.

Armored curbing shall be the same as the curbing described above, except that the upper edge of the face shall be protected with a galvanized steel bar and the top two (2) inches of the curbing shall consist of mortar.

30.2. Materials for Concrete. The Portland cement, fine aggregate, coarse aggregate, and water for the concrete shall meet the requirements of Paragraphs 16.5, 16.7, and 16.8 respectively, except that slag will not be accepted and the maximum size of the coarse aggregate shall not exceed one and one-half ($1\frac{1}{2}$) inches in diameter; and the source of supply for materials shall be approved as specified in Paragraph 16.2 for "Plain Cement Concrete Base Course."

30.3. Armor Bar. The bar for protecting the upper edge of the face of the armored curbing shall be made of steel of good quality, and galvanized. It shall have a rounded head, with a radius of approximately seven-eighths ($\frac{7}{8}$) of an inch and a dove-tailed projection which will extend into the curbing a distance of approximately two (2) inches. These bars shall be in lengths of ten (10) feet.

Suitable "frogs," which shall be of sufficient length to extend through the entire width of the curbing, shall be furnished to secure the bars in place, approximately five (5) frogs to each ten (10) foot bar.

30.4. Forms. Outside forms for this work shall be of wood or metal, of the depth of the concrete, straight, free from warp and of sufficient strength, when staked, to resist the pressure of the concrete without springing. If of wood, they shall be of two (2) inch surfaced plank, or if of metal, they shall be of approved section and shall have a flat surface on top of not less than one and three-quarters ($1\frac{3}{4}$) inches.

The curbing for combination curbing and base shall be constructed with outside forms similar to those described above, and with inside forms of such design as will permit of them being fastened securely to the outside forms.

All forms shall be cleaned thoroughly and greased or soaped before concrete is placed against them. The forms shall be joined neatly and tightly, and staked securely to line and grade at least two hundred (200) feet in advance of the point of placing concrete.

30.5. Composition. The concrete shall be composed of one (1) part of Portland cement, two (2) parts of fine aggregate, and four (4) parts of coarse aggregate. When armored curbing is to be constructed, the top two (2) inches of the curbing shall be composed of one (1) part of Portland cement and two (2) parts of fine aggregate.

30.6. Excavation for Curbing. 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.

30.7. Placing Concrete. The concrete shall be mixed as specified in Paragraphs 16.17 and 16.18, and shall be placed in the forms to the depth specified, in layers of four (4) or

five (5) inches, and tamped and spaded until mortar entirely covers its surface. Where indicated or directed, drainage openings shall be made through the curbing at the elevation and of the size required.

The top of the curbing shall be floated smooth and the outer edge shall be rounded to a radius of one (1) inch while the concrete is still soft.

30.8. Placing Armor Bar. Where armored curbing is to be constructed, the concrete shall be placed, as hereinbefore described, to within two (2) inches of the top of the curbing.

The bar shall be placed, immediately following the placing of the concrete, in the upper edge of the face of the curbing and secured in its correct position with the frogs. These frogs shall be placed at intervals of not more than two and one-half ($2\frac{1}{2}$) feet and near each end of each bar. These frogs shall be placed so that they will extend through the entire width of the curbing.

The two (2) inch mortar top shall then be placed immediately and in no case in more than thirty (30) minutes after the last of the concrete has been placed, and the top surface shall be floated smooth. Care shall be observed to see that the dove-tailed end of the bar and the frogs are entirely surrounded with the mortar.

30.9. Forming Joints. The curbing shall be constructed in uniform lengths of sections of ten (10) feet, except where shorter sections are necessary for closures, but no section shall be less than four (4) feet. These sections shall be separated by sheet steel templets set perpendicular to the face and top of the curbing. These templets shall be one-eighth ($\frac{1}{8}$) of an inch in thickness, of the width of the curbing, and not less than two (2) inches longer than the depth of the curbing. The templets shall be set carefully during the placing of concrete and allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place.

30.10. Finishing. The forms shall be removed within twenty-four (24) hours after the concrete has been placed. Honeycombed places and other minor defects shall be filled with mortar, composed of one (1) part of Portland cement and two (2) parts of fine aggregate which shall be applied with a wooden float. Plastering shall not be permitted on the faces of the curbing, and all rejected curbing shall be removed and replaced without additional compensation. The top and face of the curbing, from the top to eight (8) inches below, shall be finished while the concrete is still green by wetting a soft brick or a wood block and rubbing the surface until it is smooth. Plenty of water shall be used, either by dipping the block or brick in water, or by throwing water on the curbing with a brush. After the concrete has been rubbed smooth it shall be rubbed again until a uniform color is produced, using in place of water a thin grout composed of one (1) part of Portland cement and one (1) part of approved sand. When completed the curbing shall be protected from the elements in a satisfactory manner for a period of three (3) days or longer if directed.

30.11. Tangent Joints. Where circular concrete curbing unites with the tangent, or straight curbing, there shall be embedded in the concrete two (2) reinforcing bars, one-half ($\frac{1}{2}$) inch in diameter and twenty-four (24) inches in length. These bars shall be placed three (3) inches and nine (9) inches respectively below the top of the curbing and in the center of its width, and shall extend twelve (12) inches into the curbing on both sides of the joint.

30.12. Refilling. 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 six (6) inches until firm and solid.

30.13. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Plain Cement Concrete Curbing" or "Armored Cement Concrete Curbing," as the case may be, complete in place, which price will include all materials, forms, equipment, tools, labor and work incidental thereto, also all drainage openings, excavation for curbing, refilling and disposal of surplus material.

ITEM 31. STONE CURBING.

31.1. Description. This curbing shall consist of approved granite, sandstone or other approved stone of the required dimensions placed in accordance with these specifications.

31.2. Straight Five Inch Stone Curbing. This straight five (5) inch stone curbing shall consist of granite or sandstone of approved quality, or other approved stone, free from structural defects. It shall be five (5) inches in thickness, not less than twenty (20) inches in depth and in lengths of not less than four (4) nor more than eight (8) feet. The top surface shall be dressed and beveled one-quarter ($\frac{1}{4}$) inch, the face shall be dressed and the end cut square to a depth of not less than twelve (12) inches below the top and the back dressed to a depth of three (3) inches. The top and dressed face shall be free from depressions, projections or other irregularities and defects.

31.3. Straight Six Inch Stone Curbing. This straight six inch stone curbing shall consist of approved, first quality granite, neither laminated nor stratified. It shall be hammer dressed on the face to a depth of not less than twelve (12) inches below the top, on the entire top surface and for a depth of three (3) inches on the back. The ends shall be cut square for the full depth and width of the stone. This curbing shall be six (6) inches in width on the top, not less than twenty (20) inches in depth and not less than eight (8) 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 (8) inches in width on the top, not less than twenty-four (24) inches in depth and not less than ten (10) inches in width at the base.

Straight six or eight inch stone curbing shall be in lengths of not less than six (6) feet, except when necessary for closures, where no piece shall be less than four (4) feet in length.

31.4. Curved Stone Curbing. All curved curbing shall consist of approved, first quality granite having a width at the top of six (6) or eight (8) inches as specified and the bottom shall be not less than two (2) inches wider than the top. It shall be dressed and of the depth as specified for the straight granite curbing, and in lengths of not less than five (5) feet. It shall be cut exactly true to the radius specified and with a tangent or tangents if required.

31.5. Excavation for Curbing. 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.

31.6 Placing Curbing. 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 ($\frac{1}{4}$) of an inch for a distance of twelve (12) inches from the top, but may be wider from this point to the bottom.

The joints in granite curbing shall not exceed one-quarter ($\frac{1}{4}$) 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 (1) part of Portland cement and two (2) 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 firm.

31.7. Basis of Payment. This work will be paid for at the contract unit price per linear foot 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, complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also all drainage openings, excavation for the curbing, refilling and disposal of surplus material.

ITEM 32. RESETTING CURBING.

32.1. Description. Resetting curbing shall consist of the readjustment or resetting of the existing curbing to line and grades given and cementing the joints in accordance with these specifications.

32.2. Materials. All existing curbing which is acceptable shall be used. No curbing less than four (4) feet in length shall be used. The mortar for pointing the joints shall meet the requirements of Paragraph 31 for "Stone Curbing."

32.3. 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 unacceptable 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.

32.4. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Reset Curbing" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also all necessary excavation, refilling and disposal of surplus material.

ITEM 33. WOOD GUARD FENCE.

33.1. Description. Wooden fencing shall consist of wood railings supported by wood posts erected, where indicated or directed, in accordance with these specifications.

33.2. Wood Posts. All wood posts used for this railing shall be made of seasoned, straight, sound chestnut, bois d'arc, locust or red cedar, at no place less than six (6) inches in diameter or six (6) inches square, but both round and square posts shall not be used on one contract. They shall be not less than seven (7) feet in length and the bottom shall be sawed off square, the bark removed and all knots hewn flush with the face and the surface shaved smooth.

a. Treatment of Posts. The lower portion of all posts shall be coated with approved creosote oil before being set. The creosote shall be applied, by means of a brush, in a full free coating, covering the bottom end and extending up the sides for a distance of four and one-half ($4\frac{1}{2}$) feet. The posts shall not be treated until thoroughly dry.

33.3. Wood Rails. The wood rails shall be made of well seasoned, straight, 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 eight (8) inches wide by two (2) inches thick and the side rails shall be six (6) inches by two (2) inches, and both rails shall be in lengths of sixteen (16) feet or in multiple of eight (8) feet.

33.4. Paint. The material for painting the fence after erection shall be composed of from sixty-five (65) to seventy (70) percent, by weight, of pigment in paste form and from thirty-five (35) to thirty (30) percent of vehicle; or sixty (60) to sixty-five (65) percent, by weight, of dry pigment.

a. Pigment. The pigment shall be composed of not less than sixty-five (65) percent of pure white lead and not less than twenty (20) percent of pure zinc white, all finely ground. Not more than fifteen (15) percent of inerts shall be permitted.

b. Vehicle. The vehicle shall be composed of not less than ninety (90) percent of pure raw linseed oil and sufficient first quality Japan or other approved drier to cause the applied paint to dry in approximately three (3) days, but in no case shall the drier exceed ten (10) percent.

33.5. Construction Methods. The guard rail or fencing shall be constructed in accordance with the standard plan. The posts shall be set plumb in straight lines, spaced eight (8) feet apart on centers, three and one-half ($3\frac{1}{2}$) feet in the ground and three and one-half feet ($3\frac{1}{2}$) feet above the ground and to lines and grades given. The top and side rails shall break joints and be fastened securely to each post, as shown on the plans. All joints of the fence shall be painted before being fastened together and after erection the entire fence shall be painted with two coats of the specified materials, which shall be brushed in thoroughly.

33.6. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Wooden Fencing" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also all excavation, refilling and disposal of surplus material.

ITEM 34. WIRE CABLE FENCING.

34.1. Description. Wire Cable Fencing shall consist of wire cable supported by wood posts erected as may be indicated or directed in accordance with these specifications.

34.2. Posts. All posts used shall be of the material and shall be treated as specified in Paragraph 33.2.

34.3. Wire Cable. The cable shall be manufactured of standard galvanized steel or iron wire and shall be not less than three-quarters ($\frac{3}{4}$) of an inch in diameter.

34.4. Fittings. The anchors for end posts shall be made of eye-bolts one (1) inch in diameter and four (4) feet in length, long-threaded on the straight end, with a nut and washer attached. Eye-bolts for tightening the cables shall be one (1) inch in diameter, two (2) feet in length, and threaded for eighteen (18) inches, with washers and nuts attached. Standard wire clips shall be used for fastening the cable. No. 8 soft wire shall be used for securing the two end posts. The braces to be placed between the two end posts shall consist of galvanized iron or steel pipe three (3) inches in diameter and of sufficient length to fit snugly between these posts, approximately nine and one-half ($9\frac{1}{2}$) feet. Flanges for holding this brace in place shall be high collar, slip joint, malleable railing flanges. The "dead-man" to be used shall be of the design and dimensions shown on the plans.

34.5. Paint. Paint to be used shall be similar to that specified in Paragraph 33.4.

34.6. Construction Methods. The posts shall be set plumb and firm, spaced ten (10) feet apart on center, three and one-half ($3\frac{1}{2}$) feet in the ground and three and one-half ($3\frac{1}{2}$) feet above the ground and to lines and grades given. The wire cable shall pass through holes previously bored in the center of the posts, six (6) inches and twenty (20) inches respectively, below the top of the post. Cables shall be drawn taut, fastened securely on both ends in the following manner as shown on the plans: the end posts shall be anchored by means of the four (4) foot eye-bolt, which shall have been embedded in a "dead man" buried securely in the ground. Not less than twelve (12) 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 two (2) foot eye-bolts shall pass through the end posts six (6) inches and twenty (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 two (2) wire clips each. 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.

On sections of railing more than one hundred (100) feet in length, at each end of the railing, between the end post and the next adjacent post shall be placed horizontally, the pipe brace, directly beneath and parallel with the top cable, and held in place by means of the railing flanges, these flanges having been screwed to the post with a full bearing. Four (4) strands of No. 8 soft wire, twisted, shall then be used to hold the posts in position, the wire passing from the ground line of the end post to directly above the top cable, around the top of the second or adjacent post. This wire shall then be twisted tight and fastened securely.

On sections less than one hundred (100) feet in length, the pipe and wire brace shall be omitted on one end of the railing, and eye-bolts eight (8) inches in length shall be used on this end in place of the two (2) foot eye-bolts.

After erection is completed the posts and all parts not galvanized shall be painted with two coats of the specified material which shall be brushed in thoroughly.

34.7. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Wire Cable Fencing" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also all excavation, re-filling and disposal of surplus material.

ITEM 35. IRON PIPE FENCING.

35.1. Description. Iron Pipe Fencing shall consist of galvanized iron or steel pipe and malleable fittings erected, at such points as may be indicated or directed, in accordance with these specifications.

35.2. Materials. The fencing shall be composed of approved standard galvanized iron or steel pipe of the size designated on the plans or otherwise specified. All fittings shall be made of malleable iron free from flaws and defects and of the size indicated.

35.3. Construction Methods. The iron pipe posts and anchor bolts shall be set in the concrete or masonry and shall be grouted in place securely with a grout composed of one (1) part Portland cement and two (2) parts approved, clean sand. The posts shall screw into the fittings and the rails shall screw into the end fittings and slide through intermediate fittings. All threaded joints shall be coated with white lead before assembling. The fencing 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.

35.4. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Iron Pipe Fencing" complete in place, which price will include drilling all holes necessary for the posts and anchors, assembling and erecting the railing, necessary painting and all materials, equipment, tools, labor and work incidental thereto.

ITEM 36. PLAIN AND GROUTED RIPRAP.

36.1. Description. Riprap shall be composed of approved stone laid on slopes or shoulders to protect them from slipping or washing, at places indicated on the plans or where directed, in accordance with these specifications, the interstices to be filled with spalls, or cement grout, as noted.

36.2. Stone.

a. *Plain Riprap.* This stone shall be sound "one-man stone," free from structural defects, and of approved quality, not less than one-third ($1/3$) of a cubic foot in volume, and not less than three (3) inches thick. The width of no stone shall be less than two and one-half ($2\frac{1}{2}$) times its thickness, and the depth shall be as shown on the plans.

b. *Grouted Riprap.* This stone shall be sound stone, free from structural defects, and of approved quality, not less than one-tenth ($1/10$) cubic foot in volume, and not less than four (4) inches thick, and five (5) inches wide.

36.3. 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. 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.

36.4. 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 one (1) part Portland cement and two (2) parts approved sand.

36.5. Basis of Payment. This work will be paid for at the contract unit price per square yard for "Plain Riprap," or "Grouted Riprap," as the case may be, complete in place, which price will include all necessary excavation, materials, equipment, tools, labor and work incidental thereto.

ITEM 37. CONCRETE CRIBBING.

37.1. Description. This work shall consist of standard reinforced concrete crib members of the dimensions shown on the plans, made and placed as indicated and in accordance with these specifications.

37.2. Materials. The concrete materials shall meet the requirements in Paragraphs 16.5 to 16.8 inclusive for "Cement Concrete Structures, Class 'A' Concrete."

The reinforcing materials shall meet the requirements of Paragraph 17.2 for "Reinforcement."

All drift bolts shall be made of steel one (1) inch in diameter and of the required length.

Casings for drift bolts shall be galvanized steel pipe, one and one-quarter (1¼) inches in diameter.

37.3. Making Crib Members. The crib members shall be composed of one (1) part of Portland cement and not more than two (2) parts of fine and four (4) parts of coarse aggregates, mixed as specified for Class "A" Concrete. They shall be of the dimensions and reinforced as shown on the approved plans. Casings for drift bolts shall be encased in the members as shown on the plans.

If specific details for reinforcement are not shown on the plans, or if the Contractor desires to purchase the members from manufacturers, he shall submit detailed specifications and plans with his proposal, which must be approved by the Engineer before delivery of materials is started.

All members shall be free from depressions and spalled, patched or plastered surfaces and edges. Cracked members will not be accepted.

37.4. Erecting Members. The foundation or bed for the cribbing shall be firm and shall be approved before the members are erected.

The crib members shall be handled carefully and erected as shown on the plans, and shall be secured in place by driving the drift bolts into the casings. Members which become cracked or injured during erection shall be removed and replaced.

37.5. Filling Cribbing. The cribbing shall be filled with approved material, in layers not exceeding twelve (12) inches, and tamped in a satisfactory manner. The erection of the cribbing and the placing and compacting of the fill shall progress simultaneously.

37.6. Basis of Payment. This work will be paid for at the contract unit price per cubic foot for "Concrete Cribbing" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto, also all necessary excavation for the placing. The volume to be paid for will be the actual measurement of the concrete in the crib members, as per the approved plan.

The filling of cribbing will be paid for at contract unit price per cubic yard for "Excavation," and the material will be measured in its original position.

ITEM 38. TIMBER AND CONCRETE PILING.

38.1. Description. Piling shall consist of timber or concrete piles, as may be specified, made and placed in accordance with the dimensions and elevations required or indicated and in conformity with these specifications.

38.2. Materials. The Contractor shall be responsible for determining the length of piles required, either by driving test piles, or otherwise, and the piles shall meet the following requirements:

a. *Timber Piles.* Timber piles shall be Class "A" of sound Southern yellow pine, or white oak, or they shall be Class "B" of any timber which will withstand the specified driving without splitting or excessive brooming of the heads, as noted on the plans. All piles shall have rough or loose bark removed before driving and all bark shall be removed from any portion which is embedded in the concrete. They shall be cut above the ground swell, from sound trees, when the sap is down. They shall be close grained and solid, free from injurious ring shakes, large, unsound or loose knots, or other defects which may materially affect their strength or durability. They shall have a uniform taper from butt to tip, be free from short bends, and a straight line from the center of the butt to the center of the tip shall lie wholly within the body of the pile. All knots shall be trimmed close to the body of the pile. Unless otherwise indicated on the plans, the minimum diameter of the tip shall be six (6) inches, and the minimum diameter three (3) feet from the butt shall be twelve (12) inches, and the maximum diameter at the butt twenty (20) inches. The lower end shall be cut square or tapered to a point not less than four (4) inches square, as required by the Engineer. When necessary, in the opinion of the Engineer, piles shall be shod with metal points, which will be furnished by the Department and placed by the Contractor on a "force account" basis.

b. *Concrete Piles.* Concrete piles shall be composed of one (1) part Portland cement, one and one-half (1½) parts fine aggregate, and three (3) parts coarse aggregate, all in accordance with the provisions of these specifications and the sizes and character shall be as specified in Paragraphs 16.5 to 16.8 for "Cement Concrete Structures, Class 'A' Concrete," except that slag will not be accepted. The piles shall be made strictly in accordance with the plans and the reinforcement shall be placed accurately. The concrete shall be carefully placed and tamped, using a one (1) by two (2) inch tamper so that the reinforcement shall be completely embedded in the concrete. The bottom of the forms shall first be covered with one (1) inch of one to one and one-half (1:1½) mortar. The sides of the pile shall be carefully spaded after filling the form. The piles shall be cast separately, or if in tiers, separated by tar paper carefully placed. If alternate piles are cast in a tier, the intermediate piles shall not be poured until four (4) days after the pouring of the adjacent pile. The concrete shall be poured continuously in each pile. The forms shall be true to line, built of surfaced lumber, and a one (1) inch chamfer strip shall be used in all corners; they shall be watertight and shall not be removed within twenty-four (24) hours after the concrete is poured. All surfaces of the pile above the water shall be treated as specified for "rubbed" finish in Paragraph 16.23 for "Cement Concrete Structures." No strain shall be placed on the concrete until thirty (30) days after pouring. When piles are lifted or moved they shall be supported at points not over twenty (20) feet apart, so as to avoid any strain in the reinforcement exceeding twelve thousand (12,000) pounds to the square inch.

38.3. Driving Piles. The piles shall be driven plumb, or to the batter indicated, and accurately in the required positions. They shall be driven either with gravity or steam hammers of approved type and weight and shall be handled and driven in such a manner as will ensure them from injury.

a. *Driving Timber Piles.* Timber piles shall have their butts sawed square and protected with metal bands, cushions, or other means for preventing damage thereto. They shall be driven to rock or to practical refusal, which will be understood to mean to such depth that the last three (3) blows of a three thousand (3,000) pound hammer falling

freely for a distance of fifteen (15) feet, or the mechanical equivalent thereof, upon the solid, unbroomed head of a pile, shall not produce an average penetration greater than one (1) inch for each blow. In case the above refusal cannot be obtained on account of the excessive length required, the number of piles indicated on the plans shall be increased, with the written approval of the Engineer, until the maximum load coming on any pile shall not exceed that determined from the formula,

$$P = \frac{2 WH}{S+1} \text{ for gravity hammers.}$$

$$P = \frac{2 WH}{S+0.1} \text{ for steam hammers.}$$

P = load in pounds.

W = weight of the falling hammer in pounds.

H = height of the fall in feet.

S = average penetration, in inches, by the last three blows.

All piles shall have a total penetration of not less than ten (10) feet and where the strata are of such a nature that driving is liable to injure the piles before this penetration is secured, they shall, if required, be jettted down until a satisfactory bearing is secured.

The piles shall be cut off at the required elevation.

b. *Driving Concrete Piles.* Concrete piles when driven through hard ground, shall be shod with steel points of approved design. They shall be driven to rock or shall have an average penetration per blow under the last twenty (20) blows of a steam hammer not to exceed that determined by the formula,

$$S = \frac{WH}{45,000} - 0.1$$

In case this maximum penetration cannot be obtained on account of the excessive length required, the number of piles shall be increased, with the written approval of the Engineer, until the load on each pile shall not exceed the amount indicated by the following formula:

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

When concrete piles are jettted into place, they shall either go to rock or to a solid stratum, in which case they shall be tested with steam hammers and the set and loads shall not be greater than those hereinbefore specified. When piles are placed by other means than by hammers and jetting and when they are of such design as not to permit of being driven in the same manner as timber piles, the safe loads and number required shall be determined by tests to failure, as directed, for which tests no compensation will be allowed the Contractor.

38.4. Basis of Payment. This work will be paid for at the contract unit price per linear foot for "Timber Piles" or "Concrete Piles," as the case may be, complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto. Payment will be made for the actual number of feet of piles left in place and no allowance will be made for the amount cut off or for any piles which are not driven in accordance with the specifications. The price per linear foot of pile will also include wrapping, bolting, or fastening timber fender piles and the materials used therefor.

ITEM 39. DEFINITIONS.

BRIDGES.

39.1. Bridges. Drainage structures with span lengths greater than 10 feet will be classified as Bridges; less than 10 feet, Culverts.

39.2. Superstructure. The superstructure shall include the furnishing and placing of all steel, iron, lumber, cement, sand, stone, and all other material required; the construction of all reinforced concrete, forms, false work and other temporary supports; all fabrications, erection, and painting, etc.,—of all parts of the structure above the bridge seats (except the parapets or wing walls of abutments), complete and ready for use.

39.3. Substructure. The substructure shall include the making of all necessary excavations and pumping; the furnishing and placing of all steel, iron, lumber, cement, sand, stone, and other materials required; the construction of all masonry, cofferdams, forms, false work and temporary supports, etc.,—of all parts of the structure below the bridge seats and also the parapets or wing walls of abutments, complete and ready for use.

39.4. Bridge Complete. The bridge complete shall consist of both the superstructure and substructure.

ITEM 40. GENERAL CLAUSES.

40.1. Forms for Bids. Bids shall be made upon the standard proposal forms.

40.2. Rights Reserved. The right is reserved to waive any technicality in any proposal that may be received, and to reject any or all proposals submitted in response to the advertisements. The right is also reserved to make such changes in plans and specifications as are not otherwise provided for, and which may be necessary from time to time, and such changes shall in no way invalidate this contract.

40.3. Examination of Site. Each bidder shall by personal examination satisfy himself as to the nature of local conditions at the bridge site. Also he should verify all the information that is furnished in connection with the bridge.

40.4. Standard Drawings. When possible, the State Highway Department will furnish standard drawings showing in general the details prepared for usual conditions. Designs other than the Department Standards shall possess strength and general merit, for the loadings specified, at least as great as the Standards.

When it is impracticable, as sometimes occurs in the case of movable spans, to submit plans previous to receiving bids, such plans may be submitted after the bids are received, provided the State Highway Department is notified in sufficient time as to all the steps to be followed in securing such bids. For Federal Aid this time must be sufficient to acquaint the U. S. Office of Public Roads fully with the contemplated steps to be followed.

For bridges requiring the approval of the Secretary of War, data required by him should, if practicable, be submitted for approval prior to their submission to the War Department.

40.5. Stress Sheets. Where bids are submitted on other than standard designs, the contractor shall furnish a stress sheet for each structure, showing all calculated stresses and the proposed size and grade of all materials with each bid submitted.

40.6. Estimate of Quantities. Estimates of quantities for the substructure, and for the superstructure, if it is to be of reinforced concrete, are shown in the plans. These estimates are to form the basis for the bids. Adjustments to the contract price bid for the bridge shall be made by additions to or deductions from it at the contract unit price for additions to or deductions from the quantities shown on the plans.

40.7. Unusual Changes. Should any unusual change be required involving extras in no way provided for in the proposal, a written agreement as to the price of such work should be signed by both Contractor and Engineer before such work is ordered.

40.8. Detail Drawings. Drawings showing complete details of all parts of the steel structures must be furnished for bridges exceeding 20 feet. Shop and minor details may be submitted after the contract is awarded but must be checked and approved by the State Highway Engineer before work is begun on materials. For Federal Aid, all drawings must also be approved by the Federal Government.

40.9. Approval of Drawings. For State Aid work, 3 sets of blue prints should be submitted for approval by the State Highway Engineer. For Federal Aid Work, 6 copies of blue prints should be submitted. In addition to the approval by the State Highway Engineer, the plans must be approved by the Director of Public Roads. All drawings shall be subject to modification for approval, but this approval will not relieve the contractor from his responsibility regarding the correctness of dimensions and quantities.

40.10. Discrepancies. In the event of any discrepancy between any drawing and the figures written thereon, the figures shall be taken as correct. In the event of any discrepancy between any drawing and the specifications, the specifications shall govern. Any deviation from these specifications shall be specifically noted on the plans as an exception thereto.

40.11. Material from Old Structure. Unless otherwise provided for, the contractor will be allowed to use in building temporary work for the new structure, any material of an old structure that is to be removed. Such material of the old bridge must, however, upon completion of the job, be neatly piled on the bank where it is accessible for reloading with teams.

Unless otherwise provided for, stone from old abutments and piers may be used in any plain concrete piers or abutments of the new structure.

40.12. Removal of Temporary Work. All material used in constructing the bridge, which may be classed as temporary work, must be removed and disposed of by the contractor, leaving the waterway clear and unobstructed.

40.13. Cleaning Up. Before leaving the work, the contractor shall remove all excavated material which would interfere with the clear waterway, all temporary work, and the old structure, unless otherwise particularly specified, and shall leave the bridge and premises in a neat and presentable condition.

40.14. Faulty Workmanship of Material. All work or material not conforming to the plans and specifications shall be removed at any time during the progress of the work and before its final acceptance; and shall be replaced or reconstructed to make it conform to the plans and specifications when the same shall be required by the Engineer. The fact that the Engineer may not have previously objected to or pointed out such defective or unsatisfactory work or material shall not be construed as an acceptance of such work or material, or in any way relieve the contractor from removing and replacing or reconstructing such defective or unsatisfactory work or material.

40.15. Patented Devices. The contractor shall indemnify, keep and save the party of the first part from all liabilities, judgment, cost and expense which may in any wise result from the infringement of any patent covering any design, material, machinery or device.

40.16. Stakes and Bench Marks. The contractor shall be required to preserve all stakes and bench marks established on the work until duly authorized by the Engineer to remove same.

40.17. Erection. The contractor shall erect all parts of the structures complete and ready for traffic, including drilling holes in masonry for anchor bolts, setting anchor bolts in neat Portland Cement, framing and fastening in place all flooring and fences, unless otherwise specified. The contractor shall furnish all false work and piling necessary for the erection of the structure at his own expense.

40.18. Risks. The contractor shall assume all risks from floods and storms and casualties of every description.

40.19. **Maintaining Travel.** The contractor shall preserve the roadway on which he is working from needless obstructions, and in case of a bridge crossing a stream or thoroughfare of any kind he shall conduct his operations in a manner which will not in any way interfere with or jeopardize the safety of the travel. He shall have the right, however, to close to travel that part of the road or bridge on which he is working whenever other roads can be traveled without serious inconvenience to the public, if given written permission by the Engineer.

40.20. **Final Test.** Before final acceptance, the Engineer may make a thorough test by passing over the structure the specified loads, or other equivalent, or by resting the maximum load upon the structure for 12 hours. After each test the structure shall return to its original position without showing any permanent deformation.

40.21. **Basis of Payment.** The basis of payment, whether a lump sum, or a unit price, will be specified in the attached proposal. Ordinarily the letting will be on a lump sum basis with unit prices for additions or deductions.

ITEM 41. FOUNDATIONS.

41.1. **General.** Stone masonry and plain or reinforced concrete abutments, piers, and end walls for all bridges and culverts shall be designed in accordance with the best modern practice. So-called tube foundations will not be considered.

41.2. **Foundation Soils.** The soil material upon which piers and abutments must be founded is divided into the following classes:

(a) Rock.

(b) Hard ground, such as hard pan, gravel, compact sand held laterally, and hard dry clay.

(c) Soft ground, such as soft or wet clay, silt or mud, where sustaining power must largely depend on the frictional resistance of piles; or of piling driven through the soft ground to an underlying material of harder character.

41.3. **Abutments to be Self-supporting.** Abutments, except for reinforced concrete slab bridges, shall be designed as self-supporting with the approach fills complete in place. For slab bridges if the abutment is to be of reinforced concrete, the main wall shall be designed as a vertical slab, supported at the top by the superstructure and at the bottom by the footing.

41.4. **Drainage.** Adequate drainage for the backs of abutments and wings shall be provided by tile or other pipe drains running through the walls at the lowest elevation which will provide free outlets.

41.5. **Batter.** The batter on the face of all plain concrete walls and piers shall not be less than $\frac{1}{2}$ inch to 1 foot.

41.6. **Footing.** The footing width of all plain and reinforced concrete abutments, wing and retaining walls, shall not be less than $\frac{1}{3}$ of the height of the wall in all cases where the stability of the wall with regard to overturning depends upon the width of footing.

41.7. **Depth of Footing.** Where the site of the foundation is on rock, it shall be cleared of all over-lying soil or other material, and all loose and disintegrated portions of the rock removed. Where the surface of the rock is inclined, it should be leveled in steps to prevent any tendency of the foundation to slip.

Where the site of the foundation is on hard ground, the material shall be excavated to a minimum depth of 3 feet, if above the water. For foundations in the water the excavation shall be carried to a depth below any possible scour by the river currents and to give the piers sufficient foot-hold to resist displacement by the shoving actions of floods or floating material.

Where the foundation is in soft ground, the material shall be excavated to a stratum of hard material. If this is not possible piling should be used.

For spans less than 12 feet in length, a heavily reinforced concrete floor may be used to distribute the load on the foundation.

41.8. Loads on Footings. Footings, floors of paved culverts, and abutment walls shall be designed so as to distribute the loads over the full length and width of the main wall foundation.

The pressure on ordinary soils shall not exceed 1.5 tons per square foot average, or 3 tons per square foot maximum for abutment, wing, or pier footings. Wing footings shall not be considered as taking any of the superstructure load.

When piles are used they shall be considered as carrying the entire load. They should ordinarily be spaced not less than 3 feet, nor more than 5 feet, center to center.

41.9. Cofferdam. Suitable and practically water tight cofferdams preferably of steel sheet piling or tongue and groove wood piling shall be used whenever water-bearing strata are encountered above the elevation of the bottom of the excavation.

41.10. Pumping. Pumping will not be permitted from the inside of foundation forms while the concrete is being placed and if necessary to prevent flooding, a seal of concrete shall be placed through a tremie or by means of bottom dump buckets, and allowed to set.

41.11. Placing Concrete Under Water. Concrete shall not be placed in running water and shall be placed in still water only with suitable appliances and under the direction of the Engineer.

41.12. Dimensions of Pits. The inside dimensions of pits and cofferdams shall be sufficiently large to give easy access to all parts of foundation forms.

41.13. Methods of Designing Reinforced Concrete Abutments. In properly designed reinforced concrete abutments, when the wing walls are located at an angle of 45° or more with the face of the abutment wall, advantage may be taken of the mutual support afforded by the main and wing walls when properly tied together by reinforcing steel.

All parts of such abutments shall be designed to resist a pressure, imposed upon the vertical projection of all walls, figured as that which would be caused by a fluid having the same depth as that of the earth fill and considered as weighing not less than 15 lbs per cubic foot.

Retaining walls and reinforced concrete abutments and wing walls, when the wing walls make an angle of less than 45° with the face of the abutment, shall be designed to resist a pressure, imposed upon the vertical projection of such walls, figured as that which would be caused by a fluid having the same depth as that of the earth fill and weighing not less than 21 pounds per cubic foot. In this case the width of footing shall not be less than 0.4 of the height of the wall.

In designing concrete abutments for slab bridges, it may be assumed that the slab of the superstructure supports the top of the main wall as regards the overturning effect of earth pressure.

Footings of reinforced concrete abutments, wing walls, and retaining walls shall be so proportioned that the resultant of all forces, including the weight of concrete, weight of earth fill directly over the footing, weight of super-structure (in main wall only) and the horizontal equivalent fluid pressure, shall fall at or back of the forward edge of the middle third of the footing base.

41.14. Maintaining Batter. Should it be found necessary, in the judgment of the Engineer, to increase or decrease the depth of the foundation from that shown on the plans, the thickness of the wall when 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.

41.15. Extra Foundation Work. Additional foundation not exceeding 3 feet of the depth below that shown on the plans shall be paid for at the contract unit price for each additional cubic yard of masonry. Beyond an additional depth of 3 feet, the foundation work and materials shall be classified as "Extra Work," and shall be governed by the specifications covering same under paragraph 4.8.

GENERAL SPECIFICATIONS FOR PLAIN AND REINFORCED CONCRETE BRIDGES

ITEM 42. GENERAL REQUIREMENTS.

42.1. General. The Contractor shall, during construction, adhere strictly to the plans, as the strength of the finished structure depends upon this; and the inspector shall not be allowed to make any change therein without the written authority of the State Highway Engineer, or his Deputy.

The false work and forms shall be substantial and unyielding, properly braced or tied together by means of wire or rods, and shall be so designed that the concrete will conform to the proper dimensions and contours.

All forms having been previously used shall be thoroughly cleaned before being used again.

42.2. Types. (a) *Culverts.* For culverts requiring an area of waterway of 12 square feet or less; plain or reinforced concrete arches or circular culverts, reinforced concrete boxes, reinforced concrete pipe, standard corrugated metal pipe, or standard cast iron water pipe.

For culverts having a waterway of more than 12 square feet; reinforced concrete slabs, plain or reinforced concrete arches.

(b) *Concrete Bridges.*

Span	Type
10 to 20 ft.....	Reinforced concrete slabs or arches
14 to 65 ft.....	Reinforced concrete T-Beams, through or deck girders, arches.
Greater than 65 ft.....	Reinforced concrete arches.

(c) *Arches.* In general, plans for plain or reinforced concrete arches will not be approved unless founded on solid rock or unusually firm, hard pan, except for paved culverts and very small paved bridges.

42.3. Roadways. In general, clear widths of roadways shall be as follows:

For bridges up to and including 10 ft. in length—20 to 30 ft. clear roadway.

For bridges over 10 ft. in length—16 to 24 ft. clear roadway.

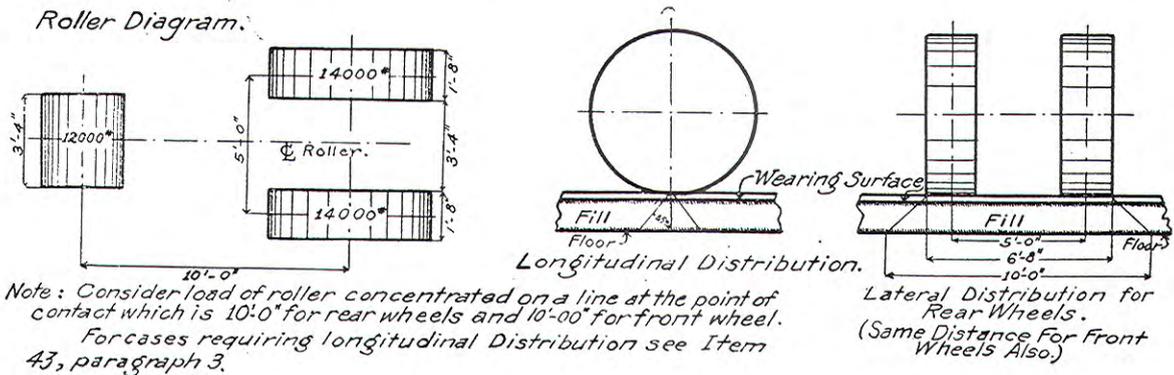
ITEM 43. LOADS.

43.1. General. All parts of the structure shall be proportioned for the maximum stresses produced by the dead load, temperature, and live loads.

43.2. Dead Loads. The dead load shall comprise the actual weight of the completed structure. The dead load used in figuring stresses must not vary more than 5% from the actual estimated weight made from the completed design. In estimating the dead load the following unit weights shall be used:

Steel	490 lbs. per cu. ft.
Concrete	144 lbs. per cu. ft.
Earth fill (dry).....	100 lbs. per cu. ft.
Earth fill (wet).....	250 lbs. per cu. ft.
Ballast	120 lbs. per cu. ft.
Macadam or Gravel.....	140 lbs. per cu. ft.
Brick	150 lbs. per cu. ft.
Asphalt Paving	130 lbs. per cu. ft.
Untreated Timber	54 lbs. per cu. ft.
Treated Timber	60 lbs. per cu. ft.

43.3. Live Loads. For the floor and its supports, a load of 125 lbs. per sq. ft. of total floor surface, or a 20 ton road roller, as shown:



For slabs, each rear wheel load is distributed 5'-0" and the front wheel 10'-0", transversely, and considered as concentrated longitudinally for fills 1 ft. or less in thickness. For fills over 1 ft. thick the longitudinal distribution shall be the distance determined by diverging 45° lines starting at the line of contact of the wheels.

Stringers and girders spaced 2'-6" or less, shall be designed to carry 1/4 of the total concentrated load of the rear wheels, and 1/4 of the concentrated load of the front wheel, the loads to be arranged for maximum moment. When the spacing is between 2'-6" and 10'-0" the portion of the concentrated loads carried by the beam shall be the distance of the spacing in feet divided by 10.

43.4. Impact. No impact will be allowed for concrete structures.

ITEM 44. ALLOWABLE STRESSES.

44.1. 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.

44.2. Co-efficient of Expansions. The coefficient of expansion of concrete, plain or reinforced, shall be taken as 0.00006.

44.3. Allowed Unit Stresses.

(a) *Bearing.* Compression applied to a surface of concrete of twice the loaded area:

Bearing on Class A Concrete.....	700 lbs. per sq. in.
Bearing on Class B Concrete.....	560 lbs. per sq. in.
Bearing on Class C Concrete.....	440 lbs. per sq. in.

(b) *Compression.*

(1) Axial Compression on plain concrete piers and columns reinforced longitudinally whose lengths do not exceed 12 diameters.

Class A Concrete.....	450 lbs. per sq. in.
Class B Concrete.....	360 lbs. per sq. in.
Class C Concrete.....	290 lbs. per sq. in.

(2) Compression in extreme fibers of beams and slabs.

Class A Concrete.....	650 lbs. per sq. in.
Adjacent to supports of continuous beams	750 lbs. per sq. in.

(c) *Shear and Diagonal Tension.* Shear (diagonal tension) in concrete when no reinforcement is provided.

Class A Concrete.....	40 lbs. per sq. in.
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Shear (diagonal tension) in concrete when reinforcement is provided for shear in excess of 40 lbs. per sq. in.

Class A Concrete.....	100 lbs. per sq. in.
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In beams with web reinforcement securely attached to the longitudinal bars in the tension side of the beam in such a way as to prevent slipping of the bar past the stirrup, 120 lbs. per sq. in.

- (d) *Bond.* Bond stress between concrete and plain reinforcing bars:
 Class A Concrete..... 80 lbs. per sq. in.
 When deformed bars are used.....100 lbs. per sq. in.
 In case drawn wire is used..... 40 lbs. per sq. in.

(e) *Tension.* No allowance for tension in concrete will be made. Tension in reinforcing steel 16,000 lbs. per sq. in.

ITEM 45. CALCULATION OF STRESSES.

45.1. Span. In the calculation of stresses the span of reinforced concrete beams or slabs shall be taken as the distance between centers of supports.

45.2. Initial Stress. Initial Stress in concrete due to a contraction or expansion shall be neglected.

45.3. Assumption for Calculations. The following assumptions shall be used as a basis of calculations:

(a) Calculations shall be made with reference to working stresses and safe loads, rather than with reference to ultimate strength and ultimate loads.

(b) A plane section before bending remains plane after bending.

(c) The modulus of elasticity of concrete in compression is constant within the usual limits of working stresses. The distribution of compressive stress in beams is therefore rectilinear.

(d) In calculating the moment of resistance of beams, the tensile stresses in the concrete are neglected.

(e) The adhesion between concrete and reinforcement is perfect. Under compressive stress the two materials are therefore stressed in proportion to their moduli of elasticity.

(f) The ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete is taken at 15.

45.4 Beam and Slab Formulas.

(a) *Simple Beams.* For simple beams, such as slabs used for one span bridges, the moment M for uniform load shall be $M = \frac{1}{8} wl^2$.

(b) *Fixed and Continuous Slabs.* For slabs fixed at the ends and continuous over interior T-beams or girders; the maximum moment for uniform load shall be taken as $M = \frac{1}{12} wl^2$.

In the case of beams and slabs continuous for two spans only, with their ends restrained, the bending moment both at the central support and near the middle of the span shall be taken as $\frac{wl^2}{10}$ for uniform loads.

45.5. Depth of Beams. The depth of a beam at any section is the distance from the compressive surface to the centroid of the tension reinforcement.

45.6. Maximum Shearing Unit Stress. The maximum shearing unit stress in beams is the total shear at the section divided by the product of the width of the section and the distance between the centroids of compression and tension, jd . This maximum shearing unit stress is to be used in place of diagonal tension stress in calculations for web stresses.

45.7. Spacing of Stirrups. For uniformly distributed loading, $S = \frac{3f_s jd A_s}{w(1-2x)}$.

For any loading, $S = \frac{3f_s jd A_s}{2V}$.

From the above formulas it is evident that the necessary spacing of stirrups is inversely proportional to the total shear V at any point.

45.8. **Bond Unit Stress.** The bond unit stress is equal to the vertical shear divided by the product of the total perimeter of the reinforcement in the tension side of the beam times the distance between the centroids of compression and tension, jd .

45.9. **Shear Allowance on Web.** Properly reinforced webs will be allowed an average shearing stress from vertical shear three times as high as a plain, unreinforced web.

45.10. **Floor Slabs Supported Along Four Sides.** For uniformly distributed loads on square slabs, one-half the live and dead load may be used in the calculations of the moment to be used in each direction. For oblong slabs, the length of which is not greater than one and one-half times the width, the moment to be resisted by the transverse reinforcement may be found by the ratio of the live and dead load equal to that given by the formula $r = \frac{l}{b} - 0.5$, where l = length, and b = breadth of slab. The longitudinal reinforcement should then be proportioned to carry the remainder of the load.

45.11. **Reinforced Columns.** Provision must be made in reinforced columns for eccentric loading, if any. Proper provision must also be made at the bottom of columns for tensile stresses, if any, and for the distribution, by means of bearing plates or otherwise, of the compressive stresses borne by the reinforcement.

45.12. **Temperature Stresses.** Temperature stresses shall be calculated in concrete structures, where the structure cannot expand and contract freely, for a variation of not less than 60 degrees Fahrenheit.

ITEM 46. CONSTRUCTION DETAILS.

46.1. **Joints.** Concrete construction shall, when possible, be cast in one operation. When joints are necessary, they shall be so located as to have the least possible effect on the strength of the structures.

Joints in columns shall be made flush with the lower side of the girders.

Joints in girders shall be made at a point midway between supports, but should a beam intersect the girder at this point the joint shall be offset a distance equal to twice the width of the beam.

Joints in the members of a floor system shall in general be made at or near the center of the span.

Joints in columns shall be perpendicular to the axis of the column and girders, beams and floor slabs perpendicular to the plane of their surfaces.

Girders shall not be constructed over freshly formed columns without permitting a period of at least two hours to elapse, thus providing for settlement or shrinkage in the columns.

46.2. **Contraction of Joints.** In massive work, such as retaining walls, abutments, etc., built without reinforcement, contraction joints shall be provided at intervals of 25 to 50 ft., and with reinforcement from 50 to 80 ft. (the smaller the height and thickness, the closer the spacing throughout the length of the structure). The joints should be tongued and grooved to maintain the alignment in case of unequal settlement.

Contraction joints shall be lubricated by an application of petroleum residuum oil or a similar material, so as to permit a free movement at the joints when the concrete expands or contracts.

46.3. **Splices in Reinforcement.** Whenever it is necessary to splice tension reinforcement the length of lap shall be determined on the basis of safe working bond stress, the stress in the bar and the shearing resistance in the concrete at the point of splice; or a connection shall be made between the bars of sufficient strength to carry the stress. Splices at points of maximum stress shall be avoided.

In columns, bars more than $\frac{3}{4}$ " diameter, not subject to tension, shall be properly squared and butted in a suitable sleeve. Smaller bars may be treated as indicated for tension reinforcement or the stress may be carried by embedment in large masses of concrete.

At foundations, bearing plates shall be provided for supporting the bars, or the bars shall be carried into the footing a sufficient distance to transmit the stress of the steel to the concrete by means of the bearing and bond resistance; in no case shall the ends of the bars be permitted merely to rest on the concrete.

46.4. Tee Beams. In beam and slab construction an effective bond shall be provided at the juncture of the beam and slab.

(a) When the principal slab reinforcement is parallel to the beam, transverse reinforcement shall be used, extending over the beam and well into the slab.

(b) When adequate bond and shearing resistance between slab and web of beam is provided, this slab may be considered as an integral part of the beam, but its width shall be determined by the following rules:

(c) It shall not exceed one-fourth of the span length of the beam.

(d) Its overhanging width on either side of the web shall not exceed three times the thickness of the slab.

Beams in which the tee form is used only for the purpose of providing additional area of concrete shall have a width of flange not more than three times the width of the stem, and a thickness of flange not less than one-third of the depth of the beam.

Tee beams acting as continuous beams shall have consideration given the tensile and compressive stresses at the supports.

46.5. Floor Slabs. Floor slabs having the supports extending along the four sides should be designed and reinforced as continuous over the supports. If the length of the slab exceeds one and one-half times its width, the entire load should be carried by transverse reinforcement.

In placing reinforcement in such slabs account may well be taken of the fact that the bending moment is greater near the center of the slab than near the edges. For this purpose two-thirds of the calculated moments may be assumed as carried by the center half of the slab and one-third by the outside quarters.

The total thickness of a slab shall not be less than $1/30$ of the slab span in the direction of the principal reinforcement nor less than 4 inches.

Square slabs shall be reinforced in both directions.

46.6. Compression Reinforcement. Where beams are reinforced on the compressive side, the steel shall be assumed to carry its proportion of stress in accordance with provisions of paragraph 44.1.

46.7. Cantilever Beams. In the case of cantilever and continuous beams, tensile and compressive reinforcement must extend sufficiently beyond the support and beyond the point of inflection to develop the requisite bond strength.

For cantilever and restrained beams full tensile stress exists in the reinforcing bars at the point of support, and the bars must be anchored in the supports sufficiently to develop this stress.

46.8. Anchorage of Bars. Ends of reinforcing bars must be secured against slipping, either by depending upon the bond, in which case the length of the free ends shall not be less than 48 diameters of the rod for plain rods or 40 diameters for deformed rods, or by bending the free end through 180 degrees to a radius of 4 diameters of rod, or by an anchorage consisting of the free end being upset and provided with a nut and washer. The free ends of stirrups, where the beam has no top reinforcement, may be turned closely through 360 degrees for this purpose. At points where top reinforcement exists the free ends of the stirrups shall be wound around the bars approximately one and one-half times.

46.9. High Bond Resistance. Where a high bond resistance is required the deformed bar shall be used.

Adequate bond strength throughout the length of the bar shall be preferred to end anchorage, but as an additional safeguard such anchorage may be used.

46.10. Beams and Girders. The minimum width of web, in beams or girders, shall not be less than one twenty-fourth ($1/24$) of the span.

46.11. Spacing of Reinforcing Bars. The lateral spacing of parallel bars shall not be less than three diameters from center to center, nor shall the distance from side of beam to nearest bar be less than two diameters.

The clear spacing between two layers of bars shall not be less than 1 inch, and the distance center to center of layers shall not be less than three diameters.

The spacing of small bars shall not be so close in either direction as to prevent the passing of concrete between the bars.

Two layers of bars crossing each other may be in contact, and in this case the bars forming the main reinforcement shall be placed outermost.

46.12. Number of Layers Permitted. The use of more than two layers of reinforcing will not be allowed, unless the layers are tied together by adequate metal connections, particularly at or near points where the bars are bent up or down.

46.13. Web Reinforcement. Web reinforcement, if vertical, shall be looped around the horizontal reinforcement. If the reinforcement is inclined it shall be securely attached to the longitudinal rods to prevent slipping.

46.14. Distribution of Points of Bend. Where the longitudinal bars are bent up to form the web reinforcement, the points of bending of the serial bars shall be distributed along a portion of the length of beam in such a way as to give a web reinforcement over the portion of the length of the beam in which it is needed.

In connection with bent up rods, and in addition to them, vertical stirrups shall be used to act in combination with the bent up rods.

46.15. Stirrups. The longitudinal spacing of stirrups or diagonal members, or the distribution of the points of bending adjacent bent up bars shall not exceed three-fourths of the depth of the beam.

Where negative moment exists, as in the case of a continuous beam at the supports, web reinforcement shall be looped over or wrapped around or be connected with the longitudinal reinforcing bars at the top of the beam.

46.16. Columns. Columns are compression members of which the ratio of unsupported length to least width exceeds four, and which are provided with reinforcement of one of the forms hereinafter described.

(a) *Ratio of Length to Width.* The ratio of unsupported length of column to its least width shall not exceed 15.

(b) *Effective Area.* The effective area of hooped columns or columns reinforced with structural shapes shall be taken as the area within the circle enclosing the spiral or the polygon enclosing the structural shapes.

(c) *Composite Columns.* Composite columns of structural steel and concrete in which the steel forms a column by itself shall not be classified as a reinforced concrete column.

When this type of column is used the concrete shall not be relied upon to tie the steel units together or transmit stresses from one unit to another.

(d) *Spacing of Column Reinforcement.* In columns having longitudinal reinforcement only, the rods shall be securely tied together at intervals not exceeding 20 diameters of the rods. In columns having circumferential reinforcement the clear spacing of such shall not exceed $1/6$ the diameter of the enclosed column, and preferably be not greater than $1/10$ and in no case be more than $2\frac{1}{2}$ inches.

(e) *Hooping.* Hooping shall be circular and the ends of bands united in such a way as to develop their full strength.

Adequate means must be provided to hold the bands or hoops in place so as to form a column, the core of which will be straight and well centered.

Where hooping is used the total amount of such reinforcement shall not be less than 1% of the enclosed column.

Hoops or bands shall not be counted on directly as adding to the strength of the columns.

(f) *Longitudinal Reinforcement.* In all cases longitudinal reinforcement shall be assumed to carry its proportion of stress in accordance with paragraph 44.1. This reinforcement shall be straight and have sufficient support to be held securely in place until the concrete has set.

46.17. Special Reinforcement. Slabs reinforced for strength in one direction only shall be reinforced to prevent shrinkage cracks by No. 9 wire netting with 4 to 6 inch mesh placed near the exposed surface. If the slab is more than 6 inches in total thickness and both surfaces are exposed, a layer of netting shall be placed near each surface.

ITEM 47. MATERIALS.

47.1. Classes of Concrete. Unless otherwise specially indicated on the plans, there will be 3 classes of concrete known as Class A, Class B, and Class C.

(a) *Class A Concrete.* Class A Concrete shall be composed of 1 part Portland cement, 2 parts fine aggregate, and 4 parts coarse aggregate.

(b) *Class B Concrete.* Class B Concrete shall be composed of 1 part Portland cement, 2½ parts fine aggregate, and 5 parts coarse aggregate.

(c) *Class C Concrete.* Class C Concrete shall be composed of 1 part Portland cement, 3 parts fine aggregate and 6 parts coarse aggregate.

47.2. Nature of Concrete Materials. Cement, water, fine aggregate and coarse aggregate shall be as specified under Item 16 in paragraphs 16.5 to 16.12, inclusive.

47.3. Concrete Reinforcement Bars. The Reinforcement shall meet the requirements specified under Item 17.

47.4. Material for Piling. The material for Piling shall meet the requirements specified under Item 38, paragraph 38.2.

47.5. Material for Forms. The material to be used in the forms shall meet the requirements of paragraph 16.13.

47.6. Use of Classes of Concrete. (a) *Class A Concrete.* All reinforced concrete, and all plain concrete masonry measuring less than 10 inches in thickness, except for the floors of steel bridges, shall be of Class A concrete unless otherwise shown on the drawings or directed in writing by the Engineer.

(b) *Class B Concrete.* Unless otherwise specified, Class B concrete shall be used in all plain concrete abutments, piers, and wing walls, and shall also be used elsewhere as may be provided for on the plans or by the written direction of the Engineer.

(c) *Class C Concrete.* Class C Concrete shall be used in all footings and at all other places provided for on the plans or specified in writing by the Engineer.

ITEM 48. MIXING AND PLACING CONCRETE.

48.1. Unit of Measure. The unit of measure shall be the cubic foot. A bag of cement containing 94 lbs., shall be considered 1 cubic foot.

The measurement of fine and coarse aggregate shall be by loose volume.

48.2. Devices for Measuring Material. The devices for measuring material shall be as specified in paragraph 16.14.

48.3. Consistency. The consistency of the concrete shall be as specified in paragraph 16.15.

48.4. Mixing and Placing Concrete. The contractor shall mix and place the concrete in strict accordance with the requirements of paragraphs 16.16 to 16.19 inclusive.

48.5. Instructions Regarding Plain Concrete. For plain concrete abutments, retaining walls, etc., the following instructions shall be followed:

(1) Each layer must be left rough to insure bonding to the layer above; and if it be already set, shall be thoroughly cleaned and scrubbed with coarse brushes and water before the next layer is placed upon it.

(2) Concrete shall be deposited in the forms in layers of such thickness and position as shall be specified by the Engineer, but in no case shall work on a section stop within 18 inches of the top.

(3) Temporary planking shall be placed at ends of partial layers so that none shall run out to a thin edge. In general, except in arch work, all plain concrete must be deposited in horizontal layers throughout.

(4) The work shall be carried up in sections of convenient length and each section completed without intermission.

48.6. Instructions Regarding Reinforced Concrete. In placing reinforced concrete it is desirable to cast the entire structure at one operation. Whenever this is not possible on account of the size of the structure, joints should be made in such places as to have the least effect on the strength of the structure.

48.7. Arches. The centers of arches must be lowered sufficiently to allow all the arch ring to assume its permanent set before the spandrel walls are poured, in order to reduce the possibilities of cracks in spandrel walls due to excessive settlement in the arch ring crown.

48.8. Protection of Concrete. The contractor shall protect the concrete as specified in paragraph 16.20.

48.9. Removal of Forms. Forms shall be removed as specified in paragraph 16.21.

48.10. Defective Work. Any defective work discovered after the forms have been removed, shall be remedied as specified in paragraph 16.22.

48.11. Finishing Concrete. The contractor shall finish the concrete as specified in paragraph 16.23.

48.12. Instructions Regarding Miscellaneous Auxiliaries. Side walks and curbing, drainage and weep holes, pipes and conduits, anchors, bolts, grillages, water proofing, and refilling shall be constructed and placed as specified in paragraphs 16.24 to 16.29 inclusive.

ITEM 49. EXPANSION DEVICES.

49.1. General. Unless otherwise shown on the plans, all reinforced concrete through or deck girder bridges, classed and designed as unrestrained structures shall be provided with expansion rockers at one end of each span.

49.2. Rockers. The rockers shall be of cast iron of the kind herein specified. They shall have a thickness of not less than $2\frac{1}{2}$ inches for spans of 45 feet or less, and a thickness of not less than 3 inches for spans over 45 feet in length, but in no case shall the unit compressive stress exceed $9000 - \frac{1}{r}$ lbs. per sq. inch. All rockers shall have bearing surfaces turned to a uniform radius and smooth surface, and shall be provided with 2 inch holes through the web to facilitate handling.

49.3. Bearing Plate. The rockers shall turn between mild or medium steel plates not less than 1 inch thick. The bearing surface of the plates shall be planed. The cut of the tool shall be in the direction of expansion.

The plates shall be set in full mortar beds and accurately leveled.

49.4. Rocker Pockets. Pockets two inches longer than the rockers shall be provided in the abutments and piers to receive the lower plates and rockers. The lower plates shall be placed so that the top of the rockers will be $\frac{1}{2}$ inch above the surface of the concrete.

49.5. Placing Rockers. The rockers shall be placed accurately at right angles to the axis of the girders and supported in position by short soft wood wedges not more than 1 inch wide placed between the ends of the rockers and the pockets. The wedges shall be soaked in water previous to driving and shall be driven only a sufficient amount to support the rockers in a vertical position. The pockets shall be completely filled with asphalt, of a quality herein specified.

The top plates shall be placed in contact with the rockers and carefully leveled. The top plate may be supported by sticks having a cross-section of not more than 1 inch and placed vertically, one on each side of the rocker and resting on the bottom of the pocket.

The bituminous felt cushion used to separate the superstructure concrete from that of the substructure at the free end shall then be placed in such a manner as to lap over the top plate not more than 1 inch at each edge.

In placing concrete over the rocker pockets, care shall be used to prevent the concrete from entering the pocket. The concrete shall be in contact with the top plate except for the margin of not more than 1 inch covered by the felt at the edges.

49.6. Asphalt for Rocker Pockets. The asphalt used for filling rocker pockets shall conform to the following requirements:

Coal tar pitch shall not be used under any condition.

The specific gravity of the asphalt at 25 degrees C. shall not be less than .965.

The bituminous material shall be soluble in chemically pure carbon-bisulphide to the extent of at least 99.5% by weight at air temperature.

When 20 grams (in a tin dish $2\frac{3}{8}$ inches in diameter and $\frac{3}{4}$ inch deep with vertical sides) are maintained at a temperature of 163 degrees C. for 5 hours in a New York testing laboratory oven, the loss by evaporation shall not exceed 5.0% by weight, and the penetration of the residue shall not be decreased more than 40% from that of the original sample.

The penetration of the asphalt as determined with the Dow machine, using a No. 2 needle, 100 grams weight, 5 seconds time and a temperature of 25 degrees C. shall not be less than 150 nor more than 200.

49.7. Bituminous Felt. Bituminous felt, when used to separate the superstructure from the substructure of concrete girder bridges at the free end, and when used to separate adjacent superstructures of multiple span concrete girder bridges, shall be provided in sheets having a manufactured thickness of not less than $\frac{1}{4}$ inch.

Ordinary tarred or plain building paper shall not be used except for separating the superstructure from the foundation of reinforced concrete slab bridges, and at the fixed end of girder bridges.

GENERAL SPECIFICATIONS FOR STEEL HIGHWAY BRIDGES

ITEM 50. DESIGN.

50.1. General Description. These specifications include the requirements for bridges which are to carry highway traffic only.

50.2. Use of. In general, plans for steel bridges will not be approved except for structures, spanning drainage ditches, navigable channels, and for locations where the cost of concrete structures would be prohibitive.

50.3. Types for Various Spans.

For bridges having spans 12 to 40 feet: steel I beams

For bridges having spans 36 to 70 feet: plate girders

For bridges having spans 36 to 102 feet: pony trusses

For bridges having spans 104 to 204 feet: through trusses.

Where bridge spans are more than 160 feet inclined upper chords should be used.

50.4 Roadways. In general, bridges up to and including 10 ft. in length, 20 to 30 ft. clear roadway.

Bridges over 10 ft. in length, 16 to 24 ft. clear roadway.

Length is understood to mean the distance face to face of abutments.

50.5. Length of Span. In calculating the stresses the length of span shall be taken as the distance center to center of end pins for pin connected trusses, centers of end bearing plates for riveted trusses and for girders, and center to center of trusses for floor beams.

50.6. Forms of Trusses. The form of truss shall preferably be as given in paragraph 50.3. In through trusses the end vertical suspenders and the two panels of the lower chord at each end shall be made rigid members if the wind load produces a reversal of stress in the lower chord. In through bridges the floor beams shall be riveted above or below the lower chord pins.

50.7. Lateral Bracing. All lateral and sway bracing shall preferably, and all portal bracing must be made of shapes capable of resisting compression as well as tension, and shall have riveted connections.

No permanent lateral bracing need be provided in the plane of the loaded chord, provided a solid concrete floor, reinforced in both directions is immediately to be placed on the structure. In this case, however, a temporary lateral system consisting of adjustable rods must be used to hold the chords in line while the floor is being placed. After the floor is completed such temporary laterals must be removed.

Low trusses and through plate girders shall be stayed by knee braces or gusset plates at each floor beam.

50.8. Spacing of Trusses. The distance between centers of trusses shall in no case be less than $1/20$ of the span between centers of end-pins or shoes, and shall preferably be not less than $1/12$ of the span. The clear roadway shall not be less than 16 ft.

50.9. Clearance. The clear head room along the center line of the bridge shall be not less than 14 ft. and shall extend transversely at least for a distance of four ft. either side of the center.

50.10. Footwalks. Where footwalks are required, they shall generally be placed outside of the trusses, and be supported on longitudinal beams resting on overhanging steel brackets.

50.11. Handrailing. A strong and suitable handrailing shall be placed at each side of the bridge and be rigidly attached to the superstructure.

50.12. Trestle Towers. Trestle Towers shall preferably be composed of two bents, bents being composed of two supporting columns; each tower thus formed, shall be thoroughly braced in both directions, and have struts between the feet of the columns. The feet of the columns must be secured to an anchorage capable of resisting one and one-half the specified wind forces.

Each tower shall have sufficient base longitudinally to be stable when standing alone, without other support than its anchorage.

Tower spans for high trestles shall not be less than 30 feet.

50.13. Standard Drawings. The State Highway Department will furnish standard drawings showing in general the details preferred with usual conditions.

50.14. Stress Sheets. Where bids are submitted on other than standard designs, the contractor shall furnish complete stress sheets, general plans of the proposed structures, and such detail drawings as will clearly show the dimensions of all parts, modes of construction and sectional areas.

50.15. Approval of Plans. The contractor shall not, except at his own risk, order any material, or commence any work until after shop drawings have been approved by the State Highway Engineer. After approval, the contractor shall furnish the State Highway Department and County Engineer, without charge, with as many sets of shop drawings as they may require.

The contractor shall check all leading dimensions and clearances as a whole and in detail, the fitting of all details, and become responsible for the exact position and elevation of all parts of the work; and approval of the working drawings shall not relieve the contractor of this responsibility.

50.16. Anchor Bolts. The contractor for the metal work shall furnish the requisite anchor bolts to the sub-structure contractor with a masonry plan showing their exact location, in time that they may be built into the masonry.

50.17. Name Plates. One or more cast iron name plates of an approved design, giving the date of construction, the names of Highway Commissioners, Highway Engineer, Bridge Engineer, County Engineer, County Commissioners Court, the Contractor for the Superstructure, and Contractor for Substructure, shall be securely bolted to the superstructure at the point or points specified.

50.18. Floorbeams. All floorbeams shall be rolled or riveted steel girders, rigidly connected to the trusses at the panel points, or may be placed on the top of deck bridges at panel points. Floorbeams shall preferably be square to the trusses or girders.

50.19. Joists and Stringers. Steel joists shall be securely fastened to the floor crossbeams, and steel stringers shall preferably be riveted to the webs of the floorbeams by means of connection angles at least 7/16 inch thick.

Where end floorbeams cannot be used, stringers resting on masonry shall have cross frames near their ends. These frames shall be riveted to girder or truss shoes where practicable.

50.20. Wooden Joists. Wooden floor joists shall be spaced not more than 2½ feet centers, and shall lap by each other so as to have a full bearing on the floorbeams, and shall be separated ½ inch for air circulation. They shall have a width of not less than 3 inches, or ¼ of the depth in width.

50.21. Proportioning Wooden Joists. Where joists are spaced not more than 2 feet centers, one joist shall be considered as carrying one-half of the concentrated live load; when spaced over 2 feet centers, each joist shall be considered as carrying two-thirds of the concentrated live load.

50.22. Bridging for Wooden Stringers. Wooden stringers which have a width less than 1/3 their depth shall be braced by two by four inch bridging as follows:

For spans from 10 to 20 ft. in length, two lines, at ¼ points.

For spans more than 20 ft. in length, three lines, at 1/6 and 1/2 points.

50.23. **Steel Joists.** Steel beams when used as joists shall have a depth of not less than $1/30$ of the span, and $1/20$ of the span when used as track stringers. Steel joists shall be spaced not to exceed 3 ft. centers. When spaced not to exceed 2 feet centers, one joist shall be considered as carrying $1/2$ the concentrated load; when spaced more than 2 ft. and not more than 3 ft. centers, one joist shall be considered as carrying $2/3$ of the concentrated load.

50.24. **Floor Plank.** For bridges with a plank floor the planks shall not be less than $2\frac{1}{2}$ in. thick for oak, or 3 in. for pine, laid with $1/4$ in. openings and spiked to each supporting joist, if wooden joists are used, or to 3 in. nailing strips securely bolted to the steel joists. When this is covered with an additional wearing floor it must be laid diagonally with $1/2$ in. openings; all planks shall be laid with heart side down. The floor plank must have a thickness in inches at least equal to the distance apart of the joists in feet. The floor planks must bear firmly upon all joists.

Where specified, an additional wearing floor $1\frac{1}{2}$ inches thick of white oak plank shall be placed over the above.

The footwalk plank shall be 2 inches thick and not over 6 in. wide, spaced $1/2$ in. openings.

50.25. **Wheel Guards.** There shall be a wheel guard not less than 4 in. x 6 in. on each side of the roadway to prevent the hubs of wheels from striking any part of the bridge. It shall be blocked up from the floor to admit drainage and air circulation and shall be secured by $3/4$ in. hook bolts with washers under the nuts to the steel joists, or if wood joists are used by $3/4$ inch lag screws with washers, at intervals of not over 4 ft.

50.26. **Solid Floors.** Pavements consisting of stone blocks, paving bricks, asphalt, etc., may rest on a reinforced concrete slab, or on a concrete bed resting on buckled plates as directed by the Highway Department.

When buckled plates are used they shall not be less than $5/16$ in. thick, and the concrete bed shall not be less than 3 inches thick for the roadway, and 2 inches thick for the foot walks, over the highest point.

When pavements are used, they shall be put down according to the specifications of the State Highway Department.

50.27. **Drainage.** Provisions shall be made for drainage clear of all parts of the metal work.

50.28. **Timber.** The timber, unless otherwise specified, shall be strictly first class spruce, white pine, southern yellow pine, or white oak bridge timber, sawed true and out of wind, full size, free from windshakes, large or loose knots, decayed or sapwood, wormholes or other defects impairing its strength or durability. It will be subject to the inspection and acceptance of the Engineer.

ITEM 51. LOADS.

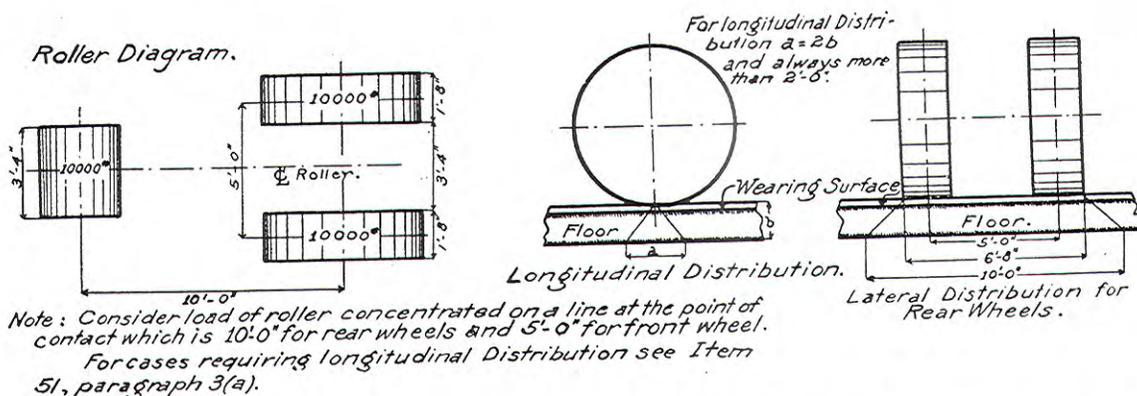
51.1. **General.** All parts of the structure shall be proportioned for the maximum stresses produced by the dead load, temperature, wind, live loads and impact as specified below.

51.2. **Dead Load.** The dead load shall comprise the actual weight of the completed structure. The dead load used in figuring stresses must not vary more than 5% from the actual estimated weights made from the completed design. In estimating the dead load the following unit weights shall be used:

Steel	490 lbs. per cu. ft.
Concrete	144 lbs. per cu. ft.
Earth fill (dry).....	100 lbs. per cu. ft.
Earth fill (wet).....	250 lbs. per cu. ft.
Ballast	120 lbs. per cu. ft.
Macadam or gravel.....	140 lbs. per cu. ft.
Brick	150 lbs. per cu. ft.
Asphalt paving.....	130 lbs. per cu. ft.
Untreated timber.....	54 lbs. per cu. ft.
Treated timber	60 lbs. per cu. ft.

51.3. Live Load.

(a) *Concentrated Live Load.* All floor systems shall be designed to sustain in addition to the dead load, a concentrated live load as indicated below:



Where the thickness of the floor and fill is 1 foot or less, the concentrated load will be assumed to have no longitudinal distribution; and where the thickness is more than 1 foot, the concentrated loading shall be assumed to be distributed longitudinally at an angle of 45° with the vertical.

(b) *Uniform Load on Stringers.* Stringers of spans under 50 feet in length shall be designed to carry a uniform live load of not less than 125 lbs. per square foot of roadway surface, and of spans over 50 feet in length, 100 lbs. per square foot of roadway surface when such uniform live load would produce stresses in excess of those produced by the above concentrated load.

(c) *Load on Floor Beams.* Floor beams shall be designed to carry in addition to the dead load, the full concentrated live load specified above, arranged in such position as to produce maximum stresses in the floor beams, or for spans of 50 ft. or less, a uniform live load of not less than 125 lbs. per square foot of roadway surface, and for spans of greater length than 50 feet, a uniform live load of not less than 100 lbs. per square foot of roadway surface, provided such uniform live load would produce greater stresses than the concentrated load described.

(d) *Loads for Trusses.* In designing all trusses and plate girders the following uniform live loads, arranged in such position as to produce the maximum stress in the member or detail under consideration, shall be used.

For spans of 50 ft. or less, a uniform live load of 125 lbs. per square foot of roadway surface.

For spans over 50 feet, up to and including 150 ft., 100 lbs. per square foot of roadway surface.

For spans longer than 150 ft., 85 lbs. per square foot of roadway surface.

For sidewalks, use the same uniform live loads as for the roadway surface.

51.4. Impact. In bridges with wooden floors 30% impact will be used.

51.5. Wind Loads. The top lateral bracing in deck bridges and the bottom lateral bracing in through bridges, shall be designed to resist a lateral wind load of 300 lbs. for each foot of span, and not less than 150 lbs. per lin. ft. of bridge for the unloaded chord. All wind is considered as a moving load.

ITEM 52. UNIT STRESSES AND PROPORTION OF PARTS.

52.1. Unit Stresses. All parts of the structure shall be proportioned so that the sum of the maximum stresses shall not exceed the following amounts in lbs. per sq. inch except as modified by No. 52.6 and No. 52.8.

52.2. Allowable Stresses.

(a) *Axial Tension on Net Section.*

Medium steel and steel castings	16,000 lbs. per sq. in.
Wrought iron	13,000 lbs. per sq. in.

(b) *Compression.*

Compression	16,000-70 l/r lbs. per sq. in.
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l = Unsupported length of member in inches.

r = Corresponding radius of gyration in inches.

The greatest l/r shall not exceed 125 for main truss members nor 150 for lateral or other secondary members.

Forked ends and extension plates	10,000-300 l/t lbs. per sq. in.
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l = distance in inches from center of pin hole to first rivet beyond point where full section of the member begins.

t = thickness of plates.

Cast steel	16,000 lbs per sq. in.
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(c) *Bending.*

Extreme fibre of rolled and built up sections and steel castings, tension and compression	16,000 lbs. per sq. in.
Extreme fibre of pins.....	24,000 lbs. per sq. in.

(d) *Shear.*

Shop rivets and pins.....	12,000 lbs. per sq. in.
Bolts and field rivets.....	10,000 lbs. per sq. in.
Webs of rolled or built up beams, gross section (Average)	10,000 lbs. per sq. in.
Pins	12,000 lbs. per sq. in.

(e) *Bearing.*

Pins and shop rivets.....	24,000 lbs. per sq. in.
Turned bolts and field rivets.....	20,000 lbs. per sq. in.
Expansion rollers (steel rollers on steel plates) 600 times diameter of roller in inches, lbs. per linear inch.....	600d.
Expansion rockers (cast iron) 300 times diameter of rocker in inches, lbs. per linear inch	300d.
Bearing on masonry.....	350 lbs. per sq. in.

(f) *Stresses in Timber.* Oak, long leaf yellow pine, and Oregon fir are to be designed for a safe bending stress of 1200 lbs. per square inch, bearing across the fiber of 350 lbs. per sq. inch, shearing along the fiber of 100 lbs. per sq. inch.

52.3. *Alternate Stresses.* Members subject to alternate stresses of tension and compression shall be proportioned for the stresses giving the largest section. If alternate stresses occur in succession during the passage of one series of loads, as in stiff counters, each stress shall be increased by 50% of the smaller. This increased stress shall be used in proportioning the connections.

52.4. *Angles Fastened by Both Legs.* Angles subject to direct tension must be connected by both legs, or the section of one leg only will be considered as effective.

52.5. *Net Sections at Rivets.* In proportioning tension members, the diameter of the rivet holes shall be taken $\frac{1}{8}$ inch larger than the nominal diameter of the rivet. In proportioning rivets the nominal diameter of the rivets shall be used.

52.6. *Limiting Lengths.* The length of riveted tension members in horizontal or inclined positions shall not exceed 200 times their least radius of gyration about the horizontal axis. The horizontal projection of the unsupported portion of the member is to be considered as the effective length.

52.7. *Combined Stresses.* Members subject to both axial and bending stresses shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress.

52.8. Stress Due to Weight and Eccentric Loading. If the fiber stress due to weight and eccentric loading on any member exceeds 10% of the allowable unit stress on the member, such excess must be considered in proportioning the members.

52.9. Counters. Rigid counters are preferred, and where subjected to reversal of stress shall preferably have riveted connections. Adjustable counters shall have open turnbuckles.

Wherever the live and dead load stresses are of opposite character, only 2/3 of the dead load stress shall be considered as effective in counteracting the live load stress.

52.10. Plate Girders. Plate girders shall be proportioned either by the moment of inertia of their net section, or by assuming that their flanges are concentrated at their centers of gravity, in which case $\frac{1}{8}$ of the gross section of the web, if properly spliced, may be used as flange section. The thickness of the web plates shall not be less than $\frac{1}{240}$ of the unsupported distance between flange angles.

Where flange plates are used, one cover plate of the top flange shall extend the whole length of the girder.

52.11. Web Plates. The webs of plate girders must be stiffened at intervals, not exceeding the depth of the girder or a maximum of 5 ft., wherever the shearing stress per sq. inch exceeds the stress allowed by the following formula:

$$\text{Allowed shearing stress} = 12,500 - 90 H.$$

Where H = ratio of depth of web to its thickness; but no web plates shall be less than $\frac{5}{16}$ in. in thickness.

52.12. Stiffeners. All stiffeners must be capable of carrying the maximum vertical shear without exceeding the allowed unit stress:

$$P = 12,000 - 55 l/r.$$

Each stiffener must connect to the webs by enough rivets to transfer the maximum stress to or from the webs. l = one-half depth of girder.

52.13. Flange Splices. All flange plates or angles, when cut on account of extreme length, must be covered by an amount of extra material equal in section to the pieces cut, with sufficient rivets on either side, to transmit the stresses.

52.14. Flange Rivets. The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer, in a distance equal to the effective depth of the girder, the total shear at any section together with any load that is applied directly on the flange.

52.15. Depth Ratios. Trusses shall preferably have a depth of not less than $\frac{1}{10}$ of the span. Plate girders and rolled beams, used as girders, shall preferably have a depth of not less than $\frac{1}{12}$ of the span. If shallower trusses, girders or beams are used, the section shall be increased so that the maximum deflection will not be greater than if the above limiting ratios had not been exceeded.

52.16. Rolled Beams. Rolled beams shall be designed by using their moments of inertia.

ITEM 53. DETAILS OF DESIGN.

53.1. General Requirements. All parts shall be so designed that the stresses coming upon them can be accurately calculated.

53.2. Water Pockets. Pockets or depressions which would hold water shall have drain holes, or be filled with waterproof material.

53.3. Open Sections. Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

53.4. Symmetrical Sections. Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of the section, and the neutral axes of intersecting main members of trusses shall meet at a common point.

53.5. **Strength of Connections.** The strength of connections shall be sufficient to develop the full strength of the members, even though the computed stress is less, the kind of stress to which the member is subjected being considered.

53.6. **Minimum Thickness.** The minimum thickness of metal shall be $5/16$ inches. The minimum angle shall be $3 \times 2\frac{1}{2} \times \frac{1}{4}$ in. The minimum rod shall have a sectional area of $75/100$ of a square inch.

53.7. **Pitch of Rivets.** The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than 3 in. for $7/8$ in. rivets, $2\frac{1}{2}$ in. for $3/4$ in. rivets, and 2 in. for $5/8$ in. rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be 16 times the thickness of the thinnest outside plate or 6 inches. For angles with two gage lines and rivets staggered, the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than 12 inches apart in either direction shall be used to hold the plates together. In tension members composed of two angles in contact, a pitch of 12 inches will be allowed for riveting the angles together.

53.8. **Edge Distance.** The minimum distance from the center of any rivet hole to a sheared edge shall be $1\frac{1}{2}$ in. for $7/8$ in. rivets, $1\frac{1}{4}$ in. for $3/4$ in. rivets, and $1\frac{1}{8}$ in. for $5/8$ in. rivets; and to a rolled edge $1\frac{1}{4}$, $1\frac{1}{8}$, and 1 in. respectively. The maximum distance from any plate edge shall be eight times the thickness of the plate, but shall not exceed 6 inches.

53.9. **Maximum diameter.** The diameter of the rivets in any angle carrying calculated stress shall not exceed $1/4$ of the width of the leg in which they are driven. In minor parts $7/8$ in. rivets may be used in 3 in. angles, $3/4$ in. rivets in $2\frac{1}{2}$ in. angles, and $5/8$ in. rivets in 2 inch angles.

53.10. **Long Rivets.** Rivets carrying calculated stress, and whose grip exceeds four diameters shall be increased in number at least 1% for each $1/16$ in. additional grip.

53.11. **Pitch at Ends.** The pitch of rivets at the ends of built up members shall not exceed four diameters of the rivets, for a length equal to $1\frac{1}{2}$ times the maximum width of the member.

53.12. **Compression Members.** In compression members the metal shall be concentrated as much as possible in the webs and flanges. The thickness of each web shall not be less than $1/30$ of the distance between its connections to the flanges. Cover plates shall have a thickness not less than $1/40$ of the distance between rivet lines, and they shall not be thicker than $3/8$ inch except where necessary to resist bending stress, or to comply with the above requirement.

53.13. **Minimum Angles.** Flanges of girders and built member without cover plates shall have a minimum thickness of $1/12$ of the width of the outstanding leg.

53.14. **Tie Plates.** The open sides of all compression members shall be stayed by tie plates at the ends and diagonal lattice-work at intermediate points. The tie plates must be placed as near the ends as practicable, and shall have a length not less than the greatest width of the member, or $1\frac{1}{2}$ times its least width.

53.15. **Lattice Bars.** The minimum width of lattice bars, and the size of the connecting rivets shall be as follows:

15 inch channels or built up sections with angles over 3 inches, width $2\frac{1}{2}$ inches, rivets $7/8$ inches.

10 and 12 inch channels or built up sections with angles over 3 inches, width $2\frac{1}{2}$ inches, rivets $3/4$ inches.

8 and 9 inch channels, width 2 inches, rivets $5/8$ inches.

6 and 7 inch channels, width $1\frac{3}{4}$ inches, rivets $5/8$ inches.

Single lattice bars shall have a thickness not less than $1/40$ or double lattice bars connected by a rivet at the intersection, not less than $1/60$ of the distance between rivets

connecting them to the members. They shall be inclined at an angle not less than 60 degrees with the axis of the member for single latticing, nor less than 45 degrees for double latticing with riveted intersections.

Lattice bars shall be so spaced that the portion of the flange included between their connections shall be as strong as the member as a whole.

53.16. Faced Joints. Abutting joints in compression members, when faced for bearing, shall be spliced on four sides sufficiently to hold the connecting members accurately in place. All other joints in riveted work, whether in tension or compression, shall be fully spliced.

53.17. Pin Plates. Pin holes shall be reinforced where necessary, and at least one plate shall be as wide as the flange will allow and be on the same side as the flanges or angles. They shall contain sufficient rivets to distribute their proportion of the pin pressure to the full cross-section of the member. At least one of these plates shall extend not less than 6 inches beyond the near edge of the tie plate.

53.18. Net Sections at Pins. Pin connected riveted tension members shall have a net section through the pin hole at least 25% in excess of the required net section of the body of the member, and the net section back of the pin hole and parallel with the axis of the member, shall be not less than 80% of the required net section of the member.

53.19. Pins. Pins shall be long enough to insure a full bearing of all the parts connected on the turned body of the pin. They shall be secured by chambered nuts. The screw ends shall be long enough to admit of burring the threads.

53.20. Filling Rings. Members packed on pins shall in all cases be held against lateral movement by means of ring fillers.

53.21. Bolts. Wherever bolts are used in place of rivets, the holes shall be reamed parallel while the members are fitted in place and the bolts turned to a driving fit.

Where members are connected by bolts, the turned unthreaded shank shall be long enough to extend through the plates connected. A washer at least $\frac{1}{4}$ inch thick shall be used under the nut. Bolts shall not be used in place of rivets except by special permission. Heads and nuts shall be hexagonal.

53.22. Indirect Splices. Where splice plates are not in direct contact with the parts they connect, as in case fillers are used, rivets shall be used in excess of the number theoretically required to the extent of $\frac{1}{3}$ of the number for each intervening plate.

53.23. Fillers other than for Indirect Splices. Rivets carrying stress and passing through fillers shall be increased 50% in number; and the excess rivets, when possible, shall be outside of the connected member.

53.24. Expansion. Provision for expansion to the extent of $\frac{1}{8}$ inch for each 10 ft. shall be made for all structures.

53.25. End Bearings. Spans of 80 ft., and over, resting on masonry shall have turned rollers or rockers at one end, and those of less strength shall be arranged to slide on smooth surfaces.

Movable bearings shall be designed to permit motion in one direction only. Fixed bearings shall be firmly anchored to the masonry.

53.26. Rollers. Expansion rollers shall not be less than three inches in diameter, for spans of 100 ft. and less, and shall be increased 1 inch for each additional 100 ft. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned.

53.27. Bolsters. Bolsters or shoes shall be so constructed that the load will be distributed over the entire bearing.

53.28. Pedestals and Base-Plates. Pedestals shall be made of riveted plates and angles. All bearing surfaces of the base plates and vertical webs must be planed. The vertical webs must be secured to the base by angles having two rows of rivets in the ver-

tical legs. No base plate or web connecting angle shall be less in thickness than $\frac{1}{2}$ inch. The vertical webs shall be of sufficient height and must contain material and rivets enough to practically distribute the loads over the bearings or rollers.

Where the size of the pedestal permits, the vertical webs must be rigidly connected transversely.

All bed plates and bearings under fixed and movable ends must be fox-bolted to the masonry; for trusses, these bolts must not be less than $1\frac{1}{4}$ inches in diameter; for plate and other girders, not less than $\frac{7}{8}$ in. in diameter.

Where two spans rest upon the same masonry, a continuous plate not less than $\frac{3}{8}$ inch thick, shall extend under the two adjacent bearings, or the two bearings must be rigidly tied together.

53.29. Inclined Bearings. Bridges on inclined grade without pin shoes shall have the sole plates beveled so that the masonry and expansion surfaces may be level.

53.30. Wall Plates. Wall plates may be cast or built up, and shall be so designed as to distribute the load uniformly over the entire bearing. They shall be secured against displacement.

53.31. Anchorage. Anchor bolts for viaduct towers and similar structures shall be long enough to engage a mass of masonry the weight of which is at least $1\frac{1}{2}$ times the uplift.

53.32. Camber. Truss spans shall be given a camber by making the panel length of the top chords, or their horizontal projections, longer than the corresponding panels of the bottom chord in the proportion of $\frac{3}{16}$ inch in 10 ft.

53.33. Eye Bars. The eye-bars composing a member shall be so arranged that adjacent bars shall not have their surfaces in contact. They shall be as nearly parallel to the axis of the truss as possible, the maximum inclination of any bar being limited to one inch in 16 ft.

ITEM 54. MATERIALS AND WORKMANSHIP.

(a) MATERIALS.

54.1. Process of Manufacture. Steel shall be made by the open hearth process.

54.2. Allowable Percentage of Phosphorus. The phosphorus shall not exceed 0.06 of one per cent for steel made by the acid method, or 0.04 for the basic method.

54.3. Finish. The steel shall be uniform in character for each specified kind. The finished bars, plates, and shapes shall be free from cracks on the face or corners, and have a clean, smooth finish. No work shall be put upon any steel at or near the blue temperature or between that of boiling water and of ignition of hardwood sawdust.

54.4. Tensile Strength. The tensile strength, elastic limit and ductility shall be determined by samples cut from the finished material after rolling. The sample shall be cut at least 12 inches long, and have a uniform sectional area not less than $\frac{1}{2}$ square inch. The elastic limit, as indicated by the drop of beam, shall be recorded in the test reports.

Material which is to be used without annealing or further treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material shall be similarly treated before testing for tensile strength.

54.5. Elongation. The elongation shall be measured on an original length of 8 inches. Two test pieces shall be taken from each melt of finished material, one for tension and one for bending.

54.6. Kind of Failure. All samples or full sized pieces shall show a uniformly fine grained fracture of a steel-gray color, entirely free from fiery lustre or blackish casts.

54.7. Ultimate Strength. Medium steel shall have an ultimate strength, when tested in samples of the dimensions above stated, of 60,000 pounds per square inch, and an elastic limit of not less than one-half of the ultimate strength, and a minimum elongation of 22% in 8 inches.

Steel for pins may have a minimum elongation of 15%.

54.8. Bending Test. Before or after heating to a low cherry red and cooling in water at 82 degrees Fahrenheit, this steel shall stand bending to a curve whose inner radius is $1\frac{1}{2}$ times the thickness of the sample, without cracking.

54.9. Drifting Test. For all medium steel $\frac{5}{8}$ inch or less in thickness, rivet holes, punched as in ordinary practice, shall stand drifting to a diameter of $\frac{1}{3}$ greater than the original holes without cracking, either in the periphery of the holes or the external edges of the pieces whether they may be sheared or rolled.

54.10. Rivet Steel. Rivet steel shall have an ultimate strength of 50,000 to 58,000 lbs. per sq. in., an elastic limit not less than half the ultimate strength, and elongation of 26%. Under a bending test the steel shall stand closing solidly together without sign of fracture.

54.11. Eye Bar Material. Eye bar material $1\frac{1}{2}$ in. and less in thickness, shall on test pieces cut from the finished material, fill the above requirements for medium steel. For a thickness greater than $1\frac{1}{2}$ inches, there will be allowed a reduction in the percentage of elongation of 1% for each $\frac{1}{8}$ inch of additional thickness, to a minimum of 20%.

54.12. Pins. Pins over 7 inches in diameter shall be forged. Blooms for pins shall have at least three (3) times the sectional area of the finished pins.

54.13. Allowable Variation. A variation of cross-section or weight in the finished members of $2\frac{1}{2}$ % from the specified size may be cause for rejection.

54.14. Thick Material. Full sized material for eye-bars and other steel $1\frac{1}{2}$ inches thick and over, tested as rolled, shall bend 180 degrees around a pin, the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of bend.

54.15. Steel Castings. Steel castings shall be true to form and dimensions, have a workmanlike finish and be free from injurious blowholes or other defects. All castings must be annealed. When tested in specimens of uniform sectional area of at least $\frac{1}{2}$ inch square for a distance of 2 inches, they shall show an ultimate strength of not less than 67,000 lbs. per sq. inch, an elastic limit of $\frac{1}{2}$ the ultimate, and an elongation in 2 inches of not less than 10%.

The metal shall be uniform in character, free from hard or soft spots, and be capable of being properly tool finished.

54.16. Cast Iron. Except where cast steel or chilled iron is required, all castings shall be of tough, gray iron, free from cold shuts or injurious blow holes, true to form and thickness, and have a workmanlike finish. Sample pieces 1 inch square cast from the same heat of metal in sand moulds, shall be capable of sustaining on a clear span of 12 inches, a central load of 2500 lbs. when tested in a rough bar. A blow from a hammer shall produce an indentation on a rectangular edge of the casting without flaking the metal.

54.17. Forgings and Shafting. The material used for forging shall be of basic, or acid medium open hearth steel, and have a good finish and uniform quality. The phosphorus content shall not exceed 0.06 of 1%. When tested of specimens of not less than $\frac{1}{2}$ inch in diameter, it shall show an ultimate strength of at least 60,000 lbs. per sq. in., with an elastic limit of at least 50% of the ultimate, and an elongation of at least 28% in 2 inches. A test specimen 1 in. by $\frac{1}{2}$ in. shall bend cold 180 degrees over a diameter equal to its thickness without sign of fracture. All steel forgings must be properly annealed.

54.18. Stamping. Every finished piece of steel shall have the melt member and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag.

54.19. Defective Material. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

(b) WORKMANSHIP.

54.20. General. All parts forming a structure shall be built in accordance with the approved working drawings. The workmanship and finish shall be equal to the best practice in modern bridge shops.

54.21. Straightening Material. Material shall be thoroughly straightened in the shop before being laid off or worked in any way.

54.22. Finish. Shearing shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

54.23. Size of Rivets. Size of rivets called for on the plans is understood to mean the actual size of the cold rivet before heating.

54.24. Rivet Holes. When reaming is not required the diameter of the punch shall not be more than $1/16$ inch greater than the diameter of the rivet, nor the diameter of the die more than $1/8$ inch greater than the diameter of the punch. Material more than $3/4$ inch thick shall be sub-punched and reamed or drilled from the solid.

54.25. Punching. All punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed. If holes must be enlarged to admit the rivets, they shall be reamed. Poor matching of holes will be considered sufficient cause for rejection.

54.26. Sub-Punching and Reaming. Where reaming is required, the diameter of the punch used shall be at least $3/16$ inch smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not more than $1/16$ inch larger than the nominal diameter of the rivet. All reaming shall be done with twist drills in such a manner that the entire circumferences of the holes match perfectly.

54.27. Reaming Field Connections After Assembling. When reaming is required, it shall be done after the members meeting at a point are assembled and firmly bolted together. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be assembled in the same position in the final setting up. No interchange of reamed parts will be allowed.

54.28. Edge Planing. Sheared edges or ends, shall when required, be planed at least $1/8$ inch.

54.29. Burrs. The outside burrs on reamed holes shall be removed.

54.30. Assembling. Riveted members shall have all parts well pinned up and firmly drawn together with bolts before riveting is commenced. Contact surfaces shall be heavily coated with paint before riveting.

54.31. Lattice Bars. Lattice bars shall have neatly rounded ends.

54.32. Web Stiffeners. Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

54.33. Splice Plates and Fillers. Web splice plates and fillers understiffeners shall be cut to fit within an $1/8$ inch of the flange angles.

54.34. Web Plates. Web plates of girders, which have no cover plates, shall be flush with the backs of the angles or project above the same not more than $1/8$ inch, unless otherwise called for. When web plates are spliced, not more than $1/4$ inch clearance between ends of the plates will be allowed.

54.35. Connection Angles. Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder.

54.36. Rivets. Shop rivets shall be driven by pressure tools wherever possible. Field rivets must be driven by pneumatic tools. Hand driving will not be allowed.

54.37. Riveting. Rivets shall have a neat and finished appearance with heads of approved shape, full and equal size. They shall be central on the shank, and shall grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary they shall be drilled out.

54.38. Members to be Straight. The several pieces forming one member shall be straight and fitted closely together, and the finished members shall be free from twists, bends or open joints.

54.39. Finish of Joints. Abutting joints shall be cut or dressed true and straight and fitted closely together, especially where open to view. In compression joints, depending on contact bearing, the surfaces shall be truly faced, so as to have an even bearing after they are riveted up complete and when perfectly aligned.

54.40. Field Connections. Holes for floor beams and stringer connections shall be sub-punched and reamed according to paragraph 54.26 to a steel templet 1 inch thick. (If required, all other field connections except those for laterals and sway bracing, shall be assembled in the shop and the unfair holes reamed; and when so reamed, the pieces shall be matched-marked before being taken apart.)

54.41. Eye Bars. Eye bars shall be straight and true to size and shall be free from twists, folds or twists in head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the Engineer, but the manufacturer shall guarantee the bar to break in body when tested to rupture. The thickness of the head and neck shall not vary more than 1/16 inch from that specified.

54.42. Boring Eye-Bars. Before boring, each bar shall be properly annealed and carefully straightened. Pin holes shall be in the center line of the bars, and in the center of the heads. Bars of the same length shall be bored so accurately that, when placed together, pins 1/32 inch smaller in diameter than the pin holes can be passed through the holes at both ends of the bars at the same time without forcing.

54.43. Pin Holes. Pin holes shall be bored true to gauge, smooth and straight, at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up.

54.44. Variation in Pin Holes. The distance center to center of pin holes shall be correct to within 1/32 of an inch and the diameter of the holes shall be not more than 1/50 inch larger than the diameter of the pin, for pins up to 5 inches in diameter and 1/32 inch for larger pins.

54.45. Pins and Rollers. Pins and rollers shall be accurately turned to gauge, shall be straight, smooth and entirely free from flaws.

54.46. Screw Threads. Screw threads shall make tight fits in the nuts and shall be U. S. Standard, except above the diameter of 1 3/8 inches, when they shall be made with six threads per inch.

54.47. Upset Ends. All bars with screw ends shall be upset, so that the diameter at the bottom of the threads shall be 1/32 inch larger than any part of the body of the bar. Where closed nuts are used on adjustable members, the effective length of thread shall be legibly stamped at the screw end of each bar. Adjustable counters are to be avoided wherever practicable.

54.48. Annealing. Steel, except in minor details, which has been partially heated, shall be properly annealed.

54.49. Steel Castings. All steel castings shall be annealed.

54.50. Welds. Welds in steel will not be allowed.

54.51. Bed Plates. Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed top and bottom. The cut of the planing tool shall correspond with the direction of expansion.

54.52. Pilot Nuts. Pilot and driving nuts shall be furnished for each size of pin.

54.53. Field Rivets. Field rivets shall be furnished to the amount of 15% plus ten rivets in excess of the nominal number required for each size.

54.54. **Shipping Details.** Pins, nuts, bolts, rivets and other small details shall be boxed or crated. The weight of every piece and box shall be marked on it in plain figures.

54.55. **Finished Weight.** Payment for pound price contracts shall be by scale weight. No allowance over 2% of the total weight of the structure as computed from the plans will be allowed for excess weight.

(c) SHOP PAINTING.

54.56. **Cleaning.** Steel work, before leaving the shop, shall be thoroughly cleaned and given one good coating of pure linseed oil, or such paint as may be called for, well worked into all joints and open spaces.

54.57. **Contact Surfaces.** In riveted work the surfaces coming in contact shall each be painted before being riveted together.

54.58. **Inaccessible Surfaces.** Pieces and parts which are not accessible for painting after erection, including tops of stringers, eye-bar heads, end of posts and chords, etc., shall have a good coat of paint before leaving the shop.

54.59. **Condition of Surfaces.** Painting shall be done only when the surface of the metal is perfectly dry. It shall not be done in wet or freezing weather unless protected under cover.

54.60. **Machine-finished Surfaces.** Machine-finished surfaces shall be coated with white lead and tallow before shipment or before being put out into the open air.

(d) INSPECTION.

54.61. **Facilities.** All facilities for inspection of materials and workmanship, shall be furnished by the contractor.

54.62. **Test Pieces.** The contractor shall furnish without charge such prepared specimens of the several kinds of steel to be used, as may be required to determine their character.

54.63. **Testing Machine.** The contractor shall furnish free of cost, the use of a testing machine capable of testing the above specimens at all mills where the steel is manufactured.

54.64. **Tests of Large Pieces.** Full sized parts of the structure may be tested at the option of the engineer, but if tested to destruction such material shall be paid for at cost, less the scrap value to the contractor, if it proves satisfactory. If it does not stand the specified tests, it will be considered rejected material, and be solely at the cost of the contractor.

54.65. **Fabrication.** The contractor shall notify the engineer from time to time of the progress of fabrication and furnish every facility necessary for the engineer to inspect the work in the fabricating shop. It is understood, however, that the engineer may waive shop inspection and make complete inspection of all fabricated work when the same is delivered at the site of the bridge. Whether or not shop inspection is made, fabricated steel may be rejected at any time prior to final acceptance of the bridge, provided it does not conform to the specifications.

(e) ERECTION.

54.66. **Erection.** If the contractor erects the bridge he shall, unless otherwise specified, furnish all staging and falsework, erect and adjust all metal work and shall frame and put in place all floor timbers, guard timbers, trestle timbers, etc., complete and ready for traffic.

The contractor shall put in place all stone bolts and anchors for attaching steel work to masonry. He shall drill all the necessary holes in the masonry, and set all bolts with neat Portland cement.

The erection will include all necessary hauling from the railroad station, the unloading of the materials and their proper care until the erection is completed.

Whenever new structures are to replace existing ones, the latter are to be carefully taken down and removed by the contractor to some place where the material can be hauled away.

The contractor shall so conduct his work as not to interfere with traffic, interfere with the work of other contractors, or close any thoroughfare on land or water, in any manner other than that directed by the Engineer.

The contractor shall assume all risks of accidents and damages to persons and property prior to the acceptance of the work.

The contractor must remove all falsework, piling, and other obstructions or unsightly material produced by his operations.

54.67. Painting After Erection. After the bridge is erected the metal work shall be thoroughly cleaned of mud, grease, or other material, then thoroughly and evenly painted with two coats of paint of the kind hereinafter specified.

All recesses which may retain water, or through which water can enter, must be filled with thick paint or some waterproof cement before the final painting. The different coats of paint must be of distinctly different shades or colors, and one coat must be allowed to dry thoroughly before the second coat is applied. No painting shall be done during wet or freezing weather.

(f) FINAL TEST.

54.68. Final Test. Before final acceptance, the Engineer may make a thorough test by passing over the structure the specified load, or other equivalent, or by resting the maximum load upon the structure for twelve hours.

After each test the structure shall return to its original position without showing any permanent deformation.

ITEM 55. PAINTING.

55.1. General. The first coat of paint, which shall be applied in the field, shall consist of pure boiled linseed oil and a mixture of 80% pure sublimed white lead and 20% pure sublimed blue lead; the second coat shall consist of pure linseed oil and pure sublimed blue lead.

55.2. Final Sample. Samples of at least 2 lbs. of the paints delivered at the shop and in the field shall be furnished the Engineer by the contractor, said samples to be selected by the inspector and tested in the laboratory of the Highway Department before any paint is applied. The contractor shall, therefore, secure the necessary paint in ample time so that no delay will be caused by the time necessarily used in testing, for which 10 days shall be allowed from the time the sample is received at the laboratory. If the paint is purchased in paste form, a sample of at least 1 pint of the boiled linseed oil which is to be mixed with this paste shall also be furnished for testing purposes.

55.3. Quantity of Pigment. The mixed paint shall contain not less than 50 nor more than 54% of pigment by weight. Should the paint be in paste form, enough paste shall be added to boiled linseed oil to give not less than 50 nor more than 54% of pigment by weight of the mixed paint.

55.4. Determination of Per Cent of Pigment. The determination of the amount of pigment will be made as follows:

The sample will be weighed and, when possible, the clear vehicle drawn off and tested to determine its conformity with the specifications.

The remaining vehicle will be extracted four (4) times with 86 degrees naphtha, and the pigment washed once with benzol and twice with ether. When the vehicle cannot be drawn off, the sample will be extracted by centrifuging the paint and after the vehicle is removed, washing the pigment with naphtha, benzol, and ether. One hundred (100) minus the percent of pigment found, will be considered as the percent of vehicle.

55.5. **Linseed Oil.** When furnished in paste or dry form the pigment shall be mixed with pure boiled linseed oil. This oil as well as the vehicle obtained from mixed paint will be subjected to standard tests for the purity of the boiled linseed oil. It shall contain no mineral oils, benzine, rosin, rosin oil, maize or corn oil, fish oil, cotton seed oil, rape oil, soya bean oil, or saponified or unsaponified oil other than linseed oil. A small amount of turpentine may be added as a drier only on the approval of the Engineer. The film obtained after flowing the oil over glass and allowing it to drain in a vertical position must be dry to the touch after 24 hours at 25 degrees C.

PROPOSAL TO

FOR BUILDING A.....ROAD
 IN.....
COUNTY, TEXAS.

APPROXIMATE QUANTITIES.

The following quantities of the work to be done are approximate only, and are intended principally to serve as a guide in figuring out the bids.

It is agreed that the quantities of work to be done and materials to be furnished may be increased or diminished as may be considered necessary, in the opinion of the Engineer, to complete the work fully as planned and contemplated.

Unit prices must be given on each item checked in the following schedule, regardless of whether quantities are shown, and should any items be omitted, the right is reserved to apply the lowest prices submitted by the other bidders in payment for work done under this proposal.

The undersigned, as bidder..., declare... that the only person or parties interested in this proposal as principals are those named herein; that this proposal is made without collusion with any other person, firm, or corporation; that ...he... ha... carefully examined the form of contract, instructions to bidders, profiles, grades, specifications, and the plans therein referred to, and ha... carefully examined the location of the proposed work; and agree... that ...he... will provide all the necessary machinery, tools, apparatus, and other means of construction, and will do all the work and furnish all the materials called for in the contract and specifications in the manner prescribed therein and according to the requirements of the Engineer as therein set forth, for the following prices:

Item No.	Approximate Quantities	ITEMS WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT BID PRICE		AMOUNT BID	
			Dollars	Cents	Dollars	Cents
1		Clearing and grubbing (new roads, gravel and soil pits) for.....				
2		Cu. yds. unclassified excavation, including all clearing and grubbing, forper cu. yd.				
3		Cu. yds. ditching, including all ditching except as outlined in cross-sections of roadway design, forper cu. yd.				
		Carry forward.....				

Item No.	Approximate Quantities	ITEMS WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT BID PRICE		AMOUNT BID	
			Dollars	Cents	Dollars	Cents
		Brought forward.....				
4		Cu. yds. crushed stone laid down at nearest delivery point, for..... per cu. yd.				
5		Cu. yds. gravel laid down at nearest delivery point, for..... per cu. yd.				
6		Cu. yds. Surfacing per one-fourth mi. Haul including loading and unloading, for..... per cu. yd. one-fourth mi.				
7		Cu. yd. placing Surfacing, including spreading, sprinkling (when called for) rolling, and other incidental work, for..... per cu. yd.				
8		Gallons bituminous material furnished and applied, including all heating, mixing, teaming, distributing and rolling, and all materials except as herein otherwise specified, and all incidental labor, tools, machinery and apparatus for applying same, for..... per gallon				
9		For vitrified clay pipe laid, including ditching and backfilling, as follows: Lin. ft. pipe 12 inches in diameter for per lin. ft.				
10		Lin. ft. pipe 15 inches in diameter for per lin. ft.				
11		Lin. ft. pipe 18 inches in diameter for per lin. ft.				
		Carry forward.....				

Item No.	Approximate Quantities	ITEMS WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT BID PRICE		AMOUNT BID	
			Dollars	Cents	Dollars	Cents
		Brought forward.....				
12		Lin. ft. pipe 23 inches in diameter for per lin. ft.				
13		Lin. ft. pipe 30 inches in diameter for per lin. ft.				
14		For corrugated metal pipe laid, including ditching and backfilling, as follows: Lin. ft. pipe 12 inches in diameter for per lin. ft.				
15		Lin. ft. pipe 15 inches in diameter for per lin. ft.				
16		Lin. ft. pipe 18 inches in diameter for per lin. ft.				
17		Lin. ft. pipe 24 inches in diameter for per lin. ft.				
18		Lin. ft. pipe 30 inches in diameter for per lin. ft.				
19		Tons of 2000 lbs. cast iron pipe for per ton				
20		For tile underdrain laid, including ditching and backfilling, as follows: Lin. ft. 4 inches in diameter for per lin. ft.				
21		Lin. ft. 6 inches in diameter for per lin. ft.				
		Carry forward.....				

Item No.	Approximate Quantities	ITEMS WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT BID PRICE		AMOUNT BID	
			Dollars	Cents	Dollars	Cents
		Brought forward.....				
22		Lin. ft. stone underdrain..... in. wide and.....in. deep forper lin. ft.				
23		Catch basins complete for..... each				
24		For road machine work, including all labor, tools, and other incidentals necessary to complete the work, as follows: Miles road machine, 8-mule team and operator, for..... per mile				
25		Miles road machine, 6-mule team and operator, for..... per mile				
26		Lin. ft. stone curb 8 in. by 24 in. in place, for.....per lin. ft.				
27		Lin. ft. concrete curb 8 in. by 24 in. in place for.....per lin. ft.				
28		Cu. yds. soil measured on roads compacted for.....per cu. yd.				
29		Sq. yds. mixing, shaping and finishing sand clay for.....per sq. yd.				
30		Cu. yds. broken stone in outlets forper cu. yd.				
		Carry forward.....				

Item No.	Approximate Quantities	ITEMS WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT BID PRICE		AMOUNT BID	
			Dollars	Cents	Dollars	Cents
		Brought forward.....				
31		Sq. yds. cobblestone gutter for per sq. yd.				
32		Lin. ft. standard guard fence, including all materials, building and other work incidental thereto, for per lin. ft.				
33		Cu. yds. cement rubble masonry for per cu. yd.				
34		Cu. yds. dry rubble masonry for per cu. yd.				
35		Cu. yds. Class A reinforced concrete, for..... per cu. yd.				
36		Cu. yds. Class B concrete for per cu. yd.				
37		Cu. yds. Class C concrete for per cu. yd.				
38		Cement concrete pavement for..... per sq. yd.				
39						
40						
41						
		Carry forward.....				

Item No.	Approximate Quantities	ITEMS WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT BID PRICE		AMOUNT BID	
			Dollars	Cents	Dollars	Cents
		Brought forward.....				
42						
43						
44						
45						
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49						
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51						

Extra work, if any, shall be performed in accordance with article 4.8, under "General Provisions" of the attached form of specifications, the amount to be as specified in the above mentioned article.

The undersigned agree.... and pledge.... himself themselves to execute the work in accordance with the attached specifications and contract and to complete it in full and true by....., 19.....

The bond, given by the undersigned, in the amount of..... Dollars (\$.....), to secure a proper compliance with the terms and provisions of this contract, and to insure and guarantee the work until final completion and acceptance, is hereto attached and made a part hereof.

Accompanying this proposal is a certified check payable to the order of the..... County, for Dollars,

(\$.....), said check to be returned to the bidder, unless in case of the acceptance of the proposalhe.... shall fail to execute a contract and file a bond within ten days of its acceptance, in which case the check is to become the property of said county, and is to be considered as payment for damages due to delay and other inconveniences suffered by said county on account of failure of the bidder to execute contract. It is understood that the party of the second part reserves the right to reject any and all bids.

The work proposed to be done shall be accepted in sections of.....miles each, when fully completed and finished to the entire satisfaction of the State Highway Engineer and after having been subjected to public team traffic for its entire length for a period of not less than thirty (30) days (except when the weather conditions have been such that the surfacing material could not be properly bonded and compacted, in which case the date of acceptance shall be delayed until ten (10) days after date of such rains as will in the opinion of the Engineer be sufficient to thoroughly bond and compact the surface.)

For the construction of this work the undersigned expects to use material from..... furnished by.....from the quarry pit at.....

The undersigned wishes to list in addition work of a similar character completed by him.

.....
.....

Signed.....

Address.....

SPECIAL PROPOSAL FOR BRIDGES

....., 191.....

To the.....of.....County, Texas.

The undersigned as bidder...., declare.... that the only person or parties interested in this proposal as principals are those named herein; that this proposal is made without collusion with any other person, firm, or corporation; that ...he... ha... carefully examined the attached form of contract, instructions to bidders, specifications, and the following plans.....

for proposed bridge over.....

near

and ha... carefully examined the location of the proposed work; and agree.... that ...he... will provide all the necessary machinery, tools, apparatus and other means of construction, and will do all the work and furnish all the materials called for in the contract, specifications and plans, in the manner prescribed therein and according to the requirements of the Engineer as therein set forth for the following prices:

Item 1. For the construction of a.....bridge as shown on the accompanying plan...., the lump sum of..... Dollars (\$.....).

Item 2. For additional concrete in foundations or wing walls, including all excavation, sheeting, and other incidentals thereto, the lump sum of..... Dollars (\$.....) per cubic yard.

Item 3. For any reduction in the quantity of the concrete in the foundations and wing walls, the lump sum shall be reduced by the sum of..... Dollars (\$.....) per cubic yard.

Item 4. Should it be found necessary to make extra fill on approaches, in addition to the material excavated from the foundations, such grading of approaches as ordered by the Engineer shall be measured in the embankment and shall be done for..... Dollars (\$.....) per cubic yard.

Item 5. Should it be found necessary to build and maintain a temporary bridge there shall be added to the lump sum mentioned above, the sum of..... Dollars (\$.....).

Item 6. Additional work that may be ordered by the Engineer at actual cost of labor and material plus.....per cent.

Item 7. If awarded this contract I we agree to begin work within..... day..., and to complete the work ready for use within.....day... from receipt of approved copy of contract, and I we further agree to furnish bond acceptable to the Texas State Highway Department and the Commissioners' Court of..... County, and to enter into contract within 10 days after receipt of notice of acceptance of this proposal.

Accompanying this proposal is a certified check payable to the order of.....
.....
of.....County, for..... Dollars (\$.....), which check is to become the property of the State as liquidated damages in lieu of actual damages, if, in case this proposal is accepted, the undersigned shall fail to furnish bond and execute contract with....., under the condition of this proposal and within the time provided, otherwise said check is to be returned to the undersigned.

It is understood that the party of the first part reserves the right to reject any and all bids.

(Signed).....

(Address).....

NOTE.—Copies of the above proposal may be secured at the Office of State Highway Engineer, Capitol Building, Austin, Texas. When alternate bids are received, or bids on more than one bridge, each bid shall be made out separately, one to each sheet, and shall be distinctly marked to conform with the notation on the plans.

CONTRACT

This agreement made this..... day of....., 19....., by and between..... County, Texas, represented by the Commissioners' Court, party of the first part, and

....., his their executor, administrators, heirs, successors or assignees, party of the second part; and subject to the approval of the Texas State Highway Commission.

WHEREAS the said County, known as the party of the first part desires to.....

..... for the improvement of the Road Bridge No....., Job No..... in the said county, commencing at Station..... near and extending thence to Station..... or as far as the money available will construct in accordance with the provisions of the State Statutes and of the notice to contractors, specifications, proposal, and plans marked..... annexed hereto, and made part hereof, and

WHEREAS the party of the second part has been engaged in and now does such work and is fully equipped, competent, and capable of performing the above desired and outlined work, and is ready and willing to perform such work in accordance with the provisions of the attached notice to contractors, specifications, proposal and plans, marked....., now

WITNESSETH: That for and in consideration of the prices and agreement mentioned in the proposal hereto attached and made part of this contract, the said contractor agrees to do, at his own proper cost and expense, all the work necessary for the improvement of Road Bridge No..... in..... County, in accordance with the provisions of the attached notice to contractors, specifications, proposal and plans which are made part of this contract, and in full compliance with all of the terms of the specifications and the requirements of the Engineer.

The said contractor further agrees to begin the work on or before..... 19....., to complete same not later than....., 19....., and to keep the Road Bridge during construction.

And said County in consideration of the full and true performance of the said work by said contractor, hereby agrees and binds itself to pay to said contractor the prices set forth in the attached proposal, and in the manner provided in the attached specifications.

IN WITNESS WHEREOF, the parties hereto have set their hands the date herein named.

Approved....., 19.....

.....County.....
Party of the first part.

By.....
County Judge.

.....
County Engineer.

.....
.....
.....

.....
County Commissioners.

Approved....., 19.....
State Highway Commission.

.....
Party of the Second Part.

By.....
State Highway Engineer.

By.....
(State Title)

CONTRACTOR'S BOND.

KNOW ALL MEN BY THESE PRESENTS, That we,.....

of County, and State of Texas, as

Principal....., and.....

of

as Surety, are held and firmly bound unto the County of, ~~of~~.....

....., State of Texas,

in the penal sum of..... Dollars,

(\$.....) Lawful money of the United States, to be paid to said County or to its certain attorneys or assigns, for which sums of money, well and truly to be paid, we bind ourselves, our heirs, successors, executors, and administrators, jointly and severally, firmly by these presents.

SEALED with our seals and dated this..... day of.....

A. D. 19.....

The condition of this obligation is such that if the said bounden principal.....

shall in all things well and truly perform all the terms and conditions of the foregoing contract, to be by them him performed, and within the time therein mentioned, and shall pay all lawful claims for labor performed in and about the construction of said Road Bridge, and shall have paid and discharged all liabilities for injuries which have been incurred in and about the said construction, under the operation of the Statutes of the State, then this obligation is to be void; otherwise to be and remain in full force and virtue.

Done in the presence of:

..... (Seal)

..... (Seal)

..... (Seal)

..... (Seal)

..... (Seal)

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