

# BRIDGE SECTION LIBRARY

*COUNTY OF TRAVIS*

**SPECIFICATIONS  
ROAD AND BRIDGE CONSTRUCTION**



**TEXAS DEPARTMENT OF TRANSPORTATION**

**COUNTY OF TRAVIS  
STATE OF TEXAS**

# **SPECIFICATIONS**

**ROAD AND BRIDGE CONSTRUCTION**

*Perry Park Road*

THE COUNTY OF TRAVIS  
STATE OF TEXAS

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SPECIFICATIONS

ROAD AND BRIDGE CONSTRUCTION

*C. 1120*

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GEO. S. MATTHEWS, County Judge

J. C. GILES,	- - - - -	Commissioner Precinct 1
J. R. RILEY,	- - - - -	Commissioner Precinct 2
H. E. BRODIE,	- - - - -	Commissioner Precinct 3
A. B. WILLIAMSON,	- - - - -	Commissioner Precinct 4

O. LEONARD, Engineer

# COUNTY OF TRAVIS—STATE OF TEXAS

## SPECIFICATIONS

### ITEM 1. DEFINITION OF TERMS

**1.1. 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:

Engineer.....	Engineer of Travis County, duly authorized by the County acting directly or through an assistant.
County.....	Party of the first part to this agreement.
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 drawings, profiles, etc., pertaining to work or to any structure connected with the work, which have been prepared by the Engineer and approved by the Commissioners Court.
Proposal.....	The offer of the bidder made out on the prescribed form giving prices for performing the work described in the plans and specifications.
Specifications.....	The directions and requirements, contained herein, together with all written agreements made, pertaining to the method or manner of performing the work or to quantities or qualities of materials to be furnished under the complete contract.
Contract.....	The agreement between the party of the first part and the party of the second part, including the advertisements for Proposals, Proposal, Instructions to Bidders, Approved Plans, General and Detail Specifications, the Specific Contract and Contract Bond, are intended to form a single instrument defining the agreement entered into between the two parties thereto.
Contract Bond.....	The approved form of security furnished by the contractor and his Surety as a guaranty of good faith on the part of the Contractor to execute the work in accordance with the terms of the Contract.

## ITEM 2. INSTRUCTION TO BIDDERS

**2.3. Estimate of Quantities.** The quantities listed in the estimate are the result of careful calculations, but are to be considered as approximate only.

Final 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.

And it is understood that the quantities of work to be done and materials to be furnished for each item of construction may be increased, or decreased, not exceeding in value twenty-five per cent of the total amount of work and materials, without in any way invalidating the bid prices. Should an increase or decrease of materials or quantities of work be made greater than twenty-five per cent of the estimated quantities shown in the contract, then adjustments in the payment for the portion of increased quantities over the twenty-five per cent mentioned above or the quantities as decreased, shall be made in accordance with the provisions of Par. 3.7.

**2.4. Examinations of Plans, Specifications and Site.** All bidders are required before submitting bids on the proposed work to visit the site of such proposed work and familiarize themselves with local conditions, the nature and extent of the work. They must also carefully examine the plans, specifications, special provisions, form of contract and bond before submitting bids on the work to be done. Professions of ignorance regarding the requirements of the work will in no way serve to modify the provisions of the contract.

**2.5. Certified Check to Accompany Proposal.** No proposal will be considered unless accompanied by a certified check, or cashier's check on a State or National Bank of the State of Texas payable to the order of the party named and to an amount stated in "Notice to Contractors."

If no award is made, all proposals will be rejected and all checks returned.

**2.6. Proposal Form.** Proposals must be made upon forms which may be obtained at the office of County Engineer, 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 or cashier's check.

**2.7. Method of Submitting Proposals and Time to Complete.** Sealed proposals must be signed properly and submitted as set forth in "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 the addresses must be given.

**2.8. Irregular Proposals.** Proposals may be rejected as being irregular if they show any omission, alterations, additions not called for, conditional bids or irregularities of any kind.

**2.9. Delivery of Proposals.** Proposals may be delivered in person by the Contractor or his 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."

**2.10. Withdrawal of Proposals.** No bid shall be withdrawn after having been filed, unless the request is made in writing prior to the opening of bids.

**2.11. 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.

**2.12. Disqualification of Bidders.** No bidder shall submit more than one proposal for any one piece of work outlined in the specifications and contract unless alternate bids are called for. All proposals not submitted in regular form and also unbalanced proposals will be rejected. Only sealed bids will be accepted.

**2.13. Award of Contract.** Contracts may 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.

**2.14. Return of Guaranty.** Certified checks or cashier's checks will be returned to the unsuccessful bidders within ten (10) days after contracts have been awarded.

**2.15. Contract and Bond.** The Contractor must execute and file a contract and a bond conforming to the requirements of Item 3.36 of these specifications, both executed on the forms hereto attached, with the party of the first part within fifteen (15) days after written notification of award of contract.

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

## ITEM 3. GENERAL PROVISIONS

**3.1. Subletting or Assignments.** No work is to be sublet or assigned by a Contractor without the written consent of the Engineer and written approval of the Commissioners Court.

**3.2. Patent Fees, Royalties, and License.** If the Contractor is required or desires to use any design, device, material or process covered by letters patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or owner, a copy of which agreement shall be filed with the Engineer; if no such agreement is made or filed as noted, the Contractor and the Surety shall indemnify and save harmless the County from any and all claims for infringement by reason of the use of any such patented design, device, trade mark, copyright, material or process, in connection with the work agreed to be performed under the contract, and shall indemnify the County for any costs, expenses and damages which either may be obliged to pay and shall defend all suits arising by reason of any such infringement, at any time during the prosecution of or after the completion of the work.

**3.3. Scope of Work.** The Contractor shall furnish, unless otherwise provided in "Special Provisions" of the Proposal and Contract hereto attached, 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.

**3.4. 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.

**3.5. 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.

**3.6. Alteration of Plans.** The right is reserved by the Engineer with the approval of the Commissioners Court, to make from time to time such alterations in the plans or in the character of the work as may be considered necessary or desirable to complete fully and perfectly the proposed construction provided such alterations do not change materially the original plans and specifications, and such alterations shall not be considered as a waiver of any conditions of the contract or bond nor to invalidate any of the provisions thereof. Should such alterations in the plans result in an increase or decrease not to exceed twenty-five per cent as mentioned in Section 2.3 of the quantity of work to be performed, the Contractor shall accept payment in full at the contract unit prices for the actual quantities of work done. No allowance will be made for anticipated profits.

**3.7. Extra Work and Force Account.** The Contractor shall perform extra work for which there is no quantity and price included in the contract or where increases or decreases in quantities beyond the limits set out in Par. 2.3 are made or whenever, to complete fully the work as contemplated, it is deemed necessary or desirable and such extra work shall be done in accordance with the specifications therefor, or in the best workmanlike manner as directed. This extra work will be paid for at a unit price or lump sum to be agreed upon previously in writing by the parties to this contract, or where such a price or sum cannot be agreed upon by both parties or where this method of payment is impracticable, the Engineer may order the Contractor to do such work on a "Force Account" basis.

All extra work done on a "Force Account" basis will be paid for in the following manner:

(a) For all labor, teams, and foreman in direct charge of the specific operation, the Contractor shall receive the current local rate of wage, to be agreed upon in writing before starting such work, for each and every hour that said labor, teams and foremen are actually engaged in such work, to which shall be added an amount equal to fifteen per centum (15%) of the sum thereof. No charge shall be made

by the Contractor for organization, overhead expense, nor shall any charge for superintendence be made except when there shall be necessarily employed on the proposed extra work at any time and in one place six (6) laborers or more in which case a foreman may be employed and his actual expense to the Contractor charged to the extra work for the actual time employed.

(b) For all materials used, the Contractor shall receive the actual cost of such materials including freight charges, as shown by original receipted bills.

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

The compensation as herein provided shall be received by the Contractor as payment in full for extra work done on a force account basis, and shall include superintendence, use of tools and equipment for which no rental is allowed, and profit. The Contractor's representative and the Inspector shall compare records of extra work done on a force account basis at the end of each day. Copies of these records shall be made upon suitable forms provided for this purpose, by the Inspector and signed by both the Inspector and the Contractor's representative, one copy being forwarded, respectively, to the Engineer and one to the Contractor. All claims for extra work done on a force account basis shall be submitted to the Engineer, by the Contractor upon certified statements to which shall be attached original receipted bills covering the cost of and the freight charges on all materials used in such work, and said statements shall be filed not later than the tenth (10th) day of the month following that in which the work was actually performed, and shall include all labor charges, etc., and material charges in so far as they can be verified.

**3.8. Unauthorized Work.** Work done by the Contractor not authorized under the plans and specifications or by the Engineer in charge in writing will not be paid for under the provisions of this Contract.

**3.9. 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 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 and in the manner specified in this Contract.

**3.10. 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 insubordinate, 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.

**3.11. Co-operation of Contractor.** The Contractor shall have in his possession a copy of all plans and specifications and shall familiarize himself with same. At all times and places where work is in progress the Contractor shall have a superintendent or head workman in charge upon the site as the Contractor's representative to receive and obey the orders of the Engineer.

**3.12. 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 ordi-

nances applying to the work in hand. 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.

**3.13. Public Convenience and Safety.** The Contractor, at all times shall conduct the work in such a manner as to insure the least possible obstruction to traffic. Materials stored upon the highway shall be placed so as to cause as little obstruction to the traveling public as possible. The Contractor will be required to maintain in a passable and safe condition such temporary roadways and structures as may be necessary for the accommodation of the traffic diverted from the roadway under construction and shall provide in safe condition approaches to the temporary structures and crossings of intersecting highways unless otherwise provided in the specifications and contract under "Special Provisions." The Contractor shall provide, erect, and maintain all necessary barricades, suitable and sufficient red lights, danger signals, and signs; provide a sufficient number of watchmen and take all necessary precautions for the protection of the work and safety of the public. Highways closed to traffic shall be protected by effective barricades, on which shall be placed acceptable warning signs. The Contractor shall provide and maintain acceptable warning and detour signs at all closures, intersections, and along the detour routes, directing the traffic around the closed portion or portions of the highways, so that the temporary detour route or routes shall be indicated clearly throughout its or their entire length or lengths. All barricades and obstructions shall be illuminated at night and all lights shall be kept burning from sunset until sunrise. When the use of explosives is necessary for the prosecution of the work, the Contractor shall use the utmost care, so as not to endanger life or property and whenever directed the number and size of the charges shall be reduced. All explosives shall be stored in a secure manner and all such places shall be marked clearly "DANGEROUS EXPLOSIVES" and shall be in care of competent watchmen at all times. (Subject to Federal regulations.)

**3.14. 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 damages or injury, all payments may be withheld until such work shall be completed to the satisfaction of the Commissioners Court.

**3.15. Responsibility Before Acceptance.** All depressions, defects and imperfections which may become evident in any portion of the roadway or structures 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.

**3.16. Inspection.** The Engineer or his representatives shall have at all times, free access to all parts of the work to all factories and warehouses, where materials are in process of manufacture, handling or stored. The Engineer may secure such samples as he desires. The Contractor shall give the Engineer adequate notice of the place of manufacture or purchase of materials so that they may be inspected at a suitable time and without delaying the work.

**3.17. 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.

**3.18. 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 other satisfactory material. If it is not necessary to replace this material, the Contractor shall not be paid for the excavation.

**3.19. 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.

**3.20. Lines and Grades.** The Contractor shall 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 shall be charged against the Contractor, to be deducted from any money due him.

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

**3.22. Inspection of Materials and Work.** On all Contracts for County road work the Contractor shall permit members of Commissioners Court to inspect the work at any time and shall, when requested, furnish them with any information pertaining to the work that they may desire.

**3.23. Examination of Work.** The Engineer, as provided in Pars. 2.1 and 2.2, 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 and 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.

**3.24. Defective Materials and Work.** All materials not conforming to the requirements of these specifications shall be considered as defective and all such materials, whether in place or not, shall be rejected and shall be removed immediately from the highway, unless otherwise permitted. No material which has been rejected, the defects of which have been corrected or removed shall be used until approval has been given. All work which has been rejected or condemned shall be remedied or, if necessary, removed and replaced in an acceptable manner by the Contractor at his own expense. Upon the failure of the Contractor to remove and properly dispose of rejected materials or work, and to replace the same immediately after receiving formal notice, the Engineer may employ labor and remove and replace such material or work and charge the cost of same to the Contractor, which shall be deducted from any money due him.

**3.25. Order and Sequence of Work.** The work shall be done at such points and in such order and sequence as the Engineer may direct. The Contractor shall notify the Engineer at a reasonable length of time in advance of the starting of any new work upon the project.

**3.26. Final Cleaning Up.** Before the work is accepted as fully complete, the Contractor shall complete the work in such a manner that the finished road will be smooth and true to cross-section, grade and alignment. All rubbish and surplus material shall be removed from the roadway, shoulders, culverts and ditches, leaving the roadway in a neat and presentable condition from end to end.

**3.27. Suspension of the 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.

**3.28. Method of Computing Time Allowance.** The computation of the number of consecutive working days shall start fifteen (15) days from the date of the approval of the contract. 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. 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 a proportionate amount as determined by the Engineer. In all cases the Engineer shall determine the number of days that the Contractor has been unavoidably delayed.

**3.29. Time of Completion and Liquidated Damages.** It is further agreed by the parties hereto that in case all the work called for under this contract, in all parts and requirements, is not finished or completed within the time specified in the Proposal and Contract, damage will be sustained by the party of the first part and that it is and will be difficult or impossible to ascertain and determine the actual damage which the party of the first part will sustain in the event of and by reason of such delay; and it is therefore agreed that said Contractor, party of the second part, will pay to the party of the first part as liquidated damages as provided in the following schedule:

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

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

**3.30. Annulment of Contract.** If the Contractor fails to begin the work under contract within the time specified, or fails to perform the work with sufficient workmen and equipment or with sufficient materials to insure the prompt completion of said work, or shall perform the work unsuitably or shall neglect or refuse to remove materials or perform anew such work as shall be rejected as defective or unsuitable, or shall discontinue the prosecution of the work, or if the Contractor shall become insolvent or be declared bankrupt, or commit any act of bankruptcy or insolvency, or allow any final judgment to stand against him unsatisfied for a period of forty-eight (48) hours, or shall make an assignment for the benefit of creditors, or from any other cause whatsoever shall not carry on the work in an acceptable manner, the Engineer shall give notice in writing to the Contractor and his Surety, of such delay, neglect or default, specifying the same, and if the Contractor, within a period of ten (10) days after such notice shall not proceed in accordance therewith, then the Commissioners Court shall, upon written certificate from the Engineer of the fact of such delay, neglect or default and the Contractor's failure to comply with such notice, have full power and authority, without violating the contract, to take the prosecution of the work out of the hands of the Contractor, to appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable and may enter into an agreement for the completion of said contract according to the terms and provisions thereof, or use such other methods as in their opinion shall be required for the completion of said contract in an acceptable manner. All costs and charges incurred by the County, together with the costs of completing the work under contract, shall be deducted from any money due or which may become due said Contractor. In case the expense so incurred by the County shall be less than the sum which would have been payable under

the contract, if it had been completed by said Contractor, then the said Contractor shall be entitled to receive the difference, and in case such expense shall exceed the sum which would have been payable under the contract, then the Contractor and the Surety shall be liable and shall pay to the County the amount of said excess.

**3.31. Measurement of Quantities.** All work done under these specifications will be measured in "U. S. Standard Measures."

**3.32. 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 satisfactory manner and according to the plans, specifications, and contract. All such payments do not constitute acceptance of said work.

**3.33. Partial Payments.** At the earliest possible date after the first day of each month, the Engineer will make current estimate in writing of the materials in place complete and the amount of work performed during the preceding month or period and the value thereof at the unit price contracted for, as shown in Proposal and Contract. In addition to the above, an estimate may be made for payment of seventy-five per cent of the value of the reinforcing steel, structural steel, crushed stone, gravel and paving brick delivered on the work and not used at the time of such estimate. 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, and ninety (90) per cent of the amount so ascertained shall be paid the Contractor.

The Contractor shall fully and promptly pay all bills incurred for labor performed or materials furnished on his contract or in connection therewith.

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

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

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

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

**3.36. Contractor's Bond.** The Contractor shall file as a guaranty of his faithful performance of said contract, and the payment of all obligations incurred for material and labor in the performance of this work a good and sufficient bond in compliance with Article 5623-A, Senate Bill No. 79, Chapter 143 of the 34th Legislature, 1915, which requires that for contracts less than \$1,000 a bond for full amount of contract be given; for those over \$1,000 and not over \$5,000, three-quarters of contract price; those over \$5,000 and not over \$100,000 one-half of contract price; those over \$100,000 one-third contract price be given. Said bond to be furnished by a Surety Company authorized to do business in the State of Texas, or responsible persons acceptable to the party of the first part. In the latter instance it is necessary that those signing the bond be certified as financially solvent to the full amount of bond.

**3.37. Work Limited to Amount of Money Available.** Before starting the work there shall be appropriated by the Commissioners Court out of the proper funds, an amount 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 Commissioners Court, and a copy of such agreement shall be furnished the Contractor. Provided, however, the increase or reduction in quantities as provided in Sections 2.3 and 3.7 may be made whenever the total cost of the work is not increased beyond the money appropriated for the work without such written agreement. If a reduction of appropriation is made in a manner other than hereinabove mentioned the Contractor shall have cause for court proceedings against the Commissioners for misappropriation of funds, and the said Commissioners shall be subject to penalties covering misappropriation of funds. The Contractor is hereby cautioned and warned and agrees that he will receive no greater amount for the work done than the amount appropriated therefor and all work done beyond that quantity which can not be paid for from appropriated money, shall be done at the Contractor's expense. Should the Engineer fail to keep the Contractor acquainted with the amount of money available then the Contractor should request such information whenever it is thought that the work done has nearly utilized the money available so that he may have sufficient time to stop the work before the appropriated money has been utilized. In case such information is not furnished the Contractor, he will be permitted to stop the work until the required information is obtained.

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

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

## ITEM 4. CLEARING AND GRUBBING

### CONSTRUCTION DETAILS

**4.1. Clearing.** The right-of-way must be cleared to the width shown on the plans, or to such width as shall be designated by the Engineer; all structures, fences, trees, brush, and all vegetable matter within the space designated shall be cut down, and the same, together with all logs, brush, wood, and trash shall be removed from the ground and disposed of, as the Engineer may direct, so as not to injure the adjoining lands or to obstruct the line of the fences along the boundaries of the said right-of-way. When the embankment exceeds two feet in height, it shall be required to cut the trees, brush and stumps close to the ground and so that tops of such stumps will be at least 18 inches below surface of the subgrade. Payment for clearing shall be made according to the price bid per acre.

**4.2. Light Clearing.** Where the trees are scattered and isolated and the work of clearing unusually light and where indicated on the plans, payment shall be made at the unit price bid per 100 foot station for light clearing. The removal of weeds, vines and small undergrowth from the right-of-way prior to starting of grading shall not be classed as clearing or light clearing, but shall be included and paid for under grading. The rebuilding of fences is not to be included in clearing, but will be done by the County's forces or by the Contractor under a separate agreement with the County.

**4.3. Grubbing.** All stumps, roots, wood or vegetable matter imbedded in the ground, within the space occupied by the roadbed and side drains, or any additional space deemed necessary by the Engineer, shall be grubbed up, removed and disposed of as the Engineer may direct; except where embankments are two feet or more in height, the stumps, roots, etc., may be cut close to the ground, and only the areas grubbed shall be estimated. Payment for grubbing shall be made according to the unit price bid per acre for grubbing.

**4.4. Light Grubbing.** Where the stumps to be grubbed are scattered and isolated and grubbing is of a very light nature, and where indicated on the plans, payment shall be made according to the unit price bid per 100 foot station for light grubbing.

**4.5. Basis of Payment.** Payment for "Clearing" shall be made at the unit contract price per acre; payment for "Light Clearing" shall be made at the unit contract price per 100 foot station; payment for "Grubbing" shall be made at the unit contract price per acre; payment for "Light Grubbing" shall be made at the unit contract price per 100 foot station.

## ITEM 5. EXCAVATION AND EMBANKMENT

**5.1. Description.** Excavation and Embankment shall consist of grading the roadway, stripping material pits, ditching, changing channels of streams and all other grading work in conformity with the plans, true to the lines and grades given. This work shall include all excavating for cuts, ditches, channels, etc., forming embankments, shaping and sloping, compacting and other work that may be necessary in bringing the roadway and its appurtenances to the required grade, alignment and cross-section, also the grading of all intersecting roadways, driveways and approaches. This work shall be done in accordance with these specifications.

**5.2. Classification.** Grading will be classified under the following heads, viz:

Solid rock excavation.  
Loose rock excavation.  
Earth excavation.

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

Loose rock excavation will include all slate or other rock which can be quarried or removed without blasting, also all detached rock or boulders measuring not less than one and one-half cubic feet nor more than one-half cubic yard each.

Earth excavation will include all loose stones, boulders, and other material of every description as found, which are not included in the above specifications as solid or loose rock.

**5.3. Roadway Excavation.** Roadway excavation shall include the removal and satisfactory disposal of all materials taken from within the limits of the work contracted for, necessary for the construction and preparation of the roadbed, embankment, sub-grade, shoulders, slopes, side ditches, trenches, waterways, intersections, approaches, private entrances, etc., as indicated and directed by the Engineer. All suitable materials removed from the excavations shall be used as far as practicable in the formation of the embankment, subgrade, shoulders, etc., and at such other places as directed by the Engineer. All breakage and slides shall be removed by the Contractor and disposed of as directed by the Engineer. Ditches and waterways shall be excavated to the depth and width shown on the plans, or as may be indicated and directed by the Engineer. No payment will be made for any excavated material which is used for purposes other than those designated. During the construction of the roadway the roadbed shall be maintained in such a condition that it will be well drained at all times.

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

**5.6. Disposal of Surplus Excavation Material.** All excavated material not required in the embankments shall be used for widening the shoulders and other purposes if directed, or this material and all material not permitted in the embankment, shoulders, etc., shall be removed from within the limits of the roadway and deposited at such point, or points, preferably below grade line, as directed by the Engineer. All surplus material shall be removed and disposed of before the subgrade rolling has been completed and before any construction materials shall be placed upon the roadway.

**5.7. (a) Borrow Excavation.** 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 contracted price per cubic yard for Excavation, which price will include all necessary work incidental thereto. When the amount of the embankment exceeds the amount of the excavation within the limits of the work contracted for, sufficient suitable materials to form or complete the embankment, subgrade, berms, etc., shall be obtained by the Contractor from borrow pits as directed by the Engineer, and included under the items of Excavation. The right of way for borrow pits will be furnished by the County. Borrow pits shall be excavated so that they can be properly drained.

(b) In general the amount of Borrow Excavation shall be arrived at by measurement of borrow pits. In cases where it is not practicable to measure the borrow pits to determine the yardage of Borrow Excavation, payments for this class of work shall be based upon the amount of the computed yardage within the embankment, as determined by cross-sections of the roadway taken before the borrowed material is placed, to which amount, in order to compensate for shrinkage, there shall be added the following percentages depending upon the height of the embankment.

The maintenance of embankments during construction shall be at the Contractor's expense.

**5.8. Haul and Overhaul.** The average length of haul shall be determined by locating the center of volume of the cut and the center of volume of the corresponding fill. If the center volume of the cut is more than two hundred (200) feet from the center of volume of the corresponding fill, overhaul will be allowed for the entire amount of material in the cut for the distance between the centers of volume in excess of two hundred (200) feet.

**5.9. Ditch and Channel Work.** All ditches and channels shall be excavated true to lines, grades and cross-sections as shown on plans or as ordered by the Engineer. Excavated material removed from ditches or channels and used in levees or embankments will be paid for once only and no "two way pay" will be allowed on this class of work. Overhaul on this material will be allowed on the same basis as on other grading work.

**5.10. Road Grader Work.** Where the material is suitable and the natural ground surface is fairly even and practically parallel to the subgrade line, the roadway and side ditch grading may be done with a road grader provided that the subgrade line is to be not over ten inches above, and the side ditches are not to be over eighteen inches in depth below the natural ground surface. Before the road grader work is started, all weeds, grass or rubbish of any nature shall be removed from within the limits of the section to be graded and disposed of as directed by the Engineer. Road grader work will include the construction of roadway ditches, but shall not include surface ditches and channel work outside the roadway proper, which work is provided for in Paragraph 5.9. All sections of road grader work shall be indicated on the plans, and no section shall be less than five consecutive stations.

**5.11. Graded Section.** The bottom of the excavation and the top of the fill when completed shall be known as the graded section and at all places shall be true to the lines, grades, and cross-sections as shown on the plans. All work in connection with the preparation thereof will be included in the contract price for "Excavation," or as "Road Grader Work."

**5.12. Method of Determining Excavation Quantities.** All excavation will be measured except as noted in Paragraph 5.7 in its original position by the cross-section method to ascertain the amount of material removed, which cross-sections will include all breakage or slides, not attributable to carelessness on the part of the Contractor, which have been removed.

**5.13. Basis of Payment.** Payments for the foregoing work will be made as follows:

a. Excavation. All "roadway excavation," including excavation of intersecting roadways, driveways, approaches, ditches, and waterways appertaining to the construction of the roadway will be paid for at the contract unit price per cubic yard for "Solid Rock Excavation," "Loose Rock Excavation" and "Earth Excavation," as the case may be, which price will include all excavation within the limits of the highway formation of embankments from excavations, disposal of surplus materials, and the furnishing of all equipment, tools, labor and work incidental thereto.

b. Excavation from borrow pits measured, either in the original position, or by cross-sections of the roadway in advance of the placing of the embankment material, shall be paid for at the contract unit price per cubic yard for "Earth Borrow Excavation."

c. Overhaul. Overhaul of excavation will be paid for at the contract unit price for over-haul excavation per cubic yard per one hundred (100) feet computed in the manner specified under the heading "Haul and Overhaul."

d. Road Grader Work. Road Grader Work will be paid for at the contract unit price per 100 foot station.

e. Rolling Embankment will be paid for at the contract unit price per cubic yard for "Embankment Rolling" and this price shall be in addition to the price paid for "Excavation."

## ITEM 6. UNDERDRAINS.

### STONE UNDERDRAIN.

**6.1. Description.** This underdrain shall consist of a trench of the dimensions shown on plans or as directed by the Engineer, filled with stones to the required depth, so as to produce voids through which water will drain.

**6.2. 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 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-quarter ( $\frac{3}{4}$ ) of an inch opening.

**6.3. Construction Methods.** Where indicated or directed, the Contractor shall excavate a trench of the required dimensions. The bottom of the trench shall be finished to the grade given, shall be smooth and firm, and tamped if necessary.

The bottom course stone shall be set carefully by hand, longitudinally with the trench, in vertical position, side by side, so as to give maximum voids. The vertical joints between ends of bottom course stone shall be staggered, and the bottom course in place shall 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 the required depth. The slabs shall be laid flat over the bottom course stone, to cover it as completely as practicable, with joints close and staggered and necessary voids filled carefully with stone or gravel, or the crushed or napped stone, or gravel may be used to fill this upper part of the trench when the slabs are not available. The remainder of the trench 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.

**6.4. 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 of the trench and the disposal of surplus material.

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

### VITRIFIED TILE UNDERDRAIN.

**6.5. Description.** This underdrain shall consist of vitrified clay pipe of the diameter shown on the plans laid with open joints covered with tar paper on a layer of stone or coarse gravel in a trench of dimensions shown on the plans or as directed by the Engineer. After which the trench shall be filled with broken stone or coarse gravel for an additional depth as shown on the plans or as directed by the Engineer.

**6.6. 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.

**6.7. Stone.** The stone for the bottom of the trench shall be composed of clean, tough, durable, approved, crushed rock or gravel of such size as will pass over a revolving screen having circular open-

ings 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.

**6.8. 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 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 upgrade and the spigot end fully entered into the adjacent hub. The pipe joints shall then be covered with approved two (2) ply tar 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 the required depth above the bottom of the pipe. The remainder of the trench shall be filled with suitable earth which shall be tamped in layers of 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.

**6.9. 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.

#### VITRIFIED TILE OUTLETS FOR UNDERDRAINS.

**6.10. 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.

**6.11. Pipe.** This pipe shall meet the requirements of Paragraph 6.6 for "Vitrified Tile Underdrain."

**6.12. Mortar.** The mortar for cementing the joints shall be composed of one (1) part of Portland cement, meeting the requirements of Item 13 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.

**6.13. Construction Methods.** The trench shall be excavated to the lines and grades given, and the bottom of the trench shall be uniformly firm and smooth, and recesses shall be excavated to receive the hubs.

The pipe shall be laid carefully and firmly upon the bottom of the trench with the hub end upgrade and the spigot end fully entered into the adjacent hub. The joints shall be calked with cement mortar and after each joint is filled and finished on the outside, it shall be wiped clean on the inside.

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.

**6.14. 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 excavations, 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 7. SAND-CLAY SURFACING

**7.1. 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.

**7.2. 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 mixture for surfacing. Stones over 2 inches in diameter must be removed.

(b) Sand. For an artificial mixture of sand and clay, or where the sand 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 slaking and shrinking satisfactory to the Engineer, and shall have good binding qualities.

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

**7.4. Preparation of Subgrade.** The graded roadbed shall be shaped to the elevation, alignment, and cross-section indicated for subgrade 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 also shall be formed where a natural mixture is to be used.

**7.5. 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 roadbed has been shaped as specified in Paragraph 7.4 the clay shall be spread over the part of the roadway as indicated on the plans in such quantities and to

such a depth, that when mixed with the sand, a compacted surfacing of.....inches in thickness and

.....feet in width 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 and clay is about two to one, or in sufficient quantity so that the clay will slightly more than fill the voids of the sand. 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 7.5 (a), except that the surface shall be plowed to a depth of four inches after which it shall be harrowed until completely pulverized and then sand is spread over the graded roadbed, 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 roadbed. 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.

(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 roadbed material consists of clay which, in the opinion of the Engineer, is not considered suitable for use in the surface, the sand layer shall be spread first, and of a depth more than is sufficient for use in surfacing. 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 7.5 (a).

(d) Top Soil or Other Natural Sand-Clay Mixture. After the roadbed 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 2 inches in diameter. The plowing, harrowing, shaping, and other work shall be as specified in Paragraph 7.5 (a).

In all cases, in order to obtain the best results, only sufficient clay to fill the voids of the sand shall 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, 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.

**7.6. 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.

**7.7. Measurement of Materials.** Sand, clay, natural sand-clay or other surfacing material hauled to the work and incorporated in the surface shall be paid for by the cubic yard. Measurement

of this material shall be made at the end of the haul and immediately before the material is unloaded or dumped on the road. No allowance will be made for waste or shrinkage of material during its transportation from the pit, car or other point of loading to the unloading point. The checker or inspector will inspect each load and check its yardage as it arrives at the unloading point. For each load of satisfactory material delivered at the unloading point, the checker will give to the driver a check or receipt upon which shall be written the correct yardage delivered in his load and the station numbers between which the load was delivered, and each receipt shall bear the full signature of the checker issuing it.

The Contractor shall so space his unloading points that the required amounts of material, as ordered by the Engineer, shall be delivered in each 100-foot station and he shall be responsible for the uniform distribution of the material throughout the length of the station.

**7.8. Basis of Payment.** The sand, clay, natural sand-clay or other surfacing material used upon this work and furnished by the Contractor shall be paid for at the contract unit price per cubic yard delivered on the work and measured as specified in Paragraph 7.7.

Hauling surfacing will be paid for at the unit price per cubic yard per one-fourth mile haul, and the price for the first one-fourth mile haul will include the loading, unloading, spreading, shaping, mixing, all preparation of subgrade other than rolling and the maintaining of the finished surface. The price for the second, third, fourth, fifth, sixth, seventh and eighth quarters shall be bid on and listed separately. The price for hauling the ninth and additional quarters above the ninth quarter shall be listed together and bid on as "Additional cubic yards— $\frac{1}{4}$ -mile haul above and including the ninth  $\frac{1}{4}$  mile."

Where all materials are found along the line grade and construction comprises only the placing and mixing of the materials at hand, the surfacing shall be paid for at the contract unit price per square yard for "Constructing Sand-Clay Surface."

Where clearing and grubbing of material pits is necessary it will be paid for at the contract unit prices for "Clearing" and "Grubbing" as listed in the "Proposal."

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

## ITEM 10. GRAVEL

**10.1. 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. Preferably the surfacing shall be placed in only one layer except where different kinds of material are to be used for the different 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.

**10.2. Gravel.** The gravel shall consist of hard, durable particles of stone mixed with sand and clay or other binding material, at least 95 per cent of which will pass through a  $3\frac{1}{2}$ -inch mesh screen.

Not less than.....per cent nor more than.....per cent, by weight, of the gravel shall consist of stone particles sufficiently large to be retained on a  $\frac{1}{4}$ -inch mesh screen. Gravel material shall be approved by the Engineer before being used in the work.

The material passing a  $\frac{1}{4}$ -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  $\frac{1}{4}$ -inch mesh screen shall be graded from fine to coarse so that not more than.....per cent and not less than.....per cent will pass a  $\frac{3}{4}$ -inch mesh screen.

Should the material contain stone that is retained on a three-inch mesh screen not to exceed 5 per cent, such stone must be thrown out at the expense of the Contractor at the pit or during the process of harrowing. Stones thrown out from surfacing material after same has been hauled onto the road shall be gathered up and disposed of at the Contractor's expense, and as ordered by the Engineer. If the amount of stone retained on a  $3\frac{1}{2}$ -inch mesh screen exceeds 5 per cent, then the Contractor will be required to screen all of the material, which work will be paid for at the prices bid per cubic yard for screening.

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.

**10.3. 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 or other binding material shall be added to secure a proper bond. The binding material shall be either intimately mixed with the gravel at the pit, or it shall be spread uniformly over the graveled surface before harrowing has been finished and before the surface has been sprinkled or rolled and shall be mixed into the surface by thorough harrowing and 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.

**10.4. Preparation of Subgrade.** The graded roadbed shall be shaped to the elevation, alignment and cross-section shown on the plans. After this is done the subgrade shall be shaped for receiving the surfacing as shown on the plans, and then rolled, when necessary, in the opinion of the Engineer, 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 subgrade shall be at least as high as the gravel will reach when loose, and the Contractor will be required to maintain them at this height until all the gravel has been placed.

**10.5. Sledged Stone, Crushed Stone, Gravel.** In localities where suitable material is available and where the nature of the material composing the subgrade is such as to make it desirable, a sub-base may be constructed upon the subgrade before the gravel surfacing is placed, if so specified. (a) Sledged Stone Sub-Base. Material for this work shall be approved by the Engineer and shall consist of spauls or stones of medium hardness, and when delivered on the work shall not contain more than 20 per cent of dust or fine material which will pass a  $\frac{1}{2}$ -inch mesh screen. This material shall be spread uniformly over the prepared subgrade after which the stone shall be broken with sledges until there shall remain no stones larger than six inches in their largest dimension. When the sledging has been finished, the surface shall be gone over and stones rearranged so as to restore the uniform distribution of the material after which the surface shall be thoroughly rolled to the satisfaction of the Engineer with a roller weighing not less than ten tons. The specifications for the other types of sub-base are as follows: (b) Crushed Stone, Par. 11.17; (c) Gravel, Item 10.

**10.6. Measurements of Materials.** Gravel, clay, sand, stone, or other material hauled to the work and incorporated in the surface shall be paid for by the cubic yard. Measurement of this material shall be made at the end of the haul and immediately before the material is unloaded or dumped onto the road. No allowance will be made for waste or shrinkage of material during its transportation from the pit, quarry, car or other point of loading to the unloading point. The checker or inspector will inspect each load and check its yardage as it arrives at the unloading point. For each load of satisfactory material delivered at the unloading point, the checker will give to the driver a check or receipt upon which shall be written the correct yardage delivered in his load and the station numbers between which the load was delivered, and each receipt shall bear the full signature of the checker issuing it.

The Contractor shall so space his unloading points that the required amount of material, as ordered by the Engineer, shall be delivered in each 100-foot station and he shall be responsible for the uniform distribution of the material throughout the length of the station.

**10.7. One-Course Gravel Surfacing.** The Contractor shall load, haul and spread upon the subgrade, prepared as hereinbefore described, the gravel, which shall have an average loose depth of..... inches, and which, after compacting, shall produce a surface of the required thickness as shown on plans. The depth may be slightly varied at the discretion of the Engineer, and with the approval of the Commissioners Court, depending upon the nature of the soil encountered in the subgrade. The gravel surface shall be constructed of the width shown on the plans.

After the gravel has been dumped upon the road as specified under Item 10.6, the Contractor shall carefully spread the material, preferably with shovels, by hand. Material must be spread on same day as hauled. If so specified the stones larger than  $3\frac{1}{2}$  inches may be worked to the sides of the prepared subgrade and placed in a specially prepared furrow, opened up immediately adjacent to the earth shoulders. If this method of disposing of the larger stones is adopted, the furrow shall be opened up after the subgrade is shaped and rolled, and shall be approximately four inches deeper than the prepared subgrade.

The gravel surface shall be shaped and maintained to the specified cross-section by dragging and grading until the traffic has caused it to properly set up. Should any depressions or weak spots develop during the process of setting up a second or patching course shall be added and the whole surface shall be maintained with grader or drags until it is uniformly smooth and firm and until the work is received by the Engineer.

After the gravel has been harrowed, mixed and shaped, should the material or the traffic conditions make it advisable, and if ordered by the Engineer, the surface shall be thoroughly compacted.

**10.8. Two-Course Gravel Surfacing.** The two-course gravel surfacing shall be constructed between the points shown on the plans or as directed by the Engineer. The first course shall have an

average loose depth of .....inches, and the second course a loose depth of.....inches, both of which courses after being compacted shall produce a surface of the average thickness shown on plans. The depth of the bottom course may be slightly varied at the discretion of the Engineer, and with the approval of the Commissioners Court, depending upon the nature of the soil encountered in the subgrade.

(a) 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 4-inch mesh screen. This gravel shall be spread

uniformly to average depth of.....inches which depth shall compact to not less than..... inches. This specified depth shall be obtained by spreading uniformly upon each 100-foot station of prepared subgrade, the yardage of gravel necessary to make up this depth. 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 carefully shaped to the specified cross-section, and maintained to this section by the use of grading machines or road drags until the surface has set up smooth and firm. Should it be considered by the Engineer advisable to place the second course immediately after placing the first course and before same has been sufficiently subjected to traffic to compact it thoroughly, the first course shall be 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 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 before the second course is placed.

(b) Reshaping Shoulders. After spreading and rolling the first course as specified 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.

(c) 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

two inches in diameter. No. 2 gravel shall be spread uniformly to a depth of.....inches as shown on plans or as directed by the Engineer as for first course gravel. This gravel shall be harrowed and compacted 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. Material in both courses must be spread on same day as hauled.

**10.9. 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 10 inches wide and 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 downhill and shall be cut through to the center of the roadbed.

**10.10. 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, if directed by the Engineer, the surface shall be sanded with course sand. The roller shall not weigh less than 10 tons.

**10.11. Crown.** The finished road shall have a uniform crown as shown on plans.

**10.12. Basis of Payment.** Hauling surfacing will be paid for at the unit price per cubic yard per one-fourth-mile haul, and the price for the first one-fourth-mile haul will include the loading, unloading, spreading, harrowing, shaping, mixing, all preparation of subgrade other than rolling and the maintaining of the finished surface. The price for the second, third, fourth, fifth, sixth, seventh and eighth quarters shall be bid on and listed separately. The price for hauling the ninth and additional quarters above the ninth quarter shall be listed together and bid on as "Additional cubic yards— $\frac{1}{4}$ -mile haul above and including the ninth  $\frac{1}{4}$  mile."

Sprinkling will be paid for per 1000 gallons for first one-mile haul, including cost of water. Each additional mile hauled will be paid for at the contract unit price for "1000 gallons additional 1-mile haul."

Rolling subgrade, surfacing and shoulders will be paid for at the contract unit price bid per hour of actual time roller is working and this price shall include all machinery, tools, fuel, equipment, labor and expenses incidental to operating the roller.

Where side drains are constructed, the ditching, placing the stone and filling with earth, sod or straw, shall be paid for at the unit price bid per linear foot for "constructing side drains." The stone or gravel filling material will be taken from the material hauled onto the road for surfacing and will be paid for at the same rate as for surfacing gravel.

Sledged Stone Sub-Base or other Sub-Base Material will be paid for at the unit price bid per cubic yard on the same basis as is specified for payment for other surfacing.

Screening Gravel will be paid for at the unit price bid per cubic yard for screening gravel, and screened gravel shall be measured at point of delivery on the work as specified under Item 10.6.

Surfacing material furnished by the Contractor whether shipped or taken from local pits, will be paid for at the contract unit price per cubic yard and measurement will be made at point of delivery upon the work as provided under Item 10.6.

# ITEM 11. CRUSHED STONE BASE AND SURFACING

## WATERBOUND MACADAM BASE.

**11.0. Definition.** Waterbound Macadam Base shall be construed to mean all surfacing of stone intended to serve as a base for a bituminous surface treatment built in successive courses of crushed and screened material, bound by the interlocking of the coarse parts through rolling, the filling of the voids with the finer material, and the cementation of the whole by flushing with water.

The following sizes of crushed and screened stone are standard:

No. 1 stone ranging in size from 2 in. to  $3\frac{1}{2}$  in.

No. 2 stone ranging in size from  $\frac{3}{4}$  in. to 2 in.

No. 3 stone ranging in size from  $\frac{1}{4}$  in. to  $\frac{3}{4}$  in.

No. 4 stone ranging in size from dust to  $\frac{1}{4}$  in.

**11.1. Materials.** The material for waterbound macadam base shall consist of broken stone of uniform quality throughout, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter. The material shall possess a French coefficient of wear of not less than eight (8) and a compressive strength of not less than 8500 pounds per square inch.

Screenings shall consist of No. 3 and 4 stone, and shall further be described as being that portion of the product of the crusher including the dust of fracture, which, when tested by means of laboratory screens will meet the following requirements:

Passing  $\frac{3}{4}$ -inch screen not less than 95 per cent.

Total passing  $\frac{1}{4}$ -inch screen, 40 to 80 per cent.

The top course shall consist of No. 2 stone and when tested by means of laboratory screens shall meet the following requirements:

Passing 2-inch screen, 95 per cent.

Total passing  $1\frac{1}{2}$ -inch screen, 25 to 75 per cent.

Retained on  $\frac{3}{4}$ -inch screen, not less than 85 per cent.

The bottom course shall consist of No. 1 stone, and when tested by means of laboratory screens shall meet the following requirements:

Passing  $3\frac{1}{2}$ -inch screen, not less than 95 per cent.

Total passing  $2\frac{1}{2}$ -inch screen, 25 to 75 per cent.

Retained on 2-inch screen, not less than 85 per cent.

**11.2. Rolling.** Whenever it is provided in these specifications that the road, subgrade materials, or shoulders shall be rolled, a self-propelled roller, weighing not less than ten tons and not more than 12 tons shall be used. Rolling shall be done in a longitudinal direction, beginning at the sides and moving gradually to the crown of the roadway.

**11.3. Trench and Shoulders.** After the road has been graded and shaped to the required dimensions, the subgrade or trench shall be cut in the finished grade of a sufficient width and depth to retain the surfacing materials as shown on the standard cross-section sheet showing construction details. This work shall be classified and paid for under "Placing Surfacing." In no case are the shoulders to be built up on top of the grade unless so ordered by the Engineer.

**11.4. Hand Work.** After all possible road machine trenching has been done, 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.

**11.6. Sledged Stone, Crushed Stone, and Gravel.** In localities where suitable material is available and where the nature of the material composing the subgrade is such as to make it desirable and where specified on the plans, a sub-base may be constructed upon the subgrade before the stone surfacing is placed. (a) Sledged Stone Sub-base material for this work shall be approved by the Engineer and shall consist of spauls or stones of medium hardness. When delivered on the work, stone shall not contain more than 20 per cent of dust or fine material which will pass a  $\frac{1}{2}$ -inch mesh screen. This material shall be spread uniformly and to the required depth over the prepared subgrade after which the stones shall be broken with sledges until there shall remain no stone larger than six inches in its longest dimension. When the sledging has been finished, the surface shall be gone over and stones rearranged so as to restore the uniform distribution of the material. The surface shall then be thoroughly rolled to the satisfaction of the Engineer with a roller weighing not less than ten tons. Should any depressions or hollows develop during the process of rolling they shall be filled with stone material and again rolled until the surface is uniform, smooth and firm. The specifications for the other types of sub-base are to conform to the following: (b) Crushed Stone, Par. 11.17, (c) Gravel, Item 10.

**11.7. 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, at intervals designated by the Engineer. The trenches shall be cut ten inches in width and 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 with such material and in such amount as is designated by the Engineer. For the filling material for side drains payment shall be made for hauling and placing on the same basis as for surfacing material.

**11.8. 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 is shaped and compacted. Should any unevenness or depressions occur upon rolling the first course, they shall be filled and levelled immediately with first course material and re-rolled. In no case shall first course material be placed upon a muddy subgrade.

**11.9. Second Course.** The second course shall consist of a layer of No. 2 stone spread evenly over the bottom course in a quantity sufficient to fill all voids. Any excess of stone shall be removed from the surface which shall then be rolled until the stone is thoroughly keyed together and the surface conforms to the cross-section shown on the plans. Rolling shall continue until the stone does not creep or wave ahead of the roller.

**11.10. Third Course.** During the finishing process of dry rolling described above, a mixture of screenings (No. 3 stone) and dust (No. 4 stone), shall be applied gradually over the surface in such an amount as will completely fill the voids. The screenings shall not be dumped on the surface of the stone, but shall be cast thinly with a sweeping motion of the shovel from piles at the roadside. The rolling shall continue while the screenings are being spread, so that the jarring effect of the roller will aid them in settling to the bottom. The screenings shall not be allowed to cake or bridge on the surface of the stone in such a manner as to prevent the perfect filling of all voids and the direct bearing of the roller on the face of the stone. The screenings shall be swept in with rattan or other fiber brooms. The spreading and rolling shall continue until no more screenings will go in dry. No excess of screenings shall be used before applying water. Immediately after the voids of a section of the macadam have been filled with screenings the macadam shall be sprinkled until saturated, the sprinkler being followed by the roller. More screenings shall be added if necessary. The sprinkling, sweeping and rolling shall continue until a grout has been formed of the screenings and water, that will fill all the voids and will form a wave of grout before the wheels of the roller. The macadam shall be kept wet at least twenty-four hours before the final rolling, and it shall be puddled as many times as may be necessary to secure satisfactory results.

**11.11. Closing the Road.** Travel shall be kept off of the newly finished portion of the roadway until the surface is, in the opinion of the Engineer, compacted and cemented enough to use.

After the road is thrown open to traffic, the sprinkling and rolling shall continue until, in the opinion of the Engineer, the road is thoroughly compacted and cemented.

**11.12. Trimming Shoulders.** After the road is thoroughly compacted and cemented, 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.

#### CRUSHER-RUN, CRUSHED STONE SURFACING.

**11.13. Definition.** Crusher-Run Crushed Stone Surfacing shall be construed to mean all stone surfacing constructed of crushed stone used as it comes from the crusher, without screening, or with only partial screening, and by methods similar to those used in constructing a gravel surfaced road.

**11.14. Material.** Stone for this class of construction shall have a crushing strength of at least 8500 pounds per square inch and a French coefficient of wear of at least eight (8). Stone shall be of such a nature that its dust of fracture, including all material passing a  $\frac{1}{4}$ -inch mesh screen will, when tested in the manner described in Bulletin No. 347 of the U. S. Department of Agriculture, show a cementing value of not less than 50.

The material retained on a  $\frac{1}{4}$ -inch mesh screen shall be graded from fine to coarse so that not more than 40 per cent nor less than 20 per cent will pass a  $\frac{3}{4}$ -inch mesh screen. All stone shall pass a 3-inch screen.

**11.15. Preparation of Material.** Stone for this class of surfacing shall be crushed to such sizes that all will pass a 3-inch mesh screen. Over size stones shall be screened out and either wasted or again passed through the crusher. A quantity of the crushed stone passing a  $\frac{3}{4}$ -inch mesh screen, to be known as screenings, not to exceed 10 per cent of the whole crusher product under 3 inches in size, shall be screened out or secured from other sources and stored in separate bins or piles to be used as a filler.

**11.16. Placing Surfacing.** After the subgrade has been prepared as specified under Items 11.3, 11.4, 11.5 and if necessary 11.6 and 11.7, the crusher run stone material shall be delivered on to the road in flat bottomed wagons and uniformly dumped upon the base in such quantities that when spread

a surface of.....inches thick, loose measurement will be produced. In case the surfacing is to be constructed wider than 12 feet the material shall be dumped upon the subgrade in two rows. After being dumped upon the road the material shall be spread and carefully shaped to a uniform thickness and cross-section and to the satisfaction of the Engineer. Each day's hauling of stone shall be spread the same day.

After being carefully spread and shaped the material shall be thoroughly rolled with a roller weighing not less than 10 tons nor more than 12 tons, and the first rolling shall include the rolling of the shoulders. After the first rolling, screenings shall be hauled, dumped upon the shoulders or shoveled directly from the wagons and spread over the surface in sufficient quantities to fill all the voids and to bring up to the proper elevation all the depressions that may have developed during rolling. In no case shall the screenings be dumped from the wagons onto the surface of the stone but they shall be cast thinly with a sweeping motion of the shovel. Rolling shall continue while the screenings are being spread. Should the weather conditions and the condition of the surfacing material be such that, in the opinion of the Engineer, sprinkling is necessary, the surface shall be thoroughly wetted during the final

rolling and the rolling and sprinkling shall continue until the surface is thoroughly compacted and bonded to the satisfaction of the Engineer. The Contractor shall maintain the surface until the final acceptance of the work.

The provisions and requirements of Items 11.12 and 11.11 shall apply also to the construction of Crusher-Run Crushed Stone Surfacing.

#### CRUSHED STONE BASE FOR BITUMINOUS PAVEMENTS.

**11.17. Foundation.** After the subgrade has been completed, the foundation of broken stone consisting of stone that will pass through a ring three (3) inches in diameter, and be retained on a ring one and one-half ( $1\frac{1}{2}$ ) inches in diameter, shall be deposited in a uniform layer having a depth as shown on plans or as directed by the Engineer, and rolled repeatedly with a ten (10) ton standard self-propelled macadam roller until compacted to the satisfaction of the Engineer.

Pieces of stone larger than above specified may be used provided they are separated and laid in a layer at the bottom of the foundation, and the surface dressed with stone of the sizes above specified.

The depth of loose stone in this course must be measured by blocks the required thickness of said loose stone. These blocks must be placed at frequent intervals on subgrade when the loose stone is being spread.

**11.18. Binder.** After thorough rolling of the foundation a quantity of stone screenings or sand shall be spread in a uniform layer, and the whole rolled until the stone ceases to sink or creep in front of the roller. The quantity and quality of this binder is to be subject to the approval of the Engineer. Gravel found along the line of the road or furnished by the contractor, of a quality approved by the Engineer, may be used instead of the stone screenings or sand as a binder. No binder shall be applied in such a quantity as will completely cover or form a coating upon this course of stone, but the angular particles of stone in the first course shall protrude above the binder, making an angular surfaced foundation to form a bond for the wearing surface.

#### MEASUREMENT AND BASIS OF PAYMENT—CRUSHED STONE PAVEMENT WORK.

**11.19. Measurement of Material.** Crushed stone, stone screenings, or other surfacing material hauled to the work and incorporated in the surface shall be paid for by the cubic yard. Measurement of this material shall be made at the end of the haul and immediately before the material is unloaded at the roadside or dumped onto the road. No allowance will be made for waste or shrinkage of material during its transportation from the pit, quarry, car or other point of loading to the unloading point. The checker or inspector will inspect each load and check its yardage as it arrives at the unloading point. For each load of satisfactory material delivered at the unloading point, the checker will give to the driver a check or receipt upon which shall be written the correct yardage delivered in his load and the station numbers between which the load is delivered, and each receipt shall bear the full signature of the checker issuing it.

The Contractor shall so space his unloading points that the required amount of material, as ordered by the Engineer, shall be delivered in each 100 foot station and he shall be responsible for the uniform distribution of the material throughout the length of the station.

**11.20. Basis of Payment.** (a) Payment for "Material" will be made on a cubic yard basis for measurement in wagons or trucks at the point of delivery as specified under Item 11.19.

(b) Payment for "Hauling Material" for first quarter mile will be made on the cubic yard basis which shall include loading, dumping, spreading, rolling of subgrade and stone, shaping of trench, surfacing of stone and brooming.

(c) In case the Contractor furnishes the material, Item 11.20 (a) and 11.20 (b) shall be combined.

(d) The "Haul" in the second, third, fourth, fifth, sixth, seventh and eighth quarters shall be listed and paid for separately at the unit contract price for the haul in each respective quarter. The yardage hauled through the ninth and additional quarters above the ninth quarter shall be listed together and bid on as additional cubic yards one-fourth mile hauled above and including the ninth one-fourth mile.

(e) "Water for Sprinkling" shall be paid for per 1000 gallons for furnishing, loading, hauling one mile and distributing. Additional haul of water beyond the first one mile shall be paid for at the unit contract price per 1000 gallons hauled additional one mile.

(f) "Side Drains" shall be paid for at the contract unit price per lineal foot for "constructing side drains."

## ITEM 12. BITUMINOUS SURFACE TREATMENT AND INVERTED PENETRATION TOP

**12.1. Description.** Bituminous Surface Treatment and Inverted Penetration Top shall consist of treating shell, gravel, waterbound macadam, and other types of road surfaces with one or more applications of bituminous material or with a surfacing course of rock asphalt in accordance with one of the following:

(a) Single bituminous application using bituminous material as specified under Par. 12.2.....  
and cover material as specified under Par 12.3.....

(b) Two or more bituminous applications, using for the first application bituminous material as specified under Par. 12.2.....and cover material as specified under Par. 12.3.....  
and using for the second application bituminous material as specified under Par. 12.2.....  
and cover material as specified under Par. 12.3.....

.....  
.....  
.....  
(c) Limestone Rock Asphalt Surfacing of.....thickness using bituminous material as specified under Par. 12.2.....as a flux.

**12.2. Bituminous Material.** The Bituminous Material to be used in this work shall be of approved quality and shall meet the requirements specified below. The class of material to be used on this work shall be as hereinafter specified.

### (a) REFINED COAL TAR PRODUCTS.

(Hot Applications.)

1. The tar shall be homogeneous and free from water.
2. Specific gravity 25° C./25° C. (77° F./77° F.) from 1.20 to 1.27.
3. Consistency.—Float test 50° C., 35 seconds to 80 seconds.
4. Total bitumen (soluble in CS<sub>2</sub>) not less than 85 per cent.
5. Free Carbon.—Not more than 15 per cent.
6. Total distillates, by weight:
  - To 170° C. not to exceed 0.5 per cent.
  - To 270° C. not to exceed 15 per cent.
  - To 300° C. not to exceed 20 per cent.

### (b) REFINED COAL TAR PRODUCTS.

(Cold Applications.)

1. The tar shall be homogeneous.
2. The specific gravity 25° C./25° C. (77° F./77° F.), 1.14 to 1.18.

3. Specific viscosity (Engler) 50° C., 5 to 15.
4. Free carbon from 4 to 12 per cent.
5. Total bitumen (soluble in CS<sub>2</sub>), 88 to 96 per cent.
6. Total distillates by weight:
  - Up to 110° C. not to exceed 1.0 per cent.
  - Up to 170° C. not to exceed 5.0 per cent.
  - Up to 300° C. not to exceed 30 per cent.

#### METHODS OF TESTING.

Tests of the physical and chemical properties of the tar shall be in accordance with the following methods:

1. Specific gravity, Department of Agriculture, Bulletin 314, p. 4.
2. Specific viscosity (on first 50 c.c.), U. S. Department of Agriculture, Bulletin 314, p. 7.
3. Distillation test, A. S. T. M. Standard Test D-20-16.
4. Total bitumen, U. S. Department of Agriculture, Bulletin 314, p. 25.

#### (c) ASPHALTIC OIL—CLASS A.

The oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.)

1. Specific gravity 25° C./25° C. (77° F./77° F.), not less than 1.000.
2. Flash point not less than 200° C. (392° F.)
3. Melting point 30° C. (86° F.) to 50° C. (122° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec.—250 to 300.
5. Loss at 163° C. (325° F.) 5 hours—2 to 5 per cent.
  - (a) Penetration of residue at 25° C. (77° F.), 100 g., 5 sec.—not less than 150.
6. Total bitumen (soluble in carbon disulphide), not less than 99.5 per cent.
7. Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C. in melting point within the test limits above specified.
8. Organic matter insoluble—not more than 0.2 per cent.

#### (d) ASPHALTIC OIL—CLASS AA.

It shall meet the following requirements:

The oil asphalt shall be homogeneous, free from water and shall not foam when heated to 175° C. (347° F.)

1. Specific gravity 25° C./25° C. (77° F./77° F.), not less than 1.000.
2. Flash point not less than 200° C. (392° F.)
3. Melting point 30° C. (86° F.) to 50° C. (122° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec.—250 to 300.
5. Loss at 163° C. (325° F.), 5 hours—less than 5 per cent.
  - (a) Penetration of residue at 25° C. (77° F.), 100 g., 5 sec.—not less than 150.
6. Total bitumen (soluble in carbon disulphide), not less than 99.5 per cent.
7. Organic matter insoluble—not more than 0.2 per cent.
8. Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10° C., in melting point within the test limits above specified.

#### (e) ASPHALTIC OIL—CLASS B.

The oil asphalt shall be homogeneous and free from water.

1. Specific gravity 25° C./25° C. (77° F./77° F.), not less than 0.990.
2. Flash point not less than 150° C. (302° F.)
3. Float test 50° C. (122° F.), 100 to 150 seconds.

4. Loss at 163° C. (325° F.), 5 hours, from 4 to 8 per cent.
5. Total bitumen (insoluble in carbon disulphide), not less than 99.5 per cent.
6. Organic matter insoluble, not more than 0.2 per cent.
7. Total bitumen insoluble in 86° B. Naphtha, 20 to 30 per cent.

(f) ASPHALTIC OIL—CLASS C.

1. The oil shall be a fluid product free from water.
2. Specific gravity 25° C./25° C. (77° F./77° F.), 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 per cent.
  - (a) Float test of residue 50° C. (122° F.), not less than 110 seconds.
7. Total bitumen (insoluble in 86° B. Naphtha), 15 to 25 per cent.
8. Total bitumen (soluble in CS<sub>2</sub>), 99.5 per cent.
9. Ductility after volatilization to 100 penetration, not less than 75.

(g) ASPHALTIC OIL—CLASS D.

1. The oil shall be a fluid product free from water.
2. Specific gravity 25° C./25° C. (77° F./77° F.), 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 per cent.
  - (a) Float test of residue at 50° C. (122° F.), not less than 90 seconds.
6. Total bitumen (soluble in CS<sub>2</sub>), 99.5 per cent.
7. Bitumen insoluble in 86° B. Naphtha, 10 to 20 per cent.
8. Ductility after volatilization to 100 penetration, not less than 75.

METHODS OF TESTING.

Tests of the physical and chemical properties of the oil asphalt shall be made in accordance with the following methods:

1. Specific gravity, U. S. Department of Agriculture, Bulletin 314, p. 5.
2. Flash point (open cup), U. S. Department of Agriculture, Bulletin 314, p. 17.
3. Melting point, A. S. T. M. Tentative Standard, D 36-16T. Proceedings A. S. T. M., 1916, p. 549.
4. Penetration, A. S. T. M. Standard Test, D 5-16.
5. Volatilization test, U. S. Department of Agriculture, Bulletin 314, p. 19, using 50-gram sample.
6. Total bitumen, U. S. Department of Agriculture, Bulletin 314, p. 25.

**12.3. Cover Material.** The grit to be used in the bituminous surface treatment shall consist of one or more of the following materials:

- |                  |                        |
|------------------|------------------------|
| (a) Coarse sand. | (c) Crushed limestone. |
| (b) Pea gravel.  | (d) Crushed trap rock. |

Cover material shall have a French coefficient of wear of at least 8, shall be free from dust or other foreign material, and shall be well graded and of such sizes that 100 per cent will be retained on No. 20 laboratory sieve. Cover material when tested by laboratory screens with circular openings shall be designated by numbers, as follows:

- No. 1.—Passing 1½-inch and retained on ¾-inch.
- No. 2.—Passing 1-inch and retained on ½-inch.
- No. 3.—Passing ¾-inch and retained on ¼-inch.
- No. 4.—Passing 3/8-inch and with dust removed.

**12.4. Preparation of Old Gravel Surfaces.** Should the surface to be treated be so uneven as to require reshaping 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 quality at least as good as that used for the top course of the original surfacing, and having all stone or pebbles 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 10.8 (c). If necessary, in order to compact the surfacing satisfactorily, it shall be sprinkled during the process of rolling, as directed by the Engineer.

**12.5. Preparation of Shell Surfaces.** Bituminous surface treatment preferably shall not be applied to surfaces composed entirely of mud shell, but before treating such a surface a course of gravel or stone at least three (3) inches in thickness may be added and thoroughly bonded to the shell surface.

(a) GRAVEL RESURFACING.

Gravel for this purpose shall conform to specifications for second course gravel material, Paragraphs 10.2, 10.3 and 10.8. Before spreading gravel upon the roadway the shoulders shall be brought up to the proper elevation for receiving the material and the shell surface shall be thoroughly scarified to a depth of at least three (3) inches. The gravel shall then be spread to the depth specified and the entire surface shall be re-scarified to a depth at least three (3) inches more than the depth of the gravel. After being re-scarified the surface shall be reshaped and thoroughly rolled with a self-propelled roller weighing not less than 10 tons. Should weather conditions be such as to make it necessary the surface shall be sprinkled with water before rolling is begun as directed by the Engineer.

(b) BROKEN STONE RESURFACING.

Stone for this work shall conform to specifications for No. 2 stone, Paragraph 11.1. The specifications for scarifying, placing of material, and rolling are the same as for Gravel Resurfacing, Paragraph 12.5 (a). After rolling the surface it shall be covered with a mixture of No. 3 stone in sufficient quantities to fill all remaining voids, the surface thoroughly watered and rolled until it is thoroughly bonded and to the satisfaction of the Engineer.

(c) SHELL RESURFACING.

Shell for this work shall conform to shell surfacing material, Paragraph 8.2. The specifications for scarifying, placing of material, rolling and sprinkling are the same as for Gravel Resurfacing, Paragraph 12.5 (a).

No surface treatment shall be applied to any surface which is not uniformly firm and hard and in such a condition that it will withstand the hardest sweeping with a good fiber rotary street broom without removal of any appreciable amount of surfacing material.

**12.6. Cleaning Surface.** All surface 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 continued 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.



In every case cover material shall be applied in sufficient quantity to prevent tracking or bleeding of the surface.

Rolling shall be done where specified and when required it shall be thoroughly done with a roller weighing not less than 5 tons.

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.

**12.9. 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 three 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 sinking from natural causes, from floods, or the breaking down of the treated surface due to the washing away of the base.

**12.10. Limestone Rock Asphalt. Cold Treatment ( $\frac{1}{2}$ -inch thick or over.)**

(a) Material. The material to be laid shall be composed of uniform, well-graded natural rock asphalt, consisting of 10 to 12 per cent asphalt and 88 to 90 per cent limestone.

(b) Preparation and Mixing of Material. The natural rock asphalt shall be crushed from..... inch to dust. A sufficient amount of the dust shall be removed therefrom to be used to spread over the treated surface after the crushed limestone rock asphalt has been laid and properly rolled.

After the dust has been taken from the crushed limestone rock asphalt, an asphaltic base oil having a specific gravity from .97 to 1.00 at 25° C. and showing approximately 50 per cent asphalt shall be added to the crushed asphalt rock in a quantity approximately four gallons to a ton of rock asphalt.

After the asphaltic oil has been added to the crushed rock, the aggregate shall be thoroughly mixed in a revolving mixer similar to a concrete mixer until all the particles of crushed rock asphalt are thoroughly coated with the asphaltic oil. In order that the mixture shall be uniform, each batch of crushed rock asphalt and the asphaltic oil flux shall be weighed or measured before being incorporated in the mixture.

(c) Preparation of Base. Before the rock asphalt, as described above, shall be placed upon the roadway, the surface shall be thoroughly cleaned of dust or dirt to the satisfaction of the Engineer after which there shall be applied to the surface a treatment of hot asphaltic oil, the same as used for flux, in an amount from .2 to .25 gallons per square yard of surface put on in two applications, the first application consisting of from 0.1 to .15 gallon to be made not less than three days prior to placing the rock asphalt and the second application of approximately 1/10 of a gallon to be made immediately before the rock asphalt is placed. This asphaltic oil shall be heated and applied as specified under Paragraph 12.6 and 12.7. Great care shall be taken that the oil treatment is regularly and evenly distributed. The amount of flux shall not vary more than five per cent on any square yard of compacted pavement.

(d) Application of Prepared Rock Asphalt. The crushed and treated rock asphalt shall be spread over the base to a uniform thickness such that, after being thoroughly rolled a mat of..... inches in thickness will be obtained; shall be thoroughly raked so that all lumps shall be separated; and thoroughly rolled with a self-propelled tandem roller, weighing not less than eight tons. After rolling, should any low or uneven places develop, they shall be filled with the same mixture and re-rolled.

After the entire surface has been satisfactorily rolled and brought to the required cross-section, a thin coat of limestone rock asphalt, free from any flux shall be spread over the entire surface and the surface shall be again rolled and the rolling shall continue until the surface is thoroughly compacted and to the cross-section as shown on the plans.

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

### 12.11. Basis of Payment.

**Scarifying and Reshaping Old Surfacing** will be paid for at the unit price per 100 foot station, and will include all scarifying, hand-picking, plowing, harrowing, reshouldering (reshaping shoulders in proper section), and all work necessary to prepare the old surface to receive the material necessary to be added to bring the road surface to the proper condition for receiving the bituminous treatment.

**The Gravel or Stone Surfacing Material** is to be paid for at the unit price bid per cubic yard, to include all stripping and removal of unacceptable material. When the county owns the deposit or is furnishing material in the pit the stripping and removing of unacceptable material will be paid for on the unit price bid for borrow excavation, but no more work of this character shall be done than is necessary for the completion of this contract.

**Hauling Surfacing Material** will be paid for at the unit price per cubic yard per one-fourth mile haul, and the price for the first one-fourth mile haul will include the loading, unloading, spreading, harrowing, shaping, mixing, all preparation or subgrade, other than rolling, and the maintaining of the finished surface. The price for the second, third, fourth, fifth, sixth, seventh and eighth quarters shall be bid on and listed separately. The price for hauling the ninth and additional quarters above the ninth quarter shall be listed together and bid on as "Additional cubic yards— $\frac{1}{4}$ -mile haul above and including the ninth  $\frac{1}{4}$ -mile."

**Screening Gravel** will be paid for at the unit price bid per cubic yard for screening gravel, and screened gravel shall be measured at point of delivery on the work as specified under Paragraph 10.6.

**Surfacing Material** furnished by the Contractor, whether shipped or taken from local pits, will be paid for at the contract unit price per cubic yard and measurement will be made at point of delivery upon the work as provided under Paragraph 10.6.

**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, 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 cubic yard, unless otherwise stated, and will include all sand, gravel, or stone, furnished and applied, all teaming, distributing, rolling and all material, labor, tools, and machinery incidental to the application of same.

**Sprinkling.** Sprinkling will be paid for at the contract unit price per 1,000 gallons. This price is to include all fuel, teams, labor and equipment necessary to satisfactorily do this work.

**Rolling.** Rolling the base will be paid for at the unit contract price for rolling per hour including all fuel, labor, and equipment necessary to satisfactorily carry on this work. Where rolling of cover material is required as specified under Paragraph 12.8 the price for rolling shall be included in the price bid per cubic yard for cover material in place.

## ITEM 13. PORTLAND CEMENT

**13.1. 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 "1918 Standards of the American Society for Testing Materials, page No. 503, Serial Designation C 9-17," etc.

**13.2. 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.

**13.3. 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 <sub>3</sub> ).....	2.00
Magnesia (MgO).....	5.00

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

(a) **Specific Gravity.** The specific gravity of cement shall be not less than three and ten one-hundredths (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.

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

(c) **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.

(d) **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.

(e) **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 of cement and three (3) parts of "Standard" Ottawa sand, by weight, shall be equal to or be higher than the following:

Age of Test (Days).	Storage of Briquettes.	Tensile Strength Lbs. 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.

**13.5. 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, and shall be considered as equal to one cubic foot. A barrel shall contain three hundred and seventy-six (376) pounds net.

**13.6. 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 pro-

test the cement from dampness. When permission is given to store in the open, a platform and ample waterproof covering shall be provided, as directed.

**13.7. 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.

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

(a) **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.

(b) **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.

(c) **Weight.** Packages varying more than five (5) per cent 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.

## ITEM 14. REINFORCEMENT

**14.1. Description.** All concrete reinforcement shall consist of square twisted, deformed or plain bars, expanded metal, wire cloth or structural steel shapes, as called for on the plans or as specified. The sizes of bars 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 considered the effective area.

**14.2. Material.** Unless otherwise specified all square twisted, deformed and plain bars shall meet the requirements of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars of the American Society for Testing Materials, Serial Designation A 15-14.

Where purchased from warehouses in small lots, reinforcement may, at the discretion of the Engineer, be accepted subject to the bending test only.

**14.3. Expanded Metal and Wire Cloth.** Expanded metal or wire cloth shall be manufactured from material fulfilling the requirements of the Standard Specifications of the American Society for Testing Materials for Billet Steel Concrete Reinforcement Bars, Serial Designation A 15-14.

**14.4. Structural Steel Shapes.** The steel for structural shapes shall fulfill the requirements of the Standard Specifications of the American Society for Testing Materials for Structural Steel for Bridges, Serial Designation A 7-16.

**14.5. Placing Reinforcement.** When placed all reinforcement shall be free from dirt, oil, paint, grease, mill-scale and loose or thick rust.

Where bending is required, it shall be accurately done and all reinforcement shall be placed in the exact position shown on the plans, and shall be so securely held in position by wiring to and blocking from the forms and by wiring together at intersections, that it will not be displaced during depositing and compacting of the concrete. Shop bending for reinforcement is preferable. All bending shall be done cold.

Placing and fastening of reinforcement in each section of the work shall be approved by the Engineer before any concrete is deposited in the section.

**14.6. Splicing Reinforcement.** Whenever it is necessary to splice reinforcement at points other than those shown on the plans, drawings showing the location of each splice shall be submitted and approved before the reinforcing steel is ordered. Splices shall be avoided at points of maximum stress; they shall, where possible, be staggered, and shall be designed to develop the strength of the bar without exceeding the allowable unit bond stress. In splicing bars, a minimum lap of forty (40) diameters shall be used and when not clipped or wired together, shall be separated at least one (1) inch. No welds will be allowed.

**14.7. Basis of Payment.** This material will be paid for at the contract unit price per pound per square foot, as the case may be, for "Deformed Steel Bars," "Plain Steel Bars," "Expanded Metal" "Wire Cloth," or "Plain Structural Steel," 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 17. PORTLAND CEMENT CONCRETE PAVEMENT

**17.1. Description.** This pavement shall consist of one or two courses of Portland cement concrete, with or without reinforcement, constructed on the prepared subgrade, having the dimensions and cross-section shown on the plans, and in accordance with these specifications.

**17.2. 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 published in the "1918 Standards of the American Society for Testing Materials, Serial Designation C 9-17," and given in Item 12 of these specifications.

**17.3. 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, while not more than twenty-five per cent (25%) by weight, shall pass a standard No. 50 laboratory sieve, nor more than five (5) per cent by weight, shall pass a No. 100 sieve. It shall contain not more than three (3) per cent 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 54.7-1-C shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) per cent 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 17.4 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 25 per cent, 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. The stone grit shall conform to the requirements of Paragraph 17.3 (b), and the sand shall conform to the requirements of Paragraph 17.3 (a), 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 less than seventy-five (75) per cent nor more than ninety (90) per cent by weight of the particles passing a No. 10 laboratory sieve nor more than twenty-five (25) per cent, by weight, of particles passing a standard No. 50 laboratory sieve, and not more than seven (7) per cent by weight, passing a No. 100 sieve, and which in combination with the coarse aggregate, cement and water, shall make an easily workable mixture.

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 54.7-1-C, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of not less than one hundred (100) per cent of that developed by mortar of the same proportions and consistency, made of the same cement and "standard" Ottawa sand.

**17.4. Coarse Aggregate.** The coarse aggregate shall consist of clean, tough, durable crushed rock or gravel, having a French coefficient of wear of not less than eight (8) and a crushing strength of not less than eight thousand five hundred (8,500) pounds per square inch unless otherwise specified. The material shall be free from dust and excess 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 two and one-half ( $2\frac{1}{2}$ ) inches in diameter, 95 per cent passing 2-inch screen and 40 to 75 per cent passing 1-inch screen. Not more than

five (5) per cent, by weight, shall pass a laboratory screen having circular openings one-quarter ( $\frac{1}{4}$ ) of an inch in diameter.

**17.5. Water.** The water used for this work shall be subject to the approval of the Engineer and shall be reasonably clean, free from oil, acid, alkali, or vegetable substances, and neither brackish nor salty.

**17.6. Joint Filler.** The filler to be used in the transverse joints in the pavement shall consist of an approved asphalt filler suitable for pouring or of an 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 and a depth of not less than one (1) inch more than the depth of the pavement.

**17.7. Approval of Source of Supply of Material.** 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 (25) 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 test upon a sample of the crushed stone of the same sizes as is 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, location of the plant and diameter of openings in screens used in their preparation.

**17.8. Construction of Subgrade.** It shall be the object to construct the subgrade so that it shall be as nearly as possible of uniform density throughout its entire width. Wherever the roadway extends outside the limits of the old traveled way, the Contractor shall loosen the compacted portion of this traveled way, reshape and then tamp so as to bring all material within the limits of the subgrade to the same density.

The subgrade shall be brought to a true shape, and after tamping, shall be tested, and if not at the proper elevation at any point, material shall be shoveled away or added, as the case may be, to bring that portion of the subgrade to the correct elevation. All soft and yielding spots and all vegetable substance or unsuitable material shall be removed and the space refilled with approved material. The subgrade shall be tamped again and the process of reshaping and tamping shall be repeated until no depressions appear.

Should the old roadbed consist of gravel or madadam and the pavement extend outside the limits of same, the Contractor shall loosen the old gravel or macadam, reshape and then tamp so as to bring the portion of the subgrade outside the limits of the old gravel or macadam roadway to the same density as the portion under the old roadway.

In locations where soil conditions are unsuitable and it is desirable to construct a sub-base, same shall be constructed as shown on the plans or as directed by the Engineer. The material used may be of crushed stone or gravel. The trench for the sub-base shall be arranged so that the top of sub-base material will be the same elevation as the established subgrade.

The specifications for the materials, methods of construction and basis of payment shall be in accordance with Items for same as follows: (a) Crushed Stone, Item 11; (b) Gravel, Item 10.

Immediately before the concrete is placed upon the subgrade it shall be tested for elevation by the

use of a templet, furnished by the Contractor. In the lower edge of the templet there shall be driven nails six (6) inches apart and to such depths that the heads will just come to the true position of the subgrade when the templet is riding on the forms. Testing the elevation of the subgrade shall be done by moving the templet back and forth on the forms. On those areas of the subgrade found to be too high by as much as one-fourth ( $\frac{1}{4}$ ) of an inch, additional excavation shall be made until the required depth is reached and the excavated material shall be deposited on the shoulders. Those areas below the true elevation shall be filled with concrete making an integral part of the slab proper, all expense for this extra concrete including both labor and material being borne by the Contractor.

Hauling by teams, trucks or otherwise, over the finally completed subgrade for a distance of more than five hundred (500) feet will not be permitted. If hauling over the subgrade for such distance results in ruts or other objectionable irregularities, the Contractor shall reshape and reroll the subgrade before materials are deposited upon it.

The subgrade shall be clear of all materials that may have fallen upon it and if dry it shall be thoroughly wetted before the concrete is placed, but not to the extent of forming mud or pools of water.

**17.9. Forms.** Outside forms for this work shall be made 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 surface plank, 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.

**17.10. Consistency.** There shall be used such an amount of water that the consistency of all the batches of concrete will be the same, the amount of water for each batch being carefully measured. There will not be tolerated a consistency that would tend to separate the fine particles from the coarse.

The consistency of the concrete shall be determined by the following test: A frustum of a cone, four (4) and eight (8) inches in diameter, top and bottom, respectively, and twelve (12) inches in length shall be filled with concrete which shall be tamped until all voids are filled and a slight film of mortar appears on the surface. The cylinder shall then be removed and the vertical settlement or "slump" of the concrete noted. This settlement shall not exceed one (1) inch when the mechanical finishing machine is to be used and shall not exceed one and one-half ( $1\frac{1}{2}$ ) inches when the finishing is to be done by other methods permitted in the specifications.

**17.11. 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.

**17.12. Mixing Concrete.** Unless hand mixing is specifically permitted by the Engineer the mixing shall be done in a batch mixer of approved type which will insure the uniform distribution of the materials throughout the mass so that the mixture is uniform in color and smooth in appearance. The mixing shall continue for a minimum time of one (1) minute after all the ingredients are assembled in the drum, during which time the drum shall revolve at the speed for which it was designed but shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute. The mixer shall be equipped with an attachment for satisfactorily locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch.

**17.13. Hand Mixing.** When hand mixing is permitted it shall be done on a watertight platform. The fine aggregate and cement shall first be mixed until a uniform color is attained and then spread over the mixing board in a thin layer.

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

After the water has been added, the mass shall be turned at least six (6) times, and more if necessary, to make the mixture uniform in color and smooth in appearance. Hand-mixed batches shall not exceed one-half ( $\frac{1}{2}$ ) cubic yard in volume.

**17.14. Checking Quantities of Cement Used.** The Engineer shall ascertain by calculation and tests, the amount of cement required for each section between transverse joints, according to these specifications, and as the work progresses, the Engineer shall compare the amount so ascertained with the amounts actually used in each section of concrete between successive transverse joints, as determined by actual count of the number of sacks of cement used in each section.

If the amount of cement used in any three (3) adjacent sections (between transverse joints) is less by more than four (4) per cent, or if the amount of cement used in any one section is less by more than five (5) per cent of the amount required as mentioned above, the Contractor shall remove all such sections and replace the same with new materials, according to these specifications and at his own expense.

**17.15. Placing Concrete.** The placing of concrete shall generally proceed upgrade. Concrete shall be placed only on a moist subgrade. If the subgrade is dry it shall be sprinkled with as much water as will be absorbed readily. The concrete shall be deposited on the subgrade rapidly in successive batches, by means of a discharging device which does not cause separation of the mortar and the coarse aggregate and shall be distributed to the required depth and for the entire width of the pavement by shoveling or other approved methods. Rakes shall not be used 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 the 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.

**17.16. Placing Transverse Joints.** Transverse joints shall be formed at right angles to the center line, at intervals indicated on the plans to the full depth and width of the pavement. They shall not be less than one-quarter ( $\frac{1}{4}$ ) not 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 bulkhead at right angles to the center line and perpendicular to the surface of the pavement against which the prepared joint filler, if specified, shall be placed before the concrete is deposited against it. The iron bulkhead 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 bulkhead shall be carefully removed leaving the prepared filler in place. The concrete shall be sufficiently tamped to make it fill the space previously occupied by the bulkhead. After the pavement is completed, the filler shall be cut off above the surface of the pavement to the height designated.

If a poured filler is to be used, the space for the filler shall be formed as above described, except that the iron bulkhead shall not be withdrawn until after the concrete has sufficiently stiffened to preserve the shape and width of the joint until setting takes place. The filler shall be heated to a suitable consistency and shall be poured in the joint after the concrete has become dry. The slot left by the bulkhead shall be entirely cleared of all debris and loose material and the joint shall be poured to project above the concrete about one-half ( $\frac{1}{2}$ ) of an inch and about one (1) inch on each side of the joint.

**17.17. Finished Concrete.**

(1) Slope Walls. The slope walls shall be poured of dry concrete that will stay to cross-section shown on plans and shall first be tamped and then struck off with a template giving desired section. The final finishing shall be done with a wooden float.

(2) Roadbed. After concrete is poured to grade as shown on plans, it shall first be tamped and

then struck off with a templet which shall be shaped to the desired cross-section and shall have sufficient strength to retain its shape under all working conditions.

This template shall be moved with a longitudinal and crosswise motion in the direction in which the work is progressing.

The final finish shall be with a wooden float.

If an earth covering is used, it shall be at least two (2) inches thick, and shall be thoroughly watered twice each day at intervals of about twelve hours for two (2) weeks, and the covering shall remain upon the road for at least fourteen (14) days from the time of its application and for a longer period of time if weather conditions, in the opinion of the Engineer, make this desirable.

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

The pavement shall be kept closed to traffic for fourteen (14) days, or if, in the opinion of the Engineer, the weather conditions make it advisable, the pavement shall be kept closed to traffic a longer period of time. In no event, however, shall there be any hauling on the concrete surface or metal shoulders until the pavement has been cleaned of all earth and other foreign material.

#### ONE COURSE PAVEMENT

**17.19. Composition.** The concrete for one course pavement shall be composed of one (1) part of Portland cement and six (6) parts of fine and coarse aggregate, each measured separately and accurately by volume. The concrete shall approximate a 1:2:4 mix but the Engineer may vary the relative proportions of fine and coarse aggregate in order to obtain a concrete of maximum density.

#### REINFORCED CONCRETE PAVEMENT

**17.26. 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. In two course concrete pavement the reinforcement shall be placed on the bottom course immediately after it has been placed and just prior to placing the top course.

#### PORTLAND CEMENT CONCRETE PAVEMENT.

**17.27. Basis of Payment.** This work will be paid for at the contract price per cubic yard for "One Course Concrete Pavement," or "One Course Reinforced Concrete Pavement" as may be specified, which price will include the preparation of subgrade, all material, forms, labor, equipment, tools and work incidental thereto, except the reinforcing material and labor and equipment incidental to placing same, and stone, excavation or fill.

Reinforcing material shall be paid for at the contract unit price per pound for "Reinforcing Material in Place" which price will include all material, labor, and other expense incident to placing same.

When additional depth of concrete pavement is required over trenches, etc., it will be paid for at the proportionate cubic yard price per inch of depth for the class of concrete involved.

Stone excavation or fill shall be paid per cubic yard, but no two way pay will be allowed.

## 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 places as indicated on the plans and where directed in accordance with these specifications.

**20.2. Stone.** All stone for this work shall be rubble stone of approved quality, sound, durable, free from structural defects, and shall be free from rounded; worn or weathered surfaces and clean of earth, clay or other foreign substances. All weak points and angles shall be removed. Selected stone, roughly squared and pitched to line, shall be used at all angles and ends of walls. No stone shall be used which has a minimum thickness of less than six (6) inches, a minimum width and length of less than twelve (12) inches, and the length shall not exceed three (3) times the thickness. Small stones of similar quality may be used for pinning and filling interstices in the heart of the wall.

**20.3. Construction Methods.** All dry rubble masonry shall be constructed by experienced masons. The stones shall, where necessary, be dressed to a reasonably true face and bed shall be laid true to the shape and dimensions of the structure, as shown on the plans. The stones shall be laid on their natural beds and so placed as to break joints and form a mechanical bond. The stone placed in the foundation shall not be less than twelve (12) inches in thickness or have less than six (6) square feet of bed. The stones shall be laid so as to form a substantial wall and shall fit neatly. Headers shall be distributed uniformly through the walls of the structure so as to form approximately one-quarter ( $\frac{1}{4}$ ) of the exposed face; and shall extend through the face wall and into the backing a distance at least equal to their thickness. Where a wall is less than two and one-half ( $2\frac{1}{2}$ ) feet in thickness the headers shall extend entirely through, from front to back face. Where a wall is two and one-half ( $2\frac{1}{2}$ ) feet or more in thickness the headers shall either extend entirely through or over-lap at least six (6) inches. The interior of the wall shall be built up so as to leave no appreciable open spaces, and only sufficient spawls shall be used to wedge the larger stones in the place. No spawls shall be used in the front face of a wall, and the stones shall be so well bedded that none will be needed. The top of the wall shall be finished with a stone coping of roughly scapped stones approximately eight (8) inches thick, and not less than eighteen (18) inches wide and in length four (4) inches greater than the top thickness of the wall. The top shall be screeded sufficiently to drain water.

**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 31. STONE CURBING

**31.1. Description.** This curbing shall consist of approved granite, limestone, 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 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 stone, 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 stone 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 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 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 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, yellow heart pine lumber, mountain cedar or other approved material, 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 six feet six inches (6'6") 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 (4½) 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 four (4) inches wide by four (4) 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) per cent, by weight, of pigment in paste form and from thirty-five (35) to thirty (30) per cent of vehicle; or sixty (60) to sixty-five (65) per cent, by weight, of dry pigment.

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

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

**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 (3½) feet in the ground and three and one-half (3½) feet above the ground and to lines and grade 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 Guard Fence" 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 51. PIPE CULVERTS

**51.1. 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 and shall conform to the following table for depth of fill over them. All pipe culverts shall be provided with a substantial concrete headwall of a design approved by the Engineer.

TABLE OF MINIMUM DEPTHS OF GOOD FILL OR BALLAST OVER PIPE CULVERTS.

On center line of roadway (C) and outer edge of shoulder (S).

Inside Diam.	Cast Iron		Corrugated Metal		Vitrified Clay		Concrete		Inside Diam.
	C	S	C	S	C	S	C	S	
12"	1'-0"	8"	1'-6"	1'-0"	1'-6"	1'-0"	1'-0"	8"	12"
14"	1'-0"	8"							14"
15"			1'-6"	1'-0"	1'-6"	1'-0"	1'-0"	8"	15"
16"	1'-0"	8"							16"
18"	1'-0"	8"	1'-6"	1'-0"	1'-6"	1'-0"	1'-0"	8"	18"
24"	1'-0"	8"	2'-0"	1'-0"	2'-0"	1'-0"	1'-0"	8"	24"
30"	1'-3"	8"	2'-6"	1'-0"	2'-6"	1'-0"	1'-3"	8"	30"
36"	1'-6"	8"	3'-0"	1'-0"	3'-0"	1'-0"	1'-6"	8"	36"
42"	1'-9"	8"							42"
48"	2'-0"	8"							48"

**NOTE:** If the material in the fill contains much clay, silt or loam, increase the above minimum depths by 4".

**51.2. 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 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) per cent 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.

**51.3. Corrugated Metal Pipe.** Two classes of base metal for use in corrugated metal pipe are recognized in these specifications, Class "A" and Class "B." Class "A" includes the metals commonly designated as pure irons, which are the product of the open hearth furnace in which the refining operation is carried forward until the impurities are reduced to a relatively low percentage.

Class "B" includes those metals commonly designated as copper bearing steels which are the normal product of the open hearth furnace with which is alloyed a small percentage of copper.

**51.4. Quality of Metals.** Class "A" base metal shall contain not more than thirty hundredths (.30) per cent in the aggregate of the following metalloids,—carbon, sulphur, phosphorus, silicon and manganese—and shall contain not more than four hundredths (.04) per cent of carbon, thirty-five thousandths (.035) per cent of sulphur, and six thousandths (.006) per cent of phosphorus.

An allowance may be made in the aggregate amount of the five metalloids specified above of four hundredths (.04) per cent.

Class "B" base metal shall contain not more than seven-tenths (.7) per cent in the aggregate of the following metalloids—carbon, sulphur, phosphorus, silicon and manganese—and shall contain not more than fifteen hundredths (.15) per cent of carbon, four hundredths (.04) per cent phosphorus, and five hundredths (.05) per cent sulphur.

Class "B" base metals shall contain not less than two-tenths (.2) per cent copper.

**51.5. Accepted Brands and Certified Analysis.** No bids shall be considered and no metal shall be accepted under these specifications for either class until the manufacturer has filed with the Commissioners Court a certified typical analysis setting forth the percentage of each of the above metals, the name and brand of the metal to be furnished and the class for which submitted, nor until the brand has been approved by the Engineer and the Commissioners Court. The certificate shall be sworn to by the head of the manufacturing company.

**51.6. Marking and Guarantee.** Each section of every metal culvert shall be identified by a stamp showing the brand, name of the manufacturer and the gauge, and these shall be placed by the sheet manufacturer in such a way that they shall appear on the outside of the finished pipe. Pipe not having each section so marked shall be rejected.

The manufacturer shall furnish with the certificate a guarantee that all metal furnished shall conform to the analysis and specifications, and shall be identified as required, and that all metal bearing his brand not complying with the specifications shall be replaced without cost to the purchaser.

**51.7. Zinc Coating.** The metal sheets shall be galvanized with not less than two ounces (2 oz.) of prime spelter per square foot of exposed surface, and this shall be applied in such a manner as to

form a continuous, impervious coating free from imperfections. Sheets having spots, holes, blisters or other defects in the galvanizing shall be rejected. Tests for the zinc spelter shall be made by the lead acetate method.

**51.8. Types of Culverts.** Unless otherwise specified, culverts submitted shall be of the full circle riveted type with lap joints.

**51.9. Sizes.** For roadway culverts the minimum diameter permitted shall be eighteen (18) inches. Corrugated metal pipe over thirty-six (36) inches in diameter shall not be used.

**51.10. Gauge of Metal.** The gauge shall be U. S. Standard. The gauge and weight per foot of pipe shall be not less than the following:

Diameter, Inches.	Gauge, U. S. Standard.	Wt. Per Ft.
12	16	10.2
15	16	13.3
18	16	15.7
20	16	17.5
24	14	25.6
30	14	30.9
36	14	38.2

**51.11. Corrugations.** The corrugations shall be not less than two and one-half ( $2\frac{1}{2}$ ) inches nor more than three (3) inches, and shall have minimum depths, respectively, of one-half ( $\frac{1}{2}$ ) inch and five-eighths ( $\frac{5}{8}$ ) inch.

**51.12. Joints.** Longitudinal laps shall be not less than two (2) inches on culverts fifteen (15) inches in diameter and under, two and one-half ( $2\frac{1}{2}$ ) inches for culverts eighteen (18) and twenty (20) inches in diameter, three (3) inches for twenty-four (24) inch culverts, and four (4) inches for larger sizes. Circumferential laps shall be not less than two and one-half ( $2\frac{1}{2}$ ) inches, and not less than one full corrugation.

**51.13. Rivets and Riveting.** All rivets shall be of the same material as specified for the culverts or of other approved material, and shall be thoroughly tinned or galvanized, and shall be not less than five-sixteenths ( $\frac{5}{16}$ ) inch in diameter. All rivets shall have sufficient length to draw the sheets tightly together and allow the forming of full hemispherical or other standard shaped heads. Rivets shall be driven without bending and shall entirely fill the hole.

Longitudinal seams shall be riveted with one rivet in each corrugation. Circumferential seams shall have a maximum spacing of rivets of eight (8) inches.

**51.14. General Details.** The inlet and outlet of all corrugated metal culverts shall be reinforced in an approved manner, and the method of reinforcement shall be stated in the bid.

Field joints shall be made of the same material as used in the culverts, and shall be not less than eight (8) inches wide for pipe up to thirty (30) inches in diameter and ten (10) inches for larger sizes, and shall be of approved form. Joints will not be permitted except when the lengths called for are too great to be handled economically; but for culverts twenty-six (26) feet or more in length, pipe may be furnished in twelve (12) foot lengths if joints are included free of cost.

**51.15. Field Inspection.** The field inspection shall be made by the Engineer, who shall be furnished an itemized bill of the shipment.

The material shall be so handled that the zinc coating shall not be bruised or broken in the shop or

in shipping, and all pipe shall be rejected if the zinc coating is bruised, broken or blistered or if the workmanship is not first-class throughout.

**51.16. Test.** The right is reserved to have any pipe tested, and all pipe failing in any particular to meet these specifications shall be rejected.

**51.17. 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.

**51.18. 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	1¼	3
18	2	1½	3¼
20	2	1 2/3	3½
22	2	1 5/6	3¾
24	2	2	4
27	2½	2¼	4
30	2½	2½	4
33	2½	2 5/8	5
36	2½	2¾	5
42	2½	3½	5

**51.19. 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 Item 13, and two (2) parts of approved, clean sand, mixed with sufficient water to form a plastic mortar.

**51.20. 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 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.

**51.21. Laying of Pipe.** The pipe shall be laid carefully, hubs up grade, 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 a width of lap as specified in Paragraph 51.14, 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.

**51.22. 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.

**51.23. 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.

**51.24. 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.

#### VITRIFIED CLAY SEGMENT BLOCK CULVERTS.

##### CIRCULAR CULVERTS.

**51.25. a-1. The material** used in this construction shall be Vitrified Clay Segment Blocks, uniformly made and hard burned, without warps, cracks, or other imperfections. The longitudinal joints shall be scarified the entire length of the block. The ends shall be shiplap jointed with abutting webs or surfaces to form a bed for mortar to insure water-tight joints in the end of the block.

**a-2. Dimensions.** All blocks used shall conform to the detailed drawings and table shown on plan SB 1 of the State Highway Department.

**a-3. Construction.** The trench shall be excavated to a width equal to the inside diameter of the circle plus twice the thickness of the respective blocks and to a depth that will bring the inner surface of the first course of blocks on a line with the natural waterway. In new excavation, and when possible in old excavation, the bottom of the trench shall be rounded out to fit the curvature of the blocks.

The blocks in the lower invert shall be laid to a line and templet and loose earth firmly packed between the outer surface and line of excavation as each course is laid in place. Special care must be used in tamping the back fill to avoid any possibility of forcing the blocks out of alignment. All blocks in the lower invert shall be laid up in this manner.

The blocks in the upper invert shall be laid with a collapsible form to prevent any serious deflection from the true circle before mortar joints have had time to set.

**a-4. Mortar Joints.** The blocks shall be bonded together with thoroughly mixed mortar of one part Portland cement to two parts screened sand and care taken to see that all joints are well filled. After collapsing the arch form, the radial joints shall be pointed up.

**a-5. Excavation Depth Minimum.** This type of culvert should not be used where excavated depth of the trench is less than one-half ( $\frac{1}{2}$ ) the outside diameter of the culvert.

**a-6. Unstable Foundations.** When this type of culvert is used on a soft unstable foundation, a four-inch layer, or more if necessary in the judgment of the Engineer, of 1:2 $\frac{1}{2}$ :5 concrete shall be laid around the lower half of the culvert.

#### SEMI-CIRCULAR CULVERTS.

**51.25. b-1. Location.** This type of culvert is especially designed for low wide waterways, and where there is insufficient dirt fill over the culvert to permit the use of a round opening large enough to provide ample drainage.

**b-2. Arch Construction.** The semi-circular arch is to be constructed of Vitriified Segment Blocks, to conform with the specifications given in 51.25 a-1, and shall be constructed in the same manner as the arch of the circular culvert.

**b-3. Concrete Base Construction.** The base shall be constructed of Class A concrete, in accordance with the requirements of Item 54, Paragraphs 54.3 to 54.12, inclusive, and according to plans of the State Highway Department.

**b-4. Reinforcing.** The reinforcing bars shall be used as indicated on plans and conform to the requirements of Item 14.

**c. Backfilling.** Loose earth shall be used in making the back fill around and over the culvert. Every four inches of fill shall be thoroughly tamped until the fill reaches the top level of the culvert. The fill from the top of the culvert to the permanent road level shall be thoroughly tamped every six inches.

**d. Minimum Fills.** The minimum fill over the culvert on dirt roads shall be not less than eighteen inches in the center when good compact soil is used. If only light shifting soil is available for the fill, the minimum fill shall in no case be less than twenty-four inches over the center of the culvert. See table on Plan SB-1 of the State Highway Department.

On hard surfaced roads of brick, concrete, macadam, gravel, etc., the minimum fill over the culvert may be reduced to the actual thickness of the paving, plus twelve inches in the center of the culvert to six inches at the side to allow for a thoroughly compacted sand or earth cushion between the pavement and the top of the culvert.

**e. Head Walls.** All segment block culverts shall be provided with head and wing walls at each end to conform with the standard Designs of the State Highway Department for pipe culverts. See plans of State Highway Department.

**f. Basis of Payment.** The basis of payment for segment block culverts shall be per lineal foot in place for culvert of a specified diameter and type. It must be stated whether the type is Circular or Semi-Circular and the price bid for each kind shall be payment in full for all joint material and for all labor employed in laying the blocks and filling the joints, excavating and backfilling. The concrete in headwalls and base construction shall be paid for at the price stated per cubic yard for the respective classes of concrete as stated in Paragraph 54.28. The reinforcing steel in headwalls and base construction shall be paid for at the price stated per pound in place.

## ITEM 52. GENERAL

### BRIDGES

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

**52.2. 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.

**52.3. 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.

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

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

**52.6. 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.

**52.7. Standard Drawings.** When possible, the County will furnish standard drawings showing in general the details prepared for usual conditions. Designs other than the Department Standards shall be made according to the Design Specifications of, and for the loadings prescribed by, the Department.

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.

**52.8. 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.

**52.9. Estimate of Quantities.** Estimate of quantities for the substructure, and for the superstructure, if it is to be of reinforced concrete, shall be 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 on the plans.

**52.10. 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 County Engineer before work is begun on materials.

**52.12. 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.

**52.13. 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.

**52.14. 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.

**52.15. 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.

**52.16. Risks.** The Contractor shall assume all risks from floods and storms and casualties of every description.

**52.17. 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 twice 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.

**52.18 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 53. SUBSTRUCTURES

### FOUNDATIONS.

**53.1. 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.

**53.2. 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.

### EXCAVATION.

**53.3. Description.** Excavation shall consist of the removal of the old structures, unless otherwise specified, including the abutments, piers, wings, and all other materials, obstructions, etc., necessary to the placing of concrete and masonry foundations for structures, in conformity with the plans or as may be directed. It shall include all clearing and grubbing, the necessary removing of materials, furnishing and placing of cofferdams, etc., refilling the excavated area around the structures to the elevation of the original adjacent surfaces after the concrete or masonry has been placed, shaping and sloping, and the disposal of the surplus material; all of which shall be done in accordance with the dimensions given and in conformity with these specifications.

**53.4. Removal of Excavation.** The Contractor shall notify the Engineer a sufficient time in advance of the beginning of excavation for structures, so that the cross-sectional elevations and measurements may be taken of the existing ground and structure. Any materials removed or excavated before these measurements have been taken will not be paid for. Any stone in the abutments, piers, and wing walls which is to be torn out and which is suitable for use in the new work shall be so used by the Contractor, unless otherwise specified, and the removal of any such material in the substructure will be considered as excavation.

**53.5. Timber and Metal Cofferdams** when used, shall be sunk to a depth well below the bottom of the excavation, shall be substantially braced in all directions and of such construction as will permit them to be pumped free of water and kept free until the concrete has set. They shall be of such size that leakage can be kept out of the concrete or masonry area. Unless otherwise shown on the plans or agreed upon, cofferdams and all sheeting and bracing shall be removed after the completion of the concrete or masonry. When the bottom is of sandy or other porous material which will not, in the opinion of the Engineer, permit the cofferdam to be pumped dry, when excavated to the correct elevation, it shall be sealed with sufficient concrete so that it may be pumped dry. This concrete shall be proportioned as directed and shall have twenty-five (25) per cent of additional cement as herein provided for concrete placed under water.

**53.6. Method of Determining Excavation Quantities.** All excavations will be measured in its original position by the cross-section method, to ascertain the amount of material removed, which cross-section will include the removal of all concrete and masonry walls, etc. No allowance will be made for foundation excavation in excess of one foot beyond the outer limits of the foundations. Clearing and grubbing and the removal of obstructions, etc., will not be measured, but will be included in the price for excavation.

"Dry Excavation" shall include all materials excavated above the water line shown on the plans.

"Wet Excavation" shall be measured from the waterline as shown on the plans to the bottom of the foundation; or where the excavation begins, below the waterline, it shall be measured from the bottom of the stream to the bottom of the foundation.

**53.7. Refilling.** After the structure has been completed, the areas around the walls shall be filled with approved material in layers of not more than six inches in depth and compacted satisfactorily to the level of the original surrounding surface. Materials which will not compact readily shall not be used in this work. In no case shall surplus material be dumped in the channel of the stream.

**53.8. Basis of Payment.** This work will be paid for at the contract unit price per cubic yard for "Dry Excavation" or "Wet Excavation" as the case may be, which price will include the removal of the excavated material, refilling, disposal of surplus material and all equipment, machinery, tools, labor and work incidental thereto. No additional compensation will be made for clearing and grubbing, cofferdams, bracing, shoring, pumping, or bailing, or for any materials or labor necessary on account of water.

## DESIGN AND CONSTRUCTION.

**53.9. 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.

**53.10. 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.

**53.11. Footing.** The footing width of all plain and reinforced concrete abutments, wing and retaining walls, shall not be less than 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.

**53.12. 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.

**53.13. 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, by designing all parts of such abutments 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 weighing not less than 21 pounds per cubic foot.

Retaining walls and reinforced concrete abutments and wing walls making 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 25 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, where clear height of abutment from ground surface to under side of slab does not exceed 15 feet, if satisfactory arrangement of materials and details

are provided, 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 superstructure (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.

**53.14. 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 where 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.

**53.15. Extra Foundation Work.** Additional foundation not exceeding three (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 three (3) feet, the foundation work and materials shall be classified as "Extra Work," and shall be governed by the specifications covering same under Paragraph 3.7.

**53.16. Basis of Payment.** For Concrete and Piling, basis of payment will be made as outlined under "Concrete Structures" and "Timber and Concrete Piling," respectively.

## ITEM 54. CONCRETE FOR STRUCTURES

**54.1. Description.** Concrete for structures shall be composed of Portland cement, water, fine and coarse aggregate and where specified hydrated lime shall be added. The proportions of fine and coarse aggregates specified may be varied slightly by the Engineer in order to make concrete of maximum density, but the proportion of cement to total aggregate, each measured separately, shall not be changed. The concrete shall be deposited in such places and of the form and the dimensions shown on the plans, or as directed.

**54.2. Classes.** In general only three classes of concrete will be used. Special structures requiring other classes of concrete, or requiring modifications in the materials used, will be provided for by means of notes on the plans or special clauses in the specifications or both.

**a. Class "A" Concrete.** Class "A" Concrete shall be composed of one (1) part of Portland cement, two (2) parts fine aggregate, and four (4) parts coarse aggregate, each measured separately.

**b. Class "B" Concrete.** Class "B" Concrete shall be composed of one (1) part of Portland cement, two and one-half (2½) parts fine aggregate, and five (5) parts coarse aggregate, each measured separately.

**c. Class "C" Concrete.** Class "C" Concrete shall be composed of one (1) part Portland cement, three (3) parts fine aggregate, and six (6) parts coarse aggregate, each measured separately.

**54.3. Uses.** The class of concrete required for each part of the structure will generally be noted on the plans, and when not so indicated the following requirements shall govern:

**a.** Class "A" concrete shall be used for superstructures, reinforced concrete, arch rings and concrete deposited in water.

**b.** Class "B" concrete shall be used for all unreinforced concrete except footings.

**c.** Class "C" concrete shall be used for all unreinforced footings, or foundations except when deposited in water.

**54.4. Portland Cement.** The cement used for this work shall conform to the requirements specified in American Society of Testing Materials, Standards 1918—Serial Designation C9-17 and shall also conform to the U. S. Bureau of Standards, Circular 33.

**54.5. Water.** All water used in concrete shall be subject to the approval of the Engineer and shall be reasonably clear, free from oil, acid, alkali, or vegetable substances, and neither brackish nor salty.

**54.6. Hydrated Lime.** Hydrated Lime shall meet the requirements of the Standard Specifications for Hydrated Lime of the American Society for Testing Materials, Serial Designation: C6-15, and shall be of the class known as "Calcium."

**54.7. Fine Aggregate for Concrete.** The fine aggregate for concrete shall consist of (1) sand, (2) a combination of sand and stone screenings, or (3) stone screenings conforming to the following requirements:

**1-a. Sand.** Sand shall consist of clean, hard, durable, uncoated grains, free from lumps, soft or flaky particles, salt, alkali, organic matter, loam or other deleterious substance.

**1-b. Grading.** Sand shall be well graded from coarse to fine and shall all pass a ¼-inch laboratory screen and not more than 5 per cent shall pass a 100 mesh "Standard" sieve. Not more than 3 per cent by weight shall be removed by the elutriation test.

**1-c. Strength.** Mortar composed of one (1) part, by weight, of Portland cement and three (3) parts, by weight, of sand, mixed and tested in accordance with methods referred to in the U. S. Bureau of Standards, Circular No. 33, shall have a tensile strength at the age of seven (7) and twenty-eight (28) days of one hundred (100) per cent of that developed by mortar of the same proportions and consistency, made of the same cement and "Standard" Ottawa sand, except that sand giving a strength ratio at seven (7) and twenty-eight (28) days of less than one hundred (100) but not less than eighty-five (85) per cent, will be accepted for use in concrete subject to the use of additional cement. The additional proportion of cement required will be determined by laboratory tests and shall be the percentage required to increase the tensile strength ratio of the mortar to not less than one hundred (100) per cent at seven (7) and twenty-eight (28) days.

**2-a. 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 54.7-a. Stone screenings 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). It shall be free from thin, elongated or laminated pieces, disintegrated stone, salt, alkali, vegetable or other deleterious matter.

**2-b. Grading.** The combination shall be well graded from coarse to fine and shall all pass  $\frac{1}{2}$ -inch, and not less than 85 per cent shall pass  $\frac{1}{4}$ -inch laboratory screens, the portion passing the  $\frac{1}{4}$ -inch screen when tested by means of laboratory sieves shall meet the following requirements:

Material—

Passing a 20 mesh "Standard" sieve, not less than 50 per cent, not more than 85 per cent.

Passing a 50 mesh "Standard" sieve, not more than 35 per cent.

Passing a 100 mesh "Standard" sieve, not more than 8 per cent.

Weight removed by the elutriation test, not more than 3 per cent.

**2-c. Strength.** The combination of sand and stone screenings when tested in accordance with Paragraph 54.7-1-c shall have a strength of 125 per cent.

**3-a. Stone Screenings.** Stone screenings shall conform to the requirements of Paragraph 54.7-2-a.

**3-b. Grading.** The stone screenings shall be well graded from coarse to fine and shall all pass  $\frac{1}{2}$ -inch, and not less than 85 per cent shall pass  $\frac{1}{4}$ -inch, laboratory screens. The portions passing the  $\frac{1}{4}$ -inch screen when tested by means of laboratory sieves shall meet the following requirements:

Materials—

Passing a 20 mesh "Standard" sieve, not less than 50 per cent, not more than 75 per cent.

Passing a 50 mesh "Standard" sieve, not more than 30 per cent.

Passing a 100 mesh "Standard" sieve, not more than 5 per cent.

**3-c. Strength.** Stone screenings when tested in accordance with Paragraph 54.7-1-c shall have a strength of 125 per cent.

**54.8. Tests.** Preliminary acceptance samples shall be subjected to both the seven (7) and twenty-eight (28) day tests and acceptance based thereon. During the progress of the work material will be accepted subject to seven (7) day tests.

**54.9. Coarse Aggregate for Concrete.** The coarse aggregate for concrete shall consist of crushed stone or gravel free from soft, thin, elongated or laminated pieces, disintegrated stone, salt, alkali, vegetable or other deleterious matter.

**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).

**b. Gravel.** Gravel shall consist of clean, hard, durable and uncoated pebbles of high resistance to abrasion.

**54.10. Sizes.** The coarse aggregate shall be graded uniformly from the maximum size to pieces one-quarter ( $\frac{1}{4}$ ) inch in diameter. The maximum size will generally be given on the plans, but if not given the following shall govern:

For Class "A" concrete the aggregate shall all pass a screen having circular openings one and one-half ( $1\frac{1}{2}$ ) inches in diameter and for Class "B" and Class "C" concrete the aggregate shall all pass a screen having circular openings two and one-half ( $2\frac{1}{2}$ ) inches in diameter.

For slabs less than six (6) inches thick, the maximum size screen openings shall not be more than one (1) inch in diameter.

**54.11. Grading.** Coarse aggregate shall be well graded from the largest to the smallest pieces and when tested by means of laboratory screens shall meet the following requirements:

PERCENTAGES OF COARSE AGGREGATE PASSING THE VARIOUS LABORATORY SCREENS.

Maximum size of aggregate	Circular Openings.								Passing screen having circular openings $\frac{1}{4}$ in. in diameter not more than
	3"	2 $\frac{1}{2}$ "	2"	1 $\frac{1}{2}$ "	1 $\frac{1}{4}$ "	1"	$\frac{3}{4}$ "	$\frac{1}{2}$ "	
3.....	100			40-75					15
2 $\frac{1}{2}$ .....		100			40-75				15
2.....			100			40-75			15
1 $\frac{1}{2}$ .....				100			40-75		15
1 $\frac{1}{4}$ .....					100			35-70	15
1.....						100		40-75	15
$\frac{3}{4}$ .....							100		15

**54.12. Samples and Tests.** On large or important structures samples of concrete materials, or of the concrete may be required for testing. If required, samples of concrete materials for testing purposes shall be supplied to the Engineer free of charge. Material shall be delivered far enough in advance of using to allow the Engineer to select samples and to forward them to the laboratory for testing. The laboratory will usually need at least 10 days for 7-day tests and 31 days for 28-day tests.

**54.13. Strength.** Cylinders of concrete from these samples made and tested in accordance with methods prescribed by the Engineer shall develop compressive strength as follows:

CRUSHING STRENGTH IN POUNDS PER SQUARE INCH.

Mix	1 : 2 : 4	1 : 2 $\frac{1}{2}$ : 5	1 : 3 : 6
Strength per square inch:			
Age 7 days.....	1,600	1,300	1,000
Age 28 days.....	2,000	1,600	1,300

If the specimens fail to fulfill the requirements for 7-day tests the concrete may be accepted if specimens fulfill the requirements for 28-day tests.

**54.14. Falsework.** Falsework shall be built on good firm foundation and be of sufficient strength to carry the loads without appreciable deformation. It shall be constructed with 1/20-inch camber for each foot of span and if necessary, wedges shall be kept driven as the weight of concrete is added so that the bottom of the slab will not drop below the lines shown on the plans. If appreciable settlement occurs in the falsework the Engineer shall stop the work and require a thorough remodeling to insure a first class product. For continuous girders, arches having spans of over 50 feet and large structures, and for trussed centers or other special means of support detail drawings of the falsework shall be submitted for approval.

**54.15. Forms.** Forms shall be so designed and constructed that they may be removed without injuring the concrete.

The material to be used in the forms for exposed surfaces shall be sized and dressed lumber, or metal in which all bolt and rivet heads are counter-sunk, so that in either case a plain, smooth surface of the desired contour is obtained. Undressed lumber may be used for backing or other unexposed surfaces.

The forms shall be built true to line, and braced in a substantial and unyielding manner. They shall be mortar-tight and, if necessary to close cracks due to shrinkage, shall be thoroughly soaked with water. Forms for re-entrant angles shall be chamfered and for corners shall be filleted. Dimensions affecting the construction of subsequent portions of the work shall be carefully checked after the forms are erected and before any concrete is placed. The interior surfaces of the forms shall be adequately oiled, greased or soaped to insure the non-adhesion of mortar. Form lumber which is to be used a second time shall be free from bulge or warp and shall be thoroughly cleaned. The forms shall be inspected immediately preceding the placing of concrete. Any bulging or warping shall be remedied and all dirt, sawdust, shavings or other debris within the forms shall be removed.

**54.16. Measuring.** All materials shall be accurately measured by volume. The cement shall be measured as packed by the manufacturer, a sack containing not less than 94 pounds net being considered one (1) cubic foot. Fine and coarse aggregate shall be measured loose. The Contractor shall furnish and use an approved water measuring and discharging device, also boxes or pans of such dimensions as will give, when filled and struck, the exact volume of aggregate required for the class of concrete specified.

Hydrated lime, when required, shall be incorporated in the mixture in the amount specified. This amount, given as a percentage of the cement, shall be treated as additional material and not as replacing any cement. Generally the hydrated lime shall not exceed 10 per cent, by volume, of the cement.

**54.17. Consistency.** Sufficient water shall be used, in mixing plain concrete to produce a mixture which will flatten and quake when deposited in place, but not enough to cause it to flow, and in mixing concrete in which reinforcement is to be imbedded, to produce a mixture which will flow sluggishly when worked and which at the same time can be conveyed from the mixer to the forms without separation of the coarse aggregate from the mortar. In no case shall the quantity of water used be sufficient to cause the collection of a surplus in the forms.

**54.18. Mixing Conditions.** The concrete shall be mixed in the quantities required for immediate use and any which has developed initial set, or which does not reach the forms within thirty (30) minutes after the water has been added, shall not be used. No concrete shall be mixed while the air temperature is at or below thirty-five (35°) degrees F. without the approval of the Engineer, and only when adequate means are employed to heat the aggregates and water.

**54.19. Mixing.** Unless hand-mixing is specifically permitted by the Engineer the mixing shall be done in a batch mixer of approved type which will insure the uniform distribution of the materials throughout the mass so that the mixture is uniform in color and smooth in appearance. The mixing shall continue for a minimum time of one (1) minute after all the ingredients are assembled in the drum during which time the drum shall revolve at the speed for which it was designed, but shall make not

less than 14 nor more than 20 revolutions per minute. The mixer shall be equipped with an attachment for automatically locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch.

**54.20. Hand-Mixing.** When hand-mixing is permitted it shall be done on a water-tight platform. The fine aggregate and cement shall first be mixed until a uniform color is attained and then spread over the mixing board in a thin layer.

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

After the water has been added the mass shall be turned at least six times, and more, if necessary, to make the mixture uniform in color and smooth in appearance. Hand-mixed batches shall not exceed one-half ( $\frac{1}{2}$ ) cubic yard in volume.

**54.21. Placing.** Concrete shall be placed in the forms immediately after mixing. It shall be so deposited that the aggregates are not separated. Dropping the concrete any considerable distance, depositing large quantities at any point and running or working it along the forms, or any other practice tending to cause segregation of the ingredients will not be allowed. It shall be compacted by continuous tamping, spading, or slicing. Care shall be taken to fill every part of the forms, to work the coarser aggregate back from the face, and to force the concrete under and around the reinforcement without displacing it. Mass concrete shall be deposited in continuous horizontal layers and whenever practicable, concrete in structures shall be deposited continuously for each monolithic section of the work.

**Depositing in Water.** Concrete shall be deposited in water only with the permission of the Engineer and under his supervision.

When depositing in water is allowed, the concrete shall be carefully placed in the space in which it is to remain in a compact mass by means of a tremie, bottom dumping bucket, or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. No concrete shall be placed in running water, and forms which are not reasonably water-tight shall not be used for holding concrete deposited under water.

**54.22. Freezing Weather.** Concrete shall not be placed when freezing temperature prevails or threatens, except upon written permission from the Engineer, which will not be granted until satisfactory provision has been made for protecting the work. Concrete placed under these conditions shall be thoroughly protected until set, and will not be accepted until after thirty (30) consecutive days, during which the temperature does not fall below 40° F.

**54.23. Construction Joints.** Wherever the work of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. So far as possible the location of construction joints shall be planned in advance and the placing of concrete carried continuously from joint to joint. These joints shall be perpendicular to the principal lines of stress and in general be located at points of minimum shear.

Where dowels, reinforcing bars, or other adequate ties are not shown on the plans or required by the Engineer, keys shall be made by imbedding water-soaked beveled timbers of a size shown on the details, or as directed by the Engineer, in the soft concrete, which shall be removed when the concrete has set. In resuming work, the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance or other soft material, with stiff wire brushes, and if deemed necessary by the Engineer, shall be roughened with a steel tool. The surface then shall be thoroughly washed with clean water and painted with a thick coat of neat cement mortar after which the concreting may proceed.

No concrete work shall be stopped or temporarily discontinued within 18 inches of the top of any finished surface; unless such work is finished with a coping having a thickness less than 18 inches, in which case the joint shall be made at the under line of the coping.

**54.24. Curing Concrete.** Careful attention shall be given by the Contractor to the proper curing of the concrete. Handrails, floors, and trowelled surfaces shall be protected from the sun, and in drying weather the whole structure shall be kept wet for a period of one (1) week. Concrete floor slabs may be covered with damp sand as soon as the concrete has taken hard set and then kept wet for one (1) week. Other precautions to insure thorough curing of the concrete shall be taken by the Contractor as directed by the Engineer.

**54.25. Removal of Forms.** In order to make possible the obtaining of a satisfactory surface finish, forms on ornamental work, railings, parapets, and vertical surfaces that do not carry loads and which will be exposed in the finished work shall be removed in not less than twelve (12) nor more than forty-eight (48) hours, depending upon weather conditions. Forms under slabs, beams, girders, and arches shall remain in place at least twenty-one (21) days in warm weather, and in cold weather at the discretion of the Engineer. Forms shall always be removed from columns before removing shoring from beneath beams and girders, in order to determine the conditions of column concrete.

No forms whatever shall be removed at any time without the consent of the Engineer. Such consent shall not relieve the Contractor of responsibility for the safety of the work. As soon as the forms are removed all rough places, holes, and porous spots shall be filled, and all blots, wires, or other appliances used to hold the forms and which pass through the concrete shall be cut off or set back one-half ( $\frac{1}{2}$ ) inch below the surface and the ends covered with cement mortar of the same mix as used in the body of the work.

**54.26. Finishing Concrete.** All concrete surfaces shall be reasonably true and even, free from stone pockets, excessive depressions or projections beyond the surface. The concrete bridge seats and tops of walls and curbs shall be brought flush with the finished top surface and generally struck off with a straight edge and floated. Unless otherwise specified the forms of all ornamental work, railings, parapets and all exposed vertical surfaces shall be removed as soon as safety of the work will permit (usually in not less than 12 nor more than 48 hours) and any small cavities filled with mortar of the same mix, as used in the concrete. The whole surface shall then be rubbed with a wooden float and clean water until all form marks are removed, leaving the surface plain, smooth and uniform in color and appearance. Cement wash will not be allowed.

**54.27. Expansion Joints.** Expansion and contraction of concrete structures shall be provided for as shown on the plans. For walls and long abutments, expansion joints shall be located at intervals not exceeding forty (40) feet for plain walls, nor eighty feet for reinforced walls. To be considered reinforced, the longitudinal steel shall be at least equal to one-half ( $\frac{1}{2}$ ) of one (1) per cent of the cross-sectional area of the wall.

In parapets, railings, and other light work superimposed on heavy work, the expansion joints shall be placed at intervals not exceeding twenty (20) feet.

**54.28. Basis of Payment.** All concrete shall be classified as and measured in accordance with the dimensions shown on the plans unless changes are ordered by the Engineer during construction. Payment will be made at the contract unit prices per cubic yard, for the several classes of concrete, complete in place which price shall include materials, forms, falsework, labor, tools, machinery and work incidental thereto, except that reinforcement will be paid for as a separate item. No allowance will be made for cofferdams, pumping, bracing, etc.

## ITEM 55. TIMBER AND CONCRETE PILING

**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.

The Contractor shall be responsible for determining the length of piles required, either by driving test piles, or otherwise.

(a) **Foundation Piles.** Piles shall be used only in places where a minimum penetration of ten feet in firm material or twenty feet in soft material can be obtained and they shall be designed to sustain the total load of the structure. Piling shall preferably be enclosed by permanent water-tight sheet piling, with top sawed off about 1 foot below low water. The tops of piles shall be cut off level at the elevation indicated on the plans and shall be embedded in the concrete footings at least one (1) foot. When subject to transverse forces, batter piles shall be driven in sufficient numbers to resist the transverse forces without assistance from the vertical piles. For foundation of arch or movable bridges or high abutments the piles shall be completely embedded in firm earth, sand, or gravel, which will afford good lateral support. When this is impracticable, the soft materials shall be excavated and replaced with heavy riprap for such distance and depth as the plans indicate or Engineer directs.

(b) **Trestle Piles and Foundation Piles for Trestle Bents.** These piles shall be used only in places where a minimum penetration of 10 feet in firm material or 20 feet in soft material can be secured, provided further that trestle piles shall have a penetration of not less than one-third ( $1/3$ ) of their length. For foundation for trestle bents piles shall be cut off level, approximately three (3) feet above the ground elevation and the cap rigidly secured by dowels or drift bolts. Trestle piles shall be cut off level at the elevation shown on the plans and the caps secured as described above. If the cut-off is 10 feet or more above the ground line, timber piles shall be braced by diagonal cross-bracing composed of 3" x 10" timbers secured to the piles by  $3/4$ " diameter bolts.

**Material and Loading.** (a) **Timber Foundation Piles.** Piles may be of any species which will satisfactorily stand driving, and shall be cut from live, sound trees, shall be solid, close grained, and free from defects such as injurious ring shakes, large unsound or loose knots, decay, or other defects, which might materially impair their strength. They shall be cut above the ground swell and have a uniform taper, and shall be free from short bends. A line drawn from the center of the butt to the center of the tip shall lie wholly within the body of the pile. Piles shall be cut when the sap is down, and if required by the Engineer shall be peeled soon after cutting. All knots shall be trimmed close to the body of the pile. For round piles, the minimum diameter at the tip shall be 8 inches, and at the butt shall be 12 inches. The maximum diameter at the butt shall be 20 inches. Square piles shall be uniform in size, generally not less than 10x10 inches for lengths up to 30 feet and 12x12 inches for lengths over 30 feet. These piles shall be submerged in water and the load to be assumed per pile shall generally be 15 tons with a maximum limit of 20 tons.

(b) **Timber Trestle Piles and Foundation Piles for Trestle Bents.** These piles shall meet the requirements for timber "Foundation Piles" except that they shall be of durable timber, peeled and driven to a safe carrying capacity of at least 10 tons each, or more when so indicated on the plans. The species will, in general, be noted on the plans, but if not so noted it shall be subject to the approval of the Engineer. It is preferable that they be treated for preservation, impregnating them with not less than 12 pounds of creosote oil per cubic foot of timber by a process approved by the Engineer.

(c) **Concrete Foundation Piles.** Concrete piles shall be made of Class "A" concrete as herein specified, except that the concrete shall preferably be waterproofed by an integral method. The average diameter shall not be less than 12 inches and the diameter at the point not less than 8 inches. The length shall not exceed thirty times the average diameter for piles driven through firm soil, and shall not exceed fifteen times the average diameter for piles driven to rock through loose, wet soil or filled ground. When lateral support is deficient so that the piles act as columns, they shall be designed as columns. Concrete piles when properly designed, reinforced, and driven to refusal may be subjected to loads as

determined by tests or formula, but not to exceed 300 pounds per square inch of total cross-section at the smallest effective point, and generally not to exceed 25 tons each when used for movable spans, arches, and high abutments, nor 30 tons each when used for other foundations.

1. **Precast Piles.** These shall be made in accordance with the plans and the reinforcement shall be accurately placed and rigidly secured in such manner as to insure its proper location in the complete pile. The concrete shall be carefully placed, tamped, and spaded, care being used to fill every part of the form and to work the concrete around and under the reinforcement without displacing it. The piles shall be cast separately, or 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 piles. Piles cast in tiers shall be separated by tar paper carefully placed. The concrete shall be poured continuously in each pile. The complete piles must be free from stone pockets, porous spots, or other defects and be straight and true to the form specified. The forms shall be true to line, built of surface lumber, and a one (1) inch chamfer strip shall be used in all corners; they shall be water-tight, and shall not be removed within twenty-four (24) hours after the concrete is poured. All exposed surfaces of the pile shall be given a "rubbed" finish. The piles shall be cured at least 40 days at a temperature of not less than 40 degrees F., or 30 days at a temperature of not less than 60 degrees F. Piles shall be at least 30 days old when driven. Great care shall be taken that green piles are not injured while curing by improperly supporting, handling, or transporting them.

When concrete piles are lifted or moved they shall be supported at the "quarter-points," and they shall be so designed that the unit stresses produced by handling, as described above, will not exceed 650 pounds compression in the concrete nor 16,000 pounds tension in the steel. They shall be provided with special reinforcement at the top and bottom to protect them from damage in driving.

2. **Piles Cast in Place.** When piles are cast in a strong metal shell which is previously driven to refusal and which remains in place after the concrete has set, the safe loads when piles are completely embedded in firm earth may be taken the same as specified above for driven reinforced concrete piles. Piles cast in place without metal reinforcement shall not be used in water or in ground so soft, in either wet or dry condition, as not to give firm lateral support. No pile of this type shall be concreted until all driving within a radius of six (6) feet has been completed, and care shall be taken that the piles are in no way disturbed until the concrete has become hard.

(d) **Concrete Trestle Piles and Foundation Piles for Trestle Bents.** These piles shall meet the requirements for concrete "Foundation Piles."

**Driven Piles.** All excavation of the foundation in which piles are to be driven shall be completed before driving is commenced. After driving is completed all loose and displaced materials shall be removed from around the piles leaving a clean solid surface to receive the concrete.

(a) **Driving Timber Piles.** In driving, the tops of the piles, when necessary to prevent splitting, shall be provided with a metal collar. Metal shoes of an approved design shall also be furnished when ordered by the Engineer. Piles shall be driven within  $\frac{1}{4}$ -inch variation per foot of length to the vertical or battered lines indicated on the plans. They shall be driven to practical refusal, which is here understood to mean, driven to such depth that the last five blows of the 2,000-lb. hammer freely falling three feet upon the solid, unbroomed head of a pile shall not produce an average penetration greater than one half inch for each blow. For other weights of drop hammers falling from 12 to 15 feet and for steam hammers, the penetration for practical refusal as above defined may be determined from the following formulas:

(a) Gravity Hammers. 
$$S = \frac{W H}{20000} \text{ --- } 1.0 \text{ average for each of last five blows.}$$

(b) Steam Hammers. 
$$S = \frac{W H}{20000} \text{ --- } 0.1 \text{ average for each of last twenty blows.}$$

Where S = Penetration in inches.  
W = Weight of the falling hammer in pounds.  
H = Height of fall in feet.

In case the above refusal cannot be obtained without injury to the pile or on account of the impracticable lengths required, the number indicated on the plans shall be increased until the maximum load coming on any pile shall not exceed its safe bearing capacity as determined from the formulas:

$$P = \frac{2 W H}{S/1} \text{---for gravity hammer.}$$

$$P = \frac{2 W H}{S/0.1} \text{---for steam hammer.}$$

Where P = Load in pounds.

For movable spans, arches, and high abutments the above loads shall be reduced 25 per cent.

(b) **Driving Concrete Piles.** Driving large concrete piles will be covered by special specifications. Under usual conditions (piles containing not over 2 cubic yards of concrete) they shall be driven with drop hammers weighing not less than the pile, or with double acting steam hammers the total weight of which is not less than 2/3 the weight of the pile. In driving, the tops of the piles shall be protected by suitable cushions of wood, rope, or other material so as to reduce the injury of the pile to a minimum. Metal shoes or points of an approved design shall be furnished when ordered by the Engineer. Piles shall go to rock or to practical refusal which is here understood to mean, driven to such depth that the last five blows of an 8000-lb. hammer freely falling five feet upon the solid head of a pile shall not produce an average penetration greater than one-third inch for each blow. For other weights of drop hammers falling from 3 to 6 feet and for steam hammers the penetration for practical refusal as above defined may be determined from the following formulas:

Gravity Hammers. 
$$S = \frac{W H}{30000} \text{---}1.0$$

Steam Hammers. 
$$S = \frac{W H}{30000} \text{---}0.1$$

In case the above refusal cannot be obtained without injury to the pile or on account of the impracticable length required, the number indicated on the plans shall be increased until the maximum load coming on any pile shall not exceed its safe carrying capacity as determined by the formulas given for timber piles. For movable spans, arches and high abutments these loads shall be reduced 20 per cent.

(c) **Jetted Piles.** Jetted piles shall extend to a good solid stratum. Their carrying capacity shall be determined by actual tests, or if driven with the aid of a jet and for the last foot of penetration driven without jet, the same formula may be applied as in the case of driven piles. If jet pipes are embedded in concrete piles they shall be filled with cement grout of 1:2 mix.

(d) **Testing.** If tests are called for in the contract, the Conductor shall submit a price per test for testing piles. The number of tests to be determined by the Engineer (which in general will be one pile for each different condition of foundation encountered). Tests shall be made by loading the pile to two times the working load without exceeding a permanent settlement of 1/4-inch in 48 hours, unless otherwise specified. In case the bearing capacity of any pile is found by test, or by formula if not tested, to be less than the load for which it was designated, additional piles shall be driven until the load per pile to be borne is reduced to the safe bearing capacity.

**Basis of Payment.** This work will be paid for at the contract unit price per lineal 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. Payments 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, or as ordered by the Engineer and acceptable to him.

# GENERAL SPECIFICATIONS FOR PLAIN AND REINFORCED CONCRETE BRIDGES

## ITEM 56. GENERAL REQUIREMENTS

**56.1. General.** The Contractor shall, during construction, adhere strictly to the plans, as the strength of the finished structure depends upon this; and no change shall be allowed without the written authority of the County Engineer, or his Deputy.

**56.2. 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, standard cast iron water pipe, or vitrified clay 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.

(d) **Roadways.** In general, clear widths of roadways shall be as follows:

For culverts—16 to 30 ft. clear roadway.

For bridges—16 to 24 ft. clear roadway.

### LOADS.

**56.3. General.** All parts of the structure shall be proportioned for the maximum stresses produced by the dead load, temperature, and live loads, with impact allowance added.

**56.4. 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 five (5) per cent 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.....	150 lbs. per cu. ft.
Earth fill (dry).....	100 lbs. per cu. ft.
Earth fill (wet).....	120 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.

**56.5. Live Loads.** Live loads shall consist of the following:

For the floor and its supports a load of 125 pounds per square foot of total floor surface or a typical truck weighing 15 tons, depending upon which gives the most unfavorable condition of loading. Each truck shall be assumed to have two-thirds of its weight on one axle, axles 10 feet between centers and wheels 6 feet between centers.

The space assumed to be occupied by the truck shall be 20 feet long and 9 feet wide. For bridges having a width of roadway not exceeding 16 feet there shall be assumed one truck, and for bridges having roadway of more than 16 feet, two trucks.

**56.6. Impact.** On all concrete structures where the fill or ballast is less than two feet in depth, an allowance for impact shall be made to the extent of twenty-five (25) per cent of all live load stresses.

**56.7. Loads to be Given on Drawings.** The dead loads and the assumed live loads used for the design of each structure shall be shown on the drawing or stress sheet.

**56.8. Distribution of Wheel Loads.** (a) **On Concrete Slabs.** Each wheel load shall be assumed to be uniformly distributed as follows:

Depth of Ballast or Paving.	Area of Distribution.
8 inches or less.....	4 ft. 0 inches square.
9 to 17 inches, inclusive.....	5 ft. 0 inches square.
18 inches or more.....	6 ft. 0 inches square.

(b) **On Stringers.** For longitudinal stringers of steel or reinforced concrete carrying concrete floor and stringers spaced 4 ft. between centers, each interior stringer shall be designed to carry two-thirds of the full specified wheel loads, and when spaced 6 feet between centers each stringer shall be designed to carry the full wheel loads which can come over it, and proportionally for other spacing. Each wheel load shall be considered as applied to the stringer at a point. Outside stringers shall be designed to provide fully for the most unfavorable position of the live load with the arrangements adopted.

**Note.**—For usual conditions outside stringers should not be placed inside the curb lines, and should have at least as much strength as interior stringers when the spacing center to center is 40 inches or more, and greater strength than interior stringers when the spacing center to center is less than 40 inches.

(c) **On Floor Beams Without Stringers.** For bridges with concrete floor slab carried on floor beams without stringers, when spacing of beams is from 5 to 10 feet, each beam shall be assumed to carry the full axle load. When spacing of beams is less than 5 feet the portion of wheel load on each beam shall be represented by a fraction whose numerator is the spacing of beams in feet and the denominator is 5. These loads shall be assumed as uniformly distributed along the floor beam as follows:

Depth of Ballast or Paving.	Length of Distribution.
8 inches or less.....	9 feet.
9 to 17 inches, inclusive.....	10 feet.
18 inches or more.....	11 feet.

#### ALLOWABLE STRESSES.

**56.9. Modulus of Elasticity.** The modulus of elasticity of steel shall be taken as 30,000,000 pounds per square inch, and of concrete as 2,000,000 pounds per square inch.

**Co-efficient of Expansions.** The co-efficient of expansion of concrete, plain or reinforced, shall be taken as 0.000006.

**56.10. Allowed Unit Stresses.** (a) **Bearing.** Compression applied to a surface of concrete of twice the load 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.

#### CALCULATION OF STRESSES.

**56.11. Span.** In the calculation of stresses the span of reinforced concrete beams or slabs shall be taken as the distance between centers of supports or the clear span plus the depth of beam or slab.

**56.12. Initial Stress.** Initial Stress in concrete due to a contraction or expansion shall be neglected.

**56.13. Assumption for Calculations.** The following assumptions shall be used as a basis of calculations:

- Calculations shall be made with reference to working stresses and safe loads, rather than with reference to ultimate strength and ultimate loads.
- A plane section before bending remains plane after bending.
- 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.
- In calculating the moment of resistance of beams, the tensile stresses in the concrete are neglected.
- The adhesion between concrete and reinforcement is perfect. Under compressive stress the two materials are therefore stressed in proportion to their moduli of elasticity.
- The ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete is taken at 15.

**56.14. 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  $M = 1/8 wl^2$ .

(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.

**56.15. 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.

**56.16. 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.

**56.17. Spacing of Stirrups.** For uniformly distributed loading, 
$$S = \frac{3f_s j d A_s}{w(1-2x)}$$

For any loading, 
$$S = \frac{3f_s j d A_s}{2V}$$
 Where:  $f_s$  = tensile unit stress in steel,  $d$  = depth of beam, top to center

of steel,  $j$  = ratio of lever arm of resisting couple to depth "d,"  $A_s$  = area of reinforcing steel,  $V$  = Total Shear,  $w$  = uniform load per lineal foot,  $L$  = span length,  $X$  = distance from left support to point under consideration.

From the above formulas it is evident that the necessary spacing of stirrups is inversely proportional to the total shear  $V$  at any point.

**56.18. 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,  $jd$ .

**56.19. 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.

**56.20. 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 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.

**56.21. 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.

**56.22. 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.

#### CONSTRUCTION DETAILS.

**56.23. 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.

**56.24. 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 feet, and with reinforcement from 50 to 80 feet (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.

**56.25. 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.

**56.26. 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.

**56.27. 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 four inches.

Square slabs shall be reinforced in both directions.

**56.28. 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.

**56.29. 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.

**56.30 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.

**56.31. 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.

**56.32. 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.

**56.33. 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 one 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.

**56.34. 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.

**56.35. 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.

**56.36. 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.

**56.37. 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.

**56.38. 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 rod. 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 2½ 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 one per cent 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 portion 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.

**56.39. Special Reinforcement.** Slabs reinforced for strength in one direction only shall be reinforced to prevent shrinkage cracks by wire mesh or fabric.

## MATERIALS.

**56.40. Classes of Concrete.** Unless otherwise specially indicated on the plans, there will be three 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.

**56.41. Nature of Concrete Materials.** Cement, water, fine aggregate and coarse aggregate shall be as specified in Paragraph 54.7 to 54.13, inclusive.

**56.42. Concrete Reinforcement Bars.** The reinforcement shall meet the requirements specified under Item 14.

**56.43. Material for Piling.** The material for piling shall meet the requirements specified under Item 55.

**56.44. Material for Forms.** The material to be used in the forms shall meet the requirements of Paragraph 54.15.

**56.45. 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 unreinforced footings and at all other places provided for on the plans or specified in writing by the Engineer.

#### MIXING AND PLACING CONCRETE.

**56.46. Unit of Measure.** The unit of measure shall be the cubic foot. A bag of cement containing 94 lbs. shall be considered one cubic foot.

The measurement of fine and coarse aggregate shall be by loose volume.

**56.47. Devices for Measuring Material.** The devices for measuring material shall be as specified in Paragraph 54.16.

**56.48. Consistency.** The consistency of the concrete shall be as specified in Paragraph 54.17.

**56.49. Mixing and Placing Concrete.** The Contractor shall mix and place the concrete in strict accordance with the requirements of Paragraphs 54.19 to 54.22, inclusive.

**56.50. 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.

**56.51. 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. See Paragraph 54.23.

**56.52. 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.

**56.53. Protection of Concrete.** The Contractor shall protect the concrete as specified in Paragraph 16.20.

**56.54 Removal of Forms.** Forms shall be removed as specified in Paragraph 54.25.

**56.55. Defective Work.** Any defective work discovered after the forms have been removed, shall be remedied as specified in Paragraph 3.24 and 54.25.

**56.56. Finishing Concrete.** The Contractor shall finish the concrete as specified in Paragraph 54.26.

**56.57. Instructions Regarding Miscellaneous Auxiliaries.** Sidewalks and curbing, drainage and weep holes, pipes and conduits, anchors, bolts, grillages, waterproofing, and refilling shall be constructed and placed as indicated on plans or as directed by the Engineer.

#### EXPANSION DEVICES.

**56.58. 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, see Item 54.27.

## STEEL SUPERSTRUCTURES

### ITEM 57. GENERAL REQUIREMENTS

**57.1. Use Of.** In general, plans for steel bridges will not be approved except for structures spanning navigable channels, and for locations where the cost of concrete structures would be prohibitive.

**57.2. Materials.** Rolled structural steel will be used in general for all structures. Rivet steel will be used for rivets. Cast steel will be used for shoes of long plate girders and important details of drawbridge machinery. Cast iron may be used for minor details upon the written approval of the Engineer.

**57.3. Types of Bridges.** The following types of bridges are preferred:

For spans up to 30 feet—Rolled beams.

For spans 30 to 80 feet—Plate girder or riveted trusses.

For spans 80 to 180 feet—Riveted trusses.

For spans over 180 feet—Either riveted or pin connected trusses.

Trusses shall preferably have single intersection web systems, and in through trusses the hip verticals shall be rigid members.

Viaducts shall consist, usually, of alternate tower spans and free spans supported on trestle bents. However, neither longitudinal nor horizontal bracing shall be used below high water.

**57.4. Drawings.** The County Engineer will furnish designs, showing details preferred with usual conditions.

**57.5. Alternate Designs.** Bidders may submit alternate designs when agreeable to the County Engineer and when so provided for in the Notice to Contractors. Alternate designs shall have as great strength and general merit as the designs furnished by the County Engineer. Bidders submitting alternate designs shall furnish stress sheets and general plans which shall show all dimensions and sectional areas.

**57.6. Depth Ratios.** Trusses shall preferably have a depth of not less than one-tenth of the span and plate girders a depth of not less than one-twelfth of the span. If shallower trusses or girders 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.

**57.7. Size of Drawings.** All drawings shall be 22x36 inches over all, with a margin of 2 inches on the left hand edge and one-half inch margins on the other edges.

**57.8. Approval of Drawings.** Upon the acceptance and execution of the contract, the Contractor shall prepare and furnish Standard Size working drawings showing complete details of all parts of the structure. Blue prints, in duplicate, of these drawings shall be submitted to the County Engineer for his approval before any material is ordered or work begun in the shop. All details shall be subject to his modification or approval.

The Contractor alone shall be responsible for the correctness of the drawings, although the drawings may have been approved by the Engineer.

**57.9. Prints for the County Commissioners Court.** After drawings have been approved, the Contractor shall furnish the County Commissioners Court, without cost, three (3) complete sets of prints and two (2) sets of all shop bills.

**57.10. Dimensions for Calculations.** The following dimensions shall be used in designing steel superstructures:

Span of beam or girder, distance center to center of bearings.  
Span of truss, distance center to center of bearings or end pins.  
Span of floor beam, distance center to center of trusses.  
Span of stringer, distance center to center of floor beams (one panel length).  
Depth of girder, distance between centers of gravity of flanges.  
Depth of truss, distance between centers of gravity of chords or between centers of pins.

**57.11. Overhead Clearance.** The overhead clearance for bridges on a straight line and having a 16-foot roadway shall not be less than fourteen (14) feet for a distance of one-half the width of the roadway. For roadways greater than sixteen (16) feet no more space shall be obstructed than is permissible for a 16-foot roadway.

**57.12. The Width of Roadway** for bridges on a straight line shall generally be not less than sixteen (16) feet. If end spans or approaches of a bridge are on a curve the width shall be increased sufficiently to permit safe and easy passage of vehicles.

**57.13. Minimum Distance Between Trusses.** The distance between centers of trusses shall be sufficient to provide for the designated width of roadway and shall in no case be less than one-fifteenth ( $1/15$ ) of the length of span.

**57.14. Roadway Floor.** For the roadway single thickness of floor planks shall be not less than four (4) inch nominal thickness. It shall be laid to conform to the section shown on the plan.

Whenever a solid floor is specified, it shall be the subject of special specifications or shall be in accordance with requirements contained elsewhere herein under "Roadway Pavement."

Rough plank shall be carefully graded as to thickness before laying, and be laid so that no two adjacent planks vary in thickness more than one-sixteenth ( $1/16$ ) of an inch.

All floors shall be cut to a straight line along the sides of the roadway and walkway.

Floor planks shall be laid heart side down with one-quarter ( $1/4$ ) inch openings and be spiked to each stringer and nailing strip with at least two seven (7) inch spikes for four (4) inch plank and two six (6) inch spikes for three (3) inch plank.

**57.15. Wheel Guards.** Wooden wheel guards having a cross-section not less than six inches by four inches shall be provided on each side of the roadway. They shall be spliced with half and half joints and six-inch lap. They shall be separated from the floor planks by blocks three inches by six inches, by twelve inches long, spaced not more than five feet apart, center to center, and fastened in place by a five-eighths-inch bolt passing through the center of each block and attached to the stringer below. Each block is also to be fastened to the wheel guard by one spike.

**57.16. Footwalk Floor.** For the footwalk, if any, planks not less than two inches in thickness shall be provided, and firmly nailed to the nailing strips with quarter-inch openings. All planks shall be laid heart side down.

**57.17. Position of Footwalks.** Where footwalks are required they will generally be carried by steel stringers on steel brackets outside of the main girders or trusses.

**57.18. Floor Stringers.** Floor stringers will be steel I-beams unless otherwise specified on the drawings.

Wooden joists, when allowed for floor stringers, shall have a width of at least three inches and a length giving a bearing of the full width of the floor beams, and separated one-half inch at the ends for free circulation of air.

The distance between centers of stringers shall in no case exceed twelve (12) times the thickness of floor plank.

**57.19. Proportioning Wooden Stringers.** When wooden stringers are used, they shall be of white oak or long leaf Southern yellow pine of grade herein specified, and shall be proportioned for the sum of the dead and live loads, without impact, with a maximum fiber stress of 1200 pounds per square inch, bearing across the fiber 350 pounds per square inch, and shearing with the fiber 150 pounds per square inch.

**57.20. Bridging for Wooden Stringers.** Wooden stringers which have a width less than one-third their depth shall be braced by two by four inch bridging, two lines of which shall be in each panel.

**57.21. Washers.** All bolt heads and nuts in contact with wood shall have washers under heads and nuts three inches in diameter by one-quarter inch thick.

**57.22. Lumber.** All lumber shall be of the kind specified on plans, free from loose knots, knots in clusters, knots greater than one and one-half inches in diameter, worm holes, wind shakes, decayed or unsound portions, bark edges, waness exceeding one-fifth of face and one-third of length, sap on more than one edge or other defects impairing its strength or durability. The lumber shall be cut from green standing timber, straight grained, sawed true, and shall be subject to the inspection and acceptance of the Engineer.

**57.23. Joists and Stringers.** Steel joists shall be securely fastened to the floor cross-beams, and steel stringers shall preferably be riveted to the webs of the floor-beams by means of connection angles at least 7/16 inch thick.

Where end floor-beams 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.

**57.24. Fences.** A fence of steel or iron, well made for its purpose, shall be placed on each side of the bridge, except where plate girders serve the same purpose, and be rigidly attached to the superstructure.

**57.25. Trestle Towers.** Each bent of high trestles shall preferably be composed of two columns and the bents united in pairs to form towers, each tower thus formed of four columns shall be thoroughly braced in both directions and have struts both ways between the feet of the columns. All columns shall have an anchorage capable of resisting one and one-half times the specified wind forces.

Each tower shall have sufficient base longitudinally to be stable when standing alone. Tower spans for high trestles shall not be less than thirty feet.

**57.26. Bolts.** Bolts may not be used in place of rivets except by special permission of the Engineer.

**57.27. Drainage.** Provision shall be made for drainage clear of all parts of the metal work.

**57.28. Name Plates.** One or more cast iron name plates of an approved design, giving the date of construction, the names of the State Highway Engineer, County Engineer, County Commissioners Court and the Contractor for the superstructure, shall be securely bolted to the superstructure at the point or points specified.

## STEEL SUPERSTRUCTURES—Continued

### ITEM 58. LOADS

**58.1. Arrangement of Loads.** All structures shall be designed to carry the dead load and live loads of the required weight, either uniform or concentrated as specified, so placed as to give the greatest stress in each part of the structure. The dead load shall comprise the actual weight of the completed structure. The dead load used in figuring stresses must not vary more than five per cent from the actual estimated weights made from the completed design.

**58.2. Assumed Loads Given on Drawings.** The loads assumed for the design of each structure shall be shown on the drawings or stress sheet.

**58.3. Dead Loading.** The dead load is the weight of all materials in the structure assumed at the following unit weights:

Steel.....	490 lbs. per cu. ft.
Concrete.....	150 lbs. per cu. ft.
Earth fill (sand and clay), dry.....	100 lbs. per cu. ft.
Earth fill (sand and clay), wet.....	120 lbs. per cu. ft.
Ballast.....	120 lbs. per cu. ft.
Macadam or gravel, rolled.....	140 lbs. per cu. ft.
Brick.....	150 lbs. per cu. ft.
Asphalt paving.....	130 lbs. per cu. ft.
Untreated lumber.....	4 lbs. per ft. B. M.
Treated lumber.....	5 lbs. per ft. B. M.

**58.4. Uniform Live Loads for Trusses and Girders.** 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 sidewalks use the same uniform live loads as for the roadway surface:

Spans 100 ft. long or less, 80 pounds per square foot.
Spans 110 ft. long, 78 pounds per square foot.
Spans 120 ft. long, 76 pounds per square foot.
Spans 130 ft. long, 74 pounds per square foot.
Spans 140 ft. long, 72 pounds per square foot.
Spans 150 ft. long, 70 pounds per square foot.
Spans 160 ft. long, 68 pounds per square foot.
Spans 170 ft. long, 66 pounds per square foot.
Spans 180 ft. long, 64 pounds per square foot.
Spans over 180 ft. long, 64 pounds per square foot.

**58.5. Concentrated Live Loads.** The concentrated live load shall consist of a truck weighing 15 tons. A truck shall be assumed to have two-thirds of its weight on one axle, axles 10 feet between centers, and wheels 6 feet between centers.

The space assumed to be occupied by a truck shall be 20 feet long and 9 feet wide.

Each steel and concrete bridge having a roadway of 16 feet or less shall be designed for one truck, and each concrete bridge having a roadway of more than 16 feet shall be designed for two trucks of the weight specified.

**58.6. Impact.** An allowance for impact shall be made to the extent of 25 per cent of all live load stresses.

**58.7. 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 pounds for each foot of span, and not less than 150 pounds per linear foot of bridge for the unloaded chord. All wind is considered as a moving load.

**58.8. Distribution of Loads on Stringers.** (a) **Wooden Floor.** For bridges having a wooden floor and longitudinal stringers spaced two feet between centers, each interior stringer shall be designed to carry one-half of the full specified wheel loads, and when spaced three feet between centers, each interior stringer shall be designed to carry three-fourths of the full specified wheel loads which can come over it, and proportionally for other spacing. Each wheel load shall be considered as applied to the stringer at a point. Generally, stringers shall not be spaced less than 18 inches nor more than 27 inches between centers.

(b) **Concrete Floor.** For longitudinal stringers of steel or reinforced concrete carrying a concrete floor and stringers spaced four (4) feet between centers, each interior stringer shall be designed to carry two-thirds of the full specified wheel loads and when spaced six (6) feet between centers each stringer shall be designed to carry the full wheel loads which can come over it, and proportionally for other spacing. Each wheel load shall be considered as applied to the stringer at a point.

NOTE.—Outside stringers shall be designed to provide fully for the most unfavorable position of the live load possible with the arrangements adopted. For usual conditions outside stringers should not be placed inside the curb lines and should have at least as much strength as interior stringers when spacing center to center is forty (40) inches or more, and greater strength than interior stringers when the spacing center to center is less than forty (40) inches.

**58.9. Distribution of Loads on Floor Beams Without Stringers.** For bridges with concrete floor slab carried on steel floor beams without stringers, when spacing of beams is from five to ten (5 to 10) feet, each beam shall be assumed to carry the full axle load. When spacing of beams is less than five (5) feet the portion of wheel load on each beam shall be represented by a fraction whose numerator is the spacing of beams in feet and the denominator is five. These loads shall be assumed as uniformly distributed along the floor beam as follows:

Depth of Ballast or Paving	Length of Distribution.
8 inches or less	9 feet.
9 to 17 inches, inclusive	10 feet.

**58.10. Concrete Floors.** In designing reinforced concrete floor slabs each wheel load shall be considered as uniformly distributed over a four-foot square for a depth of ballast or paving 8 inches or less and over a five-foot square for a depth of 9 to 17 inches, inclusive.

## STEEL SUPERSTRUCTURES—Continued

### ITEM 59. UNIT STRESSES AND PROPORTION OF PARTS

**59.1. Permissible Stresses.** All parts of structures shall be so proportioned that the sum of the maximum stresses produced by dead load, wind, live load, and impact shall not exceed the following amounts in pounds per square inch except as may be modified in the succeeding paragraphs.

	Lbs. per sq. inch.	
Axial and bending tension on net section of:		
Structural steel.....	16,000	
Upset bars and rods where not annealed in accordance with specifications.....	12,000	
Axial compression on gross section.....	16,000—70—	L R

L = Unsupported length of member in inches.

R = Corresponding radius of gyration of member in inches.

Direct compression on:

Cast steel bearing and structural steel plates.....	16,000
Cast iron blocks.....	14,000

Bending on:

Extreme fiber of pins.....	24,000
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Shearing on:

Rivets and turned bolts in floor connections, shop and field.....	8,000
Pins and shop rivets except in floor connections.....	12,000
Turned bolts and field rivets except in floor connections.....	10,000
Web of girders, net section.....	12,000
Web of girders, gross section.....	10,000

Bearing on:

Rivets and turned bolts in floor connections, shop and field.....	16,000
Pins and shop rivets except in floor connections.....	24,000
Turned bolts and field rivets except in floor connections.....	20,000
Expansion rollers, per linear inch.....	600 d
d = The diameter of the roller in inches.	
Masonry plates on Portland cement concrete.....	400

**59.2. Wind Stresses.** For stresses in girder flanges, truss members or trestle columns due to wind pressure combined with those from dead load, live load and impact, the unit stresses given in the table may be increased 25 per cent, but the section shall not be less than required for dead load, live load and impact. When the lateral forces alone or in combination with other forces can neutralize or reverse the stress in any member it shall be proportioned in accordance with the requirements for Alternate Stresses.

In trestle towers, the columns and bracing shall be proportioned to resist the following lateral forces in addition to the dead and live loads and impact. A horizontal force of 450 pounds per linear foot of span applied at the column cap and a lateral pressure of 100 pounds for each vertical linear foot of trestle bent.

**59.3. Radius of Gyration.** Compression members shall have a ratio of length to the least radius of gyration of not more than 125 for main members or 150 for lateral or secondary members.

Horizontal or inclined tension members shall not be longer than 200 R for main members or 250 R

for bracing members, where  $R$  is the radius of gyration about the horizontal axis of the section, and the length considered is the horizontal length of the unsupported portion of the member or the horizontal projection of inclined members.

**59.4. Alternate Stresses.** Members subject to alternate stress of tension and compression shall be proportioned for the stress giving the larger section. If the alternate stresses occur in succession during the passage of the live load as in stiff counters, each stress shall be increased by 50 per cent of the smaller. The connections shall, in all cases, be proportioned for the sum of the stresses.

Wherever the live and dead load stresses are of opposite character, only 70 per cent of the dead load stress shall be considered as effective in counteracting the live load stress.

In through trusses 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.

**59.5. Axial and Bending Stresses Combined.** Members subject to both axial and bending stresses shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress. In members continuous over panel points, only three-fourths of the bending stress, computed as for simple beams, shall be added to the axial stress. The bending moment at panel points shall be assumed equal to that at the center, but opposite in direction. If the fiber stress due to weight and eccentric loading on any member exceeds 10 per cent of the allowable unit stress on the member, such excess must be considered in proportioning the members.

**59.6. Net Sections.** Net sections shall be used in all cases in calculating tension members, and in deducting rivet holes they shall be taken one-eighth inch larger than the nominal size of the rivet. Angles subject to direct tension must be fastened by both legs or only 75 per cent of the net section will be considered as effective.

**59.7. Rivets.** The effective diameter of a rivet shall be the diameter of the cold rivet before driving. Rivets with countersunk heads shall be assumed to have three-fourths the value of corresponding rivets with full heads. Long rivets carrying calculated stress and whose grip exceeds four (4) diameters shall be increased one per cent in number for each additional one-sixteenth ( $1/16$ ) inch of grip.

**59.8. Flange Rivets.** Rivets connecting flanges to web plates shall be sufficient in number to transfer the horizontal shearing stress to the flange angles in a distance equal to the depth of the girder, and if the cross beams rest on the flanges there shall be enough additional rivets to transfer the direct load to the web.

Flange angles with legs exceeding five inches in width shall have at least two lines of rivets, staggered, in such legs.

**59.9. Net Section Through Pin Holes.** Pin-connected riveted tension members shall have a section through the pin holes 25 per cent in excess of the net section of the body of the member. The net section back of the pin hole shall be at least equal to the net section of the body of the member.

**59.10. Chords of Long Bridges.** Whenever the ratio of the length to width of bridge is such that the top chord acting as a whole makes a longer column than the segments of the chord, the chord will be proportioned for this greater length.

**59.11. Rolled Beams.** Rolled beams shall be proportioned by the moments of inertia of their sections. Proper allowance shall be made for any reduction of strength of the tension flange. The depth of rolled beams shall in no case be less than one-thirtieth of the span.

**59.12. Plate Girders.** Plate girders shall be proportioned either by their moment of inertia or

by assuming that the flanges are concentrated at their centers of gravity; in the latter case one-eighth of the gross section of the web, if properly spliced to resist moment, may be used as flange area.

**59.13. Compression Flange of Beams and Girders.** The gross section of the compression flange of beams and plate girders shall not be less than the gross section of the tension flange. Flanges of girders and built members without cover plates shall have a minimum thickness of one-twelfth of the width of the outstanding leg.

**59.14. End Stiffeners.** Plate girders shall have stiffener angles over end bearings, the outstanding legs of which shall extend as nearly as practicable to the outer edge of the flange angles. These end stiffeners shall be proportioned for bearing on the flange angles, and shall be so connected as to transmit the end reaction to the web.

**59.15. Intermediate Stiffeners.** The webs of plate girders shall be stiffened with angles in pairs at intervals not greater than the depth of the girder, nor exceeding six (6) feet. The spacing of intermediate stiffeners for a distance of one-sixth of the length at each end of the girders shall not exceed three-fourths of the depth of the girder. Stiffeners shall be placed at web splices and at points of concentrated loading.

**59.16. Webs and Covers.** Plate girders shall preferably be built with cover plates, and the top cover plate shall extend the full length of the girder. If no cover plates are used the web plate shall project one-eighth (1/8) inch beyond the flange angles.

**59.17. Lateral Support of Compression Flanges.** The laterally unsupported length of beams and girders shall not exceed forty (40) times the width of the compression flange. When the unsupported length (L) exceeds twelve (12) times the width (B) of the compression flange, the stress per square inch

L

in the compression flange shall not exceed  $20,200 - 350 \frac{L}{B}$ , nor shall it exceed 16,000 pounds.

B

## STEEL SUPERSTRUCTURES—Continued

### ITEM 60. DETAILS OF DESIGN

**60.1. General Requirements.** All parts shall be so designed that the stresses coming upon them can be accurately calculated.

**60.2. Open Section.** Structures shall be so designed that all parts will be accessible for inspection, cleaning, painting, and repairs, and to shed water and not retain dirt, dust, leaves, or other foreign matter. Wherever angles are used either singly or in pairs they shall be placed with vertical legs extending downward. Closed sections shall not be used. After steel work is erected and painted any solidly enclosed pocket shall be filled with good Portland cement concrete so formed that water will be drained away from the steel work.

**60.3. Symmetrical Sections.** Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of section, and the neutral axes of intersecting main members of trusses shall meet at a common point.

**60.4. Adjustable Counters.** Rigid counters are preferred; and where subject to reversal stress shall preferably have riveted connections to the chords. Adjustable counters shall have open turn-buckles. In a truss only one diagonal in any panel shall be adjustable.

**60.5. Splices and Connections.** The splices in compression members shall be located as near the panel points as practicable. Splices in compression members, in a straight line and not subject to bending, having milled joints and the abutting ends held in close contact on four sides, shall provide at least seventy-five (75) per cent of the full strength of the member. In all other cases, the splices or connections shall develop the full strength of the member, even though the computed stress is less, the kind of stress to which the member is subjected being considered.

**60.6. Minimum Thickness of Metal.** In general, the minimum thickness of metal shall be five-sixteenths ( $5/16$ ) inch except for fillers. The thickness of metal for countersunk rivets shall not be less than one-half ( $1/2$ ) the diameter of the rivet used. The webs of beams shall not be less than one-quarter ( $1/4$ ) inch thick and the webs of channels, except where same are used in handrails, shall not be less than  $22/100$ th of an inch in thickness. The minimum size of angles allowed in all main members shall be  $3'' \times 2\frac{1}{2}'' \times 5/16''$ . When used as latticing or as the web members of a handrail, angles as small as  $2'' \times 1\frac{1}{2}'' \times 1/4''$  may be used.

**60.7. Size of Rivets.** Rivets of  $3/4$ -inch and  $7/8$ -inch diameter shall generally be used in certain approved cases, however,  $5/8$ -inch rivets will be allowed in the flanges of channels or in small angles. In no cases, except for fences, shall shapes be selected that do not permit of  $5/8$ -inch rivets being used.

**60.8. Pitch of Rivets.** The minimum pitch shall be not less than three diameters of the rivet and preferably not less than the following:

For  $7/8$ -inch rivets, minimum pitch—3 inches.

For  $3/4$ -inch rivets, minimum pitch— $2\frac{1}{2}$  inches.

For  $5/8$ -inch rivets, minimum pitch— $2\frac{1}{4}$  inches.

The pitch of rivets in the direction of the stress shall not exceed six (6) inches or sixteen times thickness of thinnest plate or angle. For angles with two gauge lines and rivets staggered the maximum shall be ten (10) inches in each line.

**60.9. Stitch Rivets.** Where two or more plates are used in contact, they shall be held together by rivets spaced not exceeding ten (10) inches in either direction; the rivet lines being at right angles to each other, provided such rivets serve no other purpose than to hold pieces in contact. Tension members composed of two angles in contact shall be stitch riveted using a pitch not greater than twelve (12) inches.

**60.10. Edge Distance.** The minimum distance from the center of any rivet hole to a sheared edge shall be:

- 1½ inches for 7/8-inch rivets.
- 1¼ inches for 3/4-inch rivets.
- 1 1/8 inches for 5/8-inch rivets.

For rolled edges, except flanges of I-beams and channels:

- 1¼ inches for 7/8-inch rivets.
- 1 1/8 inches for 3/4-inch rivets.
- 1 inch for 5/8-inch rivets.

The maximum distance from any edge shall be eight (8) times the thickness of the outside plate, but shall not exceed five (5) inches.

The diameter of the rivets in any angle carrying calculated stress shall not exceed one-quarter (¼) the width of the leg in which they are driven. In minor parts 7/8-inch rivets may be used in three (3) inch angles, and ¾-inch rivets in two and one-half (2½) inch angles.

**60.11. Fillers.** Rivets carrying calculated stress and passing through fillers shall be increased in number twenty-five (25) per cent for each filler.

**60.12. Rivet Spacing in Compression Members.** The pitch of rivets at the ends of built compression members shall not exceed four (4) diameters for a length equal to one and one-half (1½) times the maximum width of the member. Beyond this point the rivet pitch may be gradually increased for a length equal to one and one-half (1½) times the maximum width of the member until the maximum spacing is reached.

**60.13. Compression Members.** In compression members, the metal shall be concentrated as much as practicable in the webs and flanges, and the center of gravity of the section brought as near the center line of the member as practicable. Thickness of webs shall not be less than one-fortieth (1/40) of the distance between their connection to the flanges and thickness of cover plates shall not be less than one-fortieth (1/40) of the distance between the nearest rivet lines.

**60.14. Tie Plates.** The open sides of compression members shall be latticed and shall have tie plates as near the ends as practicable and at intermediate points where the lattice is interrupted. End tie plates shall have a length equal to the width of the member on the connected side and intermediate ones not less than one-half (½) this distance. Their thickness shall be not less than one-fiftieth (1/50) of the distance between the rivets connecting them to the member. The minimum thickness shall be one-fourth (¼) inch.

All sections of built tension members shall be stayed at or near the ends by the plates having a length at least equal to the greatest width of the member, with a rivet spacing of the preferred minimum, and between the end tie plates by tie plates having at least two rivets in each end. Tie plates shall be spaced not more than three (3) feet between centers. The thickness of tie plates shall be not less than one-fiftieth (1/50) of the distance between rivet lines, and minimum thickness shall be 5/16 inch.

The minimum widths of lattice bars and sizes of rivets, are as follows:

For 15-inch channels, or built sections with angles larger than 3-inch angles,  $2\frac{1}{2} \times \frac{1}{2}$ -inch bar,  $\frac{7}{8}$ -inch rivets.

For 12, 10, 9 and 8-inch channels or built sections with 3- and  $2\frac{1}{2}$ -inch angles,  $2\frac{1}{4} \times \frac{3}{8}$ -inch bar,  $\frac{3}{4}$ -inch rivets.

For 7-inch channels,  $2 \times \frac{1}{4}$ -inch bar,  $\frac{5}{8}$ -inch rivets.

Single lattice bars shall have an inclination of approximately 60 degrees with the axis of the main member and shall have a minimum thickness of one-fortieth of the distance between rivets, connecting them to the member. When the distance between rivet lines exceeds 15 inches, double lattice bars with an inclination of approximately 45 degrees shall be used. The minimum thickness shall be one-fiftieth of the distance between the rivets connecting them to the member and they shall be riveted at the intersection.

**60.15. Pins.** No pin shall have a diameter less than  $3\frac{1}{2}$  inches or less than three-fourths the width of the widest eyebar connected thereto. Pins shall be placed as nearly in the neutral axis of the member as practicable. Pins up to seven inches in diameter shall be made of rolled steel. Pins shall be long enough to insure a full bearing of all parts connected upon the turned body of the pin. They shall be secured by hexagonal recessed nuts. The screw ends shall be provided with cotters to prevent the nuts from becoming dislocated. At the option of the Engineer, the screw end of pins may be of sufficient length to admit of barring the threads. All pins shall be supplied with pilot nuts for use during erection.

**60.16. Pin Plates.** Pin holes shall be reinforced by plates if necessary, and at least one plate shall be as wide as the flanges will allow and be on the same side as the angles. These reinforcing plates shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross-sections of the member and at least one plate on each side of the member shall extend not less than six (6) inches beyond the tie plate.

**60.17. Shape of Nuts.** Nuts for pins shall be recessed and shall be hexagonal in shape. All other nuts and the heads of bolts shall be square.

**60.18. Packing.** Eyebars shall be packed symmetrically about the center line of the truss as nearly as practicable, but no bar shall diverge more than one (1) inch in sixteen (16) feet. They shall be packed as closely as practicable and lateral movement shall be prevented by filling rings. Bars in the same panel shall not be in contact.

**60.19. Indirect Splices.** Where splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number theoretically required to the extent of one-third of the number for each intervening plate.

**60.20. Gusset Plates.** The thickness of gusset plates connecting the various members of the truss shall be proportional to the stress to be transferred, due allowance being made for eccentricity of connection.

**60.21. Forked Ends.** Forked ends of compression members shall have a total compression strength twenty-five per cent greater than that of the body of the member.

**60.22. Compression Splices Milled.** The surfaces of all compression members shall be truly faced. Joints in compression members shall be spliced on four (4) sides.

**60.23. Column Ends Milled.** Columns of trestle bents shall have the ends milled to take bearing; and the holes for anchor bolts slotted for the proper amount of expansion and contraction.

**60.24. Width of Trestle Bents.** The distance between column centers at the top of a bent shall not be less than the clear width of roadway.

**60.25. Expansion.** Provision for expansion to the extent of one-eighth ( $1/8$ ) inch for each ten (10) feet of length shall be made for all structures. For bridges less than eighty (80) feet long, one end shall be free to move upon planed surfaces.

**60.26. Rollers.** All bridges exceeding eighty (80) feet in length shall have pin-bearing shoes, and at one end a nest of turned friction rollers of structural steel running between planed surfaces of structural steel or cast steel, or cast steel rockers.

For spans one hundred (100) feet or less in length the minimum diameter of rollers shall be three (3) inches and the diameter shall be increased one (1) inch for each one hundred (100) feet increase of span and proportionally for intermediate spans.

**60.27. Pedestals.** Pedestals, bolsters and shoes shall be of riveted plates and angles whenever possible, and shall be so constructed that the load will be distributed over the entire bearing.

**60.28. 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.

**60.29. Anchor Bolts.** Each bearing of all main girders and trusses shall have anchor bolts roughened or swedged and set in holes drilled in masonry, in Portland cement mortar, not less than the following:

For spans less than 50 feet in length, 2 bolts 1 inch in diameter, set 10 inches in masonry.

For spans from 50 to 100 feet in length, 2 bolts  $1\frac{1}{4}$  inches in diameter, set 12 inches in masonry.

For spans from 100 to 150 feet in length, 2 bolts  $1\frac{1}{2}$  inches in diameter, set 15 inches in masonry.

For spans from 150 to 200 feet in length, 4 bolts  $1\frac{1}{2}$  inches in diameter, set 18 inches in masonry.

**60.30. 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 one and one-half ( $1\frac{1}{2}$ ) times the uplift.

**60.31. Inclined Bearings.** Bridges on an inclined grade without pin shoes shall have the sole plates beveled so that the masonry and expansion surfaces may be level.

**60.32. Floor Framing.** All floor beams shall be steel in the form of rolled beams or riveted plate girders, and shall be rigidly connected to the trusses. Wherever possible rigid plate and angle knee braces or brackets shall be placed between and efficiently riveted to floor beams and truss verticals or girder stiffeners.

Generally, floor beams shall be square to the trusses.

Threaded floor beam or stringer hangers shall not be used.

**60.33. End Struts.** Wherever possible end floor beams or end struts are required for all truss spans.

**60.34. Stringers.** Stringers shall be securely fastened to floor beams and end struts.

**60.35. Corrugated Arches.** Corrugated sheet metal arches or Steel Buckled Plates shall not be used in floor construction except by special permission. When used, thorough provision shall be made for lateral thrust.

**60.24. Width of Trestle Bents.** The distance between column centers at the top of a bent shall not be less than the clear width of roadway.

**60.25. Expansion.** Provision for expansion to the extent of one-eighth ( $1/8$ ) inch for each ten (10) feet of length shall be made for all structures. For bridges less than eighty (80) feet long, one end shall be free to move upon planed surfaces.

**60.26. Rollers.** All bridges exceeding eighty (80) feet in length shall have pin-bearing shoes, and at one end a nest of turned friction rollers of structural steel running between planed surfaces of structural steel or cast steel, or cast steel rockers.

For spans one hundred (100) feet or less in length the minimum diameter of rollers shall be three (3) inches and the diameter shall be increased one (1) inch for each one hundred (100) feet increase of span and proportionally for intermediate spans.

**60.27. Pedestals.** Pedestals, bolsters and shoes shall be of riveted plates and angles whenever possible, and shall be so constructed that the load will be distributed over the entire bearing.

**60.28. 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.

**60.29. Anchor Bolts.** Each bearing of all main girders and trusses shall have anchor bolts roughened or swedged and set in holes drilled in masonry, in Portland cement mortar, not less than the following:

For spans less than 50 feet in length, 2 bolts 1 inch in diameter, set 10 inches in masonry.

For spans from 50 to 100 feet in length, 2 bolts  $1\frac{1}{4}$  inches in diameter, set 12 inches in masonry.

For spans from 100 to 150 feet in length, 2 bolts  $1\frac{1}{2}$  inches in diameter, set 15 inches in masonry.

For spans from 150 to 200 feet in length, 4 bolts  $1\frac{1}{2}$  inches in diameter, set 18 inches in masonry.

**60.30. 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 one and one-half ( $1\frac{1}{2}$ ) times the uplift.

**60.31. Inclined Bearings.** Bridges on an inclined grade without pin shoes shall have the sole plates beveled so that the masonry and expansion surfaces may be level.

**60.32. Floor Framing.** All floor beams shall be steel in the form of rolled beams or riveted plate girders, and shall be rigidly connected to the trusses. Wherever possible rigid plate and angle knee braces or brackets shall be placed between and efficiently riveted to floor beams and truss verticals or girder stiffeners.

Generally, floor beams shall be square to the trusses.

Threaded floor beam or stringer hangers shall not be used.

**60.33. End Struts.** Wherever possible end floor beams or end struts are required for all truss spans.

**60.34. Stringers.** Stringers shall be securely fastened to floor beams and end struts.

**60.35 Corrugated Arches.** Corrugated sheet metal arches or Steel Buckled Plates shall not be used in floor construction except by special permission. When used, thorough provision shall be made for lateral thrust.

## BRACING.

**60.36. Rigid Bracing.** All lateral, sway and portal bracing, and all bracing in trestle towers and bents shall preferably be made of shapes capable of resisting compression as well as tension and shall have riveted connections.

**60.37. Laterals.** Truss and girder spans 45 feet or more in length shall have a system of bottom lateral bracing.

**60.38. Low Truss and Through Girder Spans.** The top chords of low trusses and through girders shall be securely held at each panel point by means of gusset plates, plate and angle brackets, or wide web members with web plates which shall be efficiently connected to each floor beam and to end struts.

**60.39. Deck Truss Spans.** Trusses in deck bridges shall be provided with complete systems of bracing as nearly as practicable in the planes of the top and bottom chords. At each panel point there shall be sway bracing sufficiently strong to carry one-half of the wind pressure on the chord farthest from the plane of support.

**60.40. Deck Girder Spans.** Deck girder spans shall have lateral bracing in the planes of both the top and bottom flanges. Cross frames for deck girders shall have top and bottom struts and two diagonals, and shall be used at ends and at intermediate points not more than 20 feet apart.

**60.41. Through Truss Spans.** Through truss spans shall be provided with complete systems of bracing as nearly as practicable in the planes of the top and bottom chords. The trusses shall be deep enough to permit of the construction of adequate rigid portals, and the end posts shall be proportioned to resist the bending stress produced by that part of the wind load delivered by the top lateral system. Sway bracing, or struts with knee braces, as deep as the required clearance will allow, shall be provided at all intermediate panel points sufficiently strong to carry one-half ( $\frac{1}{2}$ ) of the top chord wind load to the plane of the bottom chords, and intermediate posts shall be designed to resist bending thus produced.

**60.42. Longitudinal Bracing.** Longitudinal bracing of trestle and viaduct towers shall be proportioned to resist the same forces as provided for by the transverse bracing. In towers of more than two vertical panels there shall be diagonal bracing in a horizontal plane at the top, bottom, and alternate intermediate panel points.

## CAMBER.

**60.43. Plate Girders.** If desired, plate girder spans over 50 feet in length shall be built with camber at a rate of 1/16 inch per ten (10) feet of length.

**60.44. Trusses.** Trusses carrying concrete floors shall be cambered by making the top chord or its horizontal projection longer than the bottom chord by 3/16 inch to every ten (10) feet.

Trusses carrying plank floors shall be cambered by making the top chord or its horizontal projection longer than the bottom chord by 1/8 inch to every ten (10) feet. Camber shall be provided in the false work to correspond with the camber required for the span.

## STEEL SUPERSTRUCTURES—Continued

### ITEM 61. MATERIALS AND WORKMANSHIP

#### (a) MATERIALS.

**61.1. Description.** Structural steel shall be manufactured and fabricated in accordance with these specifications and the plans, and shall include plain structural shapes, fabricated structural steel, steel castings and iron castings.

**61.2. Materials.** Steel for plain structural shapes, fabricated structural steel and for rivets shall meet the requirements of the "Standard Specifications for Structural Steel for Bridges" of the American Society for Testing Materials, Serial Designation A7—16.

Steel Castings shall meet the requirements of the Standard Specifications of the American Society for Testing Materials for Steel Castings, Serial Designation A27—16, and shall be Class B, medium grade.

Iron Castings shall meet the requirements of the Standard Specifications of the American Society for Testing Materials for Gray Cast Iron, Serial Designation A48—05.

#### (b) WORKMANSHIP.

**61.3. General.** All parts forming a structure shall be built in accordance with approved drawings. The workmanship and finish shall be equal to the best practice in modern bridge works.

**61.4. Straightening Material.** Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way.

**61.5. Shearing.** Shearing shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

**61.6. Edge Planing.** Sheared edges or ends shall, when required, be planed at least one-eighth (1/8) of an inch.

**61.7. Size of Rivets.** The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet before driving.

**61.8. Rivet Holes.** When general 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 subpunched and reamed or drilled from the solid.

**61.9. Reaming.** Where subpunching and reaming are required, the punch used shall have a diameter not less than 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.

**61.10. Burrs.** The outside burrs on reamed holes shall be removed.

**61.11 Rivet Holes.** Rivet holes must be carefully spaced and punched, and in all cases where the cold rivet can not be entered without the aid of drift pins, the holes shall be reamed with a twist reamer.

**61.12. Field Connections.** Holes for floor beams and stringer connections shall be subpunched and reamed according to Paragraph 61.9 to a steel templet one 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 match-marked before being taken away.

**61.13. Assembling.** Riveted members shall have all parts well pinned up and firmly drawn together with bolts, before riveting is commenced. Contact surfaces shall be painted.

**61.14. Lattice Bars.** Lattice bars shall have neatly rounded ends, unless otherwise specified.

**61.15. Web Stiffeners.** Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for, the ends of stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

**61.16. Web Splices.** Web splice plates and fillers under stiffeners shall be cut to fit within one-eighth ( $1/8$ ) inch of flange angles.

**61.17. Web Plates.** Web plates of girders, which have no cover plates, shall project above the backs of flange angles one-eighth ( $1/8$ ) of an inch. When web plates are spliced, not more than one-quarter ( $1/4$ ) of an inch clearance between ends of plates will be allowed.

**61.18. Connection Angles.** Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder. In case milling (of all such angles) is needed or is required after riveting, the removal of more than  $1/16$  inch from their thickness will be cause for rejection.

**61.19. Driving.** Rivets shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving. The finished rivets shall have neat and finished appearance, with heads of approved shape, full, and of equal size. They shall be central on shank, and 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.

**61.20. Bolts.** Bolts shall not be used in place of rivets for field connections except by special permission. Where permission is given by the Engineer for the use of bolts in place of rivets which transmit shear, and unless otherwise specified, the holes shall be subpunched and reamed to an iron templet or with the several parts assembled, and the bolts turned to a driving fit. A washer not less than one-quarter ( $1/4$ ) inch thick shall be used under the nuts, and the bolts shall be threaded to such a length that the thread will end inside the washer and not extend into the effective grip of the bolt.

**61.21. Bolts for Simple Beam Spans.** Where a bridge is composed entirely of simple beam spans, if permission is given by the Engineer, field connections for bracing and railing may be made with standard bolts having square heads and nuts, provided the bolts are the proper size to fill the holes within  $1/16$  inch (that is,  $3/4$ -inch bolts shall be used in holes punched with  $13/16$ -inch punch). They shall be provided with washers not less than one-quarter ( $1/4$ ) inch nor more than one-half ( $1/2$ ) inch in thickness under the nut. The use of more than one washer under the nut to make up for deficiency in length of thread will not be allowed. After adjustment the ends of the bolts shall be effectively headed down to the nuts to prevent any bolt from losing a tight grip of the parts connected.

**61.22. Members to be Straight.** The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends, or open joints.

**61.23. 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 even bearings after they are riveted up complete and when perfectly aligned.

**61.24. Eyebars.** Eyebars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be upset on the solid bar. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eyebars are made, if satisfactory to the Engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than 1/16 inch from that specified.

**61.25. Piled Head Eyebars.** Eyebars must be upset; no pile heads will be allowed.

**61.26. Loop Bars.** Loop bars will not be allowed.

**61.27. Boring Eyebars.** Before boring, each eyebar shall be properly annealed and carefully straightened. Pinholes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that when placed together pins 1/32 inch smaller in diameter than the pinholes can be passed through the holes at both ends of the bars at the same time without forcing.

**61.28. Pinholes.** Pinholes shall be bored true to gauges, smooth and straight; at right angles to the axis of the member and parallel to each other, unless otherwise called for. In the case of a riveted member the boring shall be done after the member is riveted up.

**61.29. Variation in Pinholes.** The distance center to center of pinholes shall be correct within 1/32 inch and the diameter of the holes not more than 1/50 inch larger than that of the pin for pins up to five (5) inches diameter, and 1/32 inch for larger pins.

**61.30. Pins and Rollers.** Pins and rollers shall be accurately turned to gauges and shall be straight, smooth and entirely free from flaws.

**61.31. Bars and Rods** with screw ends shall be upset and the cross sectional area at the root of the thread on the screw end shall exceed the net section of the body of the bar or rod by at least 15 per cent. Welds will not be allowed either in the body of the bar or at the junction between the body of the bar and the upset.

**61.32. 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.

**61.33. Annealing.** Steel, except in minor details, which has been heated, shall be annealed in a suitable annealing furnace by heating to a uniform dark red heat and allowing to cool slowly. All steel castings shall be annealed.

**61.34. Welds.** Welds in steel will not be allowed.

**61.35. Checking.** Threaded ends of all pins and bolts shall be long enough to project through the nut at least one-eighth (1/8) of an inch, and they shall be effectually burred or checked after adjustment.

**61.36. 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.

**61.37. Pilot Nuts.** Pilot driving and permanent nuts shall be furnished for each size of pin, in such numbers as may be necessary to protect from injury, the threads on all pins.

**61.38. Field Rivets.** Field rivets shall be furnished to the amount of ten (10) per cent plus ten (10) rivets in excess of the nominal number required for each size.

**61.39. Shipping Details.** Pins, nuts, bolts, rivets and other small details shall be boxed or crated. Double gusset plates shall have wooden plates between them and bolted to prevent bending during shipment, or other suitable means adopted to prevent damage.

**61.40. Weights.** The weight of every piece and box shall be marked on it in plain figures.

(c) SHOP INSPECTION AND TESTING.

**61.41. Starting Work.** The Engineer shall be notified well in advance of the start of work in the shop in order that he may have an inspector on hand to inspect material and workmanship.

**61.42. Inspection.** When an inspector is furnished by the Engineer, he shall have full access, at all times, to all parts of the shop where material under his inspection is being manufactured. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of workmanship, and when required shall furnish a suitable testing machine for testing full sized members.

**61.43. Accepting Material.** The inspector shall stamp each piece accepted with private mark. Any piece not so marked may be rejected at any time and at any stage of the work. If the inspector, through an oversight or otherwise, has accepted material or work which is defective or contrary to the specifications, this material, no matter in what stage of completion, may be rejected by the Engineer.

**61.44. Shipping Invoice.** Complete copies of shipping invoices shall be furnished to the Engineer with each shipment. These shall show the scale weights of individual pieces.

**61.45. Eyebar Tests.** Full-sized tests on eyebars and similar members, to prove the workmanship, shall be made at the manufacturer's expense, and shall be paid for by the County at the contract price, if the tests are satisfactory. If the tests are not satisfactory, the members represented by them will be rejected.

In eyebar tests, the minimum ultimate strength shall be 55,000 pounds per square inch. The elongation in ten (10) feet, including fracture, shall be not less than 15 per cent. Bars shall generally break in the body and the fracture shall be silky or fine granular, and the elastic limit as indicated by the drop of the mercury shall be recorded. Should a bar break in the head but develop the specified elongation, ultimate strength and character of fracture, it shall not be cause for rejection, provided not more than one-third of the total number of bars break in the head.

(d) SHOP PAINTING.

**61.46. Cleaning.** Steel work, before leaving the shop, shall be thoroughly cleaned. All rust, mill-scale, dirt, oil, and grease shall be removed, leaving a perfectly clean surface to receive the paint.

**61.47. Painting Conditions.** Painting shall be done only when the metal is free from frost and the surface is perfectly dry. No painting shall be done in wet or freezing weather, except under cover, in a building so enclosed that the metal may be kept dry and the temperature above freezing. Material painted under cover shall be kept under cover until the paint is dry. All paint must be thoroughly dry before any succeeding coat of paint is applied.

**61.48. Applying Paint.** Paint shall be applied in a good, heavy coat completely covering every part of the surface. It shall be well worked into all joints and open spaces, and be so thoroughly and evenly spread that no excess of paint will collect at any point. No two succeeding coats of paint shall be of the same tint.

**61.49. Shop Paint.** Shop paint shall have the following composition:

- Twenty-two (22) pounds of Red Lead.
- One (1) gallon of Linseed Oil.
- Four (4) ounces of Lampblack may be used unless otherwise specified.

Red Lead shall contain not less than 90 per cent true red lead ( $Pb_3O_4$ ) and the remainder shall be practically pure lead monoxide ( $PbO$ ). It shall not contain more than 0.10 per cent of metallic lead and shall be free from caustic alkalis, vitrified particles and other adulterants.

Linseed Oil shall meet the requirements of the "Standard Specifications for Purity of Raw Linseed Oil from North American Seed," of the American Society for Testing Materials, Serial Designation D-15, adopted 1915 and revised 1918.

Lampblack shall be the fully calcined product of oils only, free from acids, grit or other adulterants. It shall contain not less than 98 per cent of carbon, and not more than 0.5 per cent of oils, tar or pitch.

**61.50. Shop Painting.** In riveted work, surfaces coming in contact shall each be painted before being assembled. Before leaving the shop steel work shall be given one coat of the paint specified in Paragraph 61.49 and pieces and parts not accessible for painting after erection, including tops of stringers, eyebar heads, ends of posts and chords, etc., shall receive an additional coat of the same paint. Machine finished surfaces shall be coated with white lead and tallow before shipment or before being put out in the open.

#### (e) ERECTION.

**61.51. Erection Tools.** The Contractor shall erect, rivet and adjust all metal work in place complete. He shall provide all tools, machinery and appliances necessary for expeditious handling of the work, including drift pins, fitting-up bolts and pneumatic riveting hammers of a type and size approved by the Engineer.

**Erection Falsework.** The method of erection and plans for falsework and erection equipment shall be subject to the approval of the Engineer, but such approval shall not relieve the Contractor from any responsibility. All bents shall be thoroughly secured against movement, both transversely and longitudinally, and well secured against settling, piles being used whenever a firm bearing cannot otherwise be obtained.

**Handling Material.** Material shall be handled carefully, without damage. No pins will be driven, without the use of driving nuts and pilot nuts to protect the threads. Light drifting will be permitted in order to draw parts together, but drifting for the purpose of matching unfair holes will not be permitted. Unfair holes shall be reamed or drilled. Erection bolts shall be of the same diameter as rivets for which the holes are punches.

All nuts on bolts remaining in the structure shall be provided with washers effectively headed down and shall be locked by checking the threads in order to prevent such bolts from losing a tight grip of the parts connected.

**Field Connections.** All splices and field connections shall be securely bolted before riveting, important connections having at least half of the number of holes filled with tightly drawn up bolts at all times during the riveting of such connections, and all other field connections having at least one-third of the open holes filled with such tightly drawn up bolts. All tension splices shall be riveted up completely before blocking is removed. No rivets will be driven in compression splices until the members are under the full dead load stress, not including the floor slab.

**Setting Bed Plates.** Bed plates and masonry plates shall be set level and shall have a full even bearing under their entire surface.

**Setting Hand Rails.** Hand rails shall in all cases be bolted and shall be adjusted firmly to true alignment. All bolts for hand railing shall have hexagonal heads and nuts and shall be provided with washers and shall be locked by checking the threads.

**Cleaning.** All metal shall be thoroughly cleaned before painting. Cleaning shall be done with steel brushes, hammers, scrapers, chisels or other effective means. Oil, paraffin and grease shall be removed by wiping with benzine or gasoline. Loose dirt and loose rust shall be brushed off with a dry bristle brush before paint is applied.

**61.52. Setting Anchor Bolts.** The Contractor shall put in place all stone bolts and anchors for attaching the steel work to the masonry. He shall drill all the necessary holes in the masonry and set all bolts with neat Portland cement.

**61.53. Hauling.** The erection will also include all necessary hauling from the railroad station, the unloading of the materials and their proper care until the erection is completed.

**61.54. Old Structures.** Whenever new structures are to replace existing ones, the procedure will be outlined in Special Provisions.

#### (f) FIELD PAINTING.

**61.55. First Field Coat.** While the metal work is being erected in place, all abrasions of the shop paint and all field rivets and bolts and location marks shall be thoroughly cleaned and be given one coat of the paint specified in Paragraph 61.49 preparatory to the first field coat. After the structure is complete in place and the "touching up" described above is thoroughly dry, it shall be given a complete coat of a kind of paint to be specified by the Engineer.

**61.56. Second Field Coat.** After the first field coat is thoroughly dry the second field coat, consisting of a kind of paint to be specified by the Engineer, shall be applied. No paint shall be applied in wet or freezing weather.

**61.57. Protecting Steel Stringers.** In addition to the painting specified in Paragraph 61.50 and 61.55, the top flanges of stringers and floor beams, which are to be in contact with wooden floors, shall be protected by a covering composed of a layer of bituminous material, acceptable to the Engineer, and one thickness of two-ply tar paper. The bituminous material shall be applied directly to the top of the flanges, the tar paper, wide enough to project six (6) inches beyond the edges of the flange, shall then be placed and the edges bent down to shed water. The wooden nailing strips may then be attached.

**61.58. Bolts.** Bolts which are to pass through hard wood or hemlock shall receive two coats of a kind of paint to be specified by the Engineer, which shall be allowed to become perfectly dry before the bolts are used. (Yellow pines are not considered hard woods in this sense.)

**61.59. Samples of Paint and Oil.** If required by the Engineer, and before ordering the paint, samples shall be furnished the Engineer, which shall be used in determining the merits of the paints furnished for the work. These samples should be secured at least twenty-one (21) days before it is desired to apply paint to the work. This applies equally to paints and oils for shop and field painting.

#### (g) PAYMENT.

**61.60. Basis of Payment.** This work will be paid for either on the (a) "pound price" or (b) "lump sum" basis. The method that will prevail will be stated in the Proposal Form. Partial payments will be made as indicated in Paragraph 3.33. (a) Pound Price. Steel superstructures will be paid for at the contract unit prices for the various items entering into the construction, which prices shall

include material, fabrication, erection and painting and all work and materials incidental to the completion of the structure, ready for traffic, in accordance with the plans and specifications, or as directed. Scale weights of steel and iron shall govern except that when they exceed the calculated weights as shown on the plans by more than two per cent, the calculated weight plus two per cent will be paid for.

(b) Lump Sum. Steel superstructures will be paid for at the contract lump sum price for the superstructure complete in place, ready for traffic, which price will include all materials, fabrications, erection, flooring, and painting and all work and materials necessary to complete the structure in accordance with the plans and specifications, or as directed.

## ITEM 62. RAILINGS FOR STRUCTURES

**62.1. Description.** Railings for Bridges, Wing Walls, Retaining Walls, etc., shall include all work erected above the top of the curb for the protection of traffic.

### CONCRETE RAILINGS.

**62.2. Materials.** Unless otherwise noted railings shall be constructed of "Class A Concrete" and the materials shall fulfill the requirements for materials for "Class A Concrete" except that the coarse aggregate shall all pass a revolving screen having circular openings three-fourths ( $\frac{3}{4}$ ) of an inch in diameter.

**62.3. Construction Methods.** For "cast in place" railings the forms shall be made of good quality tongued and grooved lumber and be of first class workmanship throughout. They shall be accurately built to the designs and dimensions shown on the plans, and all mouldings, panel work, and bevel strips shall be straight and true with neatly mitered joints. Forms shall be erected to exact line and grade and be so rigidly braced that they will maintain true alignment during the placing of concrete. Each section of the work shall be cast complete to  $1\frac{1}{2}$ -inch below the top in a single operation. The top shall be finished with  $1\frac{1}{2}$ -inch of mortar, of the same mix as used in the concrete, struck off with a templet moved on guides attached to the forms. This mortar shall be placed within ten (10) minutes after the concrete underneath is deposited. Railings shall be very carefully finished, the forms shall be carefully removed as soon as possible (in not less than 12 nor more than 48 hours) and all porous spots and places damaged in removing the forms repaired and the entire surface rubbed with clean water and a wooden float until all form marks are removed and the surface assumes a uniform sandy appearance.

**62.4. Precast Railings** shall be made in accordance with the designs and dimensions shown on the plans or as directed, and shall be erected true to line and grade in a thoroughly workmanlike manner. The members shall be straight and true to form and free from imperfections or damaged places. They shall be set in place in full beds of 1.3 cement and sand mortar, and shall be thoroughly bonded together as shown on the plans or as directed.

### PIPE RAILING.

**62.5. Materials.** Pipe and fittings for pipe railings shall consist of standard galvanized iron or steel pipe of the size designated.

**62.6. Construction Methods.** Railings shall be erected in a workmanlike manner, straight and true to line and grade. When used on steel work the fastenings of rails and posts shall be as shown on the plans. In other locations the posts or anchor bolts for same shall be set in concrete or masonry and grouted in place with 1 to 2 cement grout. The joining together of different pieces of pipes between posts by means of sheaves or couplings will not be permitted. Entire pieces must be used for this purpose.

### IRON RAILING.

**62.7. Materials.** This railing shall include all types of metal railing other than pipe rail and unless otherwise specified the materials shall conform to the requirements for structural steel.

**62.8. Construction Methods.** The railing, including posts, fastenings, etc., shall be manufactured in accordance with the plans and specifications, and shall be erected true to line and grade. The workmanship shall be of the best throughout.

**62.9. Basis of Payment.** Railings will be paid for at the contract price per foot for railing complete in place, which price will include furnishing all forms, bracing, tools, equipment, and materials, including fastenings, anchor bolts and reinforcement, etc., and doing all work necessary to complete the railing in accordance with the plans and the specifications.