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Standard Specifications
for
Construction Work
on the
Primary Road System

SERIES OF 1933
IOWA STATE HIGHWAY COMMISSION
AMES, IOWA

Standard Specifications
for
Construction Work
on the
Primary Road System

August, 1933

These specifications are standard for all construction work on the primary system and are issued to supplement and interpret the plans prepared in accordance therewith. These specifications represent minimum requirements.

Series of 1933 issued and distributed by the State Highway Commission under Chapter 238, Code of 1931.

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PART I.

GENERAL REQUIREMENTS AND COVENANTS

Section 1101. Definitions.

1101.01 DEFINITIONS OF TERMS. In these specifications and in the accompanying contract the following definitions shall obtain:

State. The State of Iowa acting thru its authorized representatives.

Commission or State Highway Commission. The State Highway Commission as constituted under the laws of the State of Iowa, Party of the First Part in the accompanying contract.

Engineer. Chief Engineer of the Iowa State Highway Commission and his authorized representatives.

Inspector. The authorized representative of the Engineer assigned to the inspection of the work or the material therefor.

Bidder. Any individual, firm or corporation submitting a written proposal in answer to advertisement for bids for the contemplated work or any portion thereof, acting directly or thru an authorized representative.

Contractor. The Party of the Second Part in the accompanying contract.

Sub-Contractor. Any individual, firm or corporation who with the approval of the Commission has contracted with the Contractor to execute and perform all or any part of the accompanying contract.

Employee of Contractor or Sub-Contractor. Any person working on the project who is under the direction or control or receives compensation from the Contractor or Sub-Contractor shall be considered an employee of the Contractor or Sub-Contractor.

Contract Period. The period from the specified date of commencing work to the specified date of completion, both dates inclusive. The contract period may be extended as provided in Paragraph 1108.06 in which case the contract period includes the new date of completion.

Contract Sum. The aggregate sum obtained by multiplying the estimated number of units of each class of work by the unit price for that class of work as specified in the contract. The contract sum is subject to change when the actual number of units is found to vary from the estimated number. It is also subject to change under the provisions of Paragraphs 1109.03 and 1109.04 hereof.

Plans. Drawings prepared by the Commission, or reproductions thereof, which show the location of the project and the general and detailed layout of the work contemplated in the accompanying contract.

Alternate Plans. Plans other than those prepared by the Commission, which are submitted by a bidder as the basis for a proposal for the work or a part thereof.

Specifications. The requirements contained herein and in special provisions applying to the contract pertaining to the method and manner of performing the work or to the quantities and quality of the materials to be furnished under the contract.

Special Provisions. Clauses or memoranda applying to the contract changing or supplementing the specifications.

Notice to Bidders. The provisions, requirements and instructions pertaining to

the work to be awarded, manner and time of submitting proposals, quality of materials required and estimated quantities of work as prepared for the information of bidders submitting proposals.

Proposal. The formal signed tender of prices by the bidder, on the standard form furnished therefor, a copy of which is herein contained.

Contract and Documents Included Therein. The agreement setting forth the terms and conditions on which the work is to be performed. The contract documents are the advertisement, notice to bidders, contractor's proposal, the price agreement, these specifications, special provisions, contract bond, general and detailed plans and all supplemental agreements.

Proposal Guaranty. The security to be furnished by the bidder as a guaranty that he will enter into a contract for any work awarded to him as required in the notice to bidders.

Contract Bond. The bond executed by the Contractor and his surety in favor of the Party of the First Part, guaranteeing the faithful performance of the work covered by the contract, and the payment of all debts pertaining to the work, a copy of the form of which is herein contained.

Surety. The individuals or corporate body other than the contractor signing the contract bond.

Right-of-Way. The portion of the highway or any other area which is reserved for or secured by the Commission for constructing the work, or for obtaining material therefor as shown on the plans.

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

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

Subgrade. That portion of the roadbed upon which the surface course or pavement is to be placed.

Superintendent. The Contractor's authorized representative in responsible charge of the work.

The Work. The construction project specified herein as indicated on the plans of the contemplated improvement.

Classes of Work. Those divisions of the work according to methods of construction involved or materials required, made for the purpose of measurement and payment and indicated by the items upon which bids have been received for each specific contract.

Culverts. Structures through fills, having a clear span of 12 feet or less measured at right angles to the axis of barrel. Structures having multiple openings each meeting the above requirements, shall be considered as culverts.

Bridges. Drainage structures having a clear span greater than 12 feet.

Substructure. All that part of a bridge below the bridge seats or below the skew-back of arches. Backwalls, wingwalls and wing protection railings shall be considered as part of the substructure.

Superstructure. All that part of a bridge above the bridge seats or above the skew-back of arches, except as noted above.

Temporary Structure. Any temporary structure required to maintain traffic dur-

ing construction of the work and which will be dismantled when the work is completed. The temporary structure shall include the earth approaches thereto.

Supplemental Agreements. Written agreements executed by the Contractor and Commission subsequent to having entered into the contract.

Section 1102. Proposal Requirements and Conditions.

1102.01 CONTENTS OF PROPOSAL FORM. Bidders will be furnished with blank proposal forms, a copy of which is herein contained, showing the location and description of the work contemplated, the approximate quantities of the work to be performed or materials to be furnished, the amount of the proposal guaranty, and the date, time and place of filing and of opening proposals. The proposal shall also refer to any special provisions or requirements which are supplemental to the standard specifications. Proposals shall be made out as required therein.

1102.02 ESTIMATE OF QUANTITIES. For all work let on a unit price basis the Engineer's estimate of quantities shown in the notice to bidders and proposal are understood to be approximate only and will be used only for comparing bids, for which purpose they are sufficiently accurate.

No material change in quantities shall be made by increasing or decreasing the length of the road or roads to be improved as shown on the plans and described in the proposal form, unless the Contractor consents in writing to such increase or decrease.

1102.03 EXAMINATION OF PLANS, SPECIFICATIONS, SPECIAL PROVISIONS AND SITE OF WORK. It is assumed that bidders will examine the plans, specifications and special provisions to make sure that the requirements are fully understood. They must satisfy themselves as to the nature of the work and all conditions affecting the performance of the contract.

1102.04 PREPARATION OF PROPOSAL. Only signed proposals submitted upon the form furnished by the Commission will be considered. The blank spaces must be filled in correctly and the amounts written legibly to insure consideration.

If the proposal is made by a partnership, the name of the partnership and the members thereof or if by a corporation the corporate name as well as the agent acting therefor shall be shown and the principal place of business.

1102.05 REJECTION OF PROPOSALS. Proposals may be rejected by the Commission if the form is altered. If there are unauthorized additions, conditional or alternate bids, irregularities of any kind; or if the bidder adds a provision reserving the right to accept or reject a contract awarded to him or if the prices are obviously unbalanced, proposals may be rejected.

1102.06 PROPOSAL GUARANTY. Proposals shall be accompanied by a certified check on a solvent bank, for 5 per cent of the proposal amount, made payable to the Iowa State Highway Commission.

A certified check to be acceptable shall bear on its face the endorsement of a solvent bank as to the amount certified, which endorsement shall be signed by an official authorized to bind the bank by his acts.

1102.07 DELIVERY OF PROPOSAL. Proposals shall be placed in a sealed envelope marked so as to indicate its contents. If forwarded by mail, this envelope shall be enclosed in an additional envelope marked as indicated above. All proposals shall be filed with the Commission at the place designated in the notice to bidders prior to the time advertised for opening bids.

1102.08 WITHDRAWAL OF PROPOSAL. A bidder will be given permission to withdraw his proposal unopened after it has been deposited, if such request is made in writing to the Commission prior to the time specified in the advertisement

for opening proposals. No proposals may be withdrawn after the time specified for opening.

1102.09 PUBLIC OPENING OF PROPOSALS. Proposals will be publicly opened and read at the time and place stipulated in the "Notice to Bidders".

1102.10 DISQUALIFICATION OF BIDDERS. Only one proposal from an individual, firm, partnership, corporation or association, under the same or different names will be received for any one project.

1102.11 COMPETENCY OF BIDDERS. Bidders will be required to make such a showing as will satisfy the Commission that they are capable of performing the various items of work before they will be awarded a contract. As a part of such showing, they will be required to furnish the Commission a detailed statement of experience on similar work, a list of machinery, plant, and other equipment which they propose to use on the work, and such statement of their financial resources as the Commission may demand.

Corporations organized under the laws of any other State shall file with the Commission a certificate from the Secretary of State of Iowa showing that they have complied with all of the provisions of Chapter 386 of the Code of Iowa, 1931, governing foreign corporations. Individuals or co-partnerships of other States shall file with the Commission an agreement consenting to the jurisdiction of the Courts of Iowa, of the County in which the construction projects may be located and as provided in Section 11037 of the 1931 Code of Iowa, as to all matters arising out of or connected with any contract entered into. Such certificates or agreements shall be filed prior to the date of letting with the financial statement herein required.

Section 1103. Award and Execution of Contract.

1103.01 Consideration of Bids. The Commission reserves the right to waive technicalities and to reject any or all proposals.

1103.02 Award of Contract. In the award of contracts consideration will be given not only to the prices bid but to the mechanical and other equipment, financial responsibility of bidder, and his ability and experience in the performance of like or similar contracts. It is contemplated that the award will be made on the day on which bids are opened, but the right is reserved to postpone the award to a later date, of which bidders will be notified after bids have been opened, read and recorded. Where bids are on excavation work for which the plans show an estimated amount of overhaul, this overhaul computed at the contract price per station yard shall be included in the total contract amount on which the proposal guaranty and the contract bond is based.

1103.03 RETURN OF PROPOSAL GUARANTY. Proposal guaranties will be returned to the unsuccessful bidders promptly after the award has been made. Should no award be made within 15 days, all proposals will be rejected and all guaranties returned. If a bidder does not have a representative present when proposal guaranties are returned, his guaranty will be returned by registered mail to the address given in the proposal.

1103.04 REQUIREMENT OF CONTRACT BOND. On all contracts amounting to \$1,000.00 or more, the Contractor shall furnish and file with the Highway Commission an acceptable bond in an amount not less than 75 per cent of the contract sum. The bond shall be executed in triplicate on the standard form of the State Highway Commission, as specified in Part V, and shall be held to cover all work included in the contract, whether performed by the Contractor or under subcontract or assignment. The bond shall be executed by the Contractor and by a surety company authorized to do business in the State of Iowa. All bonds shall be approved by the Commission.

1103.05 EXECUTION OF CONTRACT. The bidder to whom the contract has been awarded shall execute and file 3 copies of the contract with the Commission within 15 days after the award has been made.

1103.06 FAILURE TO EXECUTE CONTRACT. Failure to execute a contract and file an acceptable bond as provided herein, within 15 days from date of contract award, shall be just and sufficient cause for the annulment of the award and the forfeiture of the proposal guaranty to the Commission in liquidation of damages sustained.

1103.07 PROPOSALS ON ALTERNATE PLANS. Proposals for bridge and culvert work may be based on alternate plans prepared by Engineers registered under the laws of the State of Iowa, provided such plans conform to the requirements of these specifications, and have been approved by the Commission 10 days prior to the date of advertisement, and provided also that all bidders shall be given equal opportunity to submit proposals on such alternate plans.

1103.08 PREFERENCE AS TO EMPLOYMENT OF LABOR. Preference shall be given to Iowa domestic labor, except that this provision "shall not apply to materials and supplies to be used in the construction of any road or highway", all as provided by law.

1103.09 SUPPLIES AND MATERIAL. "By virtue of statutory authority, a preference will be given to materials, products, supplies, provisions and all other articles produced, manufactured, made or grown within the State of Iowa".

Section 1104. Scope of Work.

1104.01 INTENT OF PLANS AND SPECIFICATIONS. The intent of the plans and specifications is to provide for the construction and completion of every detail of the work described herein. It is understood that the Contractor for all or any part will furnish all labor, material, tools, transportation and necessary supplies required to make each item complete in accordance with the contract.

1104.02 SPECIAL WORK. Any conditions not covered by these standard specifications are stated in the special provisions.

1104.03 INCREASED OR DECREASED QUANTITIES. The right is reserved, without impairing the contract, to make such increase or decrease in the quantities of the work shown on the plans as may be considered necessary to complete, fully and satisfactorily, the construction included in the contract. The compensation to the Contractor for such changes shall be adjusted as provided in Paragraph 1109.04.

1104.04 EXTRA WORK. The right is reserved, without impairing the contract, to order the performance of work of a class not contemplated in the proposal, which may be considered necessary to complete satisfactorily the work included in the contract. Such extra work shall be paid for as provided in Paragraphs 1109.04.

1104.05 MAINTENANCE OF DETOURS. Unless shown on the plans, or stated in the special provisions, the Contractor will not be required to assume any responsibility in connection with the maintenance or marking of suitable detours.

1104.06 REMOVAL AND DISPOSAL OF STRUCTURES AND OBSTRUCTIONS. The Contractor for bridge and culvert work shall, as a part of the work, remove any existing structure or part of structure that interferes in any way with the new construction. In the case of road work, any materials or structures found on the right-of-way which are not to remain in place or which have not been designated for use in the new construction, shall be disposed of as stipulated in the special provisions or on the plans.

1104.07 RIGHTS IN AND USE OF MATERIALS FOUND ON THE WORK.

Unless stated to the contrary in the special provisions, all materials such as stone, gravel, sand and timber found on the right-of-way of the highway, or land acquired for the work, are the property of the State, and shall not be used or destroyed by the Contractor without special permission from the Engineer. Should the Contractor, when permitted to use material found on the right-of-way, make excavations below the grade elevations, he will be required to backfill, without extra compensation, such excavations with other material so that the finished road will conform to the grade shown on the plans.

1104.08 FINAL CLEARING UP. Before final acceptance of the work the Contractor shall remove from the right-of-way and private property all unused material and rubbish, and shall leave the right-of-way in a clean and presentable condition satisfactory to the Engineer.

1104.09 RIGHT-OF-WAY AND RAILROAD CROSSINGS. Right-of-way for the road will be provided without cost to the Contractor. Wherever the plans necessitate the securing of additional right-of-way, or involve construction with which railroad companies are concerned, the performance of the work pertaining thereto is contingent upon the securing of the right-of-way or upon the arranging for proposed construction at railroad crossings. No claims for loss or damages on account of delays in securing right-of-way or completing arrangements with railroad companies will be allowed.

Section 1105. Control of Work.

1105.01 AUTHORITY OF ENGINEER. The Engineer will supervise the work and decide any questions that arise with reference to the intent of the plans and specifications and compliance therewith. He will pass on all questions relating to materials, work, progress, disputes and mutual rights between Contractors, fulfillment of contract and compensation, in accordance with the provisions of these specifications.

1105.02 PLANS. The official plans, profiles, and cross sections on file in the office of the Commission, show the location, typical construction details, and dimensions of the work contemplated. The work is to be performed in conformity therewith except in case of error or unforeseen contingency.

The plans are made up from careful surveys and represent the foreseen construction requirements. Any deviation from the plans made necessary by the exigencies of construction or because of error will be determined by the Engineer, and if necessary, corrected or modified drawings will be provided.

1105.03 WORKING DRAWINGS. Bridge Work. General drawings showing such details as are necessary to give a comprehensive idea of the construction contemplated, will be furnished prospective bidders. The Contractor shall submit to the Commission for approval 3 copies of the detailed shop drawings of all structural steel work and centering plans, or other detailed drawings, as required by these specifications. Prior to the approval of such plans any work done or material ordered shall be at the Contractor's risk.

Shop drawings for steel structures shall give full detailed dimensions and sizes for all component parts of the structure, and details of all miscellaneous parts, such as pins, nuts, bolts, apron plates, drains, etc.

It is expressly understood that the Commission's approval of the working drawings submitted by the Contractor covers the requirements for strength and detail, and no responsibility is assumed for errors in dimensions.

Unless included on the general plans, 3 copies of the masonry layout diagrams for steel structures shall be submitted to the Commission by the Contractor prior to the construction of the substructure, and their approval secured before the substructure is completed. These diagrams shall be in sufficient detail to show the position and elevation of all masonry and bed plates and anchor bolts.

1105.04 CONFORMITY WITH PLANS AND ALLOWABLE DEVIATIONS. No deviation from plans by the Contractor will be permitted without the Engineer's approval and authorization in writing.

1105.05 COORDINATION OF SPECIFICATIONS, PLANS AND SPECIAL PROVISIONS. In the event of any discrepancy between the drawings and the figures written thereon, the figures are to be taken as correct, and in case of any discrepancy between the drawings and specifications, the drawings are to govern. In case of a discrepancy between the general specifications and the special provisions, the special provisions will govern.

The Contractor shall not take advantage of any apparent error or omission in the plans or specifications or of any discrepancy between the plans and specifications. The Engineer shall be permitted to make such correction and interpretation as may be deemed necessary for the fulfillment of the intent of the plans and specifications, subject to compensation as provided in Paragraphs 1109.03, 1109.04 and 1109.05. The Contractor shall be notified in writing of changes in plans.

1105.06 COOPERATION BY CONTRACTOR. The Contractor shall at all times have a competent authorized representative on the work, who shall have authority to take any action necessary for the fulfillment of the contract according to the plans and specifications. A copy of the official plans and specifications shall be available on the work at all times. The Contractor shall give the work his personal attention at frequent intervals, and shall cooperate with the Engineer in every possible way.

1105.07 CONSTRUCTION STAKES. The Engineer shall set the necessary center line, slope and grade stakes promptly upon notification by the Contractor that stakes are needed.

For all structures the Engineer shall set stakes for roadway centerline and such others as are necessary to definitely establish the location, elevation and alignment of the structure. If requested by the Contractor, the Engineer shall furnish stakes determining the center line of piers, pedestals or abutments, together with stakes determining the angles of the wings or retaining walls. When such stakes or lines are given by the Engineer, the Commission shall be responsible for the correctness thereof.

The Commission shall not be responsible for delays due to lack of grade or line stakes unless the Contractor shall have given the Engineer 24 hours written notice that such stakes will be needed, and unless his work is being conducted in a satisfactory manner and at the specified rate of progress.

The Contractor shall be held responsible for the preservation of stakes and marks, and if in the opinion of the Engineer any of the survey stakes or marks have been carelessly or willfully destroyed or disturbed by the Contractor, the cost of replacing them shall be charged against him and shall be deducted from the payment for the work.

1105.08 AUTHORITY AND DUTIES OF INSPECTOR. The Commission may appoint inspectors to inspect all materials used and all work done under the contract. Such inspection may extend to any part of the work and to the preparation or manufacture of the materials to be used. The inspector will not be permitted to modify in any way the provisions of these specifications, nor to delay the work by failure to inspect materials and work with reasonable promptness. An inspector is placed on the work to keep the Engineer informed as to its progress and the manner in which it is being done; also to call to the attention of the Contractor any infringements of the plans and specifications. The inspector shall not act as foreman or perform other duties for the Contractor, nor improperly interfere with the management of the work. He will not be authorized to approve or accept any portion of the work. In case of dispute between the Contractor and inspector as to quality of materials or the manner of performing the work, the inspector shall have authority to reject materials or

suspend the work until the question at issue can be decided by the Engineer. Notice of suspension of work shall be given in writing.

1105.09 INSPECTION. The Contractor shall furnish the Engineer with every reasonable facility for ascertaining whether the work is being performed in conformance with the plans and specifications. At any time before acceptance of the work, upon the request of the Engineer, the Contractor shall remove or uncover such portions of the finished work as may be directed. After examination the Contractor shall restore such portions of the work to the standard required by these specifications. Should the work thus exposed or examined prove acceptable, the uncovering or removing and replacing of the covering, or making good of the parts moved, shall be paid for as extra work, but should the work so exposed and examined prove unacceptable, the Contractor shall receive no pay for preparing the work for examination and shall replace defective work in accordance with the specifications. Work done or materials used without suitable supervision or inspection by the Engineer may be ordered removed and replaced at the Contractor's expense.

1105.10 REMOVAL OF DEFECTIVE AND UNAUTHORIZED WORK. Any defective work shall, upon the direction of the Engineer, be removed and replaced at the Contractor's expense.

Should the Contractor fail or refuse to remove defective work when so ordered by the Engineer, the Engineer shall have authority to order the Contractor to suspend further operations and withhold payment on estimates until such defective work has been removed and replaced in accordance with the plans and specifications. Continued failure or refusal on the part of the Contractor to correct defective work promptly shall be sufficient cause for the Commission to declare the contract forfeited, and proceed to have the work completed in accordance with the provisions of Paragraph 1108.08.

Work done in excess of that provided by the lines and grades shown on the plans or as given by the Engineer, or any extra work done without written authority, will be considered as unauthorized and will not be measured nor paid for.

1105.11 FINAL INSPECTION. Promptly upon notification in writing by the Contractor or his foreman that the work is completed, the Engineer shall make final inspection of each item of work included in the contract. If the work is not in accordance with the plans and specifications, the Contractor shall be advised as to the particular defects to be remedied before final acceptance can be made.

1105.12 RESTRICTIONS ON MOVING AND USE OF HEAVY EQUIPMENT. The following restrictions shall apply to the moving and use of heavy equipment:

(a) The resident engineer shall give approval, in writing, before any equipment weighing in excess of 12 tons is moved over the highway.

(b) Equipment weighing in excess of 12 tons will be permitted to travel upon the pavement only upon condition that planks or mats at least 3 inches thick and 2 feet wide shall be kept under the treads of the machine. Such planks or mats shall have no nails, bolts or metal parts in contact with the pavement surface.

(c) Draglines or shovels shall under no condition be permitted to operate with any part of the machine resting upon the pavement slab.

(d) Heavy steel-shod, tractor-drawn or self-propelled hauling equipment, with a capacity in excess of 2 cubic yards, shall not be used in shouldering operations.

(e) Equipment weighing in excess of 30 tons will not be permitted to travel upon the pavement nor to cross any bridge having a span length in excess of 14 ft., except by special written consent of the construction engineer. Under no conditions will such permission be granted for equipment weighing in excess of 35 tons.

(f) Under no conditions will machines equipped with lugs or metal projections be permitted to operate upon the pavement slab.

Section 1106. Control of Materials.

1106.01 SOURCE OF SUPPLY AND QUALITY. The materials used on the work shall be at least equal in quality to the requirements of these specifications. The source of supply of each of the materials shall be approved by the Engineer before the delivery is started. The materials proposed to be used may be inspected at any time during the process of preparation and use.

Materials complying with these specifications will be accepted from any approved source of supply, but the Commission reserves the right to reject the entire output of any source of supply from which it is impossible to get a continuous supply of satisfactory material, or when conditions are such that the use of unfit material cannot be prevented except by extraordinary inspection methods.

1106.02 SAMPLES AND TESTS. All consignments of materials shall be tested or inspected before being incorporated in the work and shall be used only after approval has been received by the Engineer in charge of the work. The Contractor shall afford such facilities as the Engineer may require for collecting and forwarding samples. Apparatus and methods used for testing materials shall conform to the American Association of State Highway Officials "Tentative Standard Methods of Sampling and Testing Highway Materials" adopted in 1931, with subsequent amendments and additions thereto, and such other apparatus and method as is specified herein.

1106.03 STORAGE OF MATERIALS. The Contractor shall be held responsible for the care and storage of materials delivered on the work or purchased for use thereon. Should any material that has been delivered on the work become damaged before actual incorporation in the work, such material may be rejected by the Engineer even though it may have been previously accepted. Stored materials shall be located so as to facilitate thorough inspection.

1106.04 DEFECTIVE MATERIALS. Materials which do not meet the requirements of these specifications will be rejected and shall be promptly removed from the work.

Section 1107. Legal Relations and Responsibility to the Public.

1107.01 LAWS TO BE OBSERVED. The Contractor is presumed to be familiar with all laws, ordinances and regulations that may in any manner affect those engaged or employed upon the work, or the materials or equipment used in or upon the work or that in any way affect the conduct of the work and the Contractor shall conduct the work so as not to conflict with any such laws, ordinances or regulations, and shall save the Commission and its representatives harmless against any claim arising from violation thereof. The Contractor shall carry liability insurance to protect the public and any representative or employee of the Highway Commission from injuries sustained by reason of the carrying on of the work. Such insurance shall cover all operations, whether performed by employees of the Contractor or any Sub-Contractor to whom a certain portion of the work may be assigned. Before the first partial payment under the contract is made, the Contractor shall file with the Commission evidence of such insurance coverage. The contractor shall meet the requirements of the Workmen's Compensation Law.

The Contractor shall give preference to Iowa Domestic Labor in accordance with the provisions of Chapter 62-B1 of the Code of Iowa, 1931. A person shall be deemed to be a domestic laborer of this State if he is a citizen and has resided in this State for more than six months.

1107.02 FOREIGN CONTRACTORS, PERMITS AND LICENSES. The Contractor shall procure all necessary permits and licenses, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work.

1107.03 PATENTED DEVICES, MATERIALS AND PROCESSES. The Contractor shall indemnify and save harmless the State and Federal Government against all claims for infringement of patents or for royalty on tools, machinery, appliances, devices or materials used in the construction and completion of the work, except such as are specifically required by the specifications.

The Commission assumes responsibility for the payment of claims for damages for patent or copyright infringement or for royalties on material, processes, specifications or types of construction that are required by the plans or specifications.

No patented or proprietary materials, specifications, processes, or types of construction will be used hereunder unless purchased or obtained on open actual competitive bidding at the same or less cost than unpatented articles equally suitable for the same purposes.

When contracts are awarded on alternate plans (plans not prepared by the Commission) the Contractor shall assume the liability for claims for royalty or damages or suits at law arising because of the use of such alternate plans, and save the Commission harmless from payments of such claims.

Plans not prepared by the Commission, which embody the use of any patented design or contemplate the use of any patented processes shall be accompanied by a written statement of the exact terms under which said plans are to be used and shall provide a definite and fixed price for which any responsible Contractor may use said plans, processes or designs without further liability.

1107.04 RESTORATION OF SURFACES OPENED BY PERMIT. If, prior to final acceptance, any repairs to the roadway constructed hereunder are made necessary by the construction or repair of drain or sewers, the laying or repairing of pipes or conduits for telegraph or electric wires or from any other disturbance of the said roadway under permission issued by the Commission, the Contractor shall, upon notification from the Engineer, immediately make the necessary repairs in conformity with the specifications. Such repairs shall be paid for as extra work. Should the Contractor refuse or neglect to make the said repairs within the time specified, the Engineer shall have the authority to cause such repairs to be made by others, but this shall not relieve the Contractor of responsibility for the work he has performed.

The Contractor shall not authorize any person or persons to make an opening in the roadway unless a duly authorized permit by the Commission is presented.

1107.05 FEDERAL PARTICIPATION. The attention of the Contractor is directed to the provisions of an act of Congress known as Federal Highway Act, approved November 9, 1921, (42 stat. 212), and any amendments thereto, and the act of Congress known as the National Industrial Recovery Act. When the United States Government is to pay all, or any portion, of the cost of the improvement or project, the construction work is under the direct supervision of the Iowa State Highway Commission and in accordance with the Laws of the State of Iowa, subject to the above mentioned Acts of Congress and all rules, regulations and requirements adopted by the Federal authorities thereunder.

Such construction work will therefore be subject to inspection by the Secretary of Agriculture of the United States or his agents, but this inspection will not make the Federal Government a party to this contract.

1107.06 SANITARY PROVISIONS. The Contractor shall provide for his employees the necessary sanitary conveniences, properly secluded and shall observe all rules and regulations of the state and local health officials, and shall take such precautions as are necessary to avoid creating unsanitary conditions.

1107.07 PUBLIC CONVENIENCE AND SAFETY. During the progress of the work the Contractor shall make provision for the convenience of the traveling public and of the residents along the improvement and claims for extra expense incurred thereby shall be considered as provided in Paragraph 1109.04.

Wherever it is possible to do so, and a suitable road is available for detour, the

Commission will close the portion of the road under construction and cause suitable detour signs to be erected marking such detour. The Contractor is not required to maintain detour roads, nor the approaches to temporary bridges.

Material stored upon the highway shall be placed so as to cause the minimum obstruction to traffic. On highways occupied by railroad tracks, temporary platforms for the entrance and exit of passengers to and from railway cars shall be provided and maintained by the Contractor. Sidewalks, gutters, sewer inlets and portions of the highways adjoining the roadway under construction shall not be obstructed more than is absolutely necessary.

1107.08 BARRICADES AND WARNING SIGNS. The Contractor shall provide and maintain barricades, danger and warning signs and suitable and efficient lights, and take every precaution to prevent accidents. When a road is closed it shall be the duty of the Contractor to provide and maintain such barriers and watchmen as are necessary to prevent travel over the closed portion.

Where the road is within his control, the Contractor will be held responsible for any damage resulting from traffic on newly completed portions of the road.

1107.09 USE OF EXPLOSIVES. 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 to the point of safety. All explosives shall be stored in a secure manner and storage places shall be clearly marked "DANGER—EXPLOSIVES" and shall be in the care of competent watchmen at all times. The attention of the Contractor is called to existing federal regulations regarding the use of explosives.

1107.10 PROTECTION AND RESTORATION OF PROPERTY. The Contractor shall replace or renew fences, sidewalks or other property damaged by reason of his work or the negligence of his employees. He shall take suitable precautions to prevent damage to telephone, telegraph, and electric transmission lines along the highway, pipes, conduits, and other underground structures, and shall carefully protect from disturbance all land monuments and property marks until an authorized agent has witnessed or otherwise referenced their location, and shall not remove them until so directed. He shall be responsible for all damage or injury to property of any character due to the prosecution of the work, or due to his failure to execute said work, and such responsibility shall not be released until the roadway shall have been completed and accepted.

1107.11 RESPONSIBILITY FOR CLAIMS AND LIABILITY. The Contractor shall indemnify and save harmless the State, the Commission and all its officers or agents from claims or liability of any character arising out of any acts or omissions, neglect or misconduct on the part of the Contractor or his employees.

Responsibility of the Contractor for all damages or injuries to the traveling public or any portion of the road shall not be released until the work on such portions has been released by the Engineer. "Release by the Engineer" shall be construed to mean a written statement from him to the effect that the Contractor may cease to maintain barriers and red lights as required and that the road may be opened to traffic, and that the Contractor is relieved from further maintenance of that portion of the road. Such "Release by the Engineer" shall not constitute an acceptance of the work.

The Contractor's responsibility for the maintenance of lights and barricades on any individual structure included in bridge and culvert work included in the contract shall cease when final estimate (not including suspended payment) on such structure has been approved by the Engineer or when specifically released in writing by the Engineer.

1107.12 OPENING OF SECTION OF HIGHWAY TO TRAFFIC. The Contractor shall not be responsible for damages to portions of the road which have been released by the Engineer and opened to traffic prior to final approval and acceptance of the

work, provided such damages are due to the action of the elements or to the ordinary wear of traffic. The Contractor is responsible for any damage which may be caused by defective work or failure to comply with the plans, specifications and contract.

1107.13 CONTRACTOR'S RESPONSIBILITY FOR WORK. The Contractor shall be held responsible for the care and maintenance of partially completed work and finished work on any portion of the road until released by the Engineer.

1107.14 PERSONAL LIABILITY OF PUBLIC OFFICIALS. In carrying out any of the provisions of the contract or in exercising any power or authority granted to him thereby, there shall be no liability upon the Engineer or his authorized assistants, either personally or as an official of the State, it being understood that in such matters he acts as the agent and representative of the State.

1107.15 NO WAIVER OF LEGAL RIGHTS. The Commission shall not be precluded or estopped by any measurement, estimate or certificate made either before or after the completion and acceptance of the work and payment therefor, from showing the true amount and character of the work performed and materials furnished by the Contractor or from showing that any such measurement, estimate, or certificate is untrue or incorrectly made, or that the work or materials do not in fact conform to the contract.

The Commission shall not be precluded or estopped, notwithstanding any such measurement, estimate or certificate and payment in accordance therewith, from recovering from the Contractor and his sureties such damages as it may sustain by reason of his failure to comply with the terms of the contract. Neither the acceptance by the Commission or any representative of the Commission, nor any payment nor acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Commission shall operate as a waiver of any portion of the contract or of any power herein reserved, or any right to damages herein provided. A waiver of any breach of the contract shall not be held to be a waiver of any other or subsequent breach.

Section 1108. Prosecution and Progress.

1108.01 ASSIGNMENT OF CONTRACT. The Contractor shall not sell or assign any portion of his contract or the work provided therein, without the written consent of the Commission.

1108.02 PROSECUTION OF WORK. The progress of the work shall be at a rate sufficient to complete the contract within the period of time specified. If it appears that the rate of progress is such that the contract will not be completed within the time limit, or if the work is not being executed in a satisfactory and workmanlike manner, the Commission may order the Contractor to take such steps as it considers necessary to complete the contract within the period of time specified or to prosecute the work in a satisfactory manner. If the Contractor fails to comply with such order within two weeks after receipt of same, the Commission shall have the right to annul the contract and to complete the work in accordance with the provisions of Paragraph 1108.08.

The Contractor's sequence of operations shall be such as will cause as little inconvenience to the general public as possible. If more than one item of work is included in the letting, the Engineer may specify in the notice to bidders and proposal the order in which the several items shall be completed.

1108.03 LIMITATIONS OF OPERATION. The Contractor shall conduct his work so as to create a minimum amount of inconvenience to traffic. At any time when in the judgment of the Engineer, the Contractor has obstructed or closed, or is carrying on operations, on a greater portion of the road than is necessary for the proper prosecution of the work, the Engineer may require the Contractor to finish the sections on which work is in progress before work is started on any additional sections.

Whenever work that is being done by other contractors or subcontractors is contiguous to or a part of the work included in this contract, the Engineer shall, in case of dispute, determine and define the respective rights of the various interests involved, in order to secure the completion of all parts of the work in general harmony and with satisfactory results.

1108.04 CHARACTER OF WORKMEN, METHODS AND EQUIPMENT. The methods, equipment, and appliances used shall produce a satisfactory quality of work, and shall be adequate to maintain the schedule of progress specified.

If at any time the equipment, appliance, or methods employed on the work are such that the quality of the finished work is not satisfactory or the rate of progress specified is not being maintained, the Contractor shall make such changes in the equipment or appliances or order such new equipment or appliances, or adopt such methods as will insure a satisfactory finished product within the contract time.

Permission given by the Engineer to use any particular methods, equipment or appliances shall not be construed:

(a) to relieve the Contractor from furnishing other equipment or appliances, or adopting other methods for the prosecution of the work, at any time that it appears necessary to do so in order to produce work complying with the specifications;

(b) to bind the Commission to accept work produced which when completed does not conform to the requirements of the contract.

Any employee of the Contractor who is careless, incompetent or disorderly, or refuses or neglects to perform his work in accordance with the specifications, or who shall commit trespass upon any public or private property in the vicinity of the work, shall be discharged upon the written request of the Engineer, and shall not be employed on any of the work unless written permission is given by the Engineer.

1108.05 TEMPORARY SUSPENSION OF THE WORK. Work shall be suspended wholly or in part when in the opinion of the Engineer weather or other conditions are unfavorable to the satisfactory prosecution of the work. Work shall also be suspended at the direction of the Engineer pending settlement of disputes arising out of failure of the Contractor to comply with the provisions of the contract.

1108.06 EXTENSION OF CONTRACT PERIOD. An extension of the contract period because of suspension of work during stormy or inclement weather, or when a substantial amount of extra work has been required, or for delays from causes for which the Commission and not the Contractor is responsible may be granted by the Commission upon written request by the Contractor.

1108.07 FAILURE TO COMPLETE WORK WITHIN THE CONTRACT PERIOD. If the Contractor fails to complete his work within the contract period, or any extension thereof as provided in Paragraph 1108.06, said contract shall thereby without further action or notice be in default. At the option of the Commission it may permit the Contractor to complete the work included in the contract, or may annul the contract and proceed to complete the work in accordance with the provisions of Paragraph 1108.08. In either event, the Contractor and his surety shall be responsible for all expenses incurred in the completion of the work, including all engineering and inspection costs, incurred after the expiration of the contract period.

1108.08 ANNULMENT OF CONTRACT. If the Contractor fails to make satisfactory progress, or to complete the work within the contract period, or fails or refuses to comply with an order of the Commission within a reasonable time, or neglects or refuses to remove rejected materials, or to perform anew defective and unsuitable work, or if the Contractor becomes insolvent or is declared bankrupt, or makes an assignment for the benefit of creditors, or for any other cause does not carry on the work in an acceptable manner, the Commission shall have the right to annul this contract without process or action at law and to take over all or any portion of the work and complete it, at its option, either by day labor or by the reletting of the same. The Contractor upon receiving notice to that effect shall vacate possession

and give up the said work or the parts thereof specified in said notice peaceably to the Engineer. All material, plant, caissons, cofferdams, piling, sheeting, formwork, scaffolding, pumps, dredges, and other erections, appliances and the plant thereon, shall, at the option of the Commission remain on the work until completed, at such a rental as the Commission may consider reasonable. Neither the Commission nor any member or employee thereof shall be liable or accountable to the Contractor or his surety in any way for the manner or price at which the said work, or any portion thereof, may have been or may be done. Should the cost of completing the work by day labor or by reletting the same be in excess of the original contract price, the Contractor and his surety shall be held responsible for such excess cost. Should the cost of such completion together with all proper charges be less than the original contract price, the amount so saved shall be paid to the Contractor. Neither by the taking over of the work by the Commission nor by the annulment of this contract, shall the Commission forfeit the right to recover damages from the Contractor or his surety for failure to complete his entire contract.

1108.09 TERMINATION OF CONTRACTOR'S RESPONSIBILITY. The contract shall be considered completed when the work has been accepted in writing by the Commission. Such acceptance shall release the Contractor from all further obligation with respect thereto, except as to conditions and requirements set forth in his bond.

Section 1109. Measurement and Payment.

1109.01 MEASUREMENT OF QUANTITIES. The work completed under the contract shall be measured according to United States Units of Measure. Payment will be based on the actual quantity of work performed according to the various classes of work specified in the contract, except that no deduction will be made for omissions due to fixtures or structures in the roadway or street, with an area of 9 square feet or less.

1109.02 SCOPE OF PAYMENT. The Contractor shall accept the compensation as herein provided, in full payment for furnishing all materials, labor, tools and equipment and for performing all work under the contract; also for all costs arising from the action of the elements, or from any unforeseen difficulties which may be encountered during the prosecution of the work and up to the time of acceptance.

1109.03 VARIATIONS IN CONTRACT QUANTITIES. When the work is completed without changes in the plans and the resultant quantities of the various classes of work vary by more than 20 per cent from the estimated quantities specified in the contract an adjustment in prices for such classes of work may be made by agreement between the engineer and contractor subject to the approval of the Commission. Either party to the contract may request such an adjustment.

1109.04 CORRECTION OR ALTERATION OF THE PLANS. It is the intent of the contract that the Contractor shall perform all work necessary to produce a complete, finished, road, structure or improvement in conformity with the detailed plans and these specifications or as directed by the Engineer. When upon the written order from the Engineer, the Contractor shall have performed more or less work of the same general character as the classes of work indicated in the contract or he shall have performed extra work of a different quality or class than included in the contract, he shall be compensated as follows:

(a) **Increased or Decreased Quantities.** When corrections or alterations in the plans increase or decrease by 20% or less the quantities involved in any class of work covered by the contract, the Contractor shall be paid for final net quantities as measured by the Engineer at the contract unit price for work of that class. When changes or alterations in the plans increase or decrease by more than 20 per cent the quantities involved in any class of work covered by the contract, an adjustment in

prices may be made by an agreement between the Contractor and the Engineer subject to the approval of the Commission. Either party to the contract may request such an adjustment, but no adjustment of contract prices will be approved by the Commission without conclusive evidence to prove that such adjusted price or prices are fair and equitable to both parties concerned. If an adjusted price cannot be agreed upon as indicated above, the question shall be settled by arbitration as provided in Paragraph 1109.10.

(b) **Extra Work.** If extra work of a quality or class not covered by the contract is ordered by the Engineer, a basis of payment shall be agreed upon in writing between the Parties to the contract before such work is undertaken. If such a method of payment cannot be agreed upon prior to beginning the work, or is impracticable, the Engineer may order the Contractor to perform the work on a "Force Account" basis as provided in Paragraph 1109.05.

1109.05 FORCE ACCOUNT. Extra work performed on a "force account" basis will be paid for in the following manner:

(a) For labor, teams, timekeepers and foremen the Contractor shall receive the current local rate of wage, to be agreed upon in writing before starting such work, for the time they are actually engaged in the extra work, plus Liability and Workmen's Compensation Insurance thereon, to which shall be added an amount equal to 15 per cent of the total thereof. This shall include compensation for the furnishing of the necessary small tools for the work.

The wages of a foreman or timekeeper who is employed partly on force account work and partly on other work shall be prorated between the two classes of work according to the number of men employed on each class of work as shown by the payrolls.

(b) For materials used on force account work the Contractor shall receive the actual cost thereof delivered on the work, including freight and haulage charges as shown by original receipted bills, to which cost shall be added a sum equal to 15 per cent thereof.

(c) For machinery, tools or equipment, fuel and lubricants therefor, except small hand tools which may be used, the Engineer shall allow the Contractor a reasonable rental at a rate to be agreed upon in writing before such work is begun. No profit percentage shall be added to the rental.

The compensation as herein provided shall be accepted 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, overhead and profit. At the end of each day the Inspector shall make up in duplicate, payrolls for labor furnished on a force account basis using the Commission's standard force account forms. Both copies shall be signed by the Inspector and the Contractor's representative, one copy being forwarded to the Engineer and one to the Contractor. Claims for extra work performed on a force account basis shall be submitted in triplicate to the Engineer, to which shall be attached the original receipted bills for materials and the freight and haulage charges on same. Such statements shall be filed not later than the 10th day of the month following that in which the work was actually performed, and shall include all labor charges, etc., and all material charges insofar as they can be verified.

1109.06 PARTIAL PAYMENTS. If the work extends over a period of more than one month the Contractor will receive monthly estimates based on the amount of work completed in an acceptable manner, and on material delivered. Monthly estimates may be allowed on cement, aggregates, center strip, reinforcing steel, structural steel, lumber, piling or other materials of acceptable quality, for individual items or structures, the cost of which exceeds \$10,000.00. The Engineer's monthly estimates are partial payments on the contract sum and the allowance of a monthly estimate by the Commission does not constitute final acceptance of the work upon which the estimates are based. Each estimate shall be filed by the Contractor in the form of

a claim against the Commission and certified to by the Engineer. Ten per cent of each estimate shall be deducted and held as a suspended payment until final acceptance of the entire contract. Should a reasonable doubt arise as to the integrity of any part of the completed work the estimate for that portion shall not be allowed until the cause for such doubt has been removed.

Where more than one item is included in the contract, 90 per cent of the contract sum for each item shall become due upon final acceptance of that item by the Commission. The remaining 10 per cent of the contract sum shall be retained by the Commission as a suspended payment until final acceptance by the Commission of all of the items included in the contract.

The monthly estimates and payments are approximate only, and shall be subject to correction in the final estimate and payment.

1109.07 ACCEPTANCE AND FINAL PAYMENT. Final acceptance is stipulated to mean a written acceptance by the Commission. The Commission shall make final examination and acceptance promptly upon the satisfactory completion of the work. Final payment shall be made promptly following the expiration of statutory time for filing claims, or following adjudication or release of claims.

The Commission shall satisfy itself as to the faithful completion of each part of the work, and may reject any portion found to be inconsistent with the terms of the contract.

1109.08 RESPONSIBILITY FOR PAYMENT. Payment for primary road work will be made by the State of Iowa by warrants drawn against State funds legally available for such work, or by the County Auditor in the county where the improvement is located, by warrants drawn against the County's Primary Road Bond Fund.

1109.09 DISPUTED CLAIMS FOR EXTRA COMPENSATION. In any case where the Contractor deems that extra compensation is due him for work or material not clearly covered in his contract, or not ordered by the Engineer as an extra as defined herein, the Contractor shall notify the Engineer in writing of his intention to make claim for such extra compensation before he begins the work on which he bases the claim. If such notification is not given, or the Engineer is not afforded facilities for keeping strict account of actual cost as defined for force account construction, then the Contractor hereby agrees to waive the claim for extra compensation for such work. Such notice by the Contractor, and the fact that the Engineer has kept account of the cost as aforesaid, shall not be construed as proving the validity of the claim. The claim must be passed upon by the Commission. In case the claim is found to be just, it shall be allowed and paid as an extra as provided herein for force account work.

1109.10 ARBITRATION. No action shall be maintained by the Contractor against the Commission to recover for material furnished, or labor performed, under this contract, until the claim for the same shall have been submitted to a Board of Arbitration, except as hereinafter provided.

The Contractor may at any time within sixty days after the acceptance by the Commission of the project for which he claims to have furnished material, or to have performed labor, serve a written demand upon the Commission to submit his claim, or claims, to a Board of Arbitration, as herein provided.

Said Board of Arbitration shall consist of three men; one to be chosen by the Commission and one by the Contractor, and the third by the two arbitrators thus chosen. Either party may have said award reviewed and tried as an equitable action by the District Court of Iowa, in and for Story County, by serving upon the other party Notice of such appeal within sixty days after the date of the rendition of said award by said Board of Arbitration.

The Board of Arbitration shall make its own rules of procedure and shall have authority to examine records kept by the Commission or Contractor. If desired records are not produced within 10 days after requested, the Board of Arbitration

shall proceed without them as best it may. In determining the award, the majority vote of the Board shall govern. Certified copies of the findings and award shall be filed with the Commission and Contractor. The Board of Arbitration shall fix the cost of the proceedings, including a reasonable compensation to the arbitrators, and shall determine how the total cost shall be borne.

The authority of the Board of Arbitration shall not extend to the interpretation of the plans and specifications, nor to the determination of the quality of the materials or workmanship furnished by the Contractor, nor shall it set aside or modify the terms or requirements of the contract. The Board of Arbitration shall only have authority to pass upon questions involving compensation to the Contractor for work actually performed but not allowed by the Engineer, and claims filed by the Contractor for extra payment for any reason not recognized by the Engineer.

1109.11 CLAIMS AGAINST CONTRACTOR. The Contractor guarantees the payment of all just claims against him or any sub-contractor in connection with this contract, and his bond will not be released by final acceptance and payment by the Commission, nor will final payment be made until all such claims are paid or released.

1109.12 TIME LIMITS FOR FINAL ADJUSTMENT. It is understood that the Commission shall not be bound to consider applications for correction of estimates and payments after sixty days from the final acceptance of the work.

PART II.
CONSTRUCTION DETAILS.
DIVISION 21. EARTHWORK.

2100.01 DESCRIPTION. Earthwork shall consist of the preparation of the right of way; roadway, approach and channel excavation, embankment, borrow and overhaul, all of which shall be done in accordance with the plans and specifications.

Section 2101. Clearing and Grubbing.

2101.01 DESCRIPTION. The right of way is to be cleared of trees, stumps, brush and weeds, which shall be burned unless otherwise directed by the Engineer. Where embankments are to be more than 2½ feet high, trees, stumps and brush shall be cut to a height of not to exceed one foot above the ground. Where embankments are to be less than 2½ feet high, and in excavation, all stumps and large roots shall be grubbed out and burned.

2101.02 MEASUREMENT AND PAYMENT. Payment for clearing and grubbing and removal of hedge or brush shall be made in accordance with the following schedule of prices:

(a) **Clearing and Grubbing.** Clearing and grubbing will be paid for at the following prices per tree or stump. The diameter of trees will be measured at a point 18 inches from the surface of the ground and will be determined by measuring the circumference and dividing by 3.1416. The diameter of old stumps will be the average diameter measured at cutoff.

Size—Diameter	Clearing	Grubbing	Clearing and Grubbing
3 in. to 6 in. inclusive.....	\$0.20	\$0.45	\$0.65
Over 6 in. to 9 in. inclusive.....	0.45	1.10	1.55
Over 9 in. to 12 in. inclusive.....	0.75	1.90	2.65
Over 12 in. to 15 in. inclusive.....	1.10	2.65	3.75
Over 15 in. to 18 in. inclusive.....	1.90	3.50	5.40
Over 18 in. to 24 in. inclusive.....	2.80	4.50	7.30
Over 24 in. to 30 in. inclusive.....	3.80	5.60	9.40
Over 30 in. to 36 in. inclusive.....	4.90	7.10	12.00
Over 36 in. to 42 in. inclusive.....	6.00	10.00	16.00
Over 42 in. to 48 in. inclusive.....	8.00	14.00	22.00
Over 48 in. to 60 in. inclusive.....	12.00	18.00	30.00
Over 60 in.	15.00	20.00	35.00

(b) **Hedge Removal.** Removal of hedges, hedge rows or hedge fences will be paid for at the rate of \$12.00 per 100 feet. If trees set close together in hedges are less than 6 inches in diameter, clearing and grubbing will be paid for at the unit price paid for hedges. If any of the trees comprising the hedge are 6 inches or larger in diameter, they will be paid for in accordance with the schedule for clearing and grubbing trees.

(c) **Brushing.** Trees and shrubs under 3 inches in diameter will be considered as brush. Removing and disposing of brush will be paid for at the rate of 20 cents per 100 square feet.

(d) **Weed Removal.** The cost of removing and disposing of all weeds, corn stalks, and other herbaceous vegetation shall be included in the price bid per cubic yard for excavation work.

Section 2102. Roadway Excavation.

2102.01 DESCRIPTION. This work shall consist of the removal of material within the limits of the detailed roadway cross section shown on the plans, with all shaping and sloping necessary for the construction of the roadway, slopes, gutters, inlet and outlet ditches and channels in conformity with the alignment, grade and cross section shown on the plans, and the disposal of the excavated material in conformance with these specifications as shown on the plans or as directed by the Engineer.

2102.02 CLASSIFICATION OF EXCAVATION. Unless specifically mentioned in the "Special Provisions", excavation will be unclassified and will include all materials of any nature whatsoever that may be encountered.

When excavation is unclassified, all materials encountered will be handled, finished, or disposed of as shown on the plans or as called for by the Engineer, and in accordance with these specifications.

Surface collections of boulders in the form of stone walls, windrows along the right-of-way fences, and other similar accumulations, will be disposed of by incorporating them in the embankment, by ricking them in neat piles at designated spots, or by burying them at least one foot beneath the surface of the ground. When boulders are buried in the embankment, care shall be used to fill all the voids with earth.

2102.03 ROCK CUTS. When excavation to the finished grade line would result in a roadbed surface consisting of loose or solid rock, the Contractor may be required to excavate the roadway one foot below the finished grade so that all rock in this area is removed and backfill to the required grade with suitable earth.

Subject to the approval of the Engineer, the earth backfill may be obtained from any point within the right-of-way where suitable backfill material is available.

The Contractor shall conduct his operations in such a way that the Engineer is given opportunity to take the cross sectional measurements required before the backfill is placed.

2102.04 PROVISION FOR DRAINAGE. If it is necessary in the prosecution of the work to interrupt the natural drainage of the surface, or the flow of artificial drains, the Contractor shall provide temporary drainage facilities that will prevent damage to public or private interests, and shall restore the original drains as soon as the work will permit. He shall be held liable for all damages which may result from neglect to provide for either natural or artificial drainage which his work may have interrupted.

In cuts along side-hills where there is a possibility of surface water causing damage by flowing down the side slope of the cut, ditches shall be constructed to intercept the surface water.

Where surface water or water from side ditches would otherwise follow the toe of slope or embankments built on sloping ground, it shall be led away from toe of slope by run-out ditches.

2102.05 BERMS. Wherever it becomes necessary to make an excavation along the side of the road as in the construction of borrow pits, ditches, etc., a berm not less than 4 feet in width shall be left between the toe of slope of the roadway embankment and the top of the excavation bank.

2102.06 FINISHING. Excavation and embankment work shall be finished in a workmanlike manner, true to grade and cross section. The back slopes shall be kept neatly finished as construction progresses. A blade grader or bulldozer of adequate size and power sufficient to handle the materials encountered shall be kept in use at all times during the finishing of excavation and embankment. All finishing work

shall be kept as close as possible to construction operations, and on roads that must be kept open to traffic during construction, provision shall be made for the safety and convenience of the traveling public. If the Contractor fails to maintain partly finished work in a satisfactory manner, construction shall be discontinued if so ordered in writing by the Engineer, until all finishing and maintenance work is in satisfactory condition. After all other earthwork and all construction are completed, the roadway shall be finished for travel to the lines, grades and typical cross sections shown on the plans.

2102.07 METHOD OF MEASUREMENT. Measurement of quantities will be made by cross sectioning before and after excavation. The volumes will be determined by the average end area method. The quantity of excavation to be paid for will include the following:

(a) Material excavated according to the requirements of the plans or as ordered by the Engineer.

(b) Additional excavation caused by over-break in excavation not attributable to carelessness on the part of the Contractor. The quantity of excavation to be paid for in any half station of 50 feet shall not be increased, by reason of over-break, more than 15 per cent.

(c) Additional excavation of soft and spongy material occurring below grade, when ordered removed by the Engineer.

(d) Excavation of the roadbed of rock cuts below grade when so directed by the Engineer except that excavation more than one foot below grade will not be included in the volumes measured for pay quantities.

2102.08 BASIS OF PAYMENT. The quantity of roadway excavation measured as provided above shall be paid for at the contract unit price per cubic yard for unclassified excavation, which price shall be full compensation for excavation, loading, transporting (provided the haul does not exceed 500 feet on projects on which over-haul is to be allowed), and depositing the excavated material in the manner prescribed in these specifications; the formation and rolling of embankments, finishing of earth roadway, side ditches and slopes; discing and harrowing of sod where required; repairing and replacing of all fences that have been carelessly or unnecessarily damaged or removed by the Contractor; and such incidental work as may be required to make the grading work complete. Payment will not be made for excavation done prior to the staking and cross-sectioning of the work by the Engineer.

Additional excavation below grade in soft or spongy material when ordered removed by the Engineer will be paid for at double the contract price for "Roadway Excavation."

If shown on the plans, intercepting ditches for the removal of surface water at side hill cuts shall be paid for at the earth excavation price. If not shown on the plans, such ditches will be paid for as an "Extra" as provided in Paragraph 1109.04.

Run-out ditches from cut to fill will be paid for at the price for excavation.

Section 2103. Channel Excavation.

2103.01 DESCRIPTION. This work shall consist of the removal of material incidental to channel changes outside the limits of the detailed roadway cross sections shown on the plans, and the disposal of the excavated material as shown on the plans or as directed by the Engineer.

2103.02 METHOD OF MEASUREMENT. The quantity to be paid for will be the cubic yards measured in the excavation, as prescribed in Paragraph 2102.07. Excavation will be unclassified as prescribed in Paragraph 2102.02.

2103.03 BASIS OF PAYMENT. The quantity of excavation performed, measured as prescribed above, shall be paid for at the contract unit price per cubic yard for "Channel Excavation", which price shall be full compensation for excavating and

disposing of the material and furnishing all equipment, tools, labor and incidentals necessary to complete the work, except for excavation underneath bridge spans. Where the clearance of the bridge structure above the original ground line on the centerline of the channel is 12 feet or more, the excavation will be paid for at the contract unit price. Where the above mentioned clearance is less than 12 feet, the excavation beneath the bridge structure and 10 feet on each side of same will be paid for at double the contract price of channel excavation.

Section 2104. Approach Excavation.

2104.01 DESCRIPTION. This work shall consist of the excavation necessary to provide suitable approaches from intersecting highways and farm entrances, and disposing of the material as directed by the Engineer.

2104.02 CONSTRUCTION. The provisions of Section 2102, "Roadway Excavation", shall apply to approach excavation.

2104.03 BASIS OF PAYMENT. The quantity of approach excavation measured as provided in Paragraph 2102.07 shall be paid for at the contract unit price per cubic yard for approach excavation, which price shall be full compensation for excavating and disposing of the material and for furnishing all equipment, tools, labor and incidentals necessary to complete the work.

Section 2105. Embankments.

2105.01 EMBANKMENTS TO BE SURFACED WITH PAVEMENT. Embankments constructed in connection with earth work incidental to paving, shall be carried up in horizontal layers not exceeding 6 inches in thickness after rolling. Each layer shall extend the full width of the embankment and shall be smoothed before compaction by means of a suitable blade grader or bulldozer with power adequate to the work involved. The entire area of each such layer shall be compacted by distributing the hauling over the entire area and by rolling at least twice with a self-propelled roller having a weight on the rear rollers of at least 275 pounds per inch of width. Throughout the work the outer portion of the embankment shall be kept lower than the middle and the surface shall be maintained smooth enough to provide adequate drainage.

Sod, weeds and material which will not compact under the roller shall not be placed in the embankment, but shall be wasted as directed by the Engineer. The slopes and surfaces of existing embankments shall be plowed before additional fill is made, so that the new material will bond with the old.

A rigid pavement shall not be placed partly on an old and partly on a new fill. If an existing roadbed is not sufficient to carry the width of the paved surface, the road bed shall be taken down to an elevation at which the old fill extends 2 feet outside the pavement slab and rebuilt to the required width as provided in this paragraph for making new fills.

2105.02 EMBANKMENTS NOT TO BE SURFACED WITH PAVEMENT. Unless otherwise specified in the proposal or contract, all embankments other than those constructed as earthwork incidental to paving shall be built in accordance with the provisions of Paragraph 2105.01 except that the thickness of each horizontal layer after rolling shall not exceed 12 inches. Sod obtained in the cuts may be deposited in the embankments provided it is not placed closer than 12 inches to the finished surface.

Where embankments are not to be rolled, the Contractor will be required to construct them to such elevation as will provide for settlement and insure a completed roadbed at the proper elevations.

In blade grader work and in fills so shallow that the sod cannot be kept at least 12 inches below the finished roadway, the sod, after being cut loose with blade grader

or plow, shall be disced and harrowed until it is reduced to small pieces which will not interfere with traffic. These small pieces of sod shall be deposited near the shoulders and shall be covered with earth. The middle portion of the road shall be formed of earth free from sod.

2105.03 ROCK FILLS. When the material removed from excavation consists largely of rock, the contractor may be required to finish embankments containing rock to one foot below finished grade and cover this material to the finished grade line with suitable earth.

The Contractor shall conduct his operations in such a way that the Engineer is given opportunity to take any cross sectional measurements required before the earth cover is placed.

2105.04 JETTING EMBANKMENTS. Jetting of embankments shall be accomplished by keeping such embankments in a thoroughly saturated condition for a period of at least 56 hours, or longer if deemed necessary by the Engineer, to insure the complete settlement and compaction. This work shall be performed at locations indicated on the plans, or specified in the Special Provisions, and in accordance with directions given by the Engineer. Such work shall be done not less than six weeks in advance of the laying of the pavements.

(a) **Construction Method.** In case jetting is not started within 10 days after the completion of the rough grading, any hard earth crust formed on the surface by traffic or other causes shall be thoroughly plowed for a distance of at least 10 feet each side of the centerline of the road. Water shall then be applied to the embankment through holes spaced at 5-foot centers and extending from the surface of the embankment to within one foot of the original ground line. Such holes may be formed either by drilling with a 6-inch auger, or by means of a jetting pipe. When a jetting pipe is used, holes shall be started by an auger, or by spudding with a heavy iron bar. Water supply equipment shall be capable of producing a pressure of not less than 60 pounds per square inch at the nozzle of the jet pipe.

Water shall be applied as long as the embankment will continue to absorb same. Arching action in the fills shall be watched continually, and whenever found, such arch action shall be broken up. Jetting shall start at the deepest and proceed to the shallowest part of the embankment.

Not less than 2 weeks in advance of the paving, all holes shall be backfilled with suitable material. Such material shall be kept saturated during the process of back-filling.

(b) **Method of Measurement.** The yardage to be paid for shall be the number of cubic yards of jetted embankments, measured in place 2 weeks after the jetting has been completed. The length of embankment paid for shall include the distance between end cross sections holed and jetted plus 10 feet.

2105.05 BASIS OF PAYMENT. The work of building embankments will not be paid for directly but shall be considered as subsidiary work pertaining to excavation or borrow except the following items:

(a) Excavation made necessary in rebuilding embankments for pavements as provided in Paragraph 2105.01 shall be paid for as provided under "Excavation", Paragraph 2102.08.

(b) Jetting of embankment shall be paid for at the contract unit price per cubic yard for this item which shall be full compensation for furnishing all water, labor, equipment and material required as well as for any subsequent difficulties or delays which the Contractors may experience in paving and shouldering operations.

Section 2106. Disposal of Surplus Material.

2106.01 REQUIREMENT. Excess excavated material shall be deposited as di-

rected by the Engineer. It will generally be used in widening the adjacent embankments to reduce the side slopes.

2106.02 BASIS OF PAYMENT. The disposal of surplus material shall not be paid for directly but shall be considered as subsidiary to excavation.

Section 2107. Borrow.

2107.01 DESCRIPTION. When sufficient material for the embankments is not obtainable within the side ditches and excavation within the limits of the detailed cross sections of the roadway as shown in the plans, the Contractor shall make up the deficiency from borrow pits laid out by the Engineer.

2107.02 CONSTRUCTION METHODS. Borrow pits must be regular in shape in order to admit of accurate measurements, and care must be taken not to injure or disfigure the land unnecessarily. Excavation shall be made from the high portions of borrow pits in a manner which will provide adequate natural drainage and in strict accordance with directions of the Engineer.

2107.03 METHOD OF MEASUREMENT. Excavation for borrow shall be unclassified as provided in Paragraph 2102.02 and shall be measured by cross sectioning before and after excavation. The volumes shall be computed by the average end area method. Payment will not be made for material excavated prior to the staking out and cross sectioning of the work by the Engineer.

2107.04 BASIS OF PAYMENT. The quantity of borrow measured as provided above shall be paid for at the contract price for excavation as provided under Paragraph 2102.08.

Section 2108. Overhaul.

2108.01 OVERHAUL. No overhaul will be allowed on material excavated from roadbed sections or from borrow pits shown on the plans or extension of such pits of 100 feet or less in either width or length. If the Contractor is required to obtain material from borrow pits not shown on the plans, overhaul will be allowed on all material excavated from such pits in accordance with the following provisions:

In determining what constitutes the necessary haul, it will be assumed that material taken from excavation will be deposited in adjacent embankments after having been hauled the minimum distance. Any material that can be so deposited within the free haul limit of 500 feet shall be eliminated from further consideration. For such portions of the excavation as cannot be deposited within the free haul limit of 500 feet, the distance between the center of gravity of the remaining excavation and the center of gravity of the corresponding embankment will be determined. From this distance shall be deducted the length of free haul. The amount of overhaul will be computed at one cent per cubic yard per 100 foot station by multiplying the remaining distance reduced to stations by the number of cubic yards outside the free haul limit. Overhaul will be computed from the final cross sectional measurements only, regardless of whether or not the plans have been changed. Overhaul for earth backfill or cover of rock excavations and embankments will not be computed separately unless the Contractor has placed backfill and cover as a separate operation and the Engineer has had opportunity to take the necessary cross sectional measurements and haul data.

Section 2109. Subgrade.

2109.01 DESCRIPTION. The preparation of subgrade shall include the shaping, consolidation and treatment of the existing roadway surface on which the surface course or pavement is to be placed.

2109.02 SUBGRADE FOR PAVEMENT. The subgrade shall be so constructed as to have uniform density throughout the entire width as nearly as is possible. It shall be brought to the proper alignment and cross section and to such elevation that after being rolled until smooth, firm and hard, the finished subgrade will be at the proper elevation. At the time the subgrade is prepared, the roadbed shall have been constructed to the full width and to at least the elevation of the finished subgrade. Wherever the subgrade extends outside the lateral limits of an old roadway or wherever an old macadam or gravel surfacing lies within 6 inches of the elevation of the subgrade, such old roadway or surfacing shall be thoroughly loosened to a depth of 6 inches below the elevation of subgrade and then re-rolled so as to bring all material within the limits of the roadbed to a uniform density. Stone over 4 inches in size shall be removed from the loosened portion of the subgrade and placed on the side slopes or outside of the limits of construction.

Depressions that develop during the rolling shall be filled with suitable material and the rolling shall continue until the subgrade is uniformly firm, properly shaped, and true to grade and alignment. It shall be so maintained until the surfacing material is in place. Material (other than sand) which will not compact readily under the roller, shall be removed and replaced with material that will readily compact, and that portion of the subgrade again rolled.

The rolling of the subgrade shall extend for at least 12 inches outside of each edge of the proposed pavement. Berms of earth or other material that would interfere with the operations of finishing the pavement shall not be left on the shoulders.

If in the preparation of the subgrade it becomes necessary to excavate below the elevation of the earth shoulders, ditches or drains shall be provided at frequent intervals to permit ready drainage of surface water from subgrade to side ditches.

If ruts or other objectionable irregularities form in the subgrade during construction, the Contractor shall reshape and reroll the subgrade before the pavement is laid.

In the construction of subgrade for concrete pavement or base course a steel-shod template resting on the side forms shall be drawn along between the mixer and that part of the subgrade upon which the concrete is being deposited. This template shall be made of steel and its rigidity shall be at least equal in all respects to that of a 10-inch I-Beam, 25-pound section, with the web vertical. Its cutting edge shall consist of adjustable blades which shall be set so as to leave the subgrade at the elevation necessary to produce pavement of the thickness shown on the plans. Each end of the template shall be supported on the forms by means of 2 visible rollers spaced not less than 36 inches apart. The device used for attaching the template to the mixer shall be sufficiently rigid to permit the mixer to back up and draw the template back and forth over the subgrade as many times as may be necessary to bring the subgrade to proper section and elevation. Provision shall be made for passing the reinforcing steel through the template in such a way that it will be left in correct position without bending.

2109.03 ROLLER. A roller weighing not less than 3 or more than 5 tons shall be used in rolling the subgrade.

2109.04 TREATMENT OF SUBGRADE FOR CONCRETE PAVEMENT OR BASE COURSE. Such sprinkling or wetting of subgrade will be required as may be necessary to insure a reasonable moisture content in the subgrade at the time the concrete is placed. Unless otherwise ordered by the Engineer, the subgrade shall be covered with a single layer of bituminous-treated paper complying with the requirements of Paragraph 4124.10. Adjacent strips of paper as applied to the subgrade shall lap 4 inches.

2109.05. BASIS OF PAYMENT. Excavation required for preparation of subgrade shall be measured as prescribed in Paragraph 2102.07. Payment will be made for the materials actually removed above the elevation of the subgrade and between vertical planes one foot outside the edges of the finished pavement. No other work connected with construction of subgrade will be paid for directly, but shall be con-

sidered as subsidiary work included in the contract price for construction of the surface course specified in the contract.

If, in the judgment of the Engineer, the moisture content of the subgrade is such that the use of bituminous-treated paper is not necessary, the same may be omitted. For paper thus omitted there shall be deducted from the amount otherwise due the Contractor a sum equal to 90 per cent of the cost of the material not used, delivered at the site of the work.

Section 2110. Shoulders for Pavement.

2110.01 FINISHING SHOULDERS AND DITCHES. The work of finishing shoulders and ditches shall include the final operations of shaping and smoothing necessary to place the surfaces, within the right-of-way lines, in an acceptable condition. As the work of paving progresses, the earth shoulders and side ditches shall be constructed in accordance with the plans and specifications. Shouldering operations shall be commenced as soon as the pavement is sufficiently strong to permit the use of necessary equipment. Adequate organization and equipment shall be assigned to this work so that all shouldering work may be completed in within 21 days after the time the pavement is opened to the Contractor in accordance with the provisions of Paragraph 2303.25.

The Contractor's attention is directed to the provision of Paragraph 1105.12 for restriction on use of heavy equipment.

2110.02 BASIS OF PAYMENT. This work will be paid for at the contract unit price for finishing shoulders, per lineal foot of pavement measured on the centerline of the slab. This price shall be full payment for furnishing all equipment and performing all labor necessary to finish the roadway in an acceptable manner.

DIVISION 22. BASE COURSES.

DIVISION 23. SURFACE COURSES AND PAVEMENTS

2300.01 DESCRIPTION. Surface courses and pavements shall be constructed on prepared subgrade or graded earth roads. They shall consist of construction in accordance with the requirements hereinafter specified for Gravel Surfacing, Treated Gravel Surfacing, and Portland Cement Concrete Pavement.

Section 2301. Gravel Surfacing.

2301.01 DESCRIPTION. Gravel surfacing shall consist of the application of a granular material consisting of crushed stone, pit run or screened gravel, or crushed burned mine shale, to the surface of an existing road in the quantity specified in the contract. The granular material may be furnished by the state either in pits or f. o. b. cars at delivery points, or may be prepared or furnished by the Contractor as specified in the contract. Unless otherwise specified the material will be spread by state forces and consolidated under traffic. This specification shall apply to new construction or to resurfacing or reconstruction accomplished as maintenance.

2301.02 QUALITY OF SURFACING MATERIAL. The surfacing material used shall conform to the requirements of Paragraph 4105.04 for the grade of material specified in the contract.

2301.03 CONTRACT SCHEDULE. Contracts may be awarded for furnishing material, or preparing, hauling, and placing the material as follows:

- (a) For furnishing and delivering surfacing material complete on the road.
- (b) For preparing and delivering on the road, material furnished by the Commission in deposits specified in the special provisions.
- (c) For preparing material furnished by the Commission in deposits specified in the special provisions, and hauling the material one mile plus additional half-mile units of haul.

The preparation of material furnished by the Commission shall include the removal of the material from the deposit and such sorting, crushing, screening and washing as may be necessary to produce finished material which will comply with the specifications for the class of material required in the contract. Delivering or hauling shall include loading, transporting and depositing the prepared material. All oversize particles 7 inches or less in diameter included in gravel furnished by the Commission shall be crushed.

When surfacing material is furnished by the Commission in deposits, the Commission shall furnish the right of way necessary for a suitable road from the deposit to a public highway. The Contractor shall assume responsibility for any construction or maintenance work that may be required on the road from the deposit to the public highway.

2301.04 PREPARATION OF SUBGRADE. The subgrade shall be shaped to a smooth surface having a proper grade and cross section. The shaping of the subgrade will be done by the Commission.

2301.05 STRIPPING AND WASTE. The Contractor will be required to remove from materials furnished by the Commission all materials which may not be included in the surfacing material.

Stripping shall be construed to include the removing and disposing of material which may not be included in the prepared surfacing material and which occurs in

the natural deposit in continuous layers 6 inches or more in thickness overlying or included between layers of satisfactory surfacing material.

Waste shall be construed to mean the removing and disposing of material which occurs intermingled with satisfactory surfacing material and which is removed from the surfacing material in the process of preparation.

In stripping deposits of material furnished by the Commission care shall be taken to avoid unnecessary injury or disfigurement of the land. The material removed as stripping or waste shall be disposed of as directed by the Engineer.

2301.06 HAULING AND PLACING. Surfacing material shall be transported in vehicles so constructed and loaded that the amount of material in each load can be readily and accurately determined. Surfacing shall be delivered on the road only when the subgrade can be maintained in proper condition.

The contractor shall place the material on the subgrade either in the center of the road or along one shoulder, as directed by the Engineer.

2301.07 METHOD OF MEASUREMENT AND BASIS OF PAYMENT. The Engineer shall determine the number of units of each kind of work performed for which the contract provides a unit price in accordance with the following provisions. The unit of measurement for material furnished, prepared or delivered shall be one cubic yard measured in the transporting vehicle at the point of delivery on the road.

(a) **Furnishing and Delivering Material on the Road.** The contract price per cubic yard for furnishing and delivering surfacing material on the road shall be full payment for furnishing, preparing, handling, transporting and depositing the material on the road in accordance with the contract and these specifications.

(b) **Preparing and Hauling Material Furnished by the Commission.** The contract price per cubic yard for preparing and hauling material furnished in deposits by the Commission shall be full payment for removing, sorting, crushing, screening, washing and transporting the material in accordance with the contract and these specifications.

In case the contract provides a unit price for material hauled one mile plus additional compensation for material hauled more than one mile, the haul shall be measured over the shortest practical route from the loading point to the point of delivery. For the purpose of computing the additional units of half-mile haul, the first mile from the loading point shall be disregarded. Beginning at a point one mile from the loading point, each half-mile section shall be numbered toward the point of delivery. The number of additional half-mile units of haul shall be computed by multiplying the number of cubic yards of material delivered in each half-mile section by the number of that section and adding the products thus obtained.

(c) **Stripping.** Unless the contract includes a unit price for stripping, this item will not be paid for separately but will be considered as included in the contract unit price for preparing and hauling surfacing material. Stripping to be paid for as a separate item shall be measured in excavation by cross-sectioning before and after excavation. The volumes shall be computed by the average end area method.

Payment will not be made for material excavated prior to the cross-sectioning of the work by the Engineer. The contract price per cubic yard for stripping shall be full payment for excavating, transporting (provided the haul does not exceed 500 feet) and disposing of the excavated material. In case the average haul exceeds 500 feet overhaul shall be paid for as provided in Section 2108.

(d) **Waste.** Payment will not be made for waste as a separate item but shall be considered as included in the contract price for preparing and hauling the material.

Section 2302. Treated Gravel Surfacing.

Tentative only. Issued separately.

Section 2303. Concrete Pavement.

2303.01 DESCRIPTION. Concrete pavement shall consist of a single course of concrete of the full depth of the pavement. The minimum thickness of the pavement shall be as shown on the plans.

2303.02 MATERIALS. All material shall conform to the requirements of Part IV, Materials Details.

The use of high early strength Portland Cement will not be required unless so stipulated in the Special Provisions. Unless otherwise specified, high early strength Portland Cement will be used in the same proportions and in the same manner as normal Portland Cement.

2303.03. CONCRETE MIXER. Concrete shall be mixed in a batch mixer equipped with an approved device for timing each batch.

2303.04 SIDE FORMS. The side forms shall be of steel of a height in one piece equal to the thickness of the pavement at the edge, except that where a curb is required the additional height needed may be secured by bolting extra forms upon the top. When the form is tested as a simple beam of 9 feet, 6 inches length of span under a center load of 1700 pounds, the maximum deflection shall not exceed $\frac{1}{4}$ inch in 10 feet.

The forms shall be straight and free from defects that would in any way impair the quality or general appearance of the finished surface.

2303.05 WATER SUPPLY EQUIPMENT. The water supply equipment shall be of such capacity and nature as to insure an ample supply and a sufficient pressure for all the requirements of the construction. The pipe line shall have a minimum diameter of 2 inches, and where pumping is necessary, duplicate pumping equipment shall be provided to insure against breakdowns.

2303.06 ELEVATED BINS FOR CONCRETE MATERIALS. Before beginning the construction of elevated bins for concrete materials, the Contractor shall submit to the Resident Engineer detailed plans in triplicate showing the plant layout, the locations of sand, gravel and stone storage piles with relation to the elevated bins, and also showing all construction details of the elevated bins and their supporting framework and foundations. These plans will be checked by the Commission and shall be modified as required to meet the Commission's approval. The plant layout and storage bins shall be constructed as shown on the approved plans, except that the use of stronger members will be permitted. The plans for said bins as checked and approved by the Commission shall be construed as showing the minimum requirement.

The upper area of both fine and coarse aggregate compartments of all bins shall be protected with a suitable substantial timber or metal grillage having openings not larger than 8 inches square.

2303.07 PROTECTION AND HANDLING OF AGGREGATE. The aggregate shall be protected from becoming mixed with dust or dirt. Horses or trucks shall not be driven upon the piles of aggregates. The fine and coarse aggregate shall be

stored in piles which shall be kept entirely separated. Aggregates shall not be stored upon the subgrade or shoulders.

Unscreened gravel shall be used from a stock pile in such a manner as to reduce to a minimum the variations in the percentage of moisture and the percentage of sand in the materials.

Class V aggregate that contains more than 2.0 per cent of moisture shall be placed in a stock pile and allowed to drain before being used.

Sand that contains more than 3.5 per cent of moisture shall be placed in a stock pile and allowed to drain before being used.

Class II coarse aggregate which has an absorption of 0.5 per cent or more shall be thoroughly wetted in stock pile or cars at least one hour before being used.

2303.08 PROTECTION OF CEMENT. Suitable provision shall be made to prevent loss of cement during handling, and to prevent leakage of cement from one batch to another in multiple-batch bodies. The trucks or batch boxes carrying cement shall either be covered to prevent loss in transit, or the cement shall be hauled to the mixer in bags.

2303.09 SUBGRADE. The subgrade shall be prepared as specified in Section 2109.

2303.10 SETTING SIDE FORMS. The subgrade for side forms shall be excavated in solid earth by means of a machine designed for this specified purpose and meeting the approval of the Engineer. The top of the form shall be accurately set to the elevation and alignment of the edge of the finished pavement and shall be supported and held securely in place by adequate stakes and bracing. After the forms are set and locked, a tamper of suitable design and weight shall be used on both sides of each form throughout its entire length, to force suitable material into intimate contact with the base of the form. Should the earth supporting the form become softened by rain or standing water so that the forms are not adequately supported, the forms shall be reset on suitable material before the concrete is placed. After the side forms have been set, the joints shall be checked with a straight-edge at least 10 feet long, and corrected to proper grade and alignment. Curb forms shall be rigidly attached to the side forms so that they will extend the plane of the side forms without variation of more than $\frac{1}{8}$ inch.

Forms shall be cleaned and oiled before any concrete is deposited against them. Side forms shall be left in place not less than 15 hours after the concrete is placed. Curb forms may be removed as soon as the concrete has taken its final set. Care must be exercised in the removal of forms to prevent cracking and spalling of the concrete.

2303.11 PROPORTIONS FOR CONCRETE MIXTURES. Any one of the following mixtures may be used:

(a) For Class I, II or III Aggregate.

Mix No.	Proportion by dry weight. Lb. cement to lb. sand to lb. coarse aggregate*	Max. size of aggregate. Allowable inches	Approx. bbl. cement per cu. yd. of concrete
1	1:1.718:3.488	1.5	1.63
2	1:1.946:2.919	2.5	1.71
3	1:2.067:2.526	2.5	1.78
4	1:2.170:2.170	2.5	1.85

* Note: In measuring materials correction may be made for particles in sand coarser than the No. 4 sieve, and for particles in the coarse aggregate finer than the No. 4 sieve.

These proportions are based upon both fine and coarse aggregate having a specific gravity of 2.65. If materials are furnished which have specific gravities other than 2.65, the proportions will be adjusted in accordance with the ratio which the actual specific gravity bears to 2.65.

(b) For Class V Aggregate.

Proportion by dry weight. Lb. cement to lb. aggregate	Max. total water allowable. Gal. per bag of cement	Approx. bbl. cement per cu. yd. of concrete
1:3.90	4.75	1.90

The proportions for Class V aggregate are based upon material having a specific gravity of 2.62.

2303.12 ADJUSTMENT OF PROPORTIONS. The estimated quantities of cement per cubic yard of concrete shown in the tables of proportions are based upon average conditions. If the combination of materials is such that the quantity of cement used is consistently more than one per cent greater or more than one per cent less than the estimated quantity, the proportions will be adjusted accordingly. This does not apply to variations in quantities caused by variations in thickness of the slab.

2303.13 PIT-RUN OR UNSCREENED GRAVEL. If the use of Class III coarse aggregate is approved, the proportions will be fixed upon the basis of the relative amounts of fine and coarse aggregate so as to be equivalent to one of the above mixes for screened aggregate. Attention is directed to the requirements as to the method of handling Class III and Class V aggregates as set forth in Paragraph 2303.07.

2303.14 WATER AND CONSISTENCY. The amount of water used shall produce concrete of uniform consistency having a "slump" of not more than 2.0 inches when tested in accordance with the A. S. T. M. "Tentative Method of Test for Consistency of Portland Cement Concrete", Designation D138-26T. The amount of water used in mixes employing Class I, II or III aggregate shall not exceed 5.5 gallons per bag of cement, including the water in the aggregates.

2303.15 MEASUREMENT OF MATERIALS.

(a) **Cement.** Measurement of cement shall be by weight, upon approved scales which shall be within 2 pounds of correct at all loads, except that the cement in unopened sacks as packed by the manufacturer may be considered to weigh 94 pounds per sack.

(b) **Water.** The water measuring equipment shall be capable of accurate measurement to one quart and shall be so arranged that the accuracy of measurement will not be affected by variations in pressure in the water supply line. Unless the water is to be weighed the water measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The volume of the auxiliary tank shall be at least equal to that of the measuring tank. The equipment shall be so arranged that the water pressure in the measuring tank cannot exceed that due to the difference in elevation between the two tanks.

(c) **Aggregates.** Aggregates shall be weighed upon approved scales which shall be within two pounds of correct at all loads. The weighing equipment shall comply with the following conditions:

1. At least that part of the total load weighed which is a fraction of 100 pounds shall be indicated on a graduated beam or dial.

2. The weighing equipment shall be so arranged that when operating the bin gates the operator stands in such a position that the weighing beam or dial is in full view and he can conveniently shovel material from the weighing hopper.

3. There shall be enough clearance at the top of the weighing hopper to permit the scale operator to shovel material out of the weighing hopper, or suitable openings shall be provided in the side of the hopper for this purpose.

4. Weighing hoppers on platform scales shall be mounted so that the center of gravity of the hopper, both loaded and unloaded, is vertically over the center of the scale platform.

5. The Contractor shall provide, with each installation of weighing equipment, at least 8 standard 50-pound test weights for the purpose of testing and calibrating weighing equipment. The test weights shall be kept clean and shall be used for no other purpose than the testing and calibrating of weighing equipment.

2303.16 MIXING CONCRETE. The method of handling the batches and charging the mixer shall insure the complete introduction of each batch separately without loss of materials. Each batch of concrete shall be completely discharged from the mixer before the materials of the next batch are placed in the drum. Water shall be introduced at the same time as the other materials.

The volume of mixed concrete in each batch shall not exceed the mixer manufacturer's rated capacity of the drum.

The mixing shall continue for a minimum of one minute after all the dry ingredients (cement, aggregates, and admixtures) are in the drum, during which time the drum shall revolve at the speed for which it was designed, but shall make not less than 12 nor more than 18 revolutions per minute. The minimum duration of the mixing period of each batch shall be indicated by an approved timing device.

2303.17 PLACING CONCRETE. The concrete shall be deposited upon the subgrade to the required depth and for the entire width of the pavement in a continuous operation without the use of intermediate forms. The concrete along the forms, expansion joints and steel center strip shall be spaded immediately after being placed.

The concrete shall be struck off and compacted by means of a screed resting upon the concrete and moved upon it in such a manner as to leave the top of the concrete slab at the proper elevation and the concrete thoroughly compacted. All equipment for this purpose shall be approved by the Engineer.

2303.18 FINISHING TOOLS. Before placing any concrete the Contractor shall provide the following hand-finishing tools for use during breakdowns of mechanical finishers and for finishing on widened curves, transition sections, inlets and other irregular sections of pavement, and for use in supplementing the work of the mechanical finisher:

1. One 6x8 timber tamper cut to correct crown and of a length to span the full width between side forms.
2. One wooden strikeboard 2 inches thick, iron bound on the lower edge, cut to crown and of proper length to span the full width between side forms and of sufficient rigidity to maintain its shape when in use.
3. Two wooden floats of a size approximately one foot by 3 feet with handles at least 12 feet long.
4. Two small wooden hand floats.
5. Two light straight-edges, 10 feet long mounted on handles at least 12 feet long, for use in detecting irregularities in the surface, and two heavy straight-edges of similar size for use in smoothing the surface.
6. Four edgers for edging the pavement edges, expansion joints and flumes.
7. Two belts not less than 8 inches wide and of a length sufficient to span the full width of the pavement.
8. One longitudinal float 12 inches wide and 12 feet long with the edges of its bottom surface rounded. It shall be equipped with 2 pairs of plow handles, or others of similar design, of such length that the operators may stand practically upright when working from bridges. If made of wood this float shall be 3 inches thick. If made of metal it shall have a weight approximately equal to a similar float made of 3-inch plank, and shall be lined on its bottom face with wood.
9. Two bridges from which to operate the longitudinal float.

2303.19 FINISHING. The finishing shall be done in the following manner:

- (a) A float as described above, 12 inches wide and 12 feet long, shall be operated longitudinally over the entire surface of the pavement with a combined longitudinal and transverse motion, passing slowly from one side of the pavement to the other a

sufficient number of times (at least twice) to smooth all ridges and fill all depressions until the float on its last passage shall show contact with the concrete throughout its entire length. This float shall be operated by men working on bridges that span the full width of the pavement. In moving forward with the float each successive position shall overlap the preceding position by one-half the length of the float.

(b) Immediately after the completion of the longitudinal floating described above, the surface of the concrete shall be given a preliminary belting with a belt not less than 8 inches wide, using a combined crosswise and longitudinal motion. Care shall be used to leave a surface equal in smoothness and finish to that obtained at the final belting.

(c) After the preliminary belting the surface of the concrete shall be checked by the finishers in the manner described in Paragraph 2303.19(e). High areas shall be removed by means of the hand tools described in Paragraph 2303.18, and depressions shall be filled with additional concrete. The entire area of surface that has been disturbed in making the corrections shall be immediately refinished by hand to a smooth and even surface. This checking and correction of the surface shall be started as soon as the condition of the concrete will permit, and the Contractor shall detail to this work a sufficient number of skilled finishers to complete the corrections before the initial set has taken place.

(d) Just before the concrete obtains its initial set and after the greater part of the water-glaze has disappeared from the surface, the concrete shall be given a final belting to remove all tool marks and to produce a uniform surface of a gritty texture. In order to secure the desired surface the Engineer may require that the length of stroke and the rate of advance be varied according to the aggregate used, the amount of water present, and the rapidity of the initial set.

(e) During the finishing operation and before the surface is "laid by", it shall be tested with a 10-foot straight-edge set parallel with the center line. Any depressions and any high areas in excess of $\frac{1}{8}$ inch shall be corrected.

(f) After the final belting, the edges of the pavement along the side forms shall be rounded in a workmanlike manner by means of a suitable edging tool.

(g) After the concrete has set sufficiently hard to bear a man's weight without injury to the surface, and before the earth covering is applied, the surface shall again be checked with the straight edge. High spots in excess of $\frac{1}{8}$ inch on 10-foot straight edge shall be smoothed to bring the surface within this $\frac{1}{8}$ inch tolerance. This smoothing shall be accomplished by rubbing with a carborundum brick or by other methods which will produce equivalent results.

In testing the surface of the pavement, successive positions of the straight-edge shall be lapped $\frac{1}{2}$ the length of the straight-edge.

2303.20 END OF RUN. Whenever the work of concreting is stopped for 30 minutes or more, the concrete already placed shall be well spaded and finished to a header plank placed on the subgrade perpendicular to the pavement surface and at right angles to the center line of the roadway. This plank shall be shaped and placed so that its upper edge will conform to the crown shown on the plans for the pavement surface. An edging tool shall be used along the plank to make a regular and well-defined construction joint. In the header plank there shall be 10 holes spaced as shown on the plans and midway of the depth, through which shall be inserted $\frac{5}{8}$ -inch plain round steel bars 2 feet long with 6 inches projecting.

When the plank is removed care shall be taken not to disturb the rods or the concrete. The fresh concrete shall be placed directly against the face of the concrete previously laid and carefully worked around the rods. The new concrete shall be well spaded along the joint and edged as described above.

2303.21 PROTECTION AND CURING. The concrete shall be cured by one of the following methods, except that Method (b), "Curing with Calcium Chloride Admixture", may be required by the Engineer after October 15, and this method of curing shall not be used between April 15 and October 15. Unless otherwise pro-

vided in the special provisions, any of the following methods of curing may be used. As soon after the removal of the side forms as the method of curing used will permit, the edges of the pavement slab shall be protected with a covering of earth.

(a) **Curing with Wet Earth, Sand, Straw or Hay.** After the final belting, the concrete shall be protected with a burlap covering applied as soon as it is possible to do so without marring the surface. During the application the burlap shall not be dragged over the Concrete or over burlap already spread. This covering shall remain in place for at least 20 hours. The burlap used shall comply with the requirements of Paragraph 4124.08 and shall be saturated with water immediately before being placed on the concrete. The burlap shall be kept continuously wet by means of a spray of water fine enough that the concrete will not be damaged by the application of the water. As soon as the burlap is removed the surface of the pavement shall be covered with at least 2 inches of earth or sand, or with at least 6 inches of hay or straw. The cover used shall be kept continuously wet until 7 days after the concrete was placed. If the earth protecting the edges of the slab is not kept thoroughly wetted, the Engineer may require that these edges be given an impervious coating as specified in Paragraph 2303.21(c).

(b) **Curing with Calcium Chloride Admixture.** There shall be incorporated in the concrete mixture a calcium chloride solution which will furnish 2 pounds of calcium chloride per bag of cement. This solution shall be measured as part of the mixing water. The ratio of water to calcium chloride in making the solution shall be as directed by the Engineer. Mechanical devices satisfactory to the Engineer shall be provided for mixing the calcium chloride and water and for introducing into the mixer the exact amount required for each batch. The calcium chloride solution shall be introduced with the rest of the mixing water and must not come in contact with the dry materials. After the final belting the concrete shall be protected by a covering of at least 2 thicknesses of burlap complying with the requirements of Paragraph 4124.08 and applied as soon as it is possible to do so without marring the surface. This covering shall remain in place for at least 24 hours. The burlap shall be saturated with water immediately before being placed and shall be kept continuously wet by means of a spray of water sufficiently fine that the concrete will not be damaged thereby.

(c) **Curing with Impervious Coatings.** After the final belting the concrete shall be protected with a covering of burlap complying with the requirements of Paragraph 4124.08, and applied as soon as it is possible to do so without marring the surface. This covering shall remain in place at least 20 hours. The burlap shall be saturated with water immediately before being placed and shall be kept continuously wet by means of a spray of water sufficiently fine that the concrete will not be damaged thereby. As soon as the burlap is removed, the top surface and the edges of the pavement shall be covered with a continuous, uniform, water-impermeable coating. If the impervious coating has a color darker than the uncoated concrete, the coated surface of the concrete shall be covered with an additional coating of white-wash made from hydrated lime and water, or a mixture of hydrated lime, powdered limestone and water approved by the Engineer, applied within 2 hours after the time the impervious coating was applied. The proportions used in the white-wash and the rate of its application shall be such as will produce on the surface of the pavement a uniform white color.

The impermeable coating used shall be such that within 2 hours after application it will "set" to form a fairly hard water-impermeable film, strongly adhering to the concrete. The impervious coating used shall be such that when applied to the surface of the mortar test slabs in the manner prescribed for the use of the material in the field, the mortar shall retain at least 90 per cent of the mixing water when exposed for 144 hours to temperatures between 90°F. and 100°F. at a relative humidity of 30 per cent to 50 per cent.

The mortar test slab used shall be composed of one part portland cement to 1.71

parts sand to 0.346 parts water by weight. The slab shall be cast in a non-absorbent, water-tight mold, and shall remain in the mold throughout the test. The slab shall be approximately 15 inches long by 15 inches wide by 2 inches deep. The coating shall be applied to the exposed surface of the slab within 2 hours of the time the slab is cast.

Materials for use as impervious coatings will be approved by the Engineer on the basis of the tests outlined above. The rate of application of such coatings will be prescribed by the Engineer on the basis of the same tests.

(d) **Curing with Paper.** After the final belting the concrete shall be protected with a covering of burlap complying with the requirements of Paragraph 4124.08, for at least 20 hours. The burlap shall be saturated with water immediately before being placed, and shall be kept continuously wet by means of a spray of water sufficiently fine that the concrete will not be damaged thereby. As soon as the burlap is removed, the top surface and the edges of the pavement shall be thoroughly wetted with water and immediately covered with a layer of paper. At the junction of units of paper the units shall be lapped at least 18 inches. The paper shall be so placed and weighted as to cause it to remain in intimate contact with the surface covered. The paper shall remain in place until 7 days after the concrete was placed. The paper used for this purpose shall comply with the requirements of Paragraph 4124.09.

(e) **Curing with Wet Burlap or Other Fabrics or Mats.** After the final belting the concrete shall be protected with a covering of at least 2 thicknesses of burlap complying with the requirements of Paragraph 4124.08, for at least 72 hours. The burlap shall be saturated with water immediately before being placed, and shall be kept continuously wet by means of a spray of water sufficiently fine that the concrete will not be damaged thereby. When the side forms are removed the edges of the slab shall be covered with burlap as specified for the protection of the top surface of the pavement. The burlap used for the protection of the top surface of the pavement shall be sufficiently long to extend to the bottom corners of the slab.

In lieu of the covering of burlap specified, the concrete may be covered with other fabrics or mats approved by the Engineer. Such coverings shall be capable of preventing the evaporation of mixing water and controlling variations in the temperature of concrete to a degree at least equal to that of 2 thicknesses of burlap, complying with these specifications, kept continuously wet. Tests for the control of the evaporation of mixing water shall be conducted as outlined in Paragraph 2303.21(c) except that the test period shall be 72 hours. Tests for the control of variations in temperature shall be conducted under direct sunlight.

At the time such coverings are applied the surface of the covering to be placed in contact with the concrete shall be thoroughly wet.

Wetting subsequent to the application of the covering shall be that required by the Engineer to produce the desired results of the tests outlined above.

2303.22 WEATHER. Concrete shall not be placed when stormy or inclement weather prevents good workmanship. No lumps of frozen aggregate shall be used, and concrete shall not be placed on a frozen subgrade. If weather conditions are favorable concreting operations may be started when the temperature of the mixed concrete as discharged from the mixer is 40°F. or above, and may proceed as long as the temperature of the fresh concrete may be maintained above 40°F., and the air temperature above 38°F. No concrete shall be placed when the air temperature is lower than 38°F. Concrete placed when the air temperature is below 45°F. shall be covered with at least 6 inches of straw placed on top of the burlap before completion of the day's operation.

2303.23 NIGHT CONCRETING. Concrete shall not be placed when too dark for good workmanship. Special authorization from the Commission must be secured if it is desired to place concrete with the aid of artificial light.

2303.24 TANDEM MIXERS. Should the Contractor elect to use 2 mixers in tan-

dem they shall be connected or operated so that there is no loss of materials in the transfer of batches between the mixers. Each mixer shall be completely equipped for accurate water measurement but in operating, the water required for the batch shall all be incorporated in the mixture in the first mixer. Each mixer shall be equipped with a subgrade template. At the option of the Engineer the Contractor shall provide 2 finishing machines and such other additional labor and equipment as will be required to maintain progress of the placing, finishing and curing operations equal to the mixing operation. The mixer which deposits concrete on the subgrade shall be equipped with a boom not less than 24 feet long.

2303.25 TIME FOR OPENING PAVEMENT FOR USE. The time for opening pavement will be based on the strength of the concrete as determined upon beam specimens made during the progress of the work. The Contractor's force may be allowed upon the pavement for the purpose of removing covering and building shoulders as soon after 7 days of age as tests show the concrete to be capable of sustaining the maximum loads permitted by law. General traffic may be allowed upon the pavement as soon thereafter as the pavement is in condition for safe use.

2303.26 EXPANSION JOINTS. Expansion joints shall be constructed as shown on the plans. They shall be installed perpendicular to the surface of the pavement and to the centerline of the pavement. They shall be made by installing bituminous premoulded expansion joint material meeting the requirements of Paragraph 4106.04, or other expansion joint material approved by the Engineer, or by constructing open joints which are filled after the concrete is set, with a bituminous material complying with the requirements of Paragraph 4106.05. The ends of the dowel bars, shown on the plans as projecting six inches into the concrete, shall be fitted with metal expansion tubes as specified in Paragraph 4124.02. When premoulded expansion joint material is used, the portion of joint inserted in the curb shall be double the thickness of the joint in the pavement slab. When poured bituminous material is used in the joints in the pavement slab, the section through the curb shall be filled with suitable mastic filler or with premoulded material which shall be thoroughly ramed into the joint.

Before any dirt has been placed on the surface of the pavement in the curing operation, in the process of building shoulders or by traffic, expansion joints shall be sealed with bituminous material complying with the requirements of Paragraph 4106.02. Care shall be taken to fill the joint flush with the top of the pavement without spilling bituminous material on the pavement surface.

2303.27 LONGITUDINAL JOINTS. Longitudinal joints shall be constructed as shown on the plans. Such joints shall be true to line. They shall be constructed by installing a metal parting strip or by the employment of some method or device which will result in the creation of a definite plane of weakness extending into the slab not less than 2½ inches from the top surface. Any method or device for creating a plane of weakness shall be of a mechanical nature to insure a straight, workmanlike installation, and shall be subject to the approval of the Engineer before being used. Any method or device using pre-moulded bituminous parting strip shall be capable of continuous operation and the strip installed shall be continuous between expansion or construction joints. When the plane of weakness is made by installing a metal form to be removed after the concrete has set, the sections of metal form shall be provided with interlocking ends and shall be sufficiently rigid to hold themselves in position. The sections shall be removed from the set concrete the following day and the opening filled with bitumen. Materials used for longitudinal joints shall comply with the requirements of Paragraph 4124.01.

2303.28 BASIS OF PAYMENT. The contract price per square yard for constructing the pavement, and per cubic yard for the earthwork in connection therewith, shall be full payment for the furnishing of all materials not specifically omitted from the contract, and all tools, equipment, labor and supplies that are necessary

to construct the pavement, including curb, the earth shoulders and side ditches complete in accordance with the plans and specifications. The contract shall include a price per lineal foot of curb which price shall be applied in adjusting the compensation to the Contractor for the construction of more or less curb than that shown on the plans. The Contractor shall furnish not to exceed 2 cubic feet of concrete per day for test specimens without additional compensation.

DIVISION 24. STRUCTURES.

2400.01 DESCRIPTION. The work shall consist of the construction of all types of wood, steel or concrete bridges, viaducts, retaining walls and culverts or other similar units in accordance with the detailed plans and the requirements of the following sections.

Section 2401. Excavation for Structures.

2401.01 DESCRIPTION. Excavation shall consist of the removal of the existing structure at the site unless otherwise specified, including the abutments, piers, wings, and all other materials, obstructions, etc., necessary for the construction of the work included in the contract, in conformity with the plans or as may be directed by the Engineer. It shall include all clearing and grubbing, removal of necessary materials, furnishing and placing of cofferdams, etc., and the disposal of surplus material; all of which shall be in accordance with the dimensions given on the plans and in conformity to these specifications.

2401.02 ELEVATIONS AND DIMENSIONS OF FOOTINGS. Under normal construction conditions, footings will be constructed to the elevations shown on the detailed plans. The Engineer may order, in writing, such changes in dimensions or elevations of bottoms of footings as may be necessary to secure a satisfactory foundation.

2401.03 TREATMENT OF FOUNDATION MATERIALS. If rock foundation is secured the excavation shall be done in such a manner as to allow the rock to be exposed and prepared for receiving the concrete or masonry. All loose and disintegrated rock or thin strata shall be stripped to a clean bed acceptable to the Engineer. All seams or crevices shall be cleaned out and filled with concrete or mortar.

Whenever the footing is to rest on any excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and the final finishing of the surface shall not be done until just before the footing is to be placed.

2401.04 CONSTRUCTION OF COFFERDAMS. Cofferdams shall be constructed to comply with the requirements of Paragraph 2404.03.

2401.05 REMOVAL OF COFFERDAMS. Unless otherwise shown on the plans or agreed upon, cofferdams and all sheeting and bracing shall be removed by the Contractor after the completion of the substructure.

2401.06 INSPECTION OF EXCAVATION. After each excavation is completed the Contractor shall notify the Engineer, who shall make an inspection of the depth and character of the foundation material. No concrete or masonry shall be placed until after the Engineer has approved the depth of excavation and character of foundation material. The Commission shall be responsible for delays caused by failure to make inspection after a 24-hour notice has been given the Engineer or his representative by the Contractor or his authorized agent.

2401.07 DISPOSAL OF EXCAVATED MATERIAL. All materials excavated by the Contractor for bridge or culvert work, shall be disposed of so as to leave the site in a neat condition. Material suitable for back-filling shall be used for that purpose to the extent required to completely back-fill the structure to the original ground level or the elevation shown on the plans.

Material suitable for approach fills and not required for back-filling shall be placed in the approach fills.

Material not suitable for back-filling or approach fills shall be wasted as directed by the Engineer.

Material used for back-filling or approach fills shall be earth or other approved material, free from spongy or vegetable substances and shall contain no lumps of frozen materials.

2401.08 BACK-FILLING. The bridge or culvert contractor shall back-fill completed structures in accordance with the following requirements. No back-filling shall be placed against abutments, piers, arches, or wingwalls within 14 days after the concrete has been placed except as provided in Paragraph 2402.20.

Back-fill material except when deposited in water, shall be deposited in layers not more than 12 inches in depth before compaction, and each layer shall be thoroughly rolled, or compacted with an approved type of mechanical tamper before the succeeding layer is placed, with the following exception.

When back-fill can be deposited on one side only of abutments, piers, wingwalls or culvert headwalls, no rolling or mechanical tamping will be permitted within 6 feet of the supporting surface, but hand tamping will be required on the back-filling material within this area.

Where it is required that back-filling material be placed on both sides of a concrete wall or monolithic structure, the lifts shall be made uniformly of equal height on both sides, and rolling or mechanical tamping will be required on the entire surface of each layer.

Fills at culvert barrels, arches and on each side of end pedestals or bents shall be constructed simultaneously and the operation so conducted that the elevation of the completed fill on each side of the structure is the same. Any back-filling required in addition to that which will result from the use of material excavated during construction operations will be shown on the plans or called for in the Special Provisions.

2401.09 CLASSIFICATION OF EXCAVATION. Excavation for structures will be classified as Class I or Class II excavation. Class I excavation will include all excavation for box, arch, or circular culverts, pipe culverts and all excavation for bridges not classified as Class II excavation.

Class II excavation shall include all excavation for bridges below the elevation of the "Excavation Classification Line" shown on the plans for each specific structure.

Should rock in ledges or solid formation or nests of boulders be encountered on construction projects for which information at the time of letting had not indicated that rock would be encountered, the Contractor shall advise the Engineer in order that measurements necessary to determine the quantity of materials of this class to be removed.

2401.10 METHOD OF MEASUREMENT. All excavation will be measured in its original position by the cross section method. The yardage of excavation paid for will be that actually removed, except that unless shown on the plans or ordered by the Engineer, no payment will be made for material removed outside an area which is bounded by vertical planes spaced 12 inches outside box culvert footings or the horizontal projection of structures without footings, and 18 inches outside footings of other structures, and parallel thereto. The Contractor shall notify the Engineer not less than 48 hours in advance of beginning excavation so that the necessary measurements of existing ground may be made. Payment will not be made for any material removed before these measurements have been made.

2401.11 BASIS OF PAYMENT. Payment for excavation and fills included within the contract or as ordered by the Engineer shall be made as specified below. The price paid for excavation shall in all cases be full payment for removing, transporting and disposing of all excavated material; for pumping; and for furnishing, placing and removing all cofferdams, shoring and bracing.

When the plans call for the removal of existing structures or parts of structures, the Contractor shall be paid for such removal at the contract price therefor.

Clearing and grubbing will be paid for in accordance with the provisions of Section 2101. Excavation required for berms or channel changes will be measured in accordance with the provisions of Section 2103 and will be paid for at the contract unit price therefor. Riprap will be paid for in accordance with the provisions of Section 2506.

(a) **Excavation According to Plans.** Excavation done according to the plans shall be paid for at the unit contract prices for quantities measured and classified as specified in Paragraphs 2401.09 and 2401.10.

(b) **Extra Depth Excavation.** When so ordered in writing by the Engineer, the Contractor will be required to excavate to an extra depth below the elevation of the bottom of footings shown on the plans. When the extra depth of excavation does not exceed six feet, payment will be made for each foot in depth at the following percentages of the contract unit price for excavation of the last foot above the bottom of the footing:

First Foot	120%
Second Foot	140%
Third Foot	160%
Fourth Foot	180%
Fifth Foot	200%
Sixth Foot	220%

When extra depth of excavation exceeds six feet, such excavation shall be paid for as Extra Work as provided in Paragraph 1109.04.

(c) **Excavation for Changes in Horizontal Dimensions of Footings.** When so ordered in writing by the Engineer, the Contractor will be required to construct footings having greater horizontal dimensions than those shown on the plans. When such changes in dimensions do not necessitate the removal and reconstruction of cofferdams, payment shall be made at the contract unit prices. When such changes in dimensions necessitate the removal and replacement of cofferdams, the removal of old cofferdams and reconstruction of the new one shall be considered as "extra work" and shall be paid for as provided in Paragraph 1109.04.

(d) **Overhaul.** Excavated material will ordinarily be deposited within fifty feet from the excavation as directed by the Engineer. An additional price of 5 cents per station yard will be paid for all excavated material required to be hauled more than fifty feet, computed by the method described in Section 2108.

(e) **Rock Excavation.** Excavation of rock ledges, solid rock or boulder nests as classified in Paragraph 2401.09, shall be paid for at two and one-half times contract unit price for Class I or Class II excavation according to the class of excavation in which the deposits occur.

Section 2402. Concrete Masonry.

2402.01 DESCRIPTION. Concrete shall be composed of portland cement, fine and coarse aggregate and water, mixed in the proportions specified as follows for the various classes. The class of concrete used shall be Class "A" unless otherwise shown on the plans.

2402.02 CLASSIFICATION OF CONCRETE AND PROPORTIONS.

(a) **Class I and Class II Coarse Aggregate.** Class I and Class II coarse aggregate may be used in concrete in the following proportions:

Class of Concrete	Mix No.	Proportion by Dry Weight, Lb. Cement to Lb. Sand to Lb. Coarse Aggregate	Per cent sand in total aggregate by weight	Approx. bbl. cement per cubic yard of fresh cement
A	2	1—2.09—3.13	40	1.60
	3	1—2.23—2.72	45	1.66
	4	1—2.35—2.35	50	1.72
B	2	1—2.57—3.85	40	1.36
	4	1—2.96—2.96	50	1.44
C		1—2.5	100	
	4	1—2.0 —2.0	50	

Any proportion specified may be used at the Contractor's option provided the coarse aggregate used complies with the sieve analysis requirements for that proportion.

Concrete shall not be proportioned by volume unless such proportioning is specifically provided for in the proposal. When concrete is proportioned by volume the volumetric proportions used shall be those which are the equivalent of the weight proportions specified. The provisions of Paragraph 2402.02(d) shall not apply to concrete proportioned by volume.

(b) **Class III Aggregate.** If the use of Class III aggregate (pit-run gravel) is approved, the proportions shall be fixed in accordance with the following table according to the percentage of sand in the aggregate as determined by the Engineer at the time the material is used:

Proportions by Weight.

Percentage sand in aggregate by weight	Class "A" Concrete		Class "B" Concrete	
	Proportion, lb. cement to lb. aggregate	Bbl. cement per cubic yard	Proportion, lb. cement to lb. aggregate	Bbl. cement per cubic yard
41—45	1—4.95	1.66	1—6.17	1.40
46—50	1—4.70	1.72	1—5.92	1.44
51—55	1—4.45	1.78	1—5.67	1.49
56—60	1—4.20	1.85	1—5.42	1.54
61—65	1—3.95	1.93	1—5.17	1.59
66—70	1—3.70	2.01	1—4.92	1.64

These proportions are based on both fine and coarse aggregate having a specific gravity of 2.65. If materials are furnished which have specific gravities other than 2.65, the proportion will be adjusted in accordance with the ratio which the actual specific gravity bears to 2.65.

Class III aggregate may be used in combination with screened aggregate to produce concrete of the same proportions as specified for Class I and II coarse aggregate.

(c) **Class V Aggregate.** Class V aggregate complying with requirements of Paragraph 4105.05 may be used in bridge work in proportions listed below:

Class "A" or "B" Concrete		Class "C" Concrete	
Proportion by weight, lb. cement to lb. aggregate	Approx. bbl. cement per cu. yd. of concrete	Proportion by weight, lb. cement to lb. aggregate	Approx. bbl. cement per cu. yd. of concrete
1—3.9	1.9	1—2.5	2.50

These proportions are based on the Class V aggregate having a specific gravity of 2.62.

(d) **Adjustment of Proportions.** The estimated quantities of cement per cubic yard of concrete shown in the table of proportions are based upon average conditions. If the combination of materials is such that the quantity of cement per cubic yard of concrete placed is consistently more than 2.0 per cent greater, or more than 2.0 per cent less than the estimated quantity, the proportion will be adjusted accordingly.

(e) **Water and Consistency.** The amount of water used shall produce concrete of uniform consistency having a "slump" not more than 5 inches when tested in accordance with the A. S. T. M. "Tentative Method of Test for Consistency of Portland Cement Concrete", Designation D138-26T. The amount of water used shall not exceed the following:

Class of Concrete	Maximum amount of water including moisture in aggregates	
	Gal. per bag	Lbs. per lb.
A—Class I, II or III Aggregate.....	6.0	.510
B—Class I, II or III Aggregate.....	6.6	.577
C—.....	6.0	.510
Class A, B or C with Class V Aggregate.....	5.0	.444

2402.03 MATERIALS. All material shall conform to the requirements of Part IV, Materials Details.

The use of high early strength Portland Cement will not be required unless so stipulated in the Special Provisions. Unless otherwise specified, high early strength Portland Cement will be used in the same proportions and in the same manner as normal Portland Cement.

2402.04 MEASURING MATERIALS.

(a) **Cement.** Unopened cloth or paper bags of cement packed by the manufacturer will be accepted as weighing 94 pounds. Cement shipped in bulk shall be weighed for each batch, on scales which shall be within one pound of correct at all loads.

(b) **Water.** The water measuring equipment shall be capable of accurate measurement to one quart and shall be so arranged that the accuracy of measurement will not be affected by variations in pressure of the water supply line.

Unless the water is measured by weight, the Contractor shall provide a container in which the entire quantity of water required for one batch of concrete may be weighed.

(c) **Aggregates.** Unless otherwise specified in the proposal form, aggregates shall be proportioned by weight. The weighing equipment used shall be approved by the Engineer and shall meet the following requirements:

- (1) The scales shall be accurate within 2 pounds at all loads.
- (2) At least that part of the load which is a fraction of 100 pounds shall be

indicated on a graduated beam or springless graduated dial. Minimum graduation shall be 2 pounds for graduated beams or dials.

(3) Convenient means shall be provided for removing an overload from the weighing containers.

(4) The scales shall be of simple rugged design, manufactured by an established manufacturer of weighing equipment and recommended by the maker for the kind of service for which they are to be used.

(5) Beam scales which are used for weighing more than one aggregate shall have an independent beam for each material to be weighed.

(6) Two standard 50-pound weights shall be available at all times for checking scales. These weights shall be kept clean and not used for other purposes than checking the accuracy of the scales.

(7) All wheelbarrows or buggies used for weighing aggregate shall be plainly marked "Sand" or "Coarse Aggregate", according to the material which they will be used to convey. They shall also be plainly numbered for identification and shall be provided with permanent means of adjusting the weight to a uniform tare.

2402.05 MIXING. Concrete shall be thoroughly mixed in an approved machine mixer of the batch type. The minimum capacity of the mixer shall be a one-bag batch. For mixing concrete for bridge floors the minimum capacity of the mixing equipment used shall be the equivalent of a 2-bag batch. The concrete shall be mixed continuously for one minute after all the materials have been assembled in the drum. The minimum mixing time shall be indicated by an accurate timing device which shall be automatically started by the mixer and which shall indicate by a clearly audible signal the expiration of the required mixing period. During the time of mixing the drum shall revolve at the speed for which the machine is designed but not less than 12 nor more than 20 revolutions per minute. The mixing drum of mixers of the tilting drum type shall be operated at an angle no steeper than that recommended by the manufacturer of the mixer. The volume of the mixed concrete in each batch shall not exceed the capacity recommended by the Mixer Manufacturers Bureau "Concrete Mixer Standards", as listed below:

Size of Mixer	Capacity of mixed concrete	Minimum total interior drum volume—cubic feet	
		Non-tilting	Tilting
7-S	7	28.6	17.9
10-S	10	40.3	25.5
14-S	14	55.2	35.2

Upon cessation of mixing for any considerable length of time, the mixer shall be thoroughly cleaned and flushed with water. Each batch of concrete shall be completely discharged from the mixer before the materials for the next batch are introduced.

2402.06 RETEMPERING. Retempering of concrete or mortar which has reached its initial set or partially hardened, by remixing with or without additional materials shall not be permitted.

2402.07 PLACING CONCRETE. The concrete shall be placed in the forms immediately after mixing and in such manner as to avoid the separation or segregation of the aggregate. The mixing plant shall be equipped and arranged so as to permit the mixing and placing of the concrete quickly and uniformly. In depositing concrete all of the following precautions shall be observed:

(a) In handling the concrete from the mixer to the place of deposit care shall be taken to avoid any separation of the material.

(b) When concrete is deposited through chutes the angle of the same with the horizontal shall be such as will allow the concrete to flow slowly and without separation of the aggregate. The delivery from the chute shall be as close as possible to

the point of deposit. The free fall of concrete from the end of the chute shall not exceed 5 feet.

(c) Chutes shall be of metal or shall be metal lined. They shall be kept clean and free from material adhering to their sides and shall be thoroughly flushed with water before and after each run.

(d) Depositing large quantities at one point in the forms and running and working it along the forms will not be permitted.

(e) In depositing the concrete care shall be taken to entirely fill the form but to not bulge or distort the forms or disturb their alignment.

(f) Special care shall be taken in filling the forms, to work the coarser aggregate away from the face of the form and to force the concrete under and around the reinforcement. The concrete shall be worked with a spade, pointed steel rod, or other satisfactory implement, in such a manner as to bring a thick layer of mortar in contact with the forms and reinforcement and to prevent the formation of pockets of stone.

2402.08 PROTECTION AND CURING OF CONCRETE. Concrete which has been placed shall be protected against any vibrating, jarring or other movement which might injure it before it has reached its final set. Runways for transporting concrete or other materials over concrete floors less than 7 days old shall be supported directly over structural steel members so that the concrete is subjected to compressive stresses only. Unless the concrete is protected as specified in Paragraph 2402.09, all exposed surfaces shall be kept wet and shall be covered by means of burlap, paper, straw, sand, or other satisfactory covering for a period of 4 days after the concrete has been placed. The burlap and paper used shall conform to the requirements of Paragraphs 4124.08 and 4124.09 respectively except in regard to size of sheets.

2402.09 PLACING IN COLD WEATHER. No concrete shall be placed without the specific permission of the Engineer when the air temperature is at or below 40°F.

If concreting in freezing weather is permitted by the Engineer, care shall be taken to prevent the use of any frozen material. In addition to adequate provision for protecting the concrete against chilling or freezing, the Contractor shall be required to heat the water and aggregate so that when deposited in the forms the concrete will have a temperature of not less than 50°F. nor more than 100°F. The aggregates shall be heated by steam pipes or coils through aggregate piles or by dry heat when the aggregate is agitated mechanically during heating. Aggregates shall be so heated and handled as to avoid injury to the aggregate by overheating and to insure uniform temperature and moisture content of aggregates entering the mixer. The concrete shall be adequately protected so as to maintain its temperature above 50°F., for a minimum of 72 hours after it has been placed. Protection satisfactory to the Engineer shall be provided to keep the temperature of the concrete above 40°F. for a period of 5 days after placing. The method of heating and protection shall be satisfactory to the Engineer, but the work shall be done entirely at the Contractor's risk. At the Contractor's option calcium chloride at the rate of two pounds per bag of cement may be added to the mixture as provided in Paragraph 2303.21. When calcium chloride is used, the time of protection to keep the concrete at a temperature of 40°F. or more may be reduced to four days.

When High Early Strength Portland Cement is used, the period of protection to keep the concrete at a temperature of 40°F. or more may be reduced to three days.

2402.10 PLACING LARGE VOLUMES OF CONCRETE. Each monolithic section shall, whenever practical, be placed in one continuous operation. Whenever the volume is too great to be placed in one continuous operation, the work shall be subdivided as shown on the plans or as directed by the Engineer. In general, the order of construction or sequence of the work will be indicated on the plans.

2402.11 BONDING CONSTRUCTION JOINTS. During the process of placing, the successive layers of concrete shall be left slightly rough in order to insure good bond.

Construction joints produced between layers of concrete placed intermittently shall be properly bonded to prevent displacement by sliding or overturning. Horizontal layers so located as to produce a thin section or "feather edge" shall be so formed by means of an insert form that the succeeding layer will end in a body of concrete having a thickness of not less than six inches. When bond or dowel stones are specified, or required to be used, they shall be hand-placed in the manner specified in Paragraph 2402.15. Metal dowels shall consist of steel rods having a diameter of not less than $\frac{3}{4}$ inch and a length of not less than 18 inches. The dowels shall be staggered and their distance center to center shall not exceed four feet.

2402.12 BONDING NEW AND OLD WORK. When new concrete is to be placed in contact with old concrete or with concrete that has already reached its final set, the surface of the old concrete shall be thoroughly cleaned of all laitance, dirt or other foreign materials, then roughened and thoroughly drenched with water until saturated. Care shall be taken to tighten the forms against the face of the old concrete and to thoroughly compact the fresh concrete when placed so as to insure good bond. The use of dynamite is prohibited except on massive sections, and with the specific written permission of the Engineer. When dynamite is used at least 6 inches of concrete beyond the point of visible damage shall be removed by methods not injurious to the old concrete.

2402.13—DEPOSITING UNDER WATER. In general, concreting under water shall be avoided and it will be permitted only when provided for on the plans or when specifically authorized by the Engineer and under his direct supervision.

The cofferdams shall be sufficiently tight to prevent any current passing through the space in which concrete is being deposited. The water shall be allowed to rise to its full head, and pumping will not be permitted within the cofferdam while concrete is being placed nor until it has attained a satisfactory strength.

All concrete deposited under water shall conform to the requirements of Class A concrete to which shall be added 10 percent of excess cement.

The flow of concrete shall be as nearly continuous as possible. In case the flow is interrupted for more than one hour, the cofferdam shall be pumped out and all laitance and damaged concrete removed before proceeding with the work. The concrete shall be deposited, as nearly as possible, in horizontal layers.

The method used in depositing the concrete shall be such as will not permit the washing of the cement from the concrete. The following approved methods may be used under the direct supervision of the Engineer:

(a) **Tremie.** If a tremie is used it shall consist of a metal tube 8 to 12 inches in diameter, constructed in sections, with flanged couplings, with gaskets and tight bottom valve, and so placed as to permit the initial and all subsequent charging to take place without the concrete being dropped through the water. In operating the tremie it shall be kept filled at all times and the discharge end shall be raised only an amount sufficient to permit the concrete to be discharged. Provision shall be made in supporting the tremie so that it may be readily lowered when necessary to "choke off" or retard the flow.

(b) **Dump Bucket.** A dump bucket may be used if so designed that it may be opened when it rests upon the surface of the concrete that is to receive the charge. In lowering and raising the bucket care shall be taken to prevent any unnecessary movement of the water in the cofferdam.

2402.14 LAITANCE. Care shall be taken to prevent the formation of laitance on the top surface of the concrete and at the ends of wings, girders, etc. All laitance shall be entirely removed by means of brooms, wire brushes, or other suitable method, before the succeeding layer of concrete is placed.

2402.15 RUBBLE OR CYCLOPEAN CONCRETE. Rubble or cyclopean aggregate may be used in unreinforced sections 2 or more feet in thickness. The stones

shall be set in place by hand for $\frac{1}{2}$ the depth of the stone and shall not be less than 4 inches apart in the concrete and not less than 6 inches from the face of any form. No course of stone shall extend within 2 feet of the top surface of piers or the surface upon which the superstructure rests.

2402.16 ADMIXTURES. Approved admixtures may be used for the purpose of improving workability, upon permission of the Engineer. When so permitted, special provisions governing their use shall be provided.

2402.17 FALSEWORK. Falsework for supporting reinforced concrete superstructures shall be built on foundations of sufficient strength to carry the load without appreciable deformation. Ample falsework piling shall be driven to support all falsework which cannot be founded on rock, shale, thick deposits of compact gravel, or the heavier clays in their natural beds. On these materials mudsills or other spread footings may be used and shall be of a size to be determined by the load to be supported and the bearing value of the soil in question. Bearing values of all piles used to support falsework, shall be determined as provided in Paragraph 2501.12 and shall be at least equal to the loads imposed upon them during construction. The adequacy of mudsills as to size and soil bearing, the number and spacing of piles, and the amount of bracing in the falsework framing shall be subject to checking and approval by the Engineer.

Falsework shall be designed to carry the full loads coming upon it, without appreciable deformation. For calculating the strength of falsework and centering the following values shall be used:

- (a) Weight of "green" concrete.....150 lbs. per cu. ft.
- (b) Safe bearing value of firm sand, gravel, very firm clay and other similar confined soils in thick beds..... 2 tons per sq. ft.

Falsework for slab and girder bridges shall be set with an allowance for slight settlements, deformation of members, and closing of joints. In all cases, roadway surfaces, curbs, copings and railings shall be built to accurate grade and alignment. Girders or slabs, the lower surface of which show over one inch sag, may be rejected.

The Contractor's plans for falsework and centering on all concrete slab, girder and arch bridges, when requested by the Engineer, shall be submitted in triplicate to the Commission for checking and approval before being placed. Falsework shall remain in place until the forms supported by it may be removed in accordance with the provisions of Paragraph 2402.19.

2402.18 FORMS. Wood or metal forms shall be constructed with mortar tight joints and of materials sufficient in strength to hold the concrete without bulging between supports. If the forms bulge or sag at any point when the concrete is placed in them, the portion of concrete causing the distortion shall be immediately removed and the forms properly repaired and strengthened before continuing the work.

In designing forms and centering, the concrete shall be treated as a liquid weighing 150 pounds per cubic foot for vertical loads, and 85 pounds per cubic foot for horizontal pressure. The unsupported length of wooden columns and compression members shall not exceed 30 times the diameter or least side.

The material to be used in wood forms for exposed surfaces shall be sized and dressed lumber, free from knot holes, loose knots, cracks, splits or other defects affecting its strength or the accuracy or appearance of the finished concrete surfaces. If metal forms are used all bolt and rivet holes shall be counter-sunk so that a plane smooth surface will be obtained.

Forms shall be so designed and constructed that they may be removed without injury to the concrete. Blocks and bracing shall be removed with the forms and in no case shall any portion of the wood forms be left in the concrete. The forms shall be so constructed that the finished concrete shall be of the form and dimensions shown on the plans and true to line and grade.

Forms shall be filleted at all sharp corners and should be given a bevel in the case

of all projections such as girders, copings, etc., sufficient to insure their easy removal.

Special attention must be paid to ties and bracing, and where forms appear to be insufficiently braced or unsatisfactorily built, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected to his satisfaction.

To insure a first-class surface finish on the concrete, the forms shall be painted with a colorless oil, or some other satisfactory means taken to prevent the concrete from adhering to them. The forms should be thoroughly drenched with water immediately before the concrete is placed in them. Form lumber that is used a second time shall be thoroughly cleaned and shall be free from bulge, splits or warps.

2402.19 REMOVAL OF FORMS. Forms shall be removed as soon after the concrete has set as is practicable and safe, in order to permit the proper surface finish as provided in Paragraph 2402.22. In warm weather, forms may be removed in accordance with the following provisions, but in cool or unfavorable weather the Engineer may require the forms to remain in place for longer periods:

(a) **Forms which may be Removed in Less than 7 Days.** Forms for ornamental work, railings, parapets, and vertical surfaces may be removed whenever the concrete will not be damaged by so doing.

(b) **Forms which must Remain in Place 7 Days.** Forms supporting arches, beams or slabs of concrete with a span 4 feet or less, shall remain in place not less than 7 days. Forms supporting arches, beams or slabs of concrete with a span greater than 4 feet shall remain in place not less than 14 days except that these forms may be removed as soon after 7 days as the concrete has developed the strength required in Paragraph 2402.20.

2402.20 SUBJECTING CONCRETE TO EXTERIOR LOADS. Concrete may not be subjected to loads other than the weight of the concrete itself except as follows:

(a) **Loads Producing Simple Compressive Stress Only.** Concrete may be subjected to simple compressive stress as soon as it has set sufficiently to prevent the surface being marred or the edges being chipped from the effect of such loads.

(b) **Loads Producing Flexural Stresses.** Concrete shall not be subjected to exterior loads producing flexural stresses within 14 days after the concrete is placed, with the following exception. Concrete may be subjected to loads due to back-filling or legal traffic as soon after 7 days as the concrete has developed a modulus of rupture of 450 pounds or more per square inch. The modulus of rupture shall be determined by testing as simple beams loaded at the center, specimens molded from the concrete used in that part of the structure in question and cured under the same conditions as the concrete in the structure.

2402.21 JOINTS. Unless otherwise provided in the detailed plans, the joints in concrete masonry shall be constructed in the following manner:

(a) **Construction Joints.** Construction joints between successive layers of concrete shall be constructed in the manner as provided in Paragraph 2402.11.

The location of important construction joints in the structure will be shown on the plans, but if the volume of concrete is too great to be placed without the use of additional construction joints, they shall be so located and constructed as to impair the strength and appearance of the structure in the least possible manner. Construction joints shall be located perpendicular to the principal lines of stress and at points of minimum shear.

(b) **Expansion Joints.** Expansion joints shall be of the 3 general types as follows:

(1) **Open Joints.** Open joints shall be placed in the locations as shown on the plan and shall be constructed by the insertion and subsequent removal of a wood strip or metal plate. The insertion and removal of the template shall be accom-

plished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the plans.

(2) **Filled Joints.** Filled joints shall be constructed in the same manner as open joints and shall then be filled with a bituminous mastic or filler. When so specified on the plans or directed by the Engineer a Bituminous Premoulded Expansion joint of the required thickness shall be used in lieu of a template and shall remain in place to form the filler for the joint.

(3) **Sliding and Friction Joints.** Sliding joints which are to be provided at the ends of slab, beam, and girder bridges shall be composed of successive layers of 3-ply roofing felt and liquid asphalt. The bearing area, unless otherwise specified on the plans, shall be covered with sheets of roofing felt swabbed with liquid asphalt. When not otherwise specified on the plans the minimum thickness of the joints shall be $\frac{3}{8}$ inch.

2402.22 SURFACE FINISH. The exposed surface of all parts of concrete structures included in these specifications shall be given a surface finish as provided herein:

(a) **Horizontal Surfaces.** Horizontal surfaces not subject to wear, such as bridge seats, tops of backwalls, wing walls, railings and headwalls, shall be covered with an excess of mortar of the same class as that used in the underlying course of concrete and shall then be struck off with a template and thoroughly worked and wood-floated by hand.

(b) **Walls, Girders, Railings, Etc.** Unless otherwise specified, surface finish as described below will be required on all surfaces exposed to view from any point on the roadway as well as the outside and lower surfaces of exterior girders, T-beams, projecting slabs, fascia girders, guard walls and head walls; all surfaces of railings, cantilevers, spandrel walls, columns and sidewalk brackets and all exposed surfaces of abutments, piers and retaining walls. Abutments, piers and retaining walls located in or adjacent to water shall be finished to low water level whether or not they are at present exposed. Such parts of structures when used in viaducts and other dry crossings or when so designed as to not extend to low water shall be finished to one foot below the finished ground line. The forms shall be removed as provided in Paragraph 2402.19. The wires or rods used as bracing shall be cut off flush with the surface of the concrete and driven back at least $\frac{1}{4}$ inch below the surface. Small cavities and depressions shall be filled with mortar of the same class as has been used in the concrete to be treated. The entire surface shall be rubbed with a No. 16 carborundum brick, so that the finished surface shall have a clean, uniform appearance, free from fins, projections, cavities or porous spots. This does not necessarily mean the entire elimination of all marks of the form boards.

(c) **Class 1. Special Finish.** Class 1 special finish will be required when specified on the plans, in the special provisions, or ordered as extra work by the Engineer.

As soon as the pointing has been completed and set so as to permit, the entire surface to be treated shall be thoroughly wetted by means of a brush and clear water and immediately thereafter thoroughly rubbed with a Number 16 carborundum stone to bring the surface to a lather. All form marks and projections shall be removed by use of a carborundum stone. The entire surface shall then be lightly brushed with a coat of sand and cement in the proportion of one part of cement to 2 parts of sand. The sand used shall pass a No. 20 sieve. The final finish shall be obtained by rubbing with a No. 30 carborundum stone until the entire surface is of smooth texture. After the final rubbing the entire surface shall be drenched with water and kept wet for a period of 7 days unless otherwise directed by the Engineer. Handrail spindles or other members which have become disfigured by the drip from the finishing operation shall be thoroughly cleaned by means of a diluted solution of muriatic acid, followed by clean water.

2402.23 MEASUREMENT AND PAYMENT. Payment for structures or parts of

structures composed of concrete shall be based on the contract price per cubic yard of concrete placed in the structure in conformity with the plans or as ordered in writing by the Engineer. From the volume of concrete computed by the Engineer there shall be deducted 0.8 cubic foot for each lineal foot of piling projecting into footing or caps. No deduction from the volume of concrete shall be made for the volume displaced by the steel reinforcement. The contract price per cubic yard of concrete shall be full payment for furnishing all forms, material except steel reinforcement, all mixing, handling, placing and finishing, and all work incidental thereto necessary to complete the concrete work in conformity with the plans and these specifications.

Section 2403. Reinforcement.

2403.01 MATERIALS. All metal used as reinforcement shall conform to the requirements of Section 4112.

2403.02 CLEANING. The reinforcement when placed in the work shall have a clean, fresh surface and shall be free from dirt, scaly rust, mill scale, paint, oil, grease, or other foreign substances. Bars which have been appreciably reduced in section shall be rejected.

2403.03 BENDING. Reinforcement shall be bent cold. It shall be bent accurately to the dimensions and shapes shown on the plans. In bending care shall be taken not to injure the steel, and only proper appliances and competent workmen shall be employed on the work. Bars one inch or more in diameter shall be shop bent.

2403.04 STRAIGHTENING. Reinforcement which may have become bent during shipment or handling shall be properly straightened before being placed in the work. The straightening shall be done without heating.

2403.05 PLACING AND FASTENING. The reinforcement shall be placed in the exact positions shown on the plans and shall be held securely in place during the placing and setting of the concrete. The location and condition of the reinforcement shall be inspected and approved by the Engineer before any concrete is poured.

2403.06 METAL SUPPORTS. Metal chairs meeting the approval of the Engineer shall be used to support all horizontal reinforcement placed in concrete slabs, girders, arches, arch culverts, and concrete floors on steel bridges.

2403.07 SPLICING. Splicing of tensile reinforcement at points of maximum stress shall be avoided. All splices in the reinforcement shall have a minimum lap of 50 times the nominal diameter of the bar.

2403.08 MEASUREMENT AND PAYMENT. The quantity of reinforcement paid for shall be the theoretical weight of the size and length of bars shown on the plans or ordered by the Engineer. The contract price per pound for reinforcement shall be full payment for furnishing and placing reinforcement and such ties and supports as may be required to hold the reinforcement in proper position.

Section 2404. Foundations and Substructures.

2404.01 GENERAL REQUIREMENTS. The provisions of this section do not apply to culverts. The requirements of Sections 2401, 2402, 2403 and 2501 shall apply in addition to the following details:

(a) **Construction.** The footings shall be constructed at the depths shown on the detailed plans and no alteration or change in the footing depth will be permitted unless authorized in writing by the Engineer. Suitable wood or metal forms shall be used to enclose all footing concrete. In general, piling will be used in all foundations unless the footings rest upon solid rock or have been carried to a depth below all possible scour and are resting upon materials having satisfactory bearing values.

(b) **Inspection of Foundation Material.** No concrete or masonry shall be placed in the footings until the depth and character of the foundation material has been approved by the Engineer and permission given to the Contractor to proceed.

2404.02 CLASS OF CONCRETE. All foundations and substructures except filling for steel cylinder piers shall be constructed of Class A concrete unless otherwise specified on the plans.

2404.03 CONSTRUCTION OF COFFERDAMS. In the construction of foundations and substructures, the cofferdams used shall be constructed in a substantial manner capable of satisfactorily resisting the earth or water pressures without appreciable displacement, and the Engineer may require the Contractor to furnish satisfactory evidence that the cofferdam will meet the requirements specified herein. On important bridges or on foundations carried to unusual depths, the Engineer may require the Contractor to secure approved plans from the Commission for the cofferdams before permitting their use on the work. Cofferdams shall be of sufficient height to prevent stream overflow and consequent damage and delay to the work. Where foundation soundings indicate sand or other unstable material at the elevation of the bottom of footings, cofferdam sheeting shall be of such length as will enable it to be driven to a depth that will cut off this unstable material from flowing into the excavation. Cofferdams shall be strongly braced but no bracing shall be placed in such a manner as to be encased in the concrete of the structure. With the approval of the Engineer, small openings may be left in diaphragm walls and other thin sections to provide for cofferdam bracing provided that such openings are so located as not to interfere with the structural integrity of the bridge and in places where they can later be filled satisfactorily. No cofferdam bracing shall be so placed as to bear against the concrete at a date earlier than 4 days for the heavier sections in good weather, and for a longer period on thin sections or in unfavorable weather, at the discretion of the Engineer.

A clear space of at least 18 inches shall be provided on all sides between the footing as shown on the plans, and the cofferdam. In no case shall the cofferdam be used as a form for the concrete footing, but an independent form shall be built for the footing. The sheeting of the cofferdam shall be of such a type and shall be so driven as to prevent as nearly as possible the entrance of water through the walls of the cofferdam. The capacity of the pumps shall be such as will enable the excavation to be kept practically free of water until the concrete is in place.

If material is encountered at footing level, which, because of its porosity allows the entrance of water at a rate impossible of control by pumping, or which, because of its plasticity, cannot be cut off from flowing into the excavation by driving sheeting except to unreasonable depths, the Engineer may require the Contractor to seal the cofferdam with concrete. The Contractor shall place the seal coat below the elevation of the bottom of footings. The seal coat shall consist of Class A concrete as described in Paragraph 2402.02, and shall be placed in the manner prescribed under Paragraph 2402.13.

2404.04 ANCHORAGE. Whenever concrete or masonry foundations or substructures rest upon rock, the footing shall be carried not less than 6 inches into the solid rock to secure anchorage.

2404.05 PLACING CONCRETE. The provisions of Section 2402 shall apply to all concrete placed in foundations and substructures.

In reinforced concrete substructures the reinforcement extending into the footings shall be secured in position and inspected by the Engineer before any concrete is placed.

2404.06 CONSTRUCTION JOINTS. In general, all footings of substructures shall be constructed as a monolith. If construction joints are required, they shall be made as specified in Paragraph 2402.11.

2404.07 ICE BREAKERS. Ice breakers shall be set true to alignment and with correct batter. The anchorage shall be in place before the concrete is placed. The ice breaker shall be considered as a part of the substructure.

2404.08 SURFACE FINISH. All exposed surfaces of concrete structures shall be surface finished in the manner specified in Paragraph 2402.22.

2404.09 PLACING SUPERSTRUCTURE. The superstructure shall not be placed on concrete piers or abutments until the concrete has set not less than 7 days in warm weather, and a greater length of time, as determined by the Engineer, in cool or unfavorable weather. The limitations of this paragraph may be modified in accordance with the provisions of Paragraph 2402.20, but in no case shall the steel be placed on the concrete before the expiration of the curing period specified in Paragraphs 2402.08 or 2402.09.

2404.10 STEEL CYLINDER PIERS.

(a) **Depth.** Steel cylinder piers shall be placed at the elevations or depths as shown on the detailed plans. After placing the steel shell in exact alignment and in a vertical position it may be set to the proper depth by the use of water jets or by excavation from the interior of the steel shell.

(b) **Piling.** The excavation within the steel shell shall be completed to the required depth before the piling are driven. The piling specified shall be driven until the requirements of Paragraph 2501.13 are met. The tops of the piling shall be sawed off at right angles to the axis of the steel cylinder pier. The piling shall project from 5 to 7 feet into the concrete.

(c) **Class of Concrete.** Concrete used as filling for the steel cylinder pier shall be Class B concrete.

(d) **Painting.** Before shipment to the work the entire exterior surface of the steel cylinder shall be given one coat of shop paint. After placing and filling, the exposed surface of the steel cylinder pier shall be given 2 coats of field paint by the Contractor for the substructure. The painting shall be done in accordance with the requirements of Section 2507.

2404.11 MEASUREMENT AND PAYMENT. Foundations and substructures shall be paid for at the contract unit prices for the various items of "Excavation for Structures", "Piling", "Concrete Masonry", "Steel Reinforcement", etc., as specified in the contract. These unit prices shall be full payment for furnishing all materials, equipment, labor and performing all incidental work necessary to complete the structures in conformance with these specifications and the plans, or as ordered by the Engineer.

Seal coats in cofferdams shown on the plans or ordered by the Engineer shall be paid for at the contract unit prices for "excavation for structures" and "Concrete Masonry".

Section 2405. Concrete Slab and Girder Bridges.

2405.01 GENERAL. All concrete slabs and girders shall be constructed as shown on the plans. The requirements of Sections 2401, 2402, 2403, 2404 and 2412 shall apply in addition to the following details.

2405.02 CLASSES OF CONCRETE. In concrete slab and girder bridges Class A concrete, Paragraph 2402.02, shall be used throughout except in handrails. Class C concrete shall be used in all handrails, lamp posts and ornamental parts of the structure above the floors.

2405.03 PLACING CONCRETE. In concrete slab and girder bridges the following detailed requirements shall be additional to those specified in Section 2402.

(a) **Inspection of Falsework and Forms.** The Contractor shall give the Engineer 24 hours notice before placing concrete in the slab or girder in order to permit the Engineer to inspect and accept the falsework and forms as to strength, alignment and general fitness. The falsework and forms shall provide for the full camber and roadway crown specified on the detailed plans.

(b) **Placing Concrete in Slab Superstructure.** The entire span shall be placed in one continuous operation, except as otherwise provided on the plans, and the Contractor will be required to provide adequate equipment to insure the placing of each continuous operation within 10 hours.

(c) **Placing Concrete in Deck Girder Superstructure.** Unless otherwise provided in the plans the concrete shall be placed continuously for the entire length of each girder and brought up level in horizontal layers. The concrete in the floors shall be placed the full thickness in one operation. The floor shall be placed as quickly as possible after the girders are poured and shall be completed at least in the same working day.

2405.04 JOINTS. All joints in concrete slab and girder bridges shall be constructed in the manner provided in Paragraph 2402.21.

2405.05 DRAINAGE. Transverse drainage of the floors of slab and girder bridges shall be provided by means of crown in the roadway surface. Floor drains shall be neatly constructed and placed in the location shown on the plans.

2405.06 PLACING REINFORCEMENT. Care shall be taken to place the reinforcement in the exact positions as shown on the plans. Metal supports as specified in Paragraph 2403.06 shall be used to support all horizontal reinforcement.

2405.07 SURFACE FINISH. All exposed parts of the structure shall be given a surface finish as specified in Paragraph 2402.22. The surface of the concrete floor slab shall be given a float finish as specified in Paragraph 2412.10.

2405.08 MEASUREMENT AND PAYMENT. All concrete slab and girder bridges built in accordance with the detailed plans will be paid for at the contract unit prices for the several items of "Excavation for Structures", "Piling", "Concrete Masonry", "Steel Reinforcement", "Structural Steel", etc., as specified in the contract. These unit prices shall be full payment for furnishing all materials, equipment, labor and the performance of all incidental work necessary to complete the structures in conformance with the plans and these specifications.

No deduction will be made for the volume of concrete displaced by floor drains, expansion joints or metal strips for sealing joints. The cost of all bituminous expansion joint material, metal strips for sealing joints and other small miscellaneous items shall be included in the price per cubic yard for concrete masonry. The weight of structural steel paid for shall include all steel expansion plates, castings of steel or iron, or welded shapes for floor drains; bearing plates, anchor bolts and other steel parts except steel reinforcement for concrete and the metal fastenings therefor.

Section 2406. Concrete Viaducts.

2406.01 GENERAL. On important structures of this type, special provisions covering the special details and methods of construction will be furnished by the Commission. Unless otherwise specified, the provisions of Sections 2401, 2402, 2403, 2404 and 2412 shall apply in addition to the following details.

2406.02 CLASSES OF CONCRETE. All concrete in concrete viaduct superstructures and columns shall be Class A except in handrails and other ornamental parts. Handrails and other ornamental parts of the structure shall be Class C concrete.

2406.03 FORMS FOR COLUMNS. All forms for columns shall be constructed of

2-inch surfaced material, well matched and adequately braced. The forms shall be so constructed that free access to them can be obtained at intervals of not more than 10 feet vertically to permit proper spading and working of the concrete.

2406.04 PLACING CONCRETE. The provisions of Section 2402 shall apply to all concrete placed. Concrete in columns shall be placed continuously from base to top in one operation unless otherwise directed by the Engineer.

2406.05 DRAINAGE. Transverse drainage of the floor of concrete viaducts shall be provided by means of crown in the roadway surface. Drain holes in the floors shall be neatly constructed and in the locations as shown on the plans.

2406.06 SURFACE FINISH. All exposed surfaces of concrete viaducts shall be given a surface finish as specified in Paragraph 2402.22. The surface of concrete floor slabs shall be given a float finish as specified in Paragraph 2412.10.

2406.07 MEASUREMENT AND PAYMENT. All concrete viaducts built in accordance with the detailed plans will be paid for at the contract unit prices for the several items of "Excavation for Structures", "Piling", "Concrete Masonry", "Steel Reinforcement", "Structural Steel", etc., as specified in the contract. These unit prices shall be full payment for furnishing all materials, equipment, labor and the performance of all incidental work necessary to complete the structures in conformance with the plans and these specifications.

No deduction will be made for the volume of concrete displaced by floor drains, expansion joints or metal strips for sealing joints. The cost of all bituminous expansion joint material, metal strips for sealing joints, and other small miscellaneous items shall be included in the price per cubic yard for concrete masonry. The weight of structural steel paid for shall include all steel expansion plates, castings of steel or iron, or welded shapes for floor drains; bearing plates, anchor bolts and other steel parts except steel reinforcement for concrete and the metal fastenings therefor.

Section 2407. Concrete Arches.

2407.01 GENERAL. Construction of arches of the following types is contemplated in this specification:

1. Open spandrel arches.
2. Spandrel filled arches with low rise and low fills.
3. Spandrel filled arches with high rise and high fills.

On important structures special provisions will be issued by the Commission to cover special details and methods of construction not shown on the detailed plans. The requirements of Sections 2401, 2402, 2403, and 2404 shall apply in addition to the following details.

2407.02 CLASSES OF CONCRETE. The following classes of concrete shall be used in concrete arches:

- | | |
|--|---------|
| (a) Footings of piers and abutments (except where "Class B" is shown on plans) | Class A |
| (b) All parts of the structure above footings | Class A |
| (c) Handrails, lamp posts and ornamental parts | Class C |

2407.03 FOOTINGS.

(a) **Construction.** The footings of concrete arch bridges shall be constructed to the elevations shown on the plans, and no deviation in this requirement will be permitted unless approved by the Engineer. In general the footings of concrete arches will be carried down to solid rock foundations, but if a solid rock foundation is not secured at reasonable depths below stream bed, the Engineer will order piling to be driven. Footings resting on solid rock shall be anchored by carrying the footing a

minimum of 6 inches into the solid rock. All loose boulders and fragments of rock shall be removed and all open seams in the rock filled with concrete before the footing is placed.

(b) **Inspection of Foundation Material.** No concrete shall be placed in the footings until after the Engineer has inspected and approved the foundation.

2407.04 CENTERING. On all arches except arch culverts centering plans shall be prepared by the Contractor, and the approval of the Commission secured before starting their construction. Provision shall be made in the centering for gradually lowering the centering away from the arch ring at the time it is struck. On important arches the Contractor may be required to so construct his centering that jacks of approved design may be employed to correct any slight settlement which may occur during the period that concrete is being placed.

On spandrel filled arches with low rise and low fills and on open spandrel arches the centering shall be removed and the arch swung before concrete for the handrails, spandrels, copings and posts is poured. On spandrel filled arches with high rise and high fills the spandrel walls may be poured before the centering is removed.

No centering shall be removed from beneath the arch rings or ribs for at least 14 days in warm weather after the concrete is poured, and a longer period may be required at the discretion of the Engineer in cold or unfavorable weather. The time limitation of this paragraph may be modified in accordance with the provisions of Paragraph 2402.20.

2407.05 PLACING CONCRETE. The provisions of Section 2402 shall apply to all concrete placed in arches, in addition to the following requirements. The arch ring above the skew back shall preferably be poured as a monolith, but in case the volume is so large as to render this impossible in a single daylight run, it may be divided.

The division into appropriate sections will ordinarily be indicated on the plans. The arch ribs of open spandrel arches may be divided into radial segments or the barrels of spandrel filled arches may be divided into longitudinal rings. In either case the arrangement of sections shall be approved by the Engineer before final adoption.

The outer surfaces of arch rings or ribs shall be formed to a point where the slope of the surface will permit the concrete to stand without slumping. This slope will generally be less than 30° with the horizontal.

Under any scheme of pouring the arch ring, whether monolithic or in sections, the operation of placing concrete shall be so conducted as to load the centering symmetrically, and any section once begun shall be completed before pouring operations cease.

Should break-downs cause unavoidable delays, the concrete already in place shall be finished up to intermediate headers, placed either radially or longitudinally with the arch.

Any wing wall, spandrel wall or section of same, or spandrel column, unless otherwise permitted by the plans, shall be poured as a monolith.

For spandrel filled arches with low rise and low fills and for open spandrel arches, concrete in spandrel walls, coping and handrails shall not be placed until centering is struck as provided in Paragraph 2407.04. On spandrel filled arches with high rise and high fills all concrete may be poured before centering is struck.

2407.06 JOINTS. Joints shall be constructed in the locations shown on the plans and in the manner specified in Paragraph 2402.21. Special expansion joints such as mortise and slip joints shall be constructed as shown on the plans.

2407.07 DRAINAGE. The drains over the arch rings shall be furnished and installed by the Contractor without additional compensation. They shall be of the size shown on the plans and care shall be taken in their installation to secure even bedding and correct alignment.

2407.08 WATERPROOFING. The entire extrados of all spandrel filled arches and the lower 6 inches of the spandrel wall shall be covered with a membrane waterproofing as specified in Section 2509.

2407.09 SURFACE FINISH. All exposed surfaces of arch ribs, columns, hand-rail, copings and wings shall be given a surface finish conforming to the requirements of paragraph 2402.22. Concrete in the extrados and the surfaces of spandrel filled arches shall be finished smooth with wood floats.

2407.10 FILLING. The bridge contractor shall backfill the arch abutments with materials excavated, but will place no additional filling material unless specifically provided for in the contract. All filling materials shall be placed under the direction of the Engineer.

All filling material over arch rings shall be placed to load the arch ring symmetrically. The manner of placing the filling material shall load the various portions of the arch ring in the approximate proportion in which they will be loaded by the completed fill. Layers in which filling material is placed shall not be greater than one foot. Care shall be taken to prevent the formation of wedge-shaped sections of loose earth or other material against the spandrel walls, wingwalls or abutments.

2407.11 MEASUREMENT AND PAYMENT. All concrete arches built in accordance with the detailed plans will be paid for at the contract unit prices for the several items of "Excavation for Structures", "Piling", "Concrete Masonry", "Steel Reinforcement", "Structural Steel", etc., as specified in the contract. These unit prices shall be full payment for furnishing all materials, equipment, labor and the performance of all incidental work necessary to complete the structures in conformance with the plans and these specifications.

No deduction will be made for the volume of concrete displaced by floor drains, expansion joints or metal strips for sealing joints. The cost of all bituminous expansion joint material, metal strips for sealing joints and other small miscellaneous items shall be included in the price per cubic yard for concrete masonry. The weight of structural steel paid for shall include all steel expansion plates, castings of steel or iron, or welded shapes for floor drains; bearing plates, anchor bolts and other steel parts except steel reinforcement for concrete and the metal fastenings therefor.

Section 2408. Steel Structures.

2408.01 MATERIALS.

(a) **Rolled Shapes, Rivets and Eyebars.** Rolled structural steel shapes, rivets and eyebars shall conform to the requirements of Section 4113.

(b) **Forgings.** Forgings shall conform to the requirements of Paragraph 4114.01.

(c) **Castings.** Castings of steel and iron shall conform to the requirements of Paragraphs 4114.02 and 4114.03.

(d) **Bronze Metal.** Rolled or cast bronze metal conforming to the requirements of Paragraph 4124.05 shall be used for expansion bearings.

2408.02 STORAGE OF MATERIAL. Material shall at all times, be protected from injurious weather conditions producing rust or mechanical injury and shall be kept free from accumulations of dirt, oil, grease or other foreign matter.

2408.03 STRAIGHTENING MATERIAL. All deformed structural material shall be properly straightened by methods which are non-injurious, prior to being laid off, punched or otherwise worked in the shop. Sharp bends or kinks in the material will be cause for rejections.

2408.04 WORKMANSHIP AND FINISH. The workmanship and finish shall be first-class and equal to the best practice in modern bridge shops. Shearing and chip-

ping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished. If a cutting torch is used, all burnt metal burrs shall be removed by chipping. When edges of torch cuts are exposed to view they shall be ground smooth.

2408.05 CHANGES AND SUBSTITUTIONS. No changes shall be made in any drawing after it has been approved, except by direction or written consent of the Commission.

Sections having different dimensions than those shown on the plans shall not be used except with the written approval of the Commission.

2408.06 MAXIMUM THICKNESS OF PUNCHED METAL. The maximum thickness of punched metal shall be as follows:

(a) Holes in material $\frac{3}{4}$ inch or less in thickness may be punched full size unless otherwise shown on the plans.

(b) Holes in material more than $\frac{3}{4}$ inch thick shall be sub-punched and reamed, or drilled from the solid.

2408.07 RIVET HOLES.

(a) **Punched Holes.** Full size punched holes shall be $\frac{1}{16}$ inch larger than the nominal diameter of the rivet. The diameter of the die shall not exceed the diameter of the punch by more than $\frac{3}{32}$ inch. Holes must be clean-cut without torn or ragged edges. If any holes must be enlarged to admit the rivets they shall be reamed.

The punching of the holes shall be so accurately done that after assembling the component parts of a member a cylindrical pin $\frac{1}{8}$ inch smaller than the nominal diameter of the punched hole may be passed through at least 75 per cent of the holes without reaming. If this requirement is not fulfilled the badly punched pieces shall be rejected. If any hole will not pass a pin $\frac{3}{16}$ inch smaller than the nominal diameter of the punched hole, this shall be cause for rejection.

(b) **Sub-punched and Reamed Holes.** Sub-punched and reamed holes for rivets having diameters greater than $\frac{3}{4}$ inch shall be punched $\frac{3}{16}$ inch smaller than the nominal diameter of the rivet, and for rivets having diameters $\frac{3}{4}$ inch or less the holes shall be punched $\frac{1}{16}$ inch less than the nominal diameter of the rivet. The punch and die shall have the same relative sizes as specified for full-sized punched holes. After punching, the holes shall be reamed to a diameter $\frac{1}{16}$ inch larger than the nominal diameter of the rivets. Burrs produced by reaming shall be removed with a tool producing a $\frac{1}{16}$ inch fillet around the edge of the hole.

Reaming of rivet holes shall be done with twist drills or with short taper reamers. Reamers preferably shall not be directed by hand. No lubricant injurious to painting shall be used.

The holes shall be cylindrical and perpendicular to the member, and their accuracy shall be the same as specified for punched holes except that after reaming or drilling, 85 per cent of contiguous holes in the same surface shall not show an offset greater than $\frac{1}{32}$ inch between adjacent thicknesses of metal.

(c) **Drilled Holes.** Drilled holes shall be $\frac{1}{16}$ inch larger than the nominal diameter of the rivet. Burrs on the outside surfaces shall be removed with a tool producing a $\frac{1}{16}$ inch fillet around the edge of the hole.

The accuracy of drilled holes shall be the same as that specified for sub-punched and reamed holes, Paragraph 2408.07 (b).

2408.08 DRIFTING OF RIVET HOLES. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.

2408.09 PUNCHED vs. PUNCHED AND REAMED WORK. All rivet holes shall be punched full size unless otherwise provided upon the plans or in the requirements governing the fabrication of material.

When sub-punched and reamed rivet holes are required, the main members of the completed structure shall be fully assembled and firmly bolted together and their members adjusted to line and fit before the holes in the connecting joints are reamed. Before disassembling for shipping and handling, the respective pieces shall be match-marked so that they may be reassembled in the same position when field erected in the structure.

No interchanging of reamed parts will be permitted. The connecting joints such as floor beam and stringer connections not so assembled shall be reamed to a metal template.

2408.10 USE OF ACETYLENE TORCH. The use of an acetylene torch will not be permitted in burning holes for rivets in shop or field use or for cutting out rivets. (See Paragraph 2408.04).

2408.11 SHOP ASSEMBLY. The surfaces which will be in contact when assembled shall be carefully cleaned and free from dirt, loose mill scale or other foreign matter. Contact surfaces need not be painted. Surfaces which are not in contact but which will be inaccessible after erection shall be painted two coats in the shop. Surfaces where bond is desired with the concrete as shown on the plans shall not be painted. Machined surfaces, with small clearances, such as pins and pin holes, shall be coated with white lead and tallow applied hot as soon as the surfaces have been finished and accepted.

The component parts of a built member shall be assembled, drift-pinned to prevent lateral movement, and firmly bolted to draw the parts into close contact before reaming, drilling or riveting is begun. Assembled parts shall be dis-assembled, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends or other deformations.

Preparatory to shop riveting full sized punched material, the rivet holes shall be spear-reamed to insure free admission of the rivets. This shall not preclude the accuracy specified in Paragraph 2408.07.

End connection angles, stiffener angles, etc., shall be carefully adjusted to correct locations and rigidly bolted, clamped or otherwise firmly held in place until riveted.

2408.12 SHOP ERECTION. Unless otherwise provided, each individual truss shall be completely assembled for inspection in the shop. After camber, accuracy of punched holes and milled joints have been inspected and accepted, all full-sized punched field holes shall be spear reamed. Before disassembling all members are to be conspicuously match-marked on patch painted surfaces and the Engineer furnished with diagrams showing such marks if not already shown on the shop drawings.

2408.13 RIVETS.

(a) **Diameter.** The diameter of rivets indicated upon the plans shall be understood to mean their diameter before heating.

(b) **Heads.** Heads of driven rivets shall be of approved shape, concentric with the shanks, true to size, full, neatly formed, free from fins and in full contact with the surface of the member.

(c) **Countersinking.** Countersinking shall be neatly done and countersunk rivets shall completely fill the holes.

2408.14 FIELD RIVETS. Field rivets shall be furnished in excess of the nominal number required to the amount of 10 per cent plus 10 rivets for each size and length. They shall be carefully selected and shall be free from furnace scale on their shanks and from fins on the underside of the machine-formed head.

2408.15 BOLTS AND BOLTED CONNECTIONS. Bolted connections shall not be used unless shown on the plans. Where bolted connections are permitted, the bolts furnished shall be unfinished bolts (ordinary rough or machine bolts) or turned bolts

if provided in the plans or special provisions. Special rivet bolts may be substituted for turned bolts on approval of the Engineer.

(a) **Unfinished Bolts.** Unfinished bolts shall be standard bolts with hexagonal heads and nuts. The diameter of the bolt holes shall be 1/16 inch greater than the diameter of the bolts used. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal. The bolts shall be of such length that they will extend entirely through their nuts but not more than 1/4 inch beyond them. The number of bolts furnished shall be 5 per cent more than the actual number shown on the plans for each size and length.

(b) **Turned Bolts.** Holes for turned bolts shall be carefully reamed and the bolts turned to a driving fit with the threads entirely outside of the holes. The heads and nuts shall be hexagonal. One-fourth inch nut locks shall be used on all turned bolts unless otherwise specified on the plans. Turned bolts shall be finished by a finishing cut.

2408.16 RIVETING. Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. When ready for driving they shall be free from slag, scale, and other adhering matter and when driven they shall completely fill the holes. Burned, burred or otherwise defective rivets, or rivets which throw off sparks when taken from the furnace or forge shall not be driven.

Loose, burned, badly formed or otherwise defective rivets shall be cut out. Caulking and recupping of rivet holes will not be allowed. In cutting out defective rivets care shall be taken not to injure the adjacent metal and if necessary the rivet shanks shall be removed by drilling.

Shop rivets shall be driven by direct-acting riveters where practicable. The riveting machine shall retain the pressure for a short time after the upsetting is completed.

Pneumatic hammers shall be used for all field riveting.

2408.17 EDGE PLANING. Sheared edges of material more than 5/8 inch in thickness shall when shown on the plans or required by the Engineer, be planed to a depth of 1/8 inch. Re-entrant cuts shall be filleted before cutting.

2408.18 PLANING OF BEARING SURFACES. Ends of columns and pedestals shall be milled to true surfaces and correct bevels, and base and cap plates shall, if warped or deformed, be planed to fit accurately. Connection angles for base and cap plates shall be riveted to columns before the ends are faced. Milling shall in all cases be done after the member has been fully riveted.

After being riveted to the columns, cap plates and base plates not in contact with masonry, if containing warps or other deformations, shall have their outer surfaces planed. Surfaces of base plates in contact with masonry shall be rough finished if they are not free from warps and other deformations.

Sole plates of girders or trusses shall have full contact with the flange angles and shall be planed on their lower surfaces. Masonry plates shall be planed on the top surfaces, and bottom surfaces shall be free from warps and projections. Cast pedestals or plates shall be planed on the top surfaces, and on the bottom surfaces if in contact with metal. In planing expansion bearings the cut of the tool shall be in the direction of the expansion. The bottom surfaces of cast pedestals or plates which rest upon concrete shall be planed unless the surfaces are true and free from warps and projections.

Surfaces of cast bronze bearing plates intended for sliding contact shall be carefully milled and finished.

2408.19 ABUTTING JOINTS.

(a) **Ends of Compression Members.** Abutting ends of compression members shall, after being riveted, be accurately faced to secure an even bearing when assembled in the structure.

(b) **Ends of Tension Members.** Ends of tension members at splices shall be neatly sheared to secure close but not contact fitting joints.

2408.20 END CONNECTION ANGLES. End connection angles of floor beams and stringers shall be flush with each other and accurately set as to position and length of member. In general, end connection angles shall not be finished unless so indicated on the plans. However, faulty assembling and riveting may be cause for requiring them to be milled, in which case their thickness shall be reduced not to exceed 1/16 inch, nor their rivet bearing value reduced below the design requirements.

2408.21 FINISHED MEMBERS. The several pieces forming one built member shall be straight and close fitting. Finished members shall be true to detailed dimensions and free from twists, bends, open joints, or other defects resulting from faulty fabrication and workmanship.

2408.22 LACING BARS. The ends of lacing bars shall be neatly rounded unless otherwise specified on the plans.

2408.23 PLATE GIRDERS.

(a) **Web Plates.** Web plates of girders having no cover plates shall be detailed with the top edge of the web flush with the back of the flange angles. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be 1/2 inch less in width than the distance back to back of flange angles.

When web plates are spliced not more than 3/8 inch clearance between the ends of plates will be allowed.

(b) **Web Stiffeners.** End stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure a uniform even bearing against flange angles. Intermediate stiffener angles shall fit sufficiently tight to exclude water after being painted.

(c) **Web Splices and Fillers.** Web splice plates and fillers under stiffeners shall fit within 1/8 inch at each end.

2408.24 EYE-BARS.

(a) **Form of Bars.** Eye-bars shall be straight and true to size and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welds in the body or head will not be permitted. The form of the heads may be determined by the dies in use at the works where the eye-bars are to be made, if satisfactory to the Commission, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not overrun more than 1/16 inch. Piled head eye-bars will not be allowed.

(b) **Boring.** Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin-holes shall be located on the center line of the bar and in the center of the heads. Bars shall have both ends bored at the same time and shall be bored so accurately that when bars of the same length are placed together, pins 1/32 inch smaller in diameter than the pin-holes can be passed through the holes at both ends at the same time without driving.

2408.25 ANNEALING.

(a) **Eye-Bars.** All eye-bars shall be annealed by heating uniformly to the proper temperature followed by slow and uniform cooling in the furnace. The temperature of the bars shall be under full control at all stages.

(b) **Other Steel Parts.** Forged pins and other steel parts requiring their full strength, which have been partially heated shall be subsequently annealed. Slight

bends in pieces of secondary importance may be made without heating the metal. Crimped web stiffeners need not be annealed.

2408.26 PINS AND ROLLERS. Pins and rollers shall be accurately turned to detailed dimensions and shall be smooth, straight and free from flaws. The final surface shall be produced by a finishing cut.

(a) **Forged Pins.** Pins six inches in diameter and over shall be forged and annealed.

(b) **Bored Pins.** Pins larger than eight inches in diameter shall have a hole not less than two inches in diameter bored longitudinally through their centers before the pins are annealed. Pins showing defective interior conditions shall be rejected.

2408.27 BORING PIN HOLES. Pin holes shall be bored true to detailed dimensions, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. A finishing cut shall always be made.

The length outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from detailed dimensions more than 1/16 inch. Boring of holes in built up members shall be done after the riveting is completed.

2408.28 PIN CLEARANCE. The difference in diameter between the pin and the pin-hole shall be 1/32 inch.

2408.29 WELDS. Welding of steel shall not be permitted unless shown on the plans or with specific written approval of the Engineer.

2408.30 SCREW THREADS. Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for diameters greater than 1½ inches they shall be made with 6 threads to the inch.

2408.31 PILOT AND DRIVING NUTS. On pin connected spans, pilot and driving nuts shall be furnished for each size pin unless provided on the plans.

For riveted spans where shoes are pinned to bottom chord sections or bolster, no pilot or driving nuts need be furnished.

2408.32 MILL AND SHOP INSPECTION. The Contractor shall give the Engineer ample notice of the beginning of work at the mill and shop so that inspection may be provided. In the event that inspection of the rolling is waived, the Engineer shall be furnished with complete test reports of mill inspection, showing chemical analysis and physical tests for each melt as required in Section 4113.

No material shall be fabricated before the Engineer has been notified where the orders have been placed.

(a) **Inspector's Authority.** The Inspector shall have the power to reject materials or workmanship which does not fulfill the requirements of these specifications; but in cases of dispute the Contractor may appeal to the Engineer, whose decision shall be final.

Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility in regard to imperfect material or workmanship and the necessity for replacing the same.

(b) **Facilities for Inspection.** The Contractor shall furnish all facilities for inspection of material and workmanship in the mill and shop, and Inspectors shall be allowed free access to the necessary parts of the premises.

(c) **Mill Orders and Shipping Statements.** The Contractor shall furnish the Engineer with as many copies of mill orders and shipping statements as may be requested. The weights of the individual members shall be shown.

(d) **Rejection.** The acceptance of any material or finished members by the In-

spector shall not be a bar to their subsequent rejection if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

2408.33 MARKING AND SHIPPING. Members weighing more than 3 tons shall have the weight marked thereon. Bolts and rivets of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of the shipping container.

The weight of all tools and erection material shall be kept separate. Anchor bolts, washers and other anchorage or grillage materials shall be shipped in advance of the masonry construction if so required.

2408.34 FIELD INSPECTION. All work of erection shall be subject to the inspection of the Engineer who shall be given all facilities required for a thorough inspection of workmanship.

Material and workmanship not previously inspected may be inspected upon its delivery to the site of the work.

2408.35 HANDLING AND STORAGE. The loading, transportation, unloading and piling of structural members shall be so conducted that the metal will be kept clean and free from injury by rough handling.

All material shall be stored in such manner as to prevent deterioration by rust or loss of minor parts. No material shall be piled so as to rest upon the ground or in water but must be placed on suitable skids or platforms. Girders and beams shall be placed upright and shored. The skids beneath long members such as columns or chords shall be close enough together to prevent injuring the members by deflection.

2408.36 ERECTION.

(a) **Falsework.** Unless otherwise provided, detailed plans for falsework or centering shall be supplied to the Engineer upon request, but, in no case shall the Contractor be relieved of responsibility for results obtained by the use of these plans. The adequacy of falsework for the purpose in view shall be subject to checking and approval by the Engineer before erection of the structure which the falsework is to carry. Falsework for supporting steel during erection shall be designed to carry without appreciable settlement or deformation the full load coming upon it. It may consist either of full length pile bents or framed bents supported by piles or spread footings. The bearing values of the piles shall be determined as provided in Paragraph 2501.12 and shall be at least equal to the loads imposed upon them during construction. The number and size of spread footings or mudsills used shall be determined by the load to be supported and the bearing value of the soil on which they rest, due consideration being given to the softening of soils during high water, thawing of frozen ground, etc. Mud-sills shall not be used on soils or in situations where scour is likely to occur.

The safe bearing value of sand, gravel, firm clay and other similar confined materials in thick beds shall be considered 2 tons per square foot.

If necessary to extend false work above the elevation to which piles are driven, all piles in any bent shall be cut off at the same elevation and capped, and a framed bent constructed to the required height. Each false work bent shall be capped transversely at the proper elevation with timber of adequate size securely bolted or drifted to each pile or post in the bent. All bents shall be securely braced longitudinally and transversely with diagonal bracing.

(b) **Preparation of Bearing Area.** Column bases, truss and girder pedestals and shoes shall have a full uniform bearing upon the substructure masonry. Masonry bearing plates shall not be placed upon the bridge seat areas of piers or abutments which are improperly finished, deformed or irregular.

On truss and girder spans and columns for steel viaducts the pedestals and shoes shall be placed upon a layer of canvas and red lead applied as follows:

Thoroughly paint the top surface of the bridge seat bearing and place upon it 3 layers of 12 to 14-ounce duck swabbed freely with red lead paint between each layer. Place the superstructure shoe or pedestal in position while the paint is plastic.

(c) **Handling Members.** The field assembling of the component parts of a structure shall involve the use of methods and appliances not likely to produce injury by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until its defects are corrected, and members seriously damaged in handling shall be rejected.

(d) **Alignment.** Before beginning the field riveting the structure shall be adjusted to correct grade and alignment and the elevations of panel points (end of floor beams) properly regulated.

(e) **Straightening Bent Material.** The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture. The metal shall not be heated unless permitted by the Engineer, in which case the metal shall not be heated to a higher temperature than that producing a dark cherry red color and it shall be cooled as slowly as possible.

Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

(f) **Assembling and Riveting.** All field connections and splices shall be securely drift-pinned and bolted before riveting. Important connections in trusses, girders, floor systems, etc., shall have at least 25% of the holes filled with drift pins and 25% of the holes filled with bolts drawn up snugly. On milled compression chord connections of truss spans, except the hip connection, the number of drift pins may be reduced to not less than 10% of the number of holes. The number of drift pins used shall be sufficient to prevent slipping at joints and splices.

The results obtained in the field assembling and riveting of the members of a structure shall fulfill the requirements of shop assembling and riveting. All field driven rivets shall be inspected and accepted before being painted. Field riveting shall be done before the falsework is removed, unless special permission to the contrary is given by the Engineer.

(g) **Adjustment of Pin Nuts.** All nuts or pins shall be thoroughly tightened and the pins so located in the holes that the members shall take full and even bearing upon them.

(h) **Setting Anchor Bolts.** Anchor bolt holes shall be drilled in correct locations vertically to the plane of the bridge seat, and the anchor bolts set in cement mortar. The mortar shall consist of one part of Portland cement and one part of clean, fine-grained sand, mixed sufficiently wet to flow freely.

Anchor bolts shall first be dropped into the dry holes to assure their proper fit after setting. They shall then be set as follows:

Fill the hole about $\frac{2}{3}$ full of mortar and by a uniform, even pressure or by light blows with a hammer (flogging and ramming will not be permitted), force the bolt down until the mortar rises to the top of the hole and the anchor bolt nut rests firmly against the metal shoe or pedestal. Remove all excess mortar which may have flushed out of the hole, to permit proper field painting of the metal surfaces.

The location of the anchor bolts in relation to the slotted holes in expansion shoes shall be varied with the prevailing temperature. The nuts on anchor bolts at the expansion ends of spans shall permit the temperature movement of the span.

Anchor bolts which are to be set in the masonry prior to the erection of the superstructure shall be carefully set to proper location and elevation with templates or

other suitable means. Such anchor bolts shall be furnished by the Contractor for the superstructure and set by the Contractor for substructure.

(i) **Setting Rocker Bearings.** Rocker bearings at expansion end of spans shall be adjusted to provide for movement due to temperature, elongation of bottom chord and probable substructure movement.

2408.37 MEASUREMENT AND PAYMENT. All steel structures will be paid for at the contract price per pound for "Plain Structural Steel" and for "Fabricated Structural Steel" as specified in the contract. The contract unit price shall be full payment for furnishing all materials, preparation, including fabrication, transportation and erection of the steel in the structure together with furnishing all labor, equipment and incidentals necessary to complete the structure including painting of the completed structure in accordance with the plans and these specifications. The class of steel involved will be specified on the proposal.

(a) **Plain Structural Steel.** The weight of plain structural steel shall include the net weights of all rolled shapes such as beams, diaphragms, bracing, castings for anchorage or bearing plates, expansion devices, bolts, rivets, metal railings, etc., incorporated in I-Beam spans or structures requiring lesser amounts of fabrication except steel reinforcement in concrete.

(b) **Fabricated Structural Steel.** The weight of fabricated structural steel shall include the net weights of all rolled shapes composing fabricated members, casting for anchorage, or bearing plates, expansion devices, bolts, rivets, metal railings, etc. incorporated in trusses, arches, girders, and viaducts except steel reinforcement in concrete.

(c) **Weight Paid For.** The weights of plain structural steel or fabricated structural steel which will be paid for will be the weight estimated by the Engineer as shown on the plans and proposals.

(d) **Variation in Weight.** If the weight of any member is more than 2½ per cent less than the computed weight, it may be rejected.

(e) **Computed Weight.** The Engineer's estimate of weight of structural steel will be made on the following basis:

The weight of steel shall be assumed at 490 pounds per cubic foot.

The weight of cast iron shall be assumed at 450 pounds per cubic foot.

The weights of rolled shapes and of plates up to and including 36 inches in width shall be computed on the basis of their nominal weights and dimensions as shown on the approved shop drawings, deducting for copes and cuts.

The weights of plates wider than 36 inches shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts. To this shall be added ½ of the allowed percentage of overrun in weight given in the A. S. T. M. "Standard Specifications for Structural Steel for Bridges", Designation A7-29.

The weights of heads of shop driven rivets shall be included in the computed weight, assuming the weights to be as follows:

Diameter of Rivet	Weight for 100 Heads
½ inch	4.0 pounds
5/8 inch	7.5 pounds
¾ inch	12.5 pounds
7/8 inch	18.5 pounds
1 inch	27.0 pounds

The weight of castings shall be computed from the dimensions shown on the approved shop drawings with an addition of 5 per cent for fillets and overrun.

To the total computed weight of metal may be added an allowance of 0.4 per cent for shop paint.

(f) **Changes in Plans.** Should changes in the plans subsequent to award of contracts require material with increase or decrease in the published mill price, "Net Extra for Size", the contract unit prices for plain structural steel or fabricated structural steel will be adjusted in accordance with such increase or decrease.

Section 2409. Timber Structures.

2409.01 GENERAL. These specifications shall apply to the construction of structures composed wholly of timber or timber combined with structural steel or concrete. The requirements of Sections 2401, 2402, 2403, 2408, 2501, 2507 and 2508 shall apply to the various phases of construction. All structures shall be built to conform to the detailed plans.

2409.02 MATERIALS. All materials used in timber bridges shall conform to the requirements of Part IV for the respective material as follows:

(a) **Timber and Lumber.**

- | | |
|---|--------------|
| 1. Untreated Structural Parts S4S Class A | Section 4120 |
| 2. Untreated Non-structural Parts S4S Class C | Section 4120 |
| 3. Treated Timber | Section 4119 |
| 4. Piling | Section 4122 |

(b) **Steel.**

- | | |
|--|--------------|
| 1. Steel Rods for Tension Members and all Plates and Structural Shapes | Section 4113 |
| 2. Steel Reinforcement for Concrete | Section 4112 |

(c) **Paint** Section 4115

(d) **Creosote** Paragraph 4116.02

(e) **Hardware.** All hardware shall be of standard quality. All bolts, rods, lag-screws, washers and nuts (except female threads) used through or in contact with wood in treated structures shall be coated with not less than 1.0 oz. spelter per square foot by the Hot Dip Process. Unless otherwise shown on plans all bolts through wood shall be square head and square nut machine bolts with washers under all heads or nuts which would otherwise be in contact with wood. At the option of the Contractor, the washers may be either cast or malleable iron but their diameter shall be at least 3½ times the diameter of the bolt with which they are used.

Nails shall be round or oval steel wire nails of standard quality. Machine bolts, drift bolts and dowels may be either wrought iron or Structural Grade Steel.

(f) **Asphalt Mastic.** The asphalt mastic shall be composed of mineral matter, asphalt either in form of emulsion or cut-back with slightly volatile solvent, with or without asbestos fibrous matter. The mastic shall be of such consistency that at normal air temperature, without heat, it can be applied with a trowel and will not run or sag at a temperature of 140°F. It shall retain its adhesive and plastic character with prolonged exposure to weather.

2409.03 STORAGE OF MATERIALS. Lumber and timber when delivered to the site of the work shall be stored in neat piles. The ground underneath and in the vicinity of material piles shall be cleared of weeds and rubbish. Untreated lumber shall be open stacked on suitable skids at least twelve inches above ground and above possible high water. The piles of lumber shall be arranged to shed water and prevent warping, and when stored over a long period, shall be further protected by suitable covering.

Treated timber and treated piling shall be close stacked and piled. When stored for long periods, the tops of stacks shall be covered to protect the material from the direct rays of the sun.

Miscellaneous material and hardware shall be stored in a manner which will prevent loss or damage to the same.

2409.04 HOLES FOR BOLTS, DOWELS, RODS AND LAGSCREWS. Holes for drift bolts and dowels shall be bored 1/16 inch smaller than the nominal diameter of the bolt or dowel used. Holes shall be bored to the proper depth so that they are fully occupied when the dowels are in place. Holes for rods and bolts other than drifts and dowels shall be bored to the same size as the nominal diameter of the bolt or rod used. Holes for lagscrews shall be bored with a bit not larger than the body of the screw at the base of the thread.

Where the heads of bolts or lagscrews would interfere with traffic or with other structural parts, they shall be countersunk.

2409.05 TREATMENT OF CREOSOTED PILE HEADS. After cutting to receive the cap all creosoted pile heads shall be given two heavy brush coats of hot creosote oil and all freshly exposed surfaces shall be coated with a thin layer of asphalt mastic. For uncapped piles and piles with wood caps, the cutoff shall be covered with a sheet of copper or zinc weighing not less than 16 ounces per square foot. This metal covering shall be neatly fitted and bent down the sides of the pile 6 to 8 inches. The edges shall be neatly trimmed to a horizontal line and firmly fastened to the pile with galvanized roofing nails.

For steel channel caps the entire freshly cut surface shall be coated with a layer of asphalt mastic and after the cap is in place, all joints between the cap and the pile head shall be troweled full of mastic.

2409.06 TREATMENT OF UNTREATED TIMBER. When specified on the plans or Special Provisions the following surfaces of untreated timbers and lumber shall be given two hot brush coats of creosote oil: ends, tops and all contact surfaces of sills, caps, floor beams and stringers; all ends, joints and contact surfaces of posts, bracing, and truss members; and all piling tops after cut-off. The back faces of bulk head plank and all other timber which is in contact with earth, metal or other timber shall be similarly treated.

2409.07 WORKMANSHIP. All workmanship shall be first class throughout. Competent bridge carpenters shall be employed and all framing shall be true and exact. Nails and spikes shall be driven with just sufficient force to set the heads flush with the wood surface. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship.

Treated timbers shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the treated surface with tools such as cant-hooks, peaveys, timber tongs or pike poles. All cutting, framing and boring of treated timbers shall be done before treatment whenever practicable. Whenever boring or framing must be performed after creosote treatment the exposed surfaces shall be treated as follows: All daps, cuts, chamfers and all abrasions, after having been carefully trimmed, shall be given two brush coats of hot creosote. All holes for bolts and lag screws shall be thoroughly treated with hot creosote oil applied with a swab. All countersunk holes shall be given 2 coats of hot creosote oil before the bolt is placed.

2409.08 FRAMING. All lumber and timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces.

2409.09 PILE BENTS. Pile bents shall be driven as accurately as possible in the correct location and to the vertical or batter lines indicated on the plans. In case a pile is driven out of line it shall be straightened without injury before it is cut off or braced. Piles damaged in driving or straightening, or piles driven below grade shall be removed and replaced. No shimming on tops of piles will be permitted.

Piles for any one bent shall be carefully selected as to size to avoid undue bending or distortion of the swaybracing.

Cut-offs shall be accurately made to insure perfect bearing between the cap and all piles of a bent. The edges of piles outside the cap shall be trimmed to a slope of approximately 45 degrees with the horizontal.

2409.10 FRAMED BENTS. Framed bents shall be constructed as shown on the plans. In general they will be supported by piles cut off approximately 3 feet above ground level. Earth shall be removed from contact with the sills to allow free circulation of air. Sills shall be fastened to the piles and posts fastened to sills by dowels not smaller than $\frac{3}{4}$ inch in diameter projecting into both pile and sill not less than 6 inches.

2409.11 CAPS. Timber caps shall be placed to secure an even and uniform bearing on the top of supporting piles or posts. They shall be fastened to piles by drift bolts not less than $\frac{3}{4}$ inch in diameter extending at least 9 inches into the pile. The drift pins shall be placed approximately in the center of the pile or cap.

When steel channel caps are used the tops of all piles shall be accurately shaped to provide snug fit in the caps.

2409.12 BRACING. The ends of bracing shall be bolted through the pile, post or cap with bolts not less than $\frac{5}{8}$ inch diameter. Intermediate intersection shall be fastened with bolts and spikes as shown on the plans. In all cases spikes shall be used in addition to bolts. Notching the piles or shimming under the bracing shall be avoided whenever possible.

2409.13 STRINGERS. Stringers shall be sized at bearings and shall be placed in position so that knots near the edges shall be in the top portions of the stringer. Outside stringers may have butt joints but interior stringers shall be lapped to take full bearing on caps. Stringers shall be fastened to caps as shown on the plans.

Bridging shall be of the size and type shown on the plans but shall be preferably of solid diaphragm type not less than 3 inches thick. With untreated stringers and floors the bridging shall be so placed that an air space of at least one inch shall be left beneath the floor. With treated stringers and floors the bridging shall be placed flush with the top of the stringers.

2409.14 PAINTING. Wood handrails shall be painted with 3 coats of white paint conforming with the requirements of Paragraph 4115.04 (a).

Parts of the structure other than handrails, which are to be painted will be designated on the plans or special provisions.

All metal work except hardware shall be given one coat of shop paint and 2 coats of field paint after erection. The provisions of Section 2508 shall apply to the application of the paint.

2409.15 MEASUREMENT AND PAYMENT. All structures of timber or timber combined with steel or concrete, built in accordance with the detailed plans shall be paid for at the contract unit prices for "Excavation for Structures"; "Piling"; "Untreated Timber Class A, or Class C"; "Treated Timber"; "Concrete Masonry"; "Steel Reinforcement"; "Structural Steel"; etc. as specified in the contract. These unit prices shall be full payment for furnishing all material, equipment, labor and the performance of all incidental work necessary to complete the structure in conformance with the plans and these specifications.

The weight of structural steel paid for shall include weights of rolled shapes or plates, rods used as tension members, and all bolts or rivets used to fasten steel parts together. The weight of all drift bolts, dowels, washers, bolts, or other hardware used to fasten wood pieces together or to steel members will not be included in the weight of structural steel paid for. These items, except spikes and nails, will be paid for at the contract price for miscellaneous hardware. The cost of spikes and nails used shall be included in the contract price per 1000 board feet for the various classes of lumber.

Section 2410. Plank Floors.

2410.01 GENERAL. This construction shall consist of furnishing and installing either treated or untreated single or double plank floors in accordance with the detailed plans and the following provisions.

2410.02 MATERIALS. All materials used in construction of plank bridge floors shall conform to the stipulations of the plans, proposals or special provisions, and to the requirements of Part IV for the respective materials as listed below:

Untreated Lumber	Section 4120
Treated Lumber	Section 4119

Hardware shall conform to the requirements of Paragraph 2409.02 (e).

When the plank floor is to be covered with creosoted wood blocks, the plank shall be surfaced on both sides and splined or tongue and grooved. When the plank floor is to be covered with bituminous plank wearing surface the floor plank shall be surfaced on at least one side and one edge. Plank floors which are installed as sub-floors for creosoted wood block or asphalt plank wearing surface or for double plank floors shall be given full pressure preservative treatment as specified in Section 4117.

The preservative used shall be creosote distillate oil unless otherwise specified.

2410.03 SINGLE PLANK FLOORS. Single plank floors shall consist of a single thickness of plank supported by stringers or joists and shall be laid with the heart side down. Rough plank shall be laid with not more than $\frac{1}{4}$ inch opening between the plank. Adjacent plank laid in the floor shall not vary more than $\frac{1}{4}$ inch in thickness. Surfaced plank shall fit tightly together and present a smooth uniform surface without variation due to difference in thickness or surfacing of the plank. Each plank shall be securely spiked to each nailing strip or joist with not less than 2 wire spikes. The length of spikes used shall be 3 inches greater than the nominal thickness of the plank. All shims and scupper blocks shall be fastened securely to the plank floor. The ends of the plank shall be cut to a true line parallel to the centerline of the roadway.

2410.04 DOUBLE PLANK FLOORS. Double plank floors when specified on the plans shall consist of 2 layers of plank supported by stringers or joists. The lower course of plank shall be laid parallel to the abutments of the bridge and the top course parallel to the centerline of the roadway. The plank shall be laid in the manner specified in Paragraph 2410.03. The top course of plank shall be fastened to the lower course by 2 spikes placed at intervals of not more than 4 feet. The length of spikes used shall be 3 inches greater than the nominal thickness of the plank. At the ends of the bridge the planks shall be beveled in such a manner as to provide a smooth riding surface.

2410.05 MEASUREMENT AND PAYMENT. Plank bridge floors built in accordance with the detailed plans will be paid for at the contract unit prices per 1000 board feet for the types and grades of lumber included in the contract. These prices shall be full payment for furnishing all lumber, nails, miscellaneous hardware and other materials, and the performance of all incidental work necessary to complete the structure in accordance with the plans and these specifications.

Section 2411. Laminated or Strip Floors.

2411.01 MATERIALS.

(a) **Lumber.** The floor strips shall be of the nominal dimensions and either rough or surfaced on one side and one edge (S1S1E) as specified on the plans. All strips for untreated floors shall be Douglas Fir or Southern Pine conforming to the requirements for Class C lumber, Section 4120. When specified on the plans or special provisions this grade of lumber may also be used in treated floors.

(b) **Hardware.** All hardware shall conform to the requirements of Paragraph 2409.02 (e).

2411.02 CONSTRUCTION. The floor strips shall be placed on edge and securely toe-nailed to each of the stringers or nailing strips with 20d wire nails. Each strip when in place shall be brought to bear firmly against the adjacent strip by nailing between each joist or stringer with one nail whose length is $2\frac{1}{2}$ times the nominal thickness of the strips. The openings between adjacent strips shall not exceed $\frac{1}{8}$ inch in width. The surface of the floor when completed shall show not more than $\frac{1}{4}$ inch variation between any 2 adjacent strips. Floor drainage shall be provided by means of crown in the roadway surface. The ends of each strip shall be sawed square and in true line when in the floor.

2411.03 MEASUREMENT AND PAYMENT. Laminated or strip floors built in accordance with the detailed plans will be paid for at the contract unit price per 1000 board feet for Class C lumber. This price shall be full payment for furnishing all lumber, hardware and other material, and performance of all incidental work necessary to complete the structure in accordance with the detailed plans and these specifications.

Section 2412. Concrete Floors.

2412.01 GENERAL. The construction herein specified shall apply to all concrete floors or concrete wearing surfaces on timber, concrete or steel bridges. The requirements of Sections 2402 and 2403 shall apply to this construction in addition to the following details. Supplemental specifications will be issued by the Commission for concrete floors requiring other or special treatment.

2412.02 CLASS OF CONCRETE. The concrete use for all concrete floors and concrete wearing surfaces shall be Class A concrete as specified in Section 2402.

2412.03 SWINGING THE SPAN. Before the concrete is placed in the floor on steel spans the centering shall be struck and the span swung free on its supports.

2412.04 PLACING REINFORCEMENT. The steel reinforcement in the floor shall be rigidly wired at intersections and placed in the exact locations shown on the plans.

Horizontal reinforcement shall be supported in the exact positions shown on the plan by means of an adequate number of metal supports as specified in Paragraph 2403.06. The Contractor shall not place the concrete in the floor until the Engineer has inspected and approved the placing of the reinforcement. The longitudinal reinforcement shall preferably be continuous for each span, but when splicing is necessary, it shall be made as nearly as practical at points of least tension in the steel.

2412.05 PLACING CONCRETE. Concrete floors on steel pony truss spans shall preferably be placed in one continuous operation without construction joints. No exception to this rule will be made for spans designed without joists except in case of unavoidable shut-down where a vertical transverse keyed joint may be permitted by the Engineer in charge, midway between floor beams. Concrete floors on pony trusses having longitudinal steel joists, may be placed with a vertical transverse joint directly above centerline of a floor beam.

On high truss spans concrete floors shall be placed by one of the following methods:

(a) Beginning near mid-span and working toward both ends simultaneously with the aid of two outfits working one at each end.

(b) Starting from a vertical transverse header over centerline of a floor beam located approximately at the third point of span, and working toward the farther end. This means placing the center zone first followed successively with each of the end zones. By this method one construction joint is required and a second similar one will be permitted at the floor beam point symmetrically opposite the starting point.

2412.06 PLACING WEARING SURFACES. Concrete wearing surfaces placed as a second course on concrete slab floors of steel or concrete bridges shall be placed continuously from one end of bridge. Expansion joints shall be furnished and installed to match existing expansion joints and extending through curb unless otherwise provided on plans.

2412.07 CURBS. Concrete curbs shall in general be placed monolithically with the floor slab. If placed separately, they shall be anchored to the floor by means of 1/2-inch steel dowels placed at not less than 24-inch centers.

2412.08 JOINTS. Expansion joints shall be constructed between spans, between the ends of the floor and backwall, and under the ends of each floor resting on the abutment and in the exact locations shown on the plans. Expansion joints shall be filled with an asphalt joint filler, or constructed by means of the use of a bituminous premoulded expansion joint. The width of expansion joint shall be that specified on the detailed plans.

Vertical expansion joints in concrete floors shall be protected by means of steel plates of the types specified on the detailed plans. The Contractor for the superstructure shall furnish and install all such plates including any required at the ends of the bridge to connect with existing pavements or structures.

2412.09 DRAINAGE. Transverse drainage shall be secured by means of crown in the roadway surface. Longitudinal drainage shall be secured by cast iron or welded steel drains placed in the concrete floor or curb in the locations shown on the plans. All drains and their covers shall be furnished and installed by the Contractor for the superstructure.

2412.10 SURFACE FINISH. After the concrete is placed, it shall be struck off with a template to provide the proper crown. The top surface of all concrete floors, unless otherwise specified on the plans, shall be hand finished to a smooth even surface as provided under Paragraph 2303.19 for concrete pavement. For this purpose the Contractor shall provide equipment of the type specified under Paragraph 2303.18.

2412.11 CURING. The concrete shall be kept damp for a period of 4 days as provided in Paragraph 2402.08.

2412.12 MEASUREMENT AND PAYMENT. Concrete floors built in accordance with the detailed plans will be paid for at the contract unit prices for "Concrete Masonry", "Steel Reinforcement", "Structural Steel", etc., as specified in the contract. These unit prices shall be full payment for furnishing all materials, equipment, labor, and performing all work necessary to complete the structure in conformance with the plans and these specifications.

No deduction will be made for the volume of concrete displaced by floor drains, expansion joints and metal strips for sealing joints.

The cost of bituminous expansion joint material, and metal strips for sealing joints shall be included in the price per cubic yard for concrete masonry. The weight of structural steel paid for shall include all steel expansion plates, castings of steel or iron, or welded shapes for floor drains; bearing plates, anchor bolts and other steel parts except steel reinforcement for concrete and the metal fastenings therefor.

Section 2413. Creosoted Wood Block Floors.

2413.01 MATERIALS.

(a) **Lumber and Wood Blocks.** All timbers, dimension lumber and wood blocks shall be of material pressure-treated in conformance to the requirements of Sections 4118 and 4119.

(b) **Hardware.** The hardware used shall conform to the requirements of Paragraph 2409.02 (e).

(c) **Asphalt Filler.** The asphalt used for mop coat on subfloor and for filler between the blocks shall comply with the requirements of Paragraph 4106.05.

2413.02 PREPARATION OF SUB-FLOOR. Before placing the blocks, the entire surface of the plank sub-floor shall be given a mop coat of hot asphalt. This shall be immediately covered with a layer of roofing felt or tar paper so placed that the sides and ends are turned up the depth of the blocks used. After placing the first strip of roofing felt or tar paper, the surface shall be mopped with hot asphalt and the succeeding strip so laid as to overlap the first strip $\frac{1}{2}$ width. Each succeeding strip shall be placed in a similar manner.

2413.03 DIPPING BLOCKS. Immediately before laying the wood blocks they shall be dipped for the lower $\frac{1}{2}$ of their depth in hot asphalt.

2413.04 LAYING BLOCKS. The wood blocks shall be laid by setting them hand tight on the base with the fibre of the wood vertical and in straight parallel courses. A space of one inch in width shall be left next to each curb for an expansion joint. The blocks shall be laid closely together as possible with joints preferably not exceeding $\frac{1}{8}$ inch in width, but in no case shall a joint be more than $\frac{3}{16}$ inch in width. They may be drawn together lightly every fourth course to keep the rows parallel and straight. Only whole blocks may be used except in breaking courses at the curb lines and in no case shall the lap joints be less than 3 inches. Immediately after laying the blocks they shall be tamped until firmly embedded in the asphalt bed.

2413.05 FILLING JOINTS. After the blocks have been thoroughly tamped the joints between the blocks shall be filled with a bituminous filler. The filler shall be brought to the proper temperature and poured into the joints. All excess filler on the surface of the blocks must be spread out thinly as possible by means of squeegees.

2413.06 EXPANSION JOINTS. The expansion joints shall be of the size and in the locations specified on the plans. They may be constructed by the insertion and subsequent removal of wood boards of proper thickness, placed in such a manner as to prevent the displacement of the blocks upon their removal. The boards shall be removed after the blocks have been thoroughly tamped and the spaces filled with bituminous filler.

2413.07 SURFACE TREATMENT. The surface of the finished floor shall be completely covered to a depth of about $\frac{1}{2}$ inch with clean, coarse, dry sand, which shall remain in place on the floor surface.

2413.08 MEASUREMENT AND PAYMENT. All creosoted wood block floors built in accordance with the detailed plans will be paid for at the unit prices per 1000 board feet for lumber, and per square yard for creosoted block wearing surface as specified in the contract. These prices shall be full payment for furnishing all materials and performance of all incidental work necessary to complete the structure in accordance with the plans. The cost of all bituminous material for filling joints and bituminous treated paper, shall be included in the price per square yard paid for creosoted wood block wearing surface. The cost of all bolts, nails and miscellaneous hardware shall be included in the price per 1000 board feet for lumber.

Section 2414. Asphalt Plank Wearing Surface.

2414.01 GENERAL. This work consists of the construction of bituminous plank wearing surface on plank floors or concrete floors in accordance with the plans and the following provisions.

2414.02 MATERIALS. The materials used in construction of bituminous plank wearing surfaces shall conform to the requirements for the respective materials in Part IV as listed below:

Asphalt Plank	Paragraph 4106.08
Asphalt for Sealing Cracks and for Mop Coat on Floors.....	Paragraph 4106.05
Bituminous Treated Paper	Paragraph 4124.10

Nails used to fasten bituminous plank shall be 20d common wire nails coated with not less than one ounce of spelter per square foot of surface.

2414.03 PREPARATION OF CONCRETE FLOOR. Where asphalt plank wearing surface is to be laid on concrete floor, the concrete shall be cleaned of all dirt and foreign material. If necessary it shall be flushed with water and thoroughly brushed with stiff brooms. If the floor is not smooth and true to grade and cross-section, a mortar cushion of Class C concrete as specified in Section 2402, shall be spread on the old concrete floor. This cushion shall be spread to provide a minimum thickness of one inch and produce a surface true to line and grade with not more than 1/8 inch variation in the surface. This mortar coat shall be cured with wet burlap as specified in paragraph 2303.21 (e), and shall be allowed to harden for at least 4 days before the plank wearing surface is placed on it. The mortar surface shall be thoroughly dry before the mop coat is applied.

Asphalt heated to 275°F. to 325°F. shall be mopped over the surface and the asphalt plank placed before the asphalt has cooled and set. In heating the asphalt care shall be used to prevent the material from being overheated. The asphalt shall be applied in a thin uniform layer avoiding all lumps and irregularities due to congealing of excess material.

2414.04 PREPARATION OF PLANK FLOORS. When asphalt plank wearing surface is to be laid on plank floors, the floors shall be cleaned of all loose and foreign material. Untreated floors of rough lumber shall be securely fastened to prevent vibration. All cracks greater than 1/4 inch shall be calked with oakum and filled flush with the surface with asphalt. Variation in thickness of adjacent plank greater than 1/4 inch shall be corrected by replacing with new material.

Creosoted plank floor shall be covered with 2 layers of bituminous treated paper by lapping successive pieces of paper 1/2 width. Care shall be used in jacking or forcing the bituminous plank into position to avoid tearing the paper.

2414.05 HANDLING AND STORAGE. Asphalt planks shall be handled and stored in such a manner as to avoid any breakage or deformation. In storage they shall be protected from the direct rays of the sun.

A plank which becomes deformed or misshapen shall be rejected. A plank shall be considered deformed when either face departs more than 1/4 inch from a plane surface upon which it is placed.

2414.06 LAYING ASPHALT PLANK. When the floor has been prepared and the mop coat or treated paper spread, the asphalt plank shall be laid immediately thereon. The asphalt plank shall be laid parallel to the centerline of the roadway.

Plank shall be forced tightly together with jacks or other devices so that cracks between the planks will not exceed 3/16 inch. The edges of the plank to which pressure is applied shall be protected from battering or breaking. The plank shall be kept straight in alignment and to an even surface. Plank with edges broken or split in nailing shall be replaced by the Contractor.

Asphalt plank shall be laid on wood or concrete floors as specified below:

(a) **Wood Floors.** On wood floors the bituminous plank shall be nailed at all corners and at intervals of not more than one foot on both edges. Nails shall not be placed further than 2 inches from the edge of the plank. If the plank show any tendency to split, in the nailing, 3/16 inch holes shall be drilled and countersunk for all nails. Heads of nails shall be sunk flush with the surface of the plank, or when countersunk they shall be in close contact with the plank and not more than 1/8 inch below the surface.

(b) **Concrete Floors.** On concrete floors the asphalt plank shall be laid in hot

asphalt. This material shall be mopped over the concrete and the plank laid while the asphalt is still hot and plastic. The plank shall be rolled with a heavy hand roller to insure intimate contact of the plank with the coated concrete at all points.

2414.07 FILLING CRACKS. After the bituminous plank floor has been laid all cracks shall be neatly sealed with asphalt heated to 275°F. to 325°F. Care shall be used that the asphalt is not over-heated and not spread over the surface of the plank but enough material is used to completely fill the crack. Suitable pouring cans with narrow spout and controlled orifice shall be used.

2414.08 WEATHER CONDITIONS. Whenever possible, this work shall be performed during warm weather with the temperature above 60°F. For work during weather when the temperature is below 60°F. the plank shall be thoroughly heated for at least 2 hours by immersion in tank of water maintained between 90° and 120°F.

2414.09 BASIS OF PAYMENT. Asphalt plank wearing surface built in accordance with the detailed plans will be paid for at the unit price per square yard for the thickness of plank specified in the contract. This price shall be full payment for furnishing all materials and performing all work necessary to complete the surface in accordance with the plans and these specifications.

Section 2415. Bituminous Mat Wearing Surfaces.

2415.01 MATERIALS.

(a) **Bituminous Materials.** The bituminous materials used shall comply with the requirements of Section 4106 for the following materials:

Tar Mat.	Primer	Tar	4106.01 (a)
	Binder	Tar	4106.01 (b)
Asphalt Mat.	Primer	Cut Back Asphalt, Light	4106.03
	Binder (Mixed Method)	Cut Back Asphalt, Heavy.....	4106.03
	Binder (Penetration Method)	Asphalt	4106.01 (c)

(b) **Aggregate.** Aggregate for construction of tar mats or asphalt mats shall comply with the requirements of Paragraph 4105.03.

Sand for cover "Mixing Method" shall comply with the requirements for fine aggregate for concrete, Section 4104.

2415.02 NOTICE TO ENGINEER. After the preparation of the sub-floor and before placing the first coat the contractor shall notify the Engineer who shall inspect and, if satisfactory, approve the surface to be treated.

2415.03 PREPARATION OF SUB-FLOOR.

(a) **Wood Sub-floor.** Before placing the carpet coat, all parts of the sub-floor shall be securely fastened to prevent vibration, and all sharp corners, projections or irregularities in the surface shall be removed. Wood that is worn or contains defects which may be injurious to the bituminous carpet shall be removed and replaced with new material. Any openings in the floor shall be completely sealed by caulking with oakum. All dust, dirt, debris, or foreign material on or adhering to the surface to be treated shall be removed and if necessary the surface shall be flushed with water. If water is used the sub-floor shall be allowed to become thoroughly dry and then shall be swept with stiff brooms before applying the first coat.

(b) **Concrete Sub-floor.** The requirements as to cleanliness specified above for wood sub-floors shall also apply to concrete sub-floors. Irregularities in the surface such as might project into or injure the bituminous carpet shall be removed. Immediately before applying the first coat the surface shall be swept clean and no traffic permitted thereon until the carpet coat is placed.

2415.04 CONSTRUCTION OF TAR MAT SURFACE.

(a) **First Coat.** After the sub-floor has been prepared as hereinbefore specified and is thoroughly dry, the entire surface shall be covered with a paint coat of the tar for "First" or "Prime Coat". The tar shall be applied cold at the rate of $\frac{1}{4}$ gallon per square yard of surface treated. No traffic shall be permitted to use the surface thus treated. The first coat shall remain in place 12 hours before applying the second coat.

(b) **Second Coat.** When the tar primer has set, a coat of tar binder shall be applied at the rate of $\frac{1}{2}$ gallon per square yard. The tar shall be heated to a temperature between 200°F. and 225°F. and applied evenly over the surface. Care shall be taken not to overheat the material, the proper temperature being obtained when it will flow with reasonable freedom and remain fluid for a sufficient period to permit gravel, stone chips or slag to become thoroughly incorporated in the mass. Immediately after the application of this coat of tar the surface shall be covered with aggregate at a rate of 50 pounds per square yard of floor surface. Accurate measuring and weighing devices shall be provided by the contractor to insure the proper quantity of aggregate being used. The aggregate shall be spread evenly over the surface by means of square pointed shovels and the entire mass stirred with steel hand rakes. As soon as practicable the surface shall be hand-tamped or rolled with a heavy hand roller.

After rolling or tamping is completed a second application of the tar and aggregate shall be applied in the same manner and in the same quantities as specified for the first application. The entire surface shall then be rolled or hand-tamped as specified above.

The complete second coat shall contain a total of one gallon of tar and 100 pounds of aggregate per square yard of surface. Care shall be taken to secure a smooth, even surface, free from depressions or irregularities, which when tested with a 10-foot straight-edge will not exceed $\frac{1}{4}$ inch variation from the specified surface contour.

2415.05 CONSTRUCTION OF ASPHALT MAT SURFACE. (Penetration Method).

(a) **First Coat.** After the sub-floor has been prepared as hereinbefore specified, and is thoroughly dry, the entire surface shall be covered with a paint or prime coat of cut-back asphalt at the rate of .25 to .3 gallons per square yard. This application shall be sprayed or brushed evenly over the surface. No traffic shall be allowed on the primed surface which shall stand uncovered until the asphalt has set and become sticky, when the second coat may be applied.

(b) **Second Coat.** After the paint or prime coat has set sufficiently to become sticky the surface to be treated shall be covered with a thin layer of the aggregate applied evenly over the surface by means of square-pointed shovels.

Asphalt binder heated to a temperature between 250 and 325°F. shall be applied over the surface covered with the aggregate, at the rate of $\frac{1}{2}$ gallon per square yard. Care shall be taken not to over-heat the material, the proper temperature being obtained when it will flow with reasonable freedom and remain fluid for a sufficient period to thoroughly penetrate the aggregate. Immediately after the application of this coat of asphalt the surface shall be covered with a thin layer of aggregate applied in the manner specified above and a second application of hot asphalt applied at the rate of $\frac{1}{2}$ gallon per square yard. The entire surface shall then be hand-tamped or rolled with a heavy hand roller. Care shall be exercised to secure a smooth even surface, free from depressions or irregularities, which when tested with a 10-foot straight-edge will not exceed $\frac{1}{4}$ inch variation from the specified surface contour.

The completed second coat shall contain a total of one gallon of asphalt and approximately 100 pounds of aggregate per square yard. The thickness of the asphalt mat coat shall be not less than $\frac{3}{4}$ inch nor more than one inch at any point on the surface.

2415.06 CONSTRUCTION OF ASPHALT MAT SURFACE. (Mixed Method).

(a) **First Coat.** The paint or prime coat of asphalt shall be applied in the same amount and manner as specified herein for the first coat of asphalt mat surface by the penetration method.

(b) **Second Coat.** When the prime coat has set sufficiently the second coat shall be spread upon it. This second coat shall consist of a mixture of aggregate coated with cut-back asphalt binder. The aggregate and bitumen may be mixed in a small concrete mixer or by hand on a suitable platform. The quantities of bitumen and aggregate shall be accurately measured to insure uniform composition of successive batches. The amount of cut-back asphalt used shall be sufficient to coat all the particles uniformly. Ordinarily this will require 9 to 12 gallons of cut-back per cubic yard of aggregate. The aggregate shall be free from surface moisture at the time of mixing.

The mixture shall be prepared sufficiently in advance of spreading to allow the volatile fractions of the cut-back to evaporate. The mixture shall be spread uniformly to a depth which will give $\frac{3}{4}$ to one inch after compaction. When the mixture has been spread it shall be allowed to stand until the bitumen has thoroughly set and the volatile fraction evaporated before it is compacted. It shall then be rolled or tamped with a mechanical tamper until compacted. Care shall be exercised to secure a smooth even surface, free from depressions or irregularities, which when tested with a 10-foot straight-edge will not exceed $\frac{1}{4}$ inch variation from the specified surface contour.

2415.07 APPLICATION OF SEAL COAT. After the second coat has been completed the entire surface shall be given a seal coat of the same bituminous material as specified for the second coat. The asphalt and tar binders shall be applied hot. Cut-back asphalt shall be warmed to flow freely. This application shall be sprayed or spread evenly over the surface by means of squeegees at the rate of $\frac{1}{4}$ gallon per square yard. After the seal coat has been applied, a light dressing of clean dry sand shall be spread evenly over it to absorb any excess bituminous material remaining on the surface. Approximately 20 to 30 pounds of sand shall be applied per square yard.

2415.08 OPENING TO TRAFFIC. No traffic shall be allowed on the surface that is being treated, for a period of 24 hours after the seal coat is applied.

2415.09 MEASUREMENT AND PAYMENT. Bituminous mat wearing surface will be paid for at the contract price per square yard. This price shall be full payment for furnishing all materials and equipment and performing all work necessary to complete the surface in accordance with the plans and these specifications.

Section 2416. Railings.

2416.01 GENERAL. The construction herein specified shall apply to all railings constructed on either steel or concrete bridges. The requirements of Sections 2402, 2403, 2404 and 2408 shall apply in addition to the following details, and all railings shall be constructed as shown on the plans.

2416.02 CONCRETE RAILINGS.

(a) **Class of Concrete.** Class C concrete shall be used in all concrete railings and posts.

(b) **Railings Cast in Place.** Forms for concrete railings cast in place shall be made of good quality surfaced lumber and shall be of first-class workmanship throughout. All mouldings, panel work and bevel strips shall be straight and true, with neatly mitered joints. The top surface shall be hand-finished as specified in Paragraph 2402.22 (a). The forms shall be removed in not less than 12 nor more than 48 hours

and the entire surface given a surface finish as provided in Paragraph 2402.22 (b). Porous spots and places damaged by the removal of forms shall be repaired promptly after the removal of the forms and before the surface is finished. Expansion joints shall be constructed of the size and in the locations shown on the plans.

(c) **Pre-cast Railings.** The base and top course of pre-cast concrete rails shall be cast in place. The spindles shall be pre-cast of the form shown on the plans. The reinforcement shall extend through the spindle and project not less than 2 inches into the base and cap. Care shall be taken to secure true alignment of the base, spindles and cap rails. Spindles which are defective or which become damaged in handling shall be rejected. The cast spindles shall be given a surface finish conforming to the requirements of Paragraph 2402.22 (b), before being placed in the structure. After the forms are removed all parts of the railing, including spindles, shall be surface finished as specified in Paragraph 2402.22 (b).

2416.03 PIPE OR STEEL ANGLE RAILINGS. Steel angle railings on bridges, or used as protection railings on abutments or culverts, shall be constructed of material conforming to the requirements of Section 4113.

Protection railings on abutments shall be furnished and installed by the Contractor for the substructure. Before shipment to the work, protection railings shall be given one coat of shop paint conforming to the requirements of Paragraph 4115.04 (b). After erection they shall be given 2 coats of approved aluminum field paint conforming to the requirements of Paragraph 4115.04 (i). The field coats of paint shall be furnished and applied by the Contractor for the superstructure.

2416.04 BASIS OF PAYMENT. All railings will be paid for at the contract unit prices for the respective items of "Concrete Masonry", "Steel Reinforcement", or "Structural Steel", as specified in the contract. These prices shall be full payment for furnishing all materials and performing all incidental work necessary to complete the structures in accordance with the plans and these specifications.

Section 2417. Concrete Box, Arch and Circular Culverts.

2417.01 GENERAL REQUIREMENTS. All concrete culverts shall conform in detail to the standard plans of the State Highway Commission, which will be furnished by the Commission to supplement and interpret the requirements of these specifications. The requirements of Sections 2401, 2402 and 2403 shall apply in addition to the following requirements:

2417.02 FOOTINGS. The footings shall be constructed to the elevations shown on the detailed plans unless otherwise directed by the Engineer. Footing depths may be increased when necessary to prevent undermining, scour, or to secure adequate bearing. In general, footing depths shall be decreased only when solid rock is encountered at elevations above those shown on the detailed plans. Suitable wood or metal forms shall be used to enclose all footing concrete.

2417.03 CLASS OF CONCRETE. Concrete shall conform to the requirements of Section 2402. All concrete, except in handrails, shall be of Class A Concrete. The concrete in handrails shall be Class C Concrete.

2417.04 PLACING CONCRETE.

(a) **Footings.** In wet or soft foundations care shall be taken to prevent dirt, mud, or other foreign material from becoming mixed with concrete which is being placed in the footing. The footings, pavements and curtain walls between construction joints shall be constructed as a monolith if practicable. A key notch of the form shown on the plans shall be provided between the walls and footings to insure proper anchorage. All dirt, dust, shavings or other foreign material shall be removed from the key notch and wall forms before placing the concrete.

(b) **Barrels of Small Culverts.** For culverts 6 feet and less in height the sidewalls and top slab shall preferably be constructed as a monolith between construction joints. Construction joints shall be made by means of bulkheads placed at right angles to the axis of the culvert and the walls and top slab placed in monolithic sections.

(c) **Barrels of Large Culverts.** For culverts more than 6 feet in height the concrete in the sidewalls may be placed and allowed to reach its initial set before constructing the top slab. The forming and reinforcement for the entire culvert shall be in place before any concrete is placed in the sidewalls or headwalls. Care shall be taken to insure adequate bond between the sidewalls and top slab.

(d) **Headwalls.** In general, the headwalls shall be constructed as a monolith. However, when construction joints are unavoidable they shall be placed in a horizontal position and so located that no joint is visible above the road bed. Sharp edges and corners shall be avoided by means of triangular fillet strips placed in the forms.

2417.05 REMOVAL OF FORMS. Forms for all culverts shall be removed as provided in Paragraph 2402.19.

2417.06 SURFACE FINISH. All exposed parts of the wingwalls, headwalls and railings shall be surface finished in accordance with the requirements of Paragraph 2402.22.

2417.07 FILLING. Back-filling shall be performed as required in Paragraph 2401.08.

2417.08 PROTECTION RAILINGS. Protection railings shown on the plans shall be furnished and installed by the Contractor. Protection railings shall be painted as provided in Section 2416.

2417.09 MEASUREMENT AND PAYMENT. All concrete box, arch or circular culverts will be paid for at the contract unit prices for "Excavation for Structures", "Concrete Masonry", "Steel Reinforcement", and other items included in the contract. These unit prices shall be full payment for furnishing all materials, equipment, labor and performance of all work necessary to complete the structures in conformance with the plans or as ordered by the Engineer.

Protection railings when specified on plans will not be paid for directly but shall be included in the contract price per cubic yard for concrete masonry.

Section 2418. Concrete Pipe Culverts.

2418.01 GENERAL. Concrete pipe culverts shall be built as shown on the plans, and shall conform to the Standard Plans of the Iowa Highway Commission. The provisions of Section 2401 shall apply in addition to the following details.

2418.02 MATERIAL. Concrete culvert pipe shall conform to the requirements of Section 4108. For Roadway Culverts, "Standard" grade pipe will be used.

2418.03 PERMISSIBLE SIZES. The maximum and minimum permissible sizes of concrete culvert pipe used under these specifications as determined by the least nominal inside dimensions shall be as follows:

	Minimum Size	Maximum Size
(a) Roadway Culverts	18 in.	42 in.
(b) Farm Entrance Culverts	15 in.	42 in.

2418.04 MAXIMUM AND MINIMUM DEPTH OF FILL. The minimum depth of fill over concrete pipe culverts shall be 2 feet. The maximum depth of fill over concrete pipe culverts of "Standard" grade pipe shall not exceed 10 feet, except as provided in Paragraph 2418.05.

2418.05 CONSTRUCTION BY IMPERFECT DITCH METHOD. When conditions necessitate the use of pipe culverts under high fills, the maximum depths of fill as specified in Paragraph 2418.04 may be increased not to exceed 50 per cent when the pipes are installed under the direct supervision of the Engineer and by the following method:

After the pipe are in place the filling material around and under the pipe shall be thoroughly compacted by hand-tamping to a depth level with the top of the culvert pipe. The imperfect ditch condition of filling may be obtained by the placing of rigid side forms directly over and tangent to the sides of the pipe. After the fill behind these forms has been completed and compacted, the forms shall be loosely filled to the same height as the fill on the outside of the forms. The forms shall then be removed and this method of filling maintained for a height of fill equal to $\frac{1}{2}$ the total depth of fill over the culvert pipe. The remaining portion of the fill above this height may be placed in the usual manner.

The method of filling herein specified will be accepted as satisfactory. However, the Engineer may specify or accept any method of filling which permits the thorough compacting of the filling material on either side of the culvert pipe and the subsequent construction of a ditch equal in width to the outside diameter of the pipe, which ditch is to be filled with loose material for a height equal to $\frac{1}{2}$ of the total depth of fill.

2418.06 CONSTRUCTION OF CONCRETE PIPE CULVERTS.

(a) **Width of Trench.** The width of the trench (if any) in which the pipe are placed shall be sufficient to permit thorough tamping of the bedding material under and around the pipes. In order to lighten the loads which the pipe must carry, the width of the trench shall not be greater than is required above except where absolutely necessary on account of field conditions, such as the replacement of wider former construction.

(b) **Preparation of Base.** The surface upon which the pipe sections are to rest shall be brought to the desired grade which in general will be slightly cambered to correct for expected settlements and to insure tight joints in the lower half of the pipe. This surface shall be free from stones, roots or other inequalities in the bedding surface and where bed rock is encountered the trench shall be excavated so that all rock within one foot below the pipe is removed and the excavation filled to the desired elevation with thoroughly tamped earth. The bedding surface shall provide a firm but slightly yielding foundation of uniform density through the length of the culvert. The surface upon which the pipe are to rest shall be trimmed to fit a template supported at the desired grade so that the pipe will be accurately bedded on firm material for at least one-fourth of the circumference of the pipe. If in the opinion of the Engineer the material at the bottom of the excavation is of such nature as to cause unequal settlement, the trench shall be excavated below the grade and back-filled with suitable earth or soil thoroughly tamped.

(c) **Placing Pipe Sections.** Proper facilities shall be provided for lowering the sections into place, and when rolling or dropping the pipe section into place is liable to cause injury to the pipe, it shall not be permitted. Each section shall be carefully bedded and placed in close contact with the adjacent section. The pipe section when placed shall be true to alignment and grade. In general the grade shall be slightly cambered to correct for expected settlement and to insure tight joints in the lower half of the pipe.

(d) **Bedding and Backfilling Pipe Culverts.** Pipe culverts shall be bedded carefully in suitable material thoroughly tamped under and around the pipe for the full length and width of the culvert.

Except for installations under high fills as specified in Paragraph 2418.05, earth shall be filled and thoroughly tamped around and over the culvert in accordance with the provisions of Paragraphs 2401.07 and 2401.08 so that on each side of the culvert there shall be a berm of thoroughly tamped or undisturbed earth at least as wide as

the outside diameter of the culvert and extending to an elevation at least one foot above the top of the culvert. In addition to the back-filling required above, the Contractor shall build such approach fills as will provide a roadway over the culvert with grades not steeper than 10 per cent.

(e) **Joints.** Joints not exceeding $\frac{1}{8}$ inch at the bottom, $\frac{5}{8}$ inch at top and $\frac{3}{8}$ inch at sides will be accepted without further treatment. Larger joints up to 2 inch width shall be fully encased with a reinforced concrete collar not less than 6 inches wide and 3 inches thick, and in addition to the collar, the inner surface of the joint shall be pointed full and flush with sand cement mortar for the lower three-fourths of the pipe perimeter. If alignment or grade requirements result in joints larger than 2 inches, a special reinforced concrete connection as shown on Standard Design F-1 shall be constructed.

2418.07 MEASUREMENT AND PAYMENT. The length of pipe culverts specified shall be the overall laying length. All pipe culverts will be paid for at the contract unit prices for the items of "Excavation for Structures", "Concrete Pipe Culverts", etc. as specified in the contract. These unit prices shall be full payment for furnishing all materials, equipment and labor and the performance of all work necessary to complete the structures in conformance with the plans or as called for by the Engineer except as follows:

(a) **Pipe Sections.** Contracts may be awarded for pipe sections delivered f.o.b. station on the basis of the number of lineal feet of laying length.

(b) **Back-filling.** Earthwork required for back-filling or approach fills in addition to that included in the excavation necessary for the installation of the culvert, will be carried as a separate item in the proposals and contract and will be paid for at the contract price therefor.

Section 2419. Vitrified Clay Pipe Culverts.

2419.01 GENERAL REQUIREMENTS. The material used in the construction of vitrified clay pipe culverts shall conform to the detailed requirements of Section 4109. The detailed requirements of Section 2418 shall apply in all respects to vitrified clay pipe culverts.

Section 2420. Cast Iron Pipe Culverts.

2420.01 GENERAL REQUIREMENTS. Cast iron culvert pipe shall conform to the detailed requirements of Section 4110. The detailed requirements of Section 2418 shall apply in all respects to cast iron pipe culverts.

Section 2421. Corrugated Metal Pipe Culverts.

2421.01 GENERAL REQUIREMENTS. The requirements specified hereunder cover the detailed construction and installation of corrugated culvert pipe, but the attention of Contractors or material companies furnishing such material is directed to the proposal requirements for detailed information on bidding, delivery, etc.

2421.02 MATERIAL. Corrugated metal culverts shall conform to the requirements of Section 4107.

2421.03 MAXIMUM AND MINIMUM SIZES. For roadway culverts the minimum permissible diameter shall be 18 inches. The maximum standard diameter shall be 48 inches. Culverts of diameter 54 to 84 inches may be used only in special cases for which specific approval has been obtained. When called for in the Special Provisions, culvert pipe smaller than 18 inches may be furnished perforated for drainage.

For Farm Entrance Culverts the minimum permissible diameter shall be 15 inches.

2421.04 MINIMUM DEPTH OF FILL. The minimum depth of fill over corrugated metal pipe culverts except for farm entrance culverts shall be as follows:

Diameter (D)	Depth of Fill
24 in. and smaller	1 foot
30 in. to 42 in. inclusive	D/2
48 in. and larger	2 feet

2421.05 INSTALLATION. Whenever possible corrugated metal culvert pipe shall be installed in "trench condition" after the fill has been constructed to full height and consolidated. In all installations the trench below the centerline of the culvert pipe shall be shaped to fit the curvature of the pipe and the fill to the top of the pipe carefully placed and tamped. Where trench condition is not possible, the fill to the top of the culvert shall be carefully placed and firmly tamped along the full length of culvert barrel to give lateral support to the pipe. Culverts of diameters greater than 42 inches under fills greater than 8 feet shall be stiffened by vertical posts to maintain the original circular shape during the settlement of the fill. Timbers not smaller than 4" x 4" shall be placed inside the culvert for the full length for caps and sills of posts. The posts shall be cut to fit tightly against the caps and sills and shall be wedged in place to elongate the pipe slightly in the vertical plane before being covered. These posts shall remain in place until the fill has been placed and thoroughly consolidated.

2421.06 MEASUREMENT AND PAYMENT. The length of culvert specified shall be considered the length end to end of culvert when assembled. Payments for acceptable material shall be made at the unit price per lineal foot of pipe as specified in the contract, promptly after acceptance by the Engineer.

When the lengths of the individual culverts are specified in the proposal the connecting bands required to form the complete culverts shall be furnished by the seller without additional cost. If the lengths of the individual culverts are not specified in the proposal, the connecting bands furnished shall be paid for as follows: For each 7-inch band, the contract price of 1 foot of culvert of the same size; for each 12-inch band, the contract price of 1½ feet of culvert of the same size; for each 24-inch band, the contract price for 2½ feet of culvert of the same size.

Section 2422. Bituminous Coated Corrugated Metal Pipe Culverts.

2422.01 DESCRIPTION. These requirements apply to the detailed construction and installation of Bituminous Coated Corrugated Metal Culverts.

2422.02 MATERIALS. Bituminous Coated Corrugated Metal Culvert Pipe shall comply with the requirements of Section 4107A.

2422.03 GENERAL REQUIREMENTS. The detailed requirements of Paragraphs 2421.03 to 2421.06 inclusive regarding construction methods, measurement and payment shall apply to this type of construction.

DIVISION 25. INCIDENTAL CONSTRUCTION.

Section 2501. Piles and Pile Driving.

2501.01 DESCRIPTION. These requirements apply to furnishing and placing piles for foundations and for trestles or other exposed work. The piling shall conform to the following classes as called for on the plans, proposal or contract:

- Untreated wood piles for foundations
- Untreated wood piles for trestles
- Creosoted wood piles
- Sheet piles
- Precast concrete piles
- Concrete piles cast in place
- Steel piles

2501.02 MATERIALS. All piles shall conform to the requirements specified in Section 4122, and shall have the length specified on the plans or called for by the Engineer.

2501.03 CONSTRUCTION OF PRECAST PILES. Precast concrete piles shall be made of Class A concrete as specified in Section 2402, and be of the form and dimensions shown on the detailed plans, and shall be cast separately in conformity with the following requirements for construction and curing.

When individual platforms are used on which to cast single piles, the supporting foundations or false work shall be such as will prevent any settlement during the process of casting or curing the pile. When multiple platforms are used on which to cast more than one pile, special pains shall be used to secure foundations adequate to support the entire number without deflection or deformation as successive piles are added. In either case, the bearing of the casting floors shall be subject to checking and approval by the Engineer.

The forms used shall be built of surfaced lumber true to line and mortar tight. They shall provide access for tamping and consolidation of the concrete.

The concrete in each pile shall be placed continuously and shall be carefully worked and consolidated around the reinforcement without displacing it. Special care shall be used to prevent the formation of stone pockets, honeycomb or other such defects. The concrete shall be consolidated by vibrating the forms or by other means approved by the Engineer. During this consolidation the forms shall be overfilled with concrete. After consolidation the excess concrete shall be screeded off and the surface smoothed to a texture similar to that produced by the forms.

The forms shall not be removed within 24 hours after the concrete is placed. The completed pile shall be straight and true to the form specified.

All surfaces of the piles which will be exposed after driving, shall be given the surface finish specified in Paragraph 2402.22 (b). At his option, the Contractor may finish these surfaces after the forms are removed, or after the piles are placed in the structure.

(a) Protection and Curing. The piles shall be cured and allowed to age at least 40 days at a temperature not less than 50°F., or 30 days at a temperature not less than 60°F. before they are handled or driven. The concrete shall be protected and cured as specified in Paragraph 2402.08. In no case shall the piles be moved or strained in any other manner until they have been properly cured and aged ready for driving. In all moving or handling preparatory to driving, unless otherwise

specified on the plans, the piles shall be supported at points one-fifth of the length of the pile from each end.

2501.04 CONCRETE PILES CAST IN PLACE. Piles of this type will not be used unless specifically called for on the plans or special provisions at which time complete detailed requirements for their construction and use will be issued by the Commission.

2501.05 SHEET PILES. Sheet piles of wood, steel or concrete to become a permanent part of the structure will not be used unless specifically called for on the plans or special provisions at which time complete detailed requirements for their use will be issued by the Commission.

2501.06 DETERMINATION OF LENGTH OF PILES. When the length of piles required is not specified definitely on the plans, unless test piles are required, the Engineer shall, within 10 days from the date of contract award, determine the length of piles to be furnished by the Contractor. Piling as ordered by the Engineer shall be in multiples of 2 feet for lengths up to 20 feet, and in multiples of 5 feet for lengths over 20 feet. The minimum length of piling to be ordered shall be 16 feet.

2501.07 TEST PILES. When the length of piles to be ordered cannot be determined satisfactorily by other means, resort may be had to the driving of test piles. When so ordered by the Engineer, the Contractor shall provide and drive test piles of the lengths and in the locations designated by the Engineer.

2501.08 EQUIPMENT FOR DRIVING PILES. Equipment for driving piles shall comply with the following requirements. Either gravity hammers or steam hammers may be used for driving piles.

(a) **Gravity Hammers.** The fall of a gravity hammer when driving wood piles shall not exceed 20 feet, and when driving precast concrete piles shall not exceed 8 feet. In order to avoid brooming or shattering of the pile, the fall of the hammer may be limited by the Engineer to small heights.

When a gravity hammer is used for driving wood piles, the minimum weight of the hammer shall be 1800 pounds.

When a gravity hammer is used for driving concrete piles, the minimum weight of the hammer shall be 100 per cent of the total weight of the pile.

The weights as specified above shall apply only when the hoisting and tripping arrangements for the hammer are such that the hammer has a free fall. If the fall of the hammer is restricted or retarded by friction, a weight sufficient to compensate therefor shall be added to the hammer, or at the Contractor's option, a hammer larger by a similar amount may be furnished.

(b) **Steam Hammer.** When a steam hammer is used for driving wood piles, it shall deliver to the pile head an energy per blow of not less than 3500 foot-pounds at each full stroke of the piston.

When a steam hammer is used for driving concrete piles, it shall deliver to the pile head at each full stroke of the piston an energy per blow of not less than 3500 foot-pounds for each cubic yard of concrete in the pile, but in no case shall the energy per blow be less than 6000 foot-pounds.

The driving energy of double acting steam hammers is dependent on the pressure and rate at which the steam is supplied to the cylinder. If this pressure is insufficient to develop the energy with which the hammer is designed to act, the Contractor shall be required to increase boiler capacities sufficiently to secure the desired result.

(c) **Water Jets.** Where conditions will permit, water jets or a combination of water jets and driving with a hammer may be used. The jets shall not be attached to the sides of the piles but shall be operated independently.

(d) **Followers.** In general, the use of followers will not be permitted and they shall be used only with the permission of the Engineer.

2501.09 PREPARATION OF WOOD PILES FOR DRIVING. All wood piles, unless specific permission is given otherwise by the Engineer, shall be protected against splitting or brooming at the head by the use of steel pile rings or collars, special guide caps, or other suitable devices. Pile rings when used shall consist of bands of steel 2 to 3 inches in width by $\frac{1}{2}$ to one inch in thickness. They shall be of such diameter or diameters as will permit them to encircle the ordinary sizes of piles used with a minimum reduction of the area of wood in the pile head. Such reduction shall ordinarily not be greater than 25 per cent of the original area of the pile head. In all cases, the trimming of the pile head shall be such as will cause a driving fit in the pile ring or driving cap, and provide a maximum of support for the wood fibers. Driving caps shall have a depth of recess sufficient to encase the head of the pile for a depth of 6 inches. In case a pile head becomes broomed or crushed before driving is completed, it shall be cut off square at a point where the wood is sound, before driving is continued. The lower end of the pile shall be cut square or tapered to a point not less than 4 inches square, as directed by the Engineer. The tapered point, when used, shall be concentric with the center-line of the pile. Protection of piling against splitting or brooming shall be at the Contractor's expense. When not specified on the detailed plans but deemed necessary by the Engineer, he may require the Contractor to furnish and place metal shoes on the lower ends of the piles, for which the Contractor shall be compensated as "extra work" as specified in Paragraph 1109.04.

2501.10 PREPARATION OF CONCRETE PILES FOR DRIVING. The tops of all precast concrete piles shall be protected before driving is begun. This protection may consist of rope mats, wood blocks, sand boxes, or other suitable material, except that in case the plans call for extra length as protection during driving, such extra length shall be measured and paid for as part of the pile, as provided in Paragraph 2501.17. The protective cushions shall be so placed and maintained at all times as to reduce to a minimum the injury to the pile in driving. When not specified on the detailed plans but deemed necessary by the Engineer, he may require the Contractor to furnish and place metal shoes on the lower ends of the concrete piles, for which the Contractor shall be compensated as "extra work" as specified in Paragraph 1109.04.

2501.11 ACCURACY IN PLACING AND DRIVING PILES. In spotting the points of piles preparatory to driving, the Contractor shall use care to locate them as shown on the plans or as directed by the Engineer, and the deviation from such designated locations shall not exceed 3 inches at the time driving is begun, except as may be made necessary by the presence of large boulders, broken piling or other unavoidable obstructions. Only when shown on the plans or with the permission of the Engineer shall piling be driven closer together than 2 feet, 6 inches. While being driven, the piles shall be so held by toggles, shores, or cables as to deviate the minimum possible amount from the vertical, or the batter line shown on the plans.

2501.12 DETERMINATION OF BEARING VALUES. The bearing values of piles shall preferably be determined by actual load tests, in which the entire load shall be applied concentric with the pile and careful measurements taken with an engineer's level to determine the amount and rate of settlement. The test load shall not be applied until the pile has been allowed to rest at least 24 hours after driving. When bearing values are determined by actual test loads, the pile shall sustain 150 per cent of the loads specified in Paragraphs 2501.13 and 2501.14 for piles of the class being tested. The test load shall remain on the pile 48 hours with a maximum settlement of $\frac{1}{4}$ inch.

When load tests are not specified on the plans or ordered by the Engineer as "extra work", or are impractical, the bearing value of the piles shall be determined by one of the following formulas:

- (a) $P = \frac{2WH}{S + 1}$ for gravity hammers.
- (b) $P = \frac{2WH}{S + 0.1}$ for single acting steam hammers.
- (c) $P = \frac{2E}{S + 0.1}$ for double acting steam hammers.

Where P = safe load in tons.

W = weight in tons of a gravity hammer or of the moving part of a single acting steam hammer.

h = height of fall in feet.

S = average penetration of pile per blow in inches for the last few blows, (5 for gravity hammers, and 10 for steam hammers).

E = energy per blow in foot-tons of a double acting steam hammer.

The above formulas are applicable only when:

- (a) The hammer has a free fall.
- (b) The head of the pile is free from broomed or crushed fiber.
- (c) The penetration is at a reasonably quick and uniform rate.
- (d) There is no sensible bounce to the hammer after the blow.

Twice the height of the bounce shall be deducted from "h" to determine its true value for use in the formula.

Where piles are placed by jetting or by a combination of driving with a hammer and jetting, the safe bearing values shall be determined by test loads, or by the above formulas from results of driving with a hammer after the jets have been removed.

Bearing values of piles cast in place shall be determined by test loads, or as provided by plans and special provisions applying to such work.

2501.13 FOUNDATION PILES. For the purposes of this paragraph the term "foundation piles" shall be construed to mean all piles whether of wood, concrete, or steel, which support superimposed loads and whose entire length in the completed structure is driven into and supported, laterally as well as vertically, by the surrounding soil.

Foundation piles shall be used in all abutment and pier foundations wherever it is possible to drive them.

In all cases where foundation piles are to be driven, the excavation shall be completed before the driving of the piles is started. After the driving is completed, all loose and displaced materials forced up in driving shall be removed from around the piles, leaving a clean solid surface to receive the concrete.

The arrangement of pile driving equipment for foundation work shall be such as to permit the leads to be lowered to the elevation of cut-off and the use of followers to transmit the blow of the hammer to lower levels will not be permitted except with the consent of the Engineer.

After the piles have been driven, the tops shall be trimmed of all crushed or broomed wood, or shattered concrete. The top of creosoted piles after cut-off shall be painted with two coats of hot creosote oil specified in Paragraph 4116.02.

Unless otherwise shown on the plans, the piles shall project into the footing concrete 12 to 18 inches.

Unless otherwise provided on the plans, or in the Special Provisions, all foundation piles shall be driven until the bearing value, determined as provided in Paragraph 2501.12 is at least equal to that specified in the following table for the class of piles being driven:

Wood piles	18 tons
Steel piles	18 tons
Concrete piles	30 tons

In all cases, regardless of the fact that the required bearing value may have already been secured, the driving shall continue until the following requirements as to penetration have been met:

The minimum penetration in firm materials shall be 10 feet, and in soft materials or materials which may become soft when saturated with water, the minimum penetration shall be 18 feet.

In special cases, with the consent of the Engineer, not to exceed 20 per cent of the piles in any one footing or cluster may have a penetration as small as 8 feet in firm material, providing the points rest on impenetrable strata.

In the case of a stratum of soft material overlying other strata of firm material, the penetration into the strata of firm material shall be not less than 1/3 the length of the pile, and in no case less than 8 feet.

2501.14 TRESTLE PILES. For the purposes of this paragraph, the term "trestle piles" shall be construed to mean all piles whether of wood, steel or concrete, which support superimposed loads, but which in the completed structure will be exposed above ground level for a part of their length. End bents of bridges and others around which fills may later be constructed are not thereby removed from this classification.

Wood and steel piles shall be driven with such accuracy as will permit them to be capped as shown on the plans with a minimum of springing or bending, and only such springing as will not injure the structure of the pile will be permitted. If, in the judgment of the Engineer, a pile has been seriously injured by springing into place after being driven, it shall be removed and replaced.

Precast concrete piles shall be so driven as to stand without springing in the correct position, and shall not approach closer than 2 inches to the faces of the caps as shown on the plans. In case it is necessary to move a concrete pile after driving to secure the above accuracy, it shall be done by loosening the soil surrounding the pile with jets until it can be moved and stand without strain in the correct position.

Piles for trestles shall be cut off level or at the designed slope at the elevation of "cut-off" shown on the plans or as directed by the Engineer. The length above this elevation shall be sufficient to permit the complete removal of all material injured by driving.

In creosoted wood piles all bolt holes, cuts, daps or chamfers made subsequent to treatment as well as all abrasions of the surface and the tops of the piles after "cut-off" shall be given 2 coats of hot creosote oil conforming to requirements of Paragraph 4116.02. When the top of creosoted piles are not to be encased in concrete they shall be protected by covering with asphalt mastic and roofing felt as specified in Paragraph 2409.05.

Piles that are to support framed trestle bents will in general be cut off approximately 3 feet above the surface of the ground.

Unless otherwise provided on the plans or in the special provisions, all trestle piles shall be driven until the bearing value, determined as provided in Paragraph 2501.12 is at least equal to that specified in the following table for the class of piles being driven:

Wood piles	15 tons
Steel piles	15 tons
Concrete piles	25 tons

In all cases, regardless of the fact that the required bearing value may have already been secured, the driving shall continue until the following requirements as to penetration have been met.

The penetration for precast concrete piles shall be as shown on the plans and only with the consent of the Engineer shall any deviation from these requirements be permitted.

The length of wood or steel piles shown on the plans, or ordered by the Engineer, for any specific structure, shall be construed as indicating the desired penetration and the effort to secure this penetration shall be continued as long as the pile moves readily under single blows of the hammer. Ordinarily the minimum penetration in firm materials shall be 10 feet, and in soft materials or materials which may become soft when saturated with water, the minimum penetration shall be 18 feet.

In special cases, with the consent of the Engineer, not to exceed 20% plus one pile of the number of piles in any bent may have a penetration as small as 8 feet in firm material, providing the points rest on impenetrable strata.

In the case of a stratum of soft material overlying other strata of firm material, the penetration into the strata of firm materials shall be not less than 1/3 the length of the pile, and in no case less than 8 feet.

2501.15 OTHER EXPOSED PILES. Piles which do not carry superimposed loads such as fender piles, wing dam piles, revetment piles, and piles to control slides, will be driven at least to the penetrations required above for trestle piles, as shown on the plans or special provisions covering such work, without regard to their bearing values.

The heads of creosoted piles after cut-off shall be treated as specified in Paragraph 2409.05.

2501.16 EXTENSIONS AND "BUILD-UPS". Extensions, splices and "build-ups" on concrete piles shall be avoided but when necessary they shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary form work shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to placing concrete, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement. The forms shall remain in place not less than 7 days and shall then be carefully removed and the entire exposed surface of the pile finished as specified in Paragraph 2402.22 (b).

2501.17 MEASUREMENT AND PAYMENT. In all cases the length of pile upon which payment is made shall be the total length of pile as measured in the leads before driving. The contract unit price shall be full payment for furnishing, driving, bracing and cutting off all classes of piles except as follows:

(a) **For Increased Length of Piles.** When piles ordered by the Engineer are of length greater than that specified in the contract, the contract unit price shall be increased by an amount sufficient to compensate the Contractor for the additional cost per foot of pile f.o.b. the cars at unloading point.

(b) **Sheet Piles.** When sheet piles are specified to become a part of the permanent structure they shall be paid for at the contract unit price per square foot for wood or concrete sheet piles of the thickness specified and for steel sheet piles of the required weight and cross section, for the area of the wall or walls placed. The area of wall shall be determined from measurements of the length of sheet piles and the inside horizontal dimensions of the wall.

If no price for sheet piles is specified in the contract, the payment shall be made as for "extra work", Paragraph 1109.04.

(c) **Piles Ordered and Not Driven.** Piles ordered by the Engineer and not required in the construction shall be purchased by the Commission from the Contractor at the actual cost of piles delivered to the site, plus 5 per cent as an overhead charge. The piles so purchased shall become the property of the Commission.

If piles ordered by the Engineer are cut to shorter lengths before driving, payment

shall be made as follows: The portion used will be paid for at the contract price per lineal foot in the leads, except that for lengths shorter than 16 feet, payment will be made for 16 feet. Payment for the rest of the pile not paid for as above shall be at the actual cost of the material plus 5 per cent.

(d) **Test Piles.** Test piles driven as ordered by the Engineer and under his supervision shall be considered as "Extra Work" for which payment shall be made as provided in Paragraph 1109.04.

(e) **Extensions and "Build Ups".** Concrete placed for extensions and "build ups" of precast concrete piles shall be paid for at the contract unit price per cubic yard for Concrete Masonry except that no allowance will be made for concrete to replace portions of piles damaged in driving.

Section 2502. Tile Underdrains.

2502.01 DESCRIPTION. Tile underdrains consist of lines of pipe at various depths, tile intakes with gratings, blind inlets and outlet protecting walls or casings. The location and depth of underdrains, size of pipe and type of inlet are shown on the plans, and the laying is covered by these specifications.

2502.02 MATERIAL. The tile used shall meet the requirements of Paragraph 4111.01.

2502.03 BLIND INLETS TO TILE DRAINS. Where shown on the plans inlets to the tile drain shall be constructed by filling the trench for a length of about 3 feet with coarse gravel, broken stone, or other suitable porous material.

2502.04 INTAKES TO TILE DRAINS. Tile intakes of the design shown on the plans shall be constructed where shown on the plans or ordered by the Engineer.

The construction of tile intakes shall include furnishing and placing one outlet drain tile through the wall of the intake. The joints on tile lines which are outlets for tile intakes shall be cemented for a distance of 8 feet from the intake.

2502.05 LAYING PIPE. Construction shall commence at the outlet and proceed up grade continuously unless the Engineer gives permission to lay the tile in sections.

The Engineer will furnish stakes and figures for the grade of the flow line of the tile, and the pipe shall be set accurately to line and grade.

The bottom of the trench shall be shaped to fit from 60 to 90 degrees of the pipe. If rock, shale, hardpan, or other very hard material is encountered the pipe shall be carefully bedded with loam or clay.

The ends of the pipe shall be laid as close together as possible, and the space between tile shall not exceed $\frac{1}{4}$ inch. Where this is impossible the space shall be carefully covered with pieces of broken pipe. Junctions of tile lines shall be made with tile specials. Where the change in tile diameter exceeds 2 inches special connections shall be used.

When existing tile lines are encountered, all necessary precautions shall be taken to prevent injury to same. If so directed by the Engineer such tile lines shall be connected up with the drain being installed.

2502.06 BACK-FILLING. No pipes which are in trenches 6 feet or less in depth shall be covered in any way until they have been inspected by the Engineer.

Where depth of trench is more than 6 feet the pipe may be covered with the last spading in the ditch, but the Contractor shall at his own expense uncover any of the tile for inspection if requested by the Engineer to do so.

Except when porous back-filling material is specified, as soon as the pipe in the trench have been inspected and approved they shall be carefully covered to a depth of approximately 6 inches with soil or other approved material. Sand or boulders shall not be placed directly on the pipe. After the drains have been thus blinded the trench shall be entirely back-filled with all material excavated therefrom. When

porous back-filling material is specified, the Contractor shall place acceptable material consisting of crushed stone or coarse gravel around the pipe and to the depth shown on the plans. The materials removed in excavating the trench shall be disposed of as directed by the Engineer.

Where tile drains are constructed across a highway the back-filling shall be hand-tamped in 6-inch horizontal layers across the portion of the road used as a traveled way.

2502.07 BASIS OF PAYMENT. The contract price per lineal foot for tile drain complete shall be full payment for furnishing all material, equipment, tools and labor, including hauling necessary to complete the drain and place the back-fill, all in accordance with the plans and specifications except that this price shall be increased by 50 per cent for tamping the backfill. No extra compensation will be allowed for the labor of back-filling with porous material. If the depth of trench is more than 4 feet, additional compensation will be allowed for overdepth as hereinafter provided.

Any special work not shown on the plans or in the special provisions but required of the Contractor for the protection of tile outlets, will be paid for as extra work as specified in Paragraph 1109.04.

(a) **Rock Excavation.** Bids for tiling, unless otherwise provided in the special provisions, shall be based on the assumption that no rock excavation will be encountered. Should loose or solid rock, or boulders exceeding one cubic foot in volume, be encountered, the excavation of such materials will be paid for as "extra work".

(b) **Overdepth.** Bids on tile drains shall be based on a depth of trench of not to exceed 4 feet. Where the depth of trench is in excess of 4 feet, overdepth will be allowed. For the purpose of computing overdepth it will be assumed that 50 per cent of the contract price is for labor. Overdepth will be paid in accordance with the following schedule:

For each 1/10 of one foot of overdepth between 4 feet and 6 feet the labor contract price per lineal foot shall be increased by 3 per cent. For each 1/10 of one foot of overdepth between 6 feet and 8 feet the labor contract price per lineal foot shall be increased by 3 per cent of the computed price for 6-foot depth. Similarly, for depths of trench between 8 feet and 10 feet, the price on 8-foot work shall be the base price used in computing overdepths; for depths of trench between 10 feet and 12 feet, the price on 10-foot work shall be the base price used in computing overdepth; and for all depths of trench in excess of 12 feet, the price on 12-foot work shall be the base price used in computing overdepth.

The "cuts" marked on the hub stakes are not necessarily the measurements from which overdepth is computed. Overdepths will be computed from measurement from the highest part of the trench to grade line of tile.

(c) **Constructing Tile Intakes.** The contract price for constructing tile intakes shall be full payment for the furnishing of all material, labor, tools and equipment for completing the intakes in accordance with the plans, and including the cementing of the joints for outlet tile, as provided in Paragraph 2502.04, and the furnishing and placing of the cast iron grates.

(d) **Furnishing Porous Material for Back-filling.** The contract price per cubic yard for porous materials for back-filling shall be full payment for the material delivered at the roadside as near as possible to the point where it is to be used.

Section 2503. Guard Rail.

2503.01 DESCRIPTION. Guard rail consists of one or more steel cables supported on posts located on the shoulder line, with end anchors, constructed in accordance with the details shown on the plans.

2503.02 MATERIAL. The materials used in guard rail construction shall conform to the requirements of Part IV for the following materials:

Posts shall be round wood posts conforming with the requirements of Section 4121 for size, type and preservative treatment specified on the plans or contract.

Wire rope and fittings shall conform to the requirements of Paragraphs 4124.03 and 4124.04 for the size of cable specified on the plans or the contract.

2503.03 SETTING POSTS AND STRETCHING CABLE. The posts shall be set plumb and firm and to the lines and grades given by the Engineer. The back-filling in the post holes shall be thoroughly tamped and the end posts braced as shown on the plans. Cable shall be stretched taut by some mechanical device. When the cable is taut the tightening nuts shall be at approximately the center of the threaded portion of the tightening rods.

2503.04 SETTING END ANCHORAGE. End anchorage will consist of anchors or deadmen with anchor rods, turnbuckles, washers and guard posts of the type shown on the plans. Care shall be used to place the concrete deadmen at the proper angle. The excavation shall then be back-filled with the materials excavated, and thoroughly tamped in 6-inch layers. When the cables are tightened the anchor rods shall be fully threaded through nuts and turnbuckles.

2503.05 BORING, FRAMING OR DOMING TREATED POSTS. All boring, framing or doming shall be done before treatment whenever possible. When creosoted posts are bored after treatment the bolt holes shall be treated with creosote oil by a pressure process approved by the Engineer.

2503.06 PAINTING GUARD RAIL POSTS. Guard rail posts shall be painted as indicated on the plans. The painting on the upper portion of posts not pressure-treated with creosote oil shall consist of 2 coats of white paint complying with the requirements of Paragraph 4115.04 (a). The painting on the lower portion of all posts shall consist of 2 coats of black paint complying with the requirements of Paragraph 4115.04 (e).

The painting on the upper portion of posts pressure-treated with creosote shall consist of 2 coats of aluminum paint complying with the requirements of Paragraph 4115.04 (i). The paint shall be brushed thoroughly and all exposed surfaces shall be completely covered.

The provisions of Paragraphs 2507.04 and 2507.05 referring to painting conditions and application of paint shall apply to painting guard rail posts. Aluminum paint shall be spread at the rate of approximately 600 square feet per gallon, and other paints at approximately 500 square feet per gallon. Each coat shall be thoroughly dry before the next coat is applied.

2503.07 BASIS OF PAYMENT. Guard rail construction will be paid for at the contract prices per lineal foot for constructing guard rail complete and per end anchor. These prices shall be full payment for furnishing all tools, equipment and material, and performing all work necessary to complete the guard rail and set end anchors in accordance with the plans and these specifications.

Section 2504. Wood Baffle Walls.

2504.01 DESCRIPTION. Wood baffle walls consisting of plank set vertically are installed in ditches to prevent erosion. Details of design are shown on the plans.

2504.02 MATERIAL. Unless otherwise specified in the contract, material for wood baffle walls shall be 2 in. x 12 in. x 18 ft. rough Fir or Southern Pine conforming to the requirements for Class C lumber, Section 4120.

2504.03 CONSTRUCTION METHODS. In the construction of baffle walls the vertical plank may be placed either by driving or by excavating and backfilling. In back-filling the trenches excavated in baffle wall construction, the material shall be

thoroughly tamped in horizontal layers not exceeding 6 inches in depth. The plank shall be fastened to nailing strips in the manner shown on the plans.

Where ditches have widened to such an extent that a baffle wall of the dimensions shown on the standard plan is insufficient to span the ditch, the baffle wall shall be extended well into firm ground on each side of the ditch.

2504.04 BASIS OF PAYMENT. Baffle Walls Complete. The contract price for constructing standard baffle walls complete shall be full payment for furnishing all labor, tools, equipment and material necessary to complete the baffle walls in accordance with the plans and specifications. For the additional area of baffle wall that may be required by extensions of baffle walls to dimensions greater than the standard plan, the Contractor shall be paid at the prorated contract price per square foot for standard baffle wall.

Section 2505. Flumes.

2505.01 DESCRIPTION. Flumes consisting of shoulder basin, guard post, slope drain and discharge basin for the removal of surface water from pavements, shall be constructed in accordance with the plans and specifications, at the locations shown on the plans.

2505.02 MATERIALS. Materials shall conform to the detailed requirements of Part IV, "Materials Details". The guard post may be either treated or untreated round wood post conforming to the requirements of Paragraph 4121.02 and shall be painted as specified on the plans.

2505.03 CONSTRUCTION. The concrete used in flumes shall be mixed in one of the proportions specified in Paragraph 2303.11. The details of mixing, handling and placing of the concrete shall conform to the requirements of Section 2402.

2505.04 BASIS OF PAYMENT. The contract price for constructing Type A and Type B flumes shall include the furnishing of all tools, equipment, labor and material necessary for building the flumes complete and setting guard posts as shown on the plans. Adjustment of compensation for variations in lengths of slope drains from the lengths shown on the plans will be in accordance with the contract price therefor.

Section 2506. Riprap.

2506.01 DESCRIPTION. Hand-placed stone placed on stable earth slopes to prevent soil erosion by stream flow is the class of work contemplated. The location and extent of protection required shall be in accordance with the plans or special provisions.

2506.02 MATERIAL. Stone for riprap shall conform with the requirements of Paragraph 4105.05.

2506.03 METHOD OF CONSTRUCTION. Before placing the stone, the earth slopes shall be trimmed to true dimensions and to a slope of $1\frac{1}{2}$ to one, or flatter, as directed by the Engineer. The stone shall be placed to give a minimum depth of 12 inches perpendicular to the plane of the slope. Maximum depth shall be limited to the size of the stone that can be worked into the supporting bank and bring the outer surface of the stone to the prescribed plane of the outer surface of the riprap. Stone shall be placed by hand with joints normal to the slope and as small as practicable. Each stone shall be carefully bedded in the earth fill or slope so as to secure stability should support from lower courses be removed. For irregular rock, firm bedding on earth base may be secured by driving in rock spalls or tamping in loose earth. Large unavoidable joints on the outer surface of finished slope are to be filled with rock spalls. The larger pieces of stone will in general have the longest dimension horizontal, and the dimension nearest to 12 inches placed normal to the slope.

Unless otherwise specified, the riprap shall start in a trench excavated to a depth

of 2 feet (vertical) below the ground elevation at the base of the fill. Fore slope of trench shall be a continuation of, and at the same slope as the earth fill. Riprap shall be hand-placed in trench, in the same manner as prescribed for riprapping of earth slopes. The Contractor shall backfill the trench with the materials excavated.

2506.04 BASIS OF PAYMENT. Unless otherwise specified in the Special Provisions or contract, riprap of the full thickness specified on the plans, and complete in place will be paid for at the contract price per square yard of bank protection placed. The unit price shall be full payment for furnishing all material, freight, demurrage, hauling, excavation and backfilling, equipment, labor and performance of all work incidental to the completion of the riprap to the extent and thickness shown on the plans.

Section 2507. Painting Steel Structures.

2507.01 GENERAL REQUIREMENTS. Contracts involving the painting of metal structures shall include, unless otherwise provided in the contract, the proper preparation of the surfaces to be painted, the application, protection and drying of paint coatings, protection of all parts of the structure against disfigurement from spatters or splashes of paint, and the supplying of all tools, scaffolding, labor and material necessary for the work. All steel structures and metal purchased for structural steel work under these specifications shall be subject to the detailed requirements of this section regarding painting.

2507.02 MATERIALS. All paint for structural steel shall conform to the requirements of Section 4115 for the respective coating for which it is to be used.

2507.03 NUMBER OF COATS. After the erection and acceptance, all steel structures shall be painted three coats as follows:

First or Priming Coat.....	Red Lead
Second Field Coat.....	Red Lead and Lamp Black
Third Field Coat.....	(Unless otherwise specified) Aluminum Paint

2507.04 WEATHER CONDITIONS. Paint shall not be applied when the air temperature is below 40°F. or when the air is misty or when in the opinion of the Engineer, conditions are otherwise unsatisfactory for painting. It shall not be applied over damp or frosty surfaces.

2507.05 CLEANING. Prior to painting, all metal surfaces shall be cleaned of all old paint, grease, dirt, mill scale and rust or other foreign substances by means of sand blast or by power driven rotary steel brushes, scrapers, hammers, chisels, etc., which will produce results equivalent of sand blasting. Just prior to painting, all loose dirt and dust shall be removed with a bristle brush.

The bridge seats shall be cleared of all earth and debris and care shall be exercised that shoes and bearings are free from foreign matter. Expansion rollers shall be removed and thoroughly cleaned and painted before being replaced.

Should such time elapse between the cleaning and painting that rust results, such parts shall be recleaned.

2507.06 MIXING PAINT. Before paint is applied, it shall be thoroughly mixed so that the pigment is completely in suspension. It shall be kept in this uniform consistency during the application.

2507.07 APPLICATION. Paint may be applied by hand brushes or by suitable power spray. By either method the coating of paint applied shall be smoothly and uniformly spread so that no excess paint will collect at any point. To secure proper application with spray, the paint shall be brushed out where necessary and the workmanship shall be equal to that obtained by first class brush work. When brushes are used, the paint shall be so manipulated under the brush as to produce a smooth, uni-

form, even coating in close contact with the metal or with previously applied paint. Brushes used shall preferably be round or oval in shape. If flat brushes are used, they shall not be over three inches wide. On surfaces which are inaccessible to the brush, the paint shall be applied by properly constructed sheepskin daubers.

Power spraying equipment shall apply the paint in a fine even spray without the addition of any thinner. In cool weather, the paint may be warmed to reduce the viscosity for use. Such warming shall be accomplished by heating the paint containers in water or by placing them on steam radiators.

2507.08 DRYING. Each coat of paint shall be allowed to stand a sufficient length of time after application to permit the film to dry throughout the full thickness before an additional coat is applied. An additional drying or weathering period may be required for red lead paints when the surface of the dried film is too slick to receive the succeeding coat.

2507.09 RATE OF APPLICATION. The quantity of paint required per coat per ton will be approximately 0.3 gallon for I-Beams and 0.4 gallon for fabricated shapes. The Contractor shall furnish the Engineer every opportunity to check the quantity of paint actually applied to the structure.

2507.10 BASIS OF PAYMENT. The painting of new structures will not be paid for directly but will be considered as subsidiary to the furnishing and erection of structural steel, and no extra compensation will be allowed therefor.

Contracts for painting of old structures may be let on the basis of lump sum for individual structures or per gallon of paint applied, as stipulated in the Special Provisions. These contract prices shall be full payment for furnishing all materials, tools, scaffolding and other equipment and performing all cleaning and other work necessary to complete the work in accordance with these specifications.

Section 2508. Painting Woodwork.

2508.01 GENERAL REQUIREMENTS. All wood railings on timber trestle bridges and all exposed wood surfaces designated on the plans for painting, except floors, shall be given three coats of white paint conforming to the requirements of Paragraph 4115.04 (a).

For the first coat of paint applied, the paint may be thinned by adding to one gallon of paint one quart of raw linseed oil and one quart of turpentine or mineral spirits. For all subsequent coats, no thinning of paint will be permitted.

The provisions of Paragraph 2507.04 to 2507.08 inclusive shall apply to the painting of woodwork except that sand blast will not be used for cleaning.

For all coats except the priming coat on new wood, the paint shall be spread at approximately the following rates:

Aluminum paint	600 sq. ft. per gal.
Other paints	500 sq. ft. per gal.

Each coat of paint shall be thoroughly dry before the application of the succeeding coat.

2508.02 BASIS OF PAYMENT. The painting of woodwork on new construction shall be included in the unit contract prices for the structure.

Contracts for the painting of old structures may be let on the basis of lump sum for individual structures, or per gallon of paint applied, as stipulated in the Special Provisions. These contract prices shall be full payment for furnishing all materials, tools, scaffolding and other equipment and performing all cleaning and other work necessary to complete the work in accordance with these specifications.

Section 2509. Waterproofing.

2509.01 GENERAL. Reinforced concrete structures shall be waterproofed as designated on the plans and in the manner herein provided. When specified in the plans a protective coat of either a bituminous mastic or portland cement mortar shall be applied over the waterproofing coat. All waterproofing specified on the plans shall be construed to refer to the membrane waterproofing specified herein, unless otherwise specifically provided.

2509.02 INTEGRAL METHOD. The integral method of waterproofing by the addition of waterproofing compounds to the concrete when being placed shall be used only when specified on the plans. When so specified detailed specifications of the materials and method of use will be found in the special provisions covering the particular work included in the contract.

2509.03 MEMBRANE METHOD. The membrane waterproofing used shall consist of a bituminous priming coat, and two layers or plies of an asphalt saturated cotton fabric laid in and cemented with an approved asphalt.

(a) **Materials.** The materials used in the membrane waterproofing shall conform to the requirements of Part IV, as follows:

1. Asphalt Primer, Paragraph 4106.06 (b).
2. Cotton Fabric, Paragraph 4106.07.
3. Asphalt Cement, Paragraph 4106.06 (a).

(b) **Preparation of Surface.** The surface of the concrete to be treated shall be smooth and free from all sharp projections, dirt, dust or loose materials. Sharp projections which might injure the waterproof coating or prevent its adhering to the surface of the concrete shall be chiseled off and all dust or dirt carefully removed by means of brooms. The surface to receive the waterproofing shall be thoroughly dry.

(c) **Method of Construction.** The waterproof coating shall consist of a priming coat and 2 complete layers of fabric saturated with bitumen cemented together and to the structure, and the entire surface sealed by mop coats of asphalt cement.

The entire surface to be covered shall be brushed or sprayed with the primer at a rate of approximately 0.1 gallon per square yard. The amount of coating shall be sufficient to absorb any loose dust particles and provide a thin, continuous layer of bitumen adhering to the concrete. The primer coat shall set thoroughly before additional material is applied.

When the primer coat is thoroughly set, the asphalt cement heated to a temperature of 300 to 350°F. shall be mopped over the surface. The application of mop coat shall be started at the lower portion or portions and proceed to the highest portion of the surface. The mop coat shall be applied in horizontal strips. The first strip shall be half the width of the asphalt saturated fabric and a half width strip of fabric shall be spread on the freshly mopped surface. All wrinkles and air bubbles shall be removed and the fabric pressed tightly into the asphalt. The surface of this fabric strip and the adjacent concrete surface shall then be mopped with hot asphalt and a full width strip of the fabric applied and carefully smoothed. The surface of the upper half of this strip and an additional strip of concrete shall be mopped and a third strip of fabric applied. Successive strips shall be applied in this manner until the entire surface is covered.

Each successive strip of fabric shall lap at least 2 inches over the upper edge of the second sheet below. Where it is necessary to splice strips of fabric, the ends shall be lapped at least one foot. On the barrels of arches and all horizontal surfaces the ends of the waterproofing strips shall be carried up the adjacent vertical walls at least one foot to the flashing notch. At all drainage openings the fabric shall be carefully turned and mopped so that no water can get under the fabric.

After the fabric has been applied, all exposed edges, laps and flashing shall be given

an extra coat of asphalt and the entire surface shall be thoroughly mopped with the hot asphalt. The amount of asphalt applied shall not be less than 12 nor more than 14 gallons per 100 square yards of finished work.

Waterproofing shall be applied only in good weather, when the surface is thoroughly dry and the air temperature is above 40°F. The work shall be so scheduled that none of the fabric surface is left over night without being mopped with hot asphalt.

(d) Protective Coating. When specified on the plans a protective layer of portland cement mortar not less than 1½ inches in thickness shall be laid over the entire surface of the waterproofing immediately after it has cooled to normal temperature. This protective coating shall be composed of one part portland cement, 1½ parts of clean sand, and 3 parts of pea gravel or fine dustless screenings. It shall be uniformly distributed over the surface, gently tamped into place and so finished by hand that the surface is uniform and free from voids, rough spots or projections. After being placed the mortar protective coat shall be covered with straw, sand or canvas and kept wet for a period of one week. Care must be taken to prevent the protective coating from being injured after being placed.

2509.04 MEASUREMENT AND PAYMENT. Waterproofing will be paid for at the contract price per square yard of surface covered. The contract price per square yard shall be full payment for furnishing all material, equipment and labor necessary to apply the waterproofing in accordance with the plans and these specifications.

PART III.
DESIGN DETAILS

To be printed separately.

PART IV.

MATERIALS

Section 4101. General Provisions.

4101.01 SOURCE OF SUPPLY. Materials complying with these specifications will be accepted from any source of supply, but the Commission reserves the right to reject the entire output of any source from which it is impossible to get a continuous supply of satisfactory material, or when conditions are such that the use of unfit material cannot be prevented except by extraordinary methods.

4101.02 METHODS OF TESTING. Unless otherwise noted, apparatus and methods used for testing materials shall conform to the American Association of State Highway Officials "Tentative Standard Methods of Sampling and Testing Highway Materials". Unless otherwise noted, percentages contained in specification requirements are percentages by weight. Aggregates shall be separated into distinct units of not more than 100 tons which units shall be kept separate for a sufficient time to provide for proper testing and inspection. Each of such units shall conform to the requirements specified for the kind of material represented.

4101.03 SPECIFICATIONS REFERRED TO. All reference to A.S.T.M. specifications or A.S.T.M. methods of tests shall be construed to mean the latest specifications or methods of tests adopted prior to the date of contract by the American Society for Testing Materials for the material or the method of test indicated by the reference quoted.

All references to A.A.S.H.O. specifications or A.A.S.H.O. methods of tests shall be construed to mean the latest specifications or methods of tests adopted prior to the date of contract by the American Association of State Highway Officials for the material or the method indicated by the reference quoted.

Section 4102. Portland Cement.

4102.01 GENERAL REQUIREMENTS. Portland cement shall comply with the requirements of the A.S.T.M. "Standard Specifications for Portland Cement," Designation C 9-30, or with the requirements of the A.S.T.M. "Tentative Specifications for High Early Strength Portland Cement," Designation C 74-30. High Early Strength Portland Cement will not be required unless specified in the Special Provisions.

4102.02 TESTING. Cement may be tested either at the mill or at destination. Approval can ordinarily be given within 36 hours after sampling if the cement passes the specification requirements for fineness, soundness, and time of setting; but if so ordered, the cement shall be held for the 7-day or 28-day tests. The cement shall be

tested in accordance with the A.S.T.M. "Standard Methods of Sampling and Testing Portland Cement," Designation C 77-32.

Section 4103. Water for Concrete.

4103.01 GENERAL REQUIREMENTS. The water used for concrete or mortar shall be clean, clear and free from oil, acid, alkali or vegetable matter. Water shall not be used until the source of the supply has been approved. If at any time the water becomes of unsatisfactory quality or insufficient quantity, the Contractor may be required to provide water from some other source.

Section 4104. Fine Aggregate for Concrete.

4104.01 GENERAL DESCRIPTION. Fine aggregate shall consist of sand having durable grains free from injurious amounts of silt, shale, coal, organic matter or other deleterious substances.

4104.02 MAXIMUM PERMISSIBLE AMOUNTS OF INJURIOUS SUBSTANCES.

	Per Cent
Shale and coal particles retained on No. 14 sieve	1.5
Silt	1.5
Organic impurities (other than coal).....	not more than that indicated by Figure 2 when tested in accordance with the A.A.S.H.O. "Method of Test for Organic Impurities in Sands for Concrete", Tentative Method T-21.

4104.03 SIZE OF PARTICLES. When tested by means of laboratory sieves, the sand shall conform to the following requirements:

	Per Cent
Passing a $\frac{3}{8}$ inch sieve	100
Passing a No. 4 sieve	95 to 100
Passing a No. 8 sieve	80 to 95
Passing a No. 30 sieve	15 to 40
Passing a No. 100 sieve	0 to 5

Exact compliance with these grading requirements may be waived if the sand complies with the strength requirement in Paragraph 4104.04 and laboratory studies of the concrete making properties of the sand indicate that concrete of satisfactory strength can be produced by its use in the proportion specified.

4104.04 STRENGTH. Mortar briquettes, cylinders or prisms consisting of one part by weight of portland cement and 3 parts by weight of fine aggregate, mixed and tested in accordance with the methods described in the A.S.T.M. "Standard Methods of Sampling and Testing Portland Cement" Designation C77-32, shall have tensile, compressive or bending strength at the ages of 7 and 28 days equal to that of 1:3 standard Ottawa sand mortar of the same consistency made with the same cement.

Fine aggregate which fails to meet the foregoing strength requirement shall only be used in special mixtures which shall be designed by the Engineer by means of laboratory studies to yield concrete of the class required by the work.

Section 4105. Coarse Aggregate.

4105.01 COARSE AGGREGATE FOR CONCRETE. Coarse aggregate for concrete shall consist of gravel or crushed stone complying with the following requirements as to size of particles, percentages of objectionable materials and resistance to abrasion.

(a) **Soundness.** Any class of particles in coarse aggregate will be considered as

unsound if any of the particles in a representative sample of that class of particle are disintegrated, or more than 20 per cent of such particles are split when subjected to 5 alternations of the A.A.S.H.O. "Method of Test for Soundness of Coarse Aggregate (Sodium Sulphate Soundness Test)" Tentative Method T-9; or when subjected to 16 alternations of the Freezing and Thawing Test described in the A.S.T.M. "Standard Specifications for Drain Tile" Designation C4-24. In the case of deposits from which material has been used in concrete for 10 years or more the behavior of the material in such concrete will be considered in the interpretation of the results of soundness tests.

(b) **Maximum Permissible Amounts of Objectionable Materials.** The percentage of objectionable substances shall not exceed the following maximum limits:

	Per Cent
Silt and Clay	1.5
Shale	0.8
Total of shale, unsound chert, and other kinds of materials whose disintegration is accompanied by an increase in volume which may cause the spalling of concrete or mortar in which they are contained.....	2.0
Clay lumps	0.5
Coal	0.5
Sticks (wet weight)	0.1
Organic matter (other than coal and sticks)	0.0

Coarse aggregate shall not contain a combined total of more than 5 per cent of the objectionable particles listed above plus any unsound particles not listed above plus particles having more than one-fourth their surface covered with a coating of shale or clay which is not dissolved when the aggregate is immersed in water for two minutes.

Gravel shall not have a percentage of wear in excess of 20 when tested in accordance with the A.A.S.H.O. "Method of Test for Abrasion of Gravel" Tentative Method T-4, Grading B.

(c) **Sieve Analysis.** When tested by means of laboratory sieves, the coarse aggregate shall meet the following requirements except that for use in reinforced concrete masonry construction the coarse aggregate shall all pass a 1½ inch sieve regardless of the mix used. For Class C Concrete, the coarse aggregate shall all pass ¾" sieve and not less than 50% shall pass the ⅜" sieve.

For the proportions specified for the various mixes see Paragraphs 2303.11 and 2402.02.

(1) **For use in Mix No. 1, 2, 3 or 4.**

	Per Cent
Passing a 2½ inch sieve	100
Passing a 1½ inch sieve	95 to 100
Passing a ¾ inch sieve	40 to 70
Passing a ⅜ inch sieve	10 to 30
Passing a No. 4 sieve	0 to 5

(2) **For use in Mix No. 2, 3 or 4.**

	Per Cent
Passing a 2½ inch sieve	100
Passing a 1½ inch sieve	80 to 100
Passing a ¾ inch sieve	30 to 80
Passing a ⅜ inch sieve	10 to 40
Passing a No. 4 sieve	0 to 5

(3) For use in Mix No. 3 or 4.

	Per Cent
Passing a 2½ inch sieve	100
Passing a 1½ inch sieve	70 to 100
Passing a ¾ inch sieve	20 to 90
Passing a ⅜ inch sieve	5 to 50
Passing a No. 4 sieve	0 to 5

(d) **Classes of Coarse Aggregate for Concrete.** Coarse aggregate for concrete shall conform to one of the following classes as specified in the contract:

Class I. Class I coarse aggregate shall consist of clean, sound, crushed trap rock, quartzite or granite. This class of aggregate shall contain at least 85 per cent of rock crushed from ledges having a percentage of wear of 5 or less.

Class II. Class II coarse aggregate shall consist of gravel pebbles or crushed limestone. Crushed limestone shall consist of stone of which not less than 95 per cent shall be crushed from ledges having a percentage of wear of 8 or less. Gravel shall not have a percentage of wear greater than 20 when tested in accordance with the A.A.S.H.O. "Method of Test for Abrasion of Gravel", Tentative Method T-4, Grading B.

Mixtures of crushed stone and gravel pebbles may be used if approved by the Engineer provided the composition of the mixture is uniform and the sieve analysis of the crushed stone and gravel, after being combined, meets the required grading for coarse aggregate.

Class III. Class III aggregate shall consist of gravel pebbles combined with fine aggregate in the form of pit-run or unscreened gravel, or any combination of such unscreened gravel with Class I or Class II coarse aggregate. The proposed source of supply and methods of preparing and handling of unscreened gravel must be definitely approved by the Engineer before any material is delivered. Pit-run or unscreened gravel to be used in combination with Class I or Class II coarse aggregate shall contain not less than 60 per cent of particles that will pass a No. 4 sieve. Pit-run or unscreened gravel to be used without the addition of coarse aggregate shall contain not less than 45 per cent of particles that will pass a No. 4 sieve. The percentage of sand in the pit-run or unscreened gravel to be used at any single proportioning plant set-up shall not vary more than 5 per cent from the average agreed to by the Contractor in securing the approval of the Engineer for the use of such material. That portion of the unscreened gravel passing a No. 4 sieve shall conform to the requirements for fine aggregate. That portion retained on a No. 4 sieve shall conform in all respects to the requirements for Class II coarse aggregate with the following exception. When unscreened gravel is used in combination with Class I or Class II coarse aggregate, that portion of the mixture retained on a No. 4 sieve shall comply with the requirements of Paragraph 4105.01 (c).

Class V. Class V aggregate shall consist of a mixture of fine and coarse aggregates of the following composition and having such characteristics that the mixture prescribed in Paragraph 2303.11 (b) will be sufficiently plastic for use in pavements:

	Per Cent
Passing a 1½ inch sieve	100
Passing a No. 4 sieve	80 to 92
Passing a No. 8 sieve	60 to 75
Passing a No. 30 sieve	25 to 35

That portion of the combined aggregate passing a No. 4 sieve shall in other respects comply with the specifications for fine aggregate, and that part retained on the same sieve shall in other respects comply with the specifications for Class II coarse aggregate.

4105.02 RUBBLE AND CYCLOPEAN AGGREGATE. "One man stones" (i.e. stones not larger than one man can readily lift) to be used in rubble or cyclopean masonry and as bond or dowel stones in construction joints shall consist of angular fragments of tough, dense and sound rock having a percentage of wear of not more than 8. They shall be free from seams or other structural defects and from surface coatings of any character. The stone shall comply with the requirements of the soundness test specified in Paragraph 4105.01 (a).

4105.03 COARSE AGGREGATE FOR BITUMINOUS MAT FLOORS. Pea gravel or stone chips used in bituminous mats on bridge floors shall consist of clean, hard particles. The material shall comply with the requirements of the soundness test specified in Paragraph 4105.01 (a). The particles shall be of such size that at least 95% will pass a 1/2 inch sieve, not more than 15% will pass a No. 4 sieve, and not more than 5% will pass a No. 8 sieve. The amount of objectionable particles shall conform to the requirements of Paragraph 4105.01 (b).

4105.04 MATERIAL FOR GRAVEL SURFACING. When delivered on the road, the material for gravel surfacing shall be a uniform mixture of coarse and fine particles of gravel or crushed stone. Material of separated sizes shall be loaded in not less than five layers which shall be so arranged that a uniform gradation will be produced with any system of unloading. When subjected to the soundness test specified in Paragraph 4105.01 (a) only those particles showing disintegration will be considered unsound. Splitting or slight spalling will not be considered objectionable. The material shall comply with the requirements for one of the following classes of material as specified in the contract:

(a) Class A Gravel.

	Per Cent
Maximum of mudballs, sticks, clay, silt and unsound particles	5
Passing a one inch square or 1 1/4 inch round opening	100
Passing a 3/8 inch sieve	30 to 65
Passing a No. 8 sieve	15 to 35

Class A Gravel shall have a percentage of wear not greater than 25 when tested in accordance with the A.A.S.H.O. "Method of Test for Abrasion of Gravel", Tentative Method T-4, Grading C.

(b) Class B Gravel.

	Per Cent
Maximum of mudballs, sticks, clay, silt and unsound particles	8
Passing a 1 inch square or a 1 1/4 inch round opening	100
Passing a No. 4 sieve	50 to 75
Passing a No. 8 sieve	25 to 50

(c) Class C Gravel.

	Per Cent
Maximum of mudballs, sticks, clay, silt and unsound particles	12
Passing a 1 inch square or a 1 1/4 inch round opening	100
Passing a No. 8 sieve	35 to 65

(d) Class A Crushed Stone. Class A crushed stone shall consist of stone at least 85 per cent of which shall be crushed from ledges having a percentage of wear of 8 or less. When samples of the crushed product are tested in accordance with the A.A.S.H.O. "Method of Test for Abrasion of Gravel" Tentative Method T-4, Grading C, the percentage of wear shall not exceed 30.

	Per Cent
Maximum of clay balls	5
Maximum of clay balls and unsound stone	20
Passing a 1 inch square or a 1 1/4 inch round opening	100
Passing a No. 8 sieve	10 to 20

(e) **Class B Crushed Stone.** Class B crushed stone shall consist of stone at least 85 per cent of which shall be crushed from ledges having a percentage of wear of 12 or less. When samples of the crushed product are tested in accordance with the A.A.S.H.O. "Method of Test for Abrasion of Gravel" Tentative Method T-4, Grading C, the percentage of wear shall not exceed 45.

	Per Cent
Maximum of clay balls	8
Maximum of clay balls and unsound stone	20
Passing a 1 inch square or a 1 $\frac{1}{4}$ inch round opening	100
Passing a No. 8 sieve	5 to 30

4105.05 STONE FOR RIPRAP. Stone for riprap shall be sound, durable rock. The stones shall be as nearly rectangular as practical, and shall have one dimension as near 12 inches as practical. Individual stones shall weigh not less than 50 pounds and not more than 150 pounds. At least 75 per cent of the individual stones shall weigh more than 100 pounds.

The stone, when subjected to the soundness test specified in Paragraph 4105.01 (a), shall show no disintegration and not more than 10% of the particles shall split or show slight spalling. Whenever possible, the results of this test shall be corroborated by inspection of ledges of the stone which have been exposed to the weather.

Section 4106. Bituminous Materials.

4106.01 BITUMINOUS MATERIALS FOR WEARING SURFACES FOR BRIDGE FLOORS.

(a) **First Coat Tar.** The first or prime coat for tar bituminous wearing surfaces (cold application) on concrete or wood bridge floors shall conform to the requirements of the A.S.T.M. "Standard Specification for High Carbon Tar for Surface Treatment, Cold Application" Designation D104-30. The specific viscosity shall be 8 to 13.

Measurement shall be based on the volume of material at temperature of 60°F.

(b) **Second Coat Tar.** The second coat for tar bituminous wearing surfaces (hot application) on concrete or wood bridge floors shall be a homogeneous refined tar, free from water and conforming to the requirements of the A.S.T.M. "Standard Specifications for High Carbon Tar for Surface Treatment, Hot Application" Designation D108-30.

Measurement shall be based on the volume of material at temperature of 60°F.

(c) **Asphalt.** The asphalt for bituminous wearing surfaces on concrete or wood bridge floors shall be an asphaltic cement conforming to the requirements of the A.A.S.H.O. "Tentative Standard Specifications for Asphalt Cement," Specification M21 or M23 Penetration 85-100.

4106.02 BITUMINOUS MATERIALS FOR REPAIR OF CONCRETE PAVEMENT.

(a) **Tar.** Tar for the repair of concrete pavement and for filling joints and cracks except poured expansion joints, in concrete pavement, shall be homogeneous and free from water and shall conform to the following detailed requirements:

	Detailed Requirements	Minimum	Maximum
1	Specific Gravity	1.200	1.260
2	Float test at 50° C. (122° F.)	90 sec.	120 sec.
3	Total distillate by weight:		
	To 170° C. (338° F.)		1.0%
	To 270° C. (518° F.)		12.0%
	To 300° C. (572° F.)		20.0%
4	Softening Point of Residue (Ring and Ball Method)		60.0° C.
5	Specific Gravity of Distillate	1.03	
6	Total Bitumen	78%	92%
7	Inorganic matter (Ash)		0.5%

Measurement shall be based on the volume of material at temperature of 60°F.

(b) **Asphalt.** Asphalt for the repair of concrete pavement and for filling joints and cracks except poured expansion joints, in concrete pavement, shall be homogeneous and free from water and shall conform to the following detailed requirements:

	Detailed Requirements	Fluxed Natural Asphalt		Petroleum Asphalt	
		Min.	Max.	Min.	Max.
1	Specific Gravity @ 77° F.	1.15	1.24	1.00	1.10
2	Softening point	104° F.	118° F.	100° F.	120° F.
3	Penetration @ 77° F., 100 g., 5 sec.	85	100	100	120
4	Penetration @ 32° F., 200 g., 1 min.	20		35	
5	Loss on heating 50 g., 5 hr., 325° F.		2.0%		0.5%
6	Flash point, open cup	350		450	
7	Inorganic matter naturally present	15%	23%		0.5%
8	Total bitumen	70%	80%	99.5%	
9	Bitumen soluble in carbon tetrachloride	99%		99.0%	
10	Ductility @ 77° F.	50 cm.		50 cm.	
11	Penetration of residue from No. 5 @ 77° F., 100 g., 5 sec.	60% of original		70% of original	

4106.03 CUT-BACK ASPHALT. Cut-back asphalt shall be composed of solid asphalt dissolved in a volatile petroleum distillate. It shall meet the following requirements for the grade specified:

	Grade Designation	Light		Medium		Heavy	
		Min.	Max.	Min.	Max.	Min.	Max.
1	It shall be homogeneous in character and free from water.						
2	Flash point	80°F.		80°F.		80°F.	
3	Viscosity, Saybolt Furol:						
	25° C	160 Sec.	320 Sec.				
	50° C			200 Sec.	400 Sec.	600 Sec.	800 Sec.
4	Distillation, by volume:						
	Total to 225° C. (437° F.)	10%		10%		10%	
	Total to 315.5° C. (600° F.)	30%		20%		15%	
	Total to 360° C. (680° F.)		40%		35%		30%
5	Tests on residue:						
	a. Penetration, 25° C, 100 g., 5 sec.	80	110	70	110	60	110
	b. Ductility, 25° C.	60		60		60	
	c. Total bitumen soluble in carbon disulfide	99.0%		99.0%		99.0%	

4106.04 BITUMINOUS PREMOULDED EXPANSION JOINT. Bituminous premoulded expansion joint shall conform to the requirements of the A.A.S.H.O. "Tentative Standard Specifications for Premoulded Expansion Joints," Specification M-33.

4106.05 ASPHALT FOR POURED EXPANSION JOINTS OR CENTER STRIP AND FOR FILLER FOR BLOCK PAVEMENTS. The asphalt shall comply with the requirements of the A.A.S.H.O. "Tentative Standard Specification for Asphalt Filler Type B," Specification M-19.

4106.06 ASPHALT FOR WATERPROOFING. Waterproofing asphalt shall be the product of the distillation and refining of crude asphaltic petroleum. It shall be free from coal tar pitch or any of its derivatives, and shall conform to the following requirements:

(a) Asphalt cement shall conform to the requirements of the A.S.T.M. "Standard Specifications for Asphalt for Use in Damp-Proofing and Water-Proofing Above Ground Level," Designation D144-25.

(b) Asphalt primer shall conform to the requirements of the A.S.T.M. "Standard Specifications for Primer for Use with Asphalt in Damp-Proofing and Water-Proofing Below and Above Ground Level," Designation D41-26.

4106.07 ASPHALT SATURATED COTTON FABRIC. Asphalt saturated cotton fabric used for water-proofing shall conform to the requirements of the A.S.T.M. "Standard Specifications for Woven Cotton Fabric Saturated with Bituminous Substances for Use in Water-Proofing," Designation D173-27.

4106.08 ASPHALT PLANK FOR WEARING SURFACES FOR BRIDGE FLOORS. This specification refers to that commodity composed of a homogeneous mixture of various proportions of asphalt, mineral aggregates and certain finely-divided fibrous materials, and formed either by molding or extruding into board or plank-shaped pieces of regular dimensions for use as a wearing surface upon bridge or other floors subjected to the action of vehicular traffic.

The fibrous materials shall be of one of the following group: cotton fiber, felting materials, or other approved finely divided fibrous material free from coarse splinters, pieces of metal, wood, leather, paper or sawdust.

(a) **General Appearance.** The plank shall be straight, uniform in cross section, free from cracks, holes, fissures or other defects of form, and the ends of each piece shall be perpendicular to both the sides and edges.

(b) **Cross section.** The plank shall be of rectangular cross section.

(c) **Dimensions.** The dimension for the thickness, width and length of the plank shall be as shown on the plans. Variations from these dimensions as measured upon individual plank shall be within the values shown below:

Thickness	plus or minus 1/16 in.
Width	plus or minus 1/8 in.
Length	plus or minus 1/4 in.

(d) **Absorption.** The increase in weight of a sample of plank when immersed in water at a temperature of 77°F. for a period of 24 hours, shall not exceed 1½ per cent of the original weight of the specimen.

The sample used for the absorption test shall be 2 inches in width, 6 inches in length and of the full thickness of the plank. The specimens shall be cut from the body of the plank so as to provide that freshly cut surfaces form the sides of the specimen.

(e) **Hardness.** The hardness of the plank shall be determined by means of a penetrometer in which the pin in contact with the plank during the test is a right cylinder 5/8 inch in diameter for a distance of at least 1½ inches. The specimen shall be kept submerged in water maintained at the temperature specified for the test for a time sufficient to insure that the specimen has attained this temperature throughout.

The test shall be made with the specimen submerged in water at the temperatures indicated in the table below, and supported on a smooth solid support not less than 2 inches in diameter. The length of the period of application of load shall be 60 seconds in each case. The tests shall be performed upon samples at least 6 inches in

length and of the full width of the plank. Application of test shall be at points 1½ inches, or more, from the edge of the sample. When tested in the manner just described, the hardness of the plank shall meet the following requirements:

Temperature	Load in Pounds	Penetration in Inches
115°F.	50	Not more than 0.25
77°F.	200	Not more than 0.25
39°F.	1000	Not less than 0.10

(f) **Brittleness.** The test for brittleness shall be performed in a manner similar to that for the hardness, with the changes in the size and shape of the pin and the manner of loading as described in detail below.

The pin used for the brittleness tests shall be a right cylinder 1/8 inch in diameter for a distance of 1/4 inch, from which section it shall be uniformly tapered to a diameter of 1/4 inch at a distance of 1½ inches from the beginning of the tapered section. The load required to force the pin into the plank shall be applied in a uniform manner at the rate of 2 inches per minute until the point of the pin has penetrated to the plane of the supported surface of the specimen. The specimen shall be supported on a smooth solid support not less than 2 inches in diameter and having a hole 1/2 inch in diameter directly under the point of application of the pin. In this test, the behavior of the plank shall be that indicating an equal or less degree of disturbance than that described in the following statement:

- (1) **When Tested at 77°F.:** No visible cracking or crumbling of the plank.
- (2) **When Tested at 39°F.:**
 - a. The total length of crack developing either at the upper or lower surface of the specimen shall not exceed 3 inches, that is, twice the distance of the point of application of the test from the edge of the specimen.
 - b. When the test is applied at the corner positions on the specimens, the crack if produced shall develop in but one direction and be confined to a maximum length of 3 inches.

Section 4107. Corrugated Metal Culvert Pipe.

4107.01 GENERAL. Corrugated metal culvert pipe shall be fabricated from corrugated galvanized sheets. The pipe shall be of the full circle riveted type with lap joint construction.

When so specified in the contract, the pipe shall be perforated.

The pipe shall conform to the following detailed requirements.

4107.02 BASE METAL. The base metal from which corrugated metal pipe culverts are fabricated shall be made by the Open Hearth process.

The base metal in the finished sheets shall conform to the chemical requirements for one of the following kinds:

Elements	Chemical composition by ladle analysis (Position of base metals does not indicate preference)					Tolerance by check analysis of finished sheets
	Kind of Base Metal					
	Pure Iron	Copper Bearing Pure Iron	Copper Iron	Copper molybdenum iron	Copper steel	
Carbon, max. per cent						
Manganese, max. per cent						
Phosphorus, max. per cent .....	.015	.015	.015	.015		.010
Sulphur, max. per cent .....	.040	.040	.040	.040	.050	
Silicon, max. per cent						
Copper, min. per cent .....		.20	.20	.40	.20	.02
Molybdenum, min. per cent .....				.05		
Sum of first 5 elements, max. per cent .....		.10	.25	.25	.70	.04
Sum of first 6 elements, max. per cent .....	.10					.04

4107.03 SPELTER COATING. The base metal sheets shall be galvanized on both sides by the Hot Dip process after which these sheets shall be sheared to proper sizes. Sheets perforated for drainage shall be galvanized after drainage perforations have been punched. A uniform coating of Prime Western spelter or equal shall be applied at the rate of not less than 2 ounces per square foot of metal. The average spelter coating as determined from tests of samples shall show not less than 2 ounces per square foot of metal, and no one sample shall show less than 1.8 ounces of spelter per square foot of metal. Sheets shall be free from blister spots, holes or other imperfections in the galvanizing after corrugating.

4107.04 WEIGHT TOLERANCE FOR UNFABRICATED SHEETS. The theoretical weights per square foot of culvert sheets are as follows:

Gauge	Weight per Square Foot—Pounds
8	7.031
10	5.781
12	4.531
14	3.281
16	2.656

The average weight of culvert sheets as determined by weighing the sheets of one gauge and size of sheet in any shipment, shall not be less than the following percentage of the theoretical weight listed above, for that size and gauge:

Lots size	Percentage of Theoretical
6000 lb. or over	95
300 lb. to 6000 lb.	93
Individual Sheets	90

4107.05 ACCEPTED BRANDS. No proposal will be considered or metal accepted under these specifications until the sheet manufacturer's certified analysis and form of brand for identification of sheets have been accepted by the Commission. The brand of metal to be supplied shall be specified in the proposal.

Misbranding or other misrepresentation or non-uniformity of product will be considered a sufficient reason to discontinue the acceptance of any brand of metal by the Commission. The notice of the discontinuance of approval of any brand sent to

the sheet manufacturer will be considered to be notice to any culvert company supplying that particular brand.

Only one brand will be approved for each kind of base metal furnished by any one manufacturer of the sheets. A photograph or a facsimile of each brand showing all the items specified in Paragraph 4107.07 shall be filed with the Commission on sheets 8½ in. x 11 in.

4107.06 SHEET MANUFACTURER'S CERTIFIED ANALYSIS. The manufacturer of each brand of metal submitted for acceptance under these specifications shall file with the Commission a certificate setting forth the name of brand of metal to be furnished and a typical analysis showing the percentage of each of the 5 chemical elements specified in Paragraph 4107.02. The certificate shall be on the form furnished by the Commission and shall be certified by a person having legal authority to bind the company by his acts.

4107.07 IDENTIFICATION. The metal shall be identified by a stamp on each section of the culvert showing:

- (a) Name of sheet manufacturer.
- (b) Name of brand.
- (c) Gauge of metal.
- (d) Identification symbols showing heat number.
- (e) Weight of spelter coating in ounces for square foot of metal.

The identification brand shall be placed on the sheets by the manufacturers of the sheets in such a way that when rolled into culverts such identification shall appear on the outside of each section of pipe. The exact arrangement of the stamping showing all the above required identification data shall be subject to the approval of the Commission. Illegible branding will be cause for rejection of the material.

4107.08 PERFORATED PIPE. Perforated pipe shall be made by punching sheets to be used in fabrication of pipe. The perforations shall be approximately ¼ inch in diameter after galvanizing. They shall be punched in transverse rows 1½ inches (cc) and so spaced in each row that the perforations come in the inside ridges in all but the end corrugation when fabricated into pipe. The number of longitudinal rows of perforations in the finished pipe shall conform to the following table:

Diameter of Pipe	Number of Rows of Holes
8	8
10	8
12	10
15	10
18	15
24	20
30	20

4107.09 DIMENSIONS AND WEIGHTS. The lengths of sheets, widths of longitudinal laps and gauge of the uncoated metal (U. S. Standard Gauge) shall not be less than specified in the following table. The dimensions given for diameter of pipe are nominal. No individual culvert inspected after fabrication shall have a weight more than 5 per cent below the minimum specified. Circumferential joints shall lap at least three-fourths of one full corrugation.

Nominal Diam. Inches	Width of Lap—Inches	Length of Sheet before Forming Inches	Min. Gauge U.S.S.G. Uncoated Metal	Min. Wt. per Lin. Ft. of Finished Culvert Exclusive of End Finish—Pounds	Min. Width of Separate Coupling Bands Inches
8	1.5	28.5	16	7.3	7.0
10	1.5	35.0	16	9.0	7.0
12	1.5	41.0	16	10.5	7.0
15	1.5	50.5	16	12.9	7.0
18	1.5	60.0	16	15.3	7.0
24	2.0	80.0	14	25.2	12.0
30	2.0	98.0	14	30.9	12.0
36	2.0	117.0	12	51.0	12.0
42	3.0	*137.0	12	59.5	12.0
48	3.0	*156.0	12	68.0	12.0
54	3.0	(1—80.0 1—98.0)	12	77.8	24.0
60	3.0	2—98.0	10	108.9	24.0
72	3.0	2—117.0	10	130.4	24.0
84	3.0	2—137.0	8	185.2	24.0

*NOTE: Two sheets may be used by allowing sufficient total sheet lengths to provide for an additional *standard lap*.

4107.10 NET LENGTH OF FINISHED CULVERT PIPE. The length of culvert specified shall be the net length of the finished culvert not including any materials used to procure an end finish on the pipe. The average deficiency in length of any shipment of pipe shall not be greater than one per cent.

4107.11 LENGTH OF SECTIONS. All pipe shall be furnished in the lengths ordered with the following exceptions: In carload shipments, pipe for culverts more than 26 feet in length may be furnished in sections not less than 12 feet in length; in less than carload shipments, pipe for culverts longer than the lengths given in the following table may be furnished in the minimum number of sections which will produce the total lengths ordered without exceeding the section lengths given in the table.

Nominal Diameter of Pipe	Maximum Length of Section for L. C. L. Shipment
(8 in. to 18 in. incl.)	22 feet
24 inches	20 feet
30 inches	18 feet
36 inches	16 feet
42 inches	12 feet

Suitable coupling bands shall be furnished for pipe shipped in 2 or more sections, which coupling bands will be paid for in accordance with the provisions of Paragraph 2421.06.

4107.12 CORRUGATIONS. All corrugations shall be not less than $2\frac{1}{4}$ nor more than $2\frac{3}{4}$ inches (cc). The corrugations shall have a depth of not less than $\frac{1}{2}$ inch.

4107.13 RIVETS AND RIVETING. All rivets shall be of the same material as the base metal specified for the corrugated metal sheets or of other metal approved by the Commission. They shall be thoroughly galvanized or sherardized. Rivets shall have the following diameters:

Gauge of Metal	Diameter of Rivet Inches
16	5/16
14	5/16
12	3/8
10	3/8
8	3/8

All rivets shall be driven cold in such a manner that the plates shall be drawn tightly together through the width of the seam. No rivet shall be closer to the edge of the metal than twice its diameter. All rivets shall have neat, workmanlike and full hemispherical heads or other form approved by the Commission; shall be driven without bending; and must completely fill the hole. Longitudinal seams shall be riveted with one rivet in each full corrugation. Longitudinal seams in 42-inch and larger pipe shall be double riveted. Circumferential shop-riveted seams shall have a maximum rivet spacing of 6 inches, and shall lap at least three-fourths of one full corrugation, except that 6 rivets will be sufficient in 12-inch pipe.

4107.14 END FINISH. When so ordered by the Engineer, the inlet and outlet ends of pipe shall be reinforced in a manner approved by the Commission. The metal itself may be rolled back in a circular roll, or the ends may be reinforced by means of a metal band. If a band is used, it shall be riveted to the pipe at intervals of 10 inches or less. This band shall be of galvanized metal equivalent in cross-section to $\frac{3}{8}$ inch by one inch for 16-gauge metal, and $\frac{3}{8}$ inch by $1\frac{1}{2}$ inch for 14-gauge and heavier.

4107.15 COUPLING BANDS. Unless the pipe sections are connected by riveted joints, all field joints shall be made with separate bands of corrugated material or with semi-circular bands which are securely riveted with at least one circumferential seam to each section of pipe.

Separate bands shall be made of the same material and gauge as the pipe. Semi-circular bands shall be made of same material and may be two-gauge lighter than the metal of the pipe, but shall not be less than 16 gauge.

Semi-circular bands shall not be less than 7 inches in width for sizes 30 inch and smaller, and 12 inches in width for sizes 36 inches and larger.

All bands shall be so constructed as to lap an equal portion and not less than one full corrugation of the pipe section to be connected with the space between ends less than $\frac{1}{2}$ the width of corrugations.

Semi-circular bands shall be connected at the ends by angles having minimum dimensions $1\frac{1}{2}$ " x $1\frac{1}{2}$ " x $\frac{1}{8}$ " and of length equal to the full width of the band. These angles shall be riveted to the band with not less than one rivet in the crest of each corrugation. The angles shall be coated with spelter by the hot dip process after shearing to length and punching.

Separate bands may be connected by angles specified above or by other connections approved by the Engineer. When rivets attaching the connecting angles or lugs are driven by a press, they shall be so placed that the head of rivet is against the corrugated sheet metal. Each connection on separate or semi-circular bands shall be fastened with galvanized bolts $\frac{1}{2}$ inch in diameter as follows:

7 inch band at least 2 bolts; the 12 inch band at least 3 bolts, and the 24 inch band at least 5 bolts.

4107.16 WORKMANSHIP. It is the essence of these specifications that in addition to compliance with the details of construction, the completed pipe shall show careful finished workmanship in all particulars. The pipe shall be free from all the following defects:

1. Uneven laps.
2. Elliptical shaping.
3. Variations from straight center line.
4. Ragged or diagonal sheared edges.
5. Loose, unevenly lined or spaced rivets.
6. Poorly formed rivet heads.
7. Illegible brands.
8. Lack of rigidity.
9. Bruised, scaled or broken spelter coating.
10. Dents or bends in the metal itself.

4107.17 INSPECTION. All materials, processes of manufacture and finished pipe shall be subject to inspection by the Engineer. The Engineer or his representative shall have free access to the mill or shop for inspection purposes, and every facility shall be extended to him for this purpose.

Inspection of metal sheets for culverts will be made before the culverts are fabricated provided the fabricator has given the Engineer due notice that such inspection is desired on any given shipment of culverts. Such notice shall provide a reasonable length of time for the Engineer to arrange for such inspection.

In case such notice has not been given, the metal may be inspected in the field. The fabrication of culverts may be inspected in the fabricating shop or in the field as the Engineer may elect.

4107.18 SAMPLING.

(a) **Sampling of Unfabricated Sheets.** One strip of metal at least 6 inches wide shall be cut from the edge or the end of one sheet from each 500 sheets or fraction thereof of each gauge and heat number. From each of these strips 3 samples each $2\frac{1}{4}$ in. x $2\frac{1}{4}$ in., or of equivalent area, shall be cut from near the newly sheared edge of this strip. These 3 samples shall be used for the determination of the weight of spelter coating and analysis of the base metal.

If any sheet fails to meet the requirements, a retest shall be made upon check samples taken from 2 other sheets of the same lot in accordance with the procedure given below. Both of these sheets shall meet the requirements of the specifications.

A $2\frac{1}{2}$ inch strip shall be cut transversely or diagonally across the middle of the sheet with its ends approximately one inch from each edge. Three samples $2\frac{1}{4}$ in. x $2\frac{1}{4}$ in., or of equivalent area, shall be accurately cut from the middle and the 2 ends of this strip. Samples shall be cleaned with gasoline or benzol, then with alcohol and dried before proceeding with the test.

Sheets from which check samples are taken will be paid for by the state in case the check test indicates that the material is acceptable; sheets from which check samples are taken will not be paid for by the state if the check test indicates that the material is not acceptable.

(b) **Sampling of Finished Pipe.** At least one sample from which may be prepared a specimen $2\frac{1}{4}$ in. x $2\frac{1}{4}$ in., no part of which is less than 2 inches from the edge of the sheet from which the sample is taken, shall be cut from each 10 culverts of each gauge of metal in the shipment. Not less than 3 samples shall represent the culverts of any one gauge of metal in any shipment. The above mentioned specimens shall be used for the determination of the weight of spelter coating and the analysis of the base metal.

4107.19 METHODS OF TEST.

(a) **Weight of Spelter Coating.** Tests for the weight of spelter coating shall be made in accordance with the requirements of the standard method "Hydrochloric Acid-Antimony Chloride Method," Tentative Method T-65 "Methods of Determining Weight of Coating on Zinc-Coated Articles," of the American Association of State Highway Officials.

(b) **Analysis of Base Metal.** Analysis of base metal shall be conducted in accordance with the "Method of Test and Inspection of Corrugated Metal Culvert" adopted by the American Association of State Highway Officials.

(c) **Weight of Metal.** Tests for compliance with the weight requirements of these specifications shall be conducted as follows:

In the case of the inspection of unfabricated sheets, 10 sheets taken at random from each 250 sheets of each lot of the same size, gauge and heat number shall be weighed separately. If the weight of these sheets does not indicate that the lot complies with the requirements of Paragraph 4107.04 the weight of the entire lot shall be determined.

In the case of the inspection of finished pipe, at least 2 pipe of each diameter in a single shipment shall be weighed separately.

Section 4107-A. Bituminous Coated Corrugated Metal Culvert Pipe.

4107-A.01 GENERAL. Bituminous Coated Corrugated Metal Culvert Pipe shall conform to the requirements of Section 4107 and to the following additional requirements:

In addition to the spelter coating specified in Paragraph 4107.03, an additional protective coating of bituminous material shall be applied to the pipe. The bituminous coating shall cover at least 16 per cent of the inside surface of the pipe and shall be continuous and of uniform width. If the entire inside surface of the pipe is not coated, the center line of the coated portion shall conform to a single element of the pipe.

The bituminous material shall be applied in such a manner that a smooth surface shall be formed in the lower 16 per cent of the circumference of the pipe, filling the corrugations and having a thickness of not less than $\frac{1}{8}$ inch above the crest of the corrugations. The bituminous coating shall adhere to the metal tenaciously and shall be sufficiently tough and resistant to the effects of temperature and to the effects of acids and alkali to withstand the following tests:

(a) A steel ball $2\frac{1}{4}$ inches in diameter and weighing 1.67 pounds shall be dropped from a height of $7\frac{1}{2}$ feet through a vertical tube 3 inches in diameter, so that the ball falls upon the outside crest of a corrugation of a representative sample of the coated pipe. This test shall be conducted with the specimen at the temperature of 30° to 40° F. As a result of this test, the bituminous coating shall not spall from the metal nor develop cracks longer than $\frac{1}{2}$ inch from the point of contact.

(b) Parallel lines shall be drawn on the surface of the bituminous coating along the valleys of the corrugations of a representative sample of the pipe. This specimen shall be placed on end in an oven with the parallel lines in a horizontal position. The temperature of the specimen shall be maintained at not less than 148° F. nor more than 152° F. for a period of 4 hours. At the end of this period the bituminous material shall not be distorted by an amount sufficient to cause any part of any line to have moved more than $\frac{1}{4}$ inch.

(c) A 25 per cent solution of sulphuric acid or a 25 per cent solution of sodium hydroxide, or a saturated salt solution (such as sodium chloride) shall be held on the bituminous coated surface of a representative sample of pipe for a period of 48 hours. As a result of this test, the bituminous coating shall not be loosened or separated from the metal.

Section 4108. Concrete Culvert Pipe.

4108.01 DESCRIPTION. This specification applies to concrete pipe for use in culverts.

4108.02 CLASSIFICATION. Pipe shall be of two classes: standard reinforced-concrete culvert pipe, and concrete farm entrance culvert pipe.

4108.03 MATERIALS. The materials used in the construction of concrete culvert pipe shall conform to the requirements of Sections 4102, 4103, 4104, and 4112, and Paragraph 4105.01 except for the grading of the coarse aggregate.

4108.04 REINFORCED-CONCRETE PIPE FOR ROADWAY CULVERTS. Reinforced concrete pipe for roadway culverts shall comply with the requirements of the A. S. T. M. "Tentative Specifications for Reinforced-Concrete Culvert Pipe," Designation C76.

The details as to thickness of shell, form and dimensions of end connections and the size and distribution of reinforcement shall comply with standard plans adopted by the Commission.

4108.05 CONCRETE PIPE FOR FARM ENTRANCE CULVERTS. Concrete pipe for farm entrance culverts shall comply with the requirements of Paragraph 4108.04 except that such pipe having diameters 24 inches and less need not be reinforced and the minimum strength in pounds per lineal foot shall be 1500 times the nominal diameter in feet when tested by the "Three Edge Bearing" method.

4108.06 LENGTH OF SECTIONS OF CONCRETE CULVERT PIPE. Unless otherwise specified on the plans or in the proposal form, the length of sections of reinforced concrete culvert pipe shall be 6 feet for pipe having a diameter of 24 inches or larger. The length of section of no reinforced concrete culvert pipe shall be less than 4 feet.

For farm entrance culvert pipe the length of section shall not be less than the diameter, and in no case shall the length be less than 24 inches.

4108.07 STRENGTH REQUIREMENTS. The strength requirements referred to above are as follows:

Minimum Strength of Concrete Culvert Pipe in Pounds per Foot of Length—"Three Edge Bearing" Method.

Size of Pipe Inches	Reinforced Concrete Culvert Pipe for Roadway Culverts		Concrete Pipe for Farm Entrance Culverts
	Standard		
	Cracking Load	Ultimate Load	Ultimate Load
15	1800	2500	1875
18	2000	3000	2250
24	2200	4000	3000
30	2500	5000	3750
36	3000	6000	4500
42	3500	7000	5250

Section 4109. Vitrified Clay Culvert Pipe.

4109.01 GENERAL REQUIREMENTS. Vitrified clay pipe used for roadway culverts shall conform to the detailed requirements of the A. S. T. M. "Standard Specifications for Clay Sewer Pipe," Designation C13-24, insofar as applicable except for physical strength requirements.

Vitrified clay pipe used for farm entrance culverts shall comply with the requirements of the A. S. T. M. "Standard Specifications for Drain Tile," Designation C4-24, except for physical strength requirements and length. For farm entrance culvert pipe the length of section shall not be less than the diameter and in no case less than 24 inches.

4109.02 PHYSICAL STRENGTH REQUIREMENTS. Clay pipe used for roadway culverts shall conform to the strength requirements specified in Paragraph 4108.07 for "Standard Reinforced Concrete Pipe for Roadway Culverts." Clay pipe used for farm entrance culverts shall conform to the strength requirements specified in Paragraph 4108.07 for "Concrete Pipe for Farm Entrance Culverts."

Section 4110. Cast Iron Culvert Pipe.

4110.01 GENERAL REQUIREMENTS. Cast iron pipe used as culverts under these specifications shall be made of cast iron of good quality without any admixture of cinder iron or other inferior metal and shall be remelted in a cupola or air furnace. The pipe shall be well manufactured; true to pattern; and free from pouring faults, sponginess, cracks, and blow holes exceeding $\frac{1}{4}$ inch in diameter.

4110.02 TYPE AND LENGTH. Cast iron culvert pipe shall be of the full circular type, either smooth or of approved corrugated or ribbed type. The sections of pipe shall be cast vertically with a minimum length of section of 3 feet.

4110.03 PHYSICAL STRENGTH REQUIREMENTS. Each section of cast iron pipe furnished under these specifications shall conform to the requirements of Paragraph 4108.07, as to ultimate strength and tests required.

4110.04 MINIMUM WEIGHT. The weight of each section of pipe shall not be less than the computed weight obtained from the following formula:

$$W = \sqrt{W_1^2 \times \frac{L}{L_1}}$$

Where W = Minimum required weight in pounds per section.
 W_1 = Weight of the weakest section of similar pipe in a sample conforming to the strength requirements.
 L_1 = Ultimate load in pounds supported in test by the section referred to above.
 L = Required ultimate load in pounds per section.

4110.05 COATING. Each pipe shall be coated inside and out with coal tar pitch varnish. The pipe shall be heated to a temperature of 300°F. immediately before it is dipped. It shall remain completely immersed in the bath for a period of 5 minutes.

Section 4111. Drain Tile and Sewer Pipe.

4111.01 DRAIN TILE. Drain tile shall comply with the requirements of the A. S. T. M. "Standard Specifications for Drain Tile," Designation C4-24. The tile shall conform to the strength requirements of Table 1, Section 4, of the foregoing standards for "Standard Drain Tile" or "Extra Quality Drain Tile" as called for in the proposal or contract.

4111.02 SEWER PIPE.

(a) Clay sewer pipe shall comply with the requirements of the A. S. T. M. "Standard Specifications for Clay Sewer Pipe," Designation C13-24.
(b) Concrete sewer pipe shall comply with the requirements of the A. S. T. M. "Standard Specifications for Concrete Sewer Pipe," Designation C14-24.

Section 4112. Steel Reinforcement.

4112.01 BAR REINFORCEMENT. Steel for reinforcement of concrete shall comply with the A. A. S. H. O. "Tentative Standard Specifications for Billet-Steel Concrete Reinforcement Bars," Specification M-31, except that the Commission reserves the right to inspect the steel after arrival at the site of the work. Plain bars of structural steel grade only will be accepted. Reinforcing steel shall be free from excessive rust, scale, paint or coating of any character that will tend to destroy the bond.

In order to allow for possible variation in test results due to variation in the speed of the testing machine, the measurement of cross-sectional area or methods of machine operation, a tolerance of 5 per cent in the determination of the tensile strength will be allowed. Each specimen tested from a single lot of steel shall come within this tolerance.

4112.02 EXPANDED METAL AND WIRE MESH. Expanded metal used as a reinforcement shall be manufactured from material conforming to the requirements of the A. A. S. H. O. "Tentative Standard Specifications for Billet-Steel Concrete Reinforcement Bars," Specification M31. Wire mesh used as reinforcement for concrete shall have rectangular meshes. The size and spacing of wires and the weight per 100 square feet shall be as shown on the plans. The material used in the manufacture of wire mesh shall conform to the requirements of Paragraph 4112.03.

4112.03 COLD DRAWN STEEL WIRE. Cold drawn steel wire used as reinforce-

ment shall conform to the requirements of the A. S. T. M. "Standard Specifications for Cold Drawn Steel Wire for Concrete Reinforcement," Designation A82-27.

Section 4113. Structural, Rivet and Eye Bar Steel.

4113.01 GENERAL. All structural, rivet and eye bar steel shall conform to the requirements of the A. S. T. M. "Standard Specifications for Structural Steel for Bridges," Designation A7-29, supplemented by the following paragraphs:

(a) **Character of Fracture.** Test specimens of structural rivet or eye bar steel shall show a fracture of uniform, silky or fine granular structure, of bluish gray or dove color, and shall be entirely free from granular, black and brilliant specks.

(b) **Defects in Material.** Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth, uniform finish and shall be straightened in the mill before shipment.

Material shall be free from loose mill scale, scaly rust, and rust pits or other defects affecting its strength and durability.

(c) **Physical Requirements of Eye Bars.** Full size tests of eye bars shall show a yield point of not less than 29,000 pounds per square inch, and an elongation, including fracture, of not less than 10 per cent in a length of 20 feet measured in the body of the bar.

Section 4114. Miscellaneous Iron and Steel.

4114.01 STEEL FORGINGS AND PINS. Forgings from which pins, rollers, trunions or other forged parts having a diameter or thickness of six inches or more, are to be fabricated, shall conform to the requirements of the A. S. T. M. Tentative Standard Specifications for Carbon Steel Forgings for Locomotives, Designation A20-31T.

All forgings shall be thoroughly annealed prior to being machined to form finished parts.

Pins or rollers having a diameter or thickness less than six inches shall be made from Cold Rolled Steel conforming to the A.S.T.M. Standard Specifications for Cold Finished Bar Steels and Cold Finished Shafting, Designation A108-30.

4114.02 STEEL CASTINGS. Steel castings shall conform to the requirements of the A. S. T. M. "Standard Specifications for Steel Castings," Designation A27-24, Medium Grade, Class B, supplemented by the following paragraphs:

(a) **Annealing.** All steel castings shall be thoroughly annealed unless otherwise specified.

(b) **Workmanship.** Steel castings shall be true to pattern in form and dimension, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

(c) **Blow Holes.** The finished casting shall show no blow holes exceeding $\frac{1}{2}$ square inch in area or one inch in length, and the total length of cavity cut by a straight line laid in any direction shall not exceed one inch in one foot.

(d) **Welding.** Minor defects which do not impair the strength of castings may with the approval of the Engineer be welded by an approved process. Castings which have been welded without the permission of the Engineer or his representative shall be rejected.

(e) **Defects.** Large castings, if required by the Engineer, shall be suspended and hammered all over. No cracks, flaws or other defects shall appear after such treatment.

(f) **Unfilleted Corners.** No sharp unfilleted angles or corners will be allowed.

4114.03 IRON CASTINGS. Iron castings shall conform to the requirements of the A. S. T. M. "Standard Specifications for Gray Iron Castings," Designation A48-29, in addition to the following details. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes or other defects in positions affecting their strength for the service intended.

With the approval of the Engineer, minor defects which do not impair the strength of castings may be welded by an approved process. Castings which have been welded without the permission of the Engineer shall be rejected. The frames and grates for drainage openings shall be straight and shall fit properly together so that traffic will not cause them to rattle. Rough spots which prevent suitable fitting may be removed by grinding.

Section 4115. Paints.

4115.01 GENERAL REQUIREMENTS. Paint shall consist of pigments of the specified composition, ground to the required fineness in linseed oil, to which shall be added additional oil, thinner and drier, as may be required in the specifications for each kind of paint.

The fineness of the grinding shall be such that when the pigment extracted from a representative sample of the paint is washed with gasoline through a 325-mesh sieve until no trace of pigment is evidenced in the washings, not more than 3 per cent of the total weight of the sample shall be retained on the sieve.

The paint shall conform in color to the sample furnished by the Commission. The brushing consistency shall be such that when the paint is applied to a smooth and clean vertical steel surface there shall be no running, streaking or sagging of the paint during the time required to dry.

All paints shall dry to a full oil gloss in 18 hours under normal conditions of humidity and temperature.

All percentages stated are on a weight basis.

4115.02 VEHICLE. The paint vehicle for all classes of paint, except as otherwise specified, shall be linseed oil, and thinner if necessary, with the addition of the necessary amount of drier to give the paint the required drying qualities. The amount of thinner and drier shall not exceed 10 per cent of the total vehicle. The vehicle shall not contain to exceed one per cent of water. The components of the vehicle shall conform to the following requirements for the respective materials:

(a) **Raw Linseed Oil.** Raw linseed oil used shall conform to the requirements of the A. S. T. M. "Standard Specifications for Raw Linseed Oil," Designation D234-28.

(b) **Boiled Linseed Oil.** Boiled linseed oil shall conform to the requirements of the A. S. T. M. "Tentative Specifications for Boiled Linseed Oil," Designation D260-28T.

(c) **Drier.** Drier shall be composed of lead and manganese, or cobalt, or a mixture of any of these elements combined with a suitable fatty oil, with the addition of mineral spirits, turpentine, or a mixture of these solvents without resins or gums. It shall be free from sediment and suspended matter. The drier, when flowed on metal and baked for 2 hours at 212°F. shall leave an elastic film. The flash point shall not be lower than 85°F. when tested in a closed-cup tester. It shall mix with pure raw linseed oil in the proportion of one volume of drier to 19 volumes of oil without curdling, and the resulting mixture when flowed on glass shall dry within 18 hours. When mixed with pure raw linseed oil in the proportion of one volume of drier to 8 of oil the resulting mixture shall not be darker than a solution of six grams of potassium dichromate in 100 c.c. of pure sulphuric acid of specific gravity 1.84.

(d) **Thinner.** Turpentine thinner shall be steam-distilled wood turpentine conforming to the requirements of the A. S. T. M. "Standard Specifications for Steam-distilled Wood Turpentine," Designation D13-26, or destructively distilled wood turpentine conforming to the requirements of the A. S. T. M. "Standard Specifications for Destructively Distilled Wood Turpentine," Designation D236-27.

Mineral spirits thinner shall conform to the requirements of the A. S. T. M. "Tentative Specifications for Petroleum Spirits," Designation D235-26T.

(e) **Waterproof Spar Varnish.** Waterproof spar varnish shall be free from resin or turpentine substitutes. It shall be made exclusively from hard varnish resins, pure tung oil, pure turpentine, and lead-manganese or cobalt driers. It must meet the following requirements:

1. Non-volatile Matter. The non-volatile matter shall be not less than 40 per cent by weight.
2. Drying Properties. It shall be dry, hard and tough within 18 hours.
3. Working Properties. It shall have good brushing, flowing, covering and leveling properties.
4. Water Resistance. The dried film shall withstand cold water for 18 hours and boiling water for 15 minutes without whitening or dulling.

(f) **Exterior Spar Varnish for Use with Aluminum Bronze Powder.** Exterior spar varnish for use with aluminum bronze powder shall meet the following requirements:

1. The varnish shall contain not less than 50% by weight of non-volatile oils and gums.
2. The varnish shall pass a 60 per cent Kauri reduction test, as specified in Federal Board Standard Specification No. 18.
3. The varnish shall be of such consistency that when thoroughly mixed with aluminum bronze powder in the proportion of 2 pounds per gallon of vehicle, the paint shall show satisfactory spreading qualities, and shall not run or sag when applied to a vertical surface. This consistency will correspond to tubes A to E of the Gardner Holdt Air Bubble Visco Meter (0.5 to 1.25 poises).
4. The paint shall set to touch in not less than 2 or more than 6 hours, and dry hard and tough in not more than 24 hours.
5. The methods of testing given in Circular No. 103 of the Bureau of Standards (Federal Specification Board Standard Specification No. 18) shall be followed.

4115.03 PIGMENTS. The pigments used shall conform to the following detailed requirements:

(a) **White Lead.** Basic Carbonate of White Lead ($2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$) shall conform to the requirements of the A. S. T. M. "Standard Specifications for Basic Carbonate White Lead," Designation D81-31. Basic Sulphate White Lead shall conform to the requirements of the A. S. T. M. "Standard Specifications for Basic Sulphate White Lead," Designation D82-24.

(b) **Red Lead.** The red lead used shall contain not less than 97 per cent of true red lead (Pb_3O_4) and shall conform in all other respects to the requirements of the A. S. T. M. "Standard Specifications for Red Lead," Designation D83-31 (95% Grade).

(c) **Zinc Oxide.** Zinc oxide shall conform to the requirements of the A. S. T. M. "Standard Specifications for Zinc Oxide," Designation D79-24; or "Standard Specifications for Leaded Zinc Oxide," Designation D80-24, Low Leaded Grade.

(d) **Chrome Green.** Chrome green shall conform to the requirements of the A. S. T. M. "Standard Specifications for Pure Chrome Green," Designation D212-27.

(e) **Graphite.** Graphite pigment shall consist of finely ground graphite carbon and insoluble siliceous material. The graphitic carbon may be derived from either natural or artificial graphite and the insoluble siliceous matter may be either the

naturally occurring insoluble impurities of the graphite or added insoluble siliceous matter. The pigment shall contain not less than 50 per cent graphitic carbon, and not less than 30 per cent insoluble siliceous matter. The sum of the graphitic carbon and insoluble siliceous matter shall be not less than 85 per cent. Not more than 5 per cent of calcium and magnesium carbonates and sulphates shall be present.

(f) **Titanium Barium Pigment.** Titanium Barium pigment shall conform to the requirements of the A. S. T. M. "Tentative Specifications for Titanium Barium Pigment," Designation D265-27T.

(g) **Inert Pigments.** The inert pigments used shall be silica, magnesium silicate, aluminum silicate, barium sulphate, pure tinting colors, or any mixture thereof.

(h) **Aluminum Bronze Powder.**

Aluminum bronze powder shall be made only from metallic aluminum having a minimum aluminum content of 99 per cent. To determine from the finished powder that this requirement has been met a sample shall be analyzed for iron, silicon, and copper. The total weight of these impurities shall not exceed one per cent of the weight of the sample after deduction of the acetone soluble portion.

The powder shall conform to the following composition limits:

Acetone extract	Maximum 4.0 per cent
Lead and Zinc	Maximum 0.0 per cent
Copper	Maximum 0.2 per cent

Aluminum bronze powder shall be "flake-like" in form and shall be **polished**.

The fineness shall be such that it will pass through a standard 100-mesh screen 100 per cent. Due to the tendency of the powder to ball, because of the lubricant, it may be necessary to wash the last traces of powder through the screen with a suitable solvent.

Aluminum bronze powder shall contain no adulterants such as powdered mica.

(i) **Chrome Yellow.** Chrome yellow shall conform to the requirements of the A. S. T. M. "Standard Specifications for Chrome Yellow," Designation D211-27.

(j) **Lithopone.** Lithopone shall conform to the requirements of the A. S. T. M. "Standard Specifications for Lithopone," Designation D208-26.

(k) **Prussian Blue.** Prussian blue shall conform to the requirements of the A. S. T. M. "Standard Specifications for Prussian Blue," Designation D261-28.

4115.04 PAINT COMPOSITION. Paint shall be composed of pigments and vehicles conforming to the requirements of Paragraphs 4115.02 and 4115.03, and shall conform to the following requirements as to composition:

(a) **White Paint.** White paint shall be of either of the following compositions:

(1) Pigment	not less than 65%
Vehicle	not more than 35%
Weight per gallon	not less than 16.25 lb.

Pigment Composition:

Basis Carbonate of Lead	45.0% to 65.0%
Basic Sulphate of Lead	Not more than 20.0%
Zinc Oxide	20.0% to 25.0%
Calcium and Magnesium Carbonate or Sulphate	Not more than 5.0%
Inert Pigment, including Calcium and Magnesium Carbonate or Sulphate	Not more than 15.0%

Vehicle Composition:

Raw Linseed Oil	Not less than 90.0%
Thinner	Not more than 5.0%
Drier	Not more than 5.0%

- (2) Pigment not less than 65%
 Vehicle not more than 35%

Pigment Composition:

Titanium Barium Pigment70.0% to 75.0%
 Zinc Oxide25.0% to 30.0%

Vehicle Composition:

Raw Linseed OilNot less than 90.0%
 ThinnerNot more than 5.0%
 DrierNot more than 5.0%

The color of the white paint shall not be darker than the color of the sample furnished by the Commission. The covering and hiding properties shall be equal to or better than the same properties of the sample.

For the first coat of paint applied on wood the paint may be thinned by adding to one gallon of paint conforming to the above requirements, one pint of raw linseed oil and one-half pint of turpentine or mineral spirits. For all subsequent coats the paint shall not be thinned.

(b) Red Lead Paint for Priming Coat. The paint used as a priming coat for structural steel shall be a red lead paint of the following composition:

- Pigment not less than 79%
 Vehicle not more than 21%

Pigment composition:

Red Lead (97% or more Pb_3O_4)100%

Vehicle Composition:

Raw Linseed Oil50%
 Boiled Linseed Oil50%

To one gallon of the resulting paint may be added, if necessary, not to exceed $\frac{1}{3}$ pint of drier.

The finished paint shall weigh not less than 26.5 pounds per gallon.

When tested as mixed paint the extracted pigment shall show on analysis not less than 96% true red lead (Pb_3O_4).

(c) Red Lead Paint for Second Field Coat. The paint used as a second field coat for structural steel shall be a tinted red lead of the following composition:

- Pigment not less than 79%
 Vehicle not more than 21%

Pigment Composition:

Red Lead (97% or more Pb_3O_4)not less than 99.5%
 Lampblacknot more than 0.5%

Vehicle Composition:

Boiled Linseed Oilnot less than 94.5%
 Driernot more than 3.0%
 Thinnernot more than 2.5%

The resultant paint shall weigh not less than 26.5 pounds per gallon.

When tested as mixed paint the extracted pigment shall show an analysis not less than 95.5% true red lead (Pb_3O_4).

(d) Green Graphite Paint for Third Field or Maintenance Coat. The paint used as a third field or maintenance coat shall have the following composition:

- Pigment not less than 45%
 Vehicle (Boiled Linseed Oil) not more than 55%
 Weight per gallon not less than 10 lb.

The pigment shall consist of graphite pigment as specified under Paragraph 4115.03 with the addition of sufficient chrome green to give the paint the standard color adopted by the Commission. The percentage of chrome green in the total pigment shall not exceed 25. The vehicle shall be boiled linseed oil.

(e) Black Center Line Marking Paint for Concrete Highways and Black Paint for Guard Rails. This paint shall be made from a mixture of tar pitch and oils which are light tar distillates. It shall conform to the following requirements:

(1) When tested in an Engler Viscosimeter the paint shall show a specific viscosity of 8 to 15 for the first 50 c.c. at 25°C., (77° F.).

(2) When subjected to the distillation test the paint shall show from 35 per cent to 50 per cent of distillate up to 300° C.

(3) Water shall not exceed one per cent.

(4) The drying time at 70° F. shall be approximately 30 minutes. It shall be sufficiently dry within 30 minutes after application on concrete highway so that there will be no pickup under traffic, and shall be thoroughly dry, free from tackiness, within one hour after application.

(5) The color shall be a dense, lustrous black.

(f) Olive Green Equipment Paint. Olive green equipment paint shall have the following composition:

Pigment not less than 50.0%
Vehicle not more than 50.0%
Weight per gallon not less than 13.0 lbs.

Pigment Composition:

Basic Lead Carbonatenot less than 42.0%
Zinc Oxidenot less than 33.0%
Tinting Colorsnot more than 25.0%

Approximate Composition of Tinting Colors:

Ferrite Yellow10.0%
Medium Chrome Yellow 2.0%
Raw Sienna 8.0%
Carbon Black 0.5%
Raw Umber 4.5%

Vehicle Composition:

Raw Linseed Oilnot more than 62.0%
Spar Varnish (Waterproof)not less than 30.0%
Driernot more than 6.5%
Thinnernot more than 1.5%

(g) Gray Equipment Paint. The gray equipment paint shall have the following composition:

Pigment not less than 35.0%
Vehicle not more than 65.0%
Weight per gallon not less than 10 lb.

Pigment Composition:

Lithoponenot more than 25.0%
Zinc Oxidenot less than 60.0%
Titanium Barium Pigmentnot less than 15.0%
Lamp Blacksufficient to produce standard color

Vehicle Composition:

Boiled Linseed Oilnot more than 20%
Waterproof Spar Varnishnot less than 75%
Driernot more than 1%
Thinnernot more than 4%

(h) Orange Equipment Enamel. Orange equipment enamel shall have the following composition:

Pigment not less than 45.0%
Vehicle not more than 55.0%

Pigment Composition:

Orange chrome yellownot less than 92.0%
Zinc Oxidenot more than 8.0%

Vehicle Composition:

Raw Linseed Oilnot more than 62.0%
Waterproof Spar Varnishnot less than 30.0%
Driernot more than 6.5%
Thinnernot more than 1.5%

(i) **Aluminum Paint.** Aluminum paint shall be a mixture of aluminum bronze powder and exterior spar varnish.

The aluminum powder and the vehicle shall be furnished in separate containers and mixed as used. For one gallon of aluminum paint the following quantities of material shall be used:

Aluminum Powder	1.88 pounds
Exterior spar varnish	0.94 gallons

4115.05 PACKAGES AND MARK. Paint shall be packaged in strong, substantial containers plainly marked with the color and volume, in gallons, of the paint content, a true and complete statement of the percentage composition of the paint and the name and address of the manufacturer.

4115.06 INSPECTION. Unless otherwise specified in the contract, the Commission reserves the right to inspect all paint as delivered. In case the Commission elects to inspect paint at the factory, the Engineer or his representatives shall have free access to the plant for inspection purposes, and every facility shall be extended to him for this purpose.

4115.07 SAMPLES FOR TEST. Where factory inspection is to be made the manufacturer shall submit samples, upon request, of each of the ingredients of the paints he proposes to furnish, in the amounts specified, before the paint is made up. These samples shall constitute the standards for comparison for any material supplied. Samples required for testing purposes shall be not less than the amounts hereinafter specified. Ready-mixed paints shall be mixed carefully by very thorough stirring before samples are taken. All samples shall be shipped in clean tin containers with tight-fitting covers and so packed that no damage will result during transit. They shall be properly labeled and each sample shall be accompanied by a card or tag, securely attached, giving full information relative to the sample.

QUANTITIES OF SAMPLES REQUIRED

Ready-mixed paints or enamel	not less than 1 pint
Linseed oil and varnish	1 quart
Thinner and drier	not less than 1 pint
Dry pigments	¼ pound

4115.08 METHODS OF TEST. In testing paint to be used under these specifications, the Standard and Tentative Standard Methods of the A. S. T. M. shall be used when applicable.

In testing graphite pigment the following method of test shall be used:

(a) **Qualitative Analysis.** Rub a portion of the pigment in the palm of the hand; it should show the characteristic sheen of graphite. Ash another portion and make qualitative analysis following ordinary methods. The ash should be mainly siliceous; the presence of phosphate indicates adulteration with bone black.

(b) **Loss on Ignition.** Ignite 1 gm. of the pigment in a weighed porcelain crucible until all carbon is consumed. It is best to use gentle heat with free access of air. Cool, weigh and calculate the percentage of loss on ignition.

(c) **Carbon and Insoluble Siliceous Material.** Place 1 gram of the pigment in a porcelain dish, moisten with a few drops of alcohol, add 20 c.c. of concentrated hydrochloric acid, cover and heat on a steam bath for 15 minutes. Remove cover and evaporate to dryness, moisten with hydrochloric acid, add 25 c.c. of water, filter on a weighed Gooch crucible and wash thoroughly in hot water. Dry the crucible and contents at 105°C. to 110°C. for 2 hours. Cool and weigh. Calculate the loss in weight of the portion of sample taken for this determination as soluble mineral matter. Ignite the Gooch crucible and contents for 7 minutes in a current of dry carbon dioxide (using a Ross crucible cover) with a flame about 20 cm. high. Cool in a current of dry carbon dioxide and weigh. Calculate the loss in weight as volatile matter.

Treat another 1 gm. portion of the pigment with hydrochloric acid as above, but filter on an ashless paper instead of a Gooch crucible. After thorough washing,

transfer the paper and contents to a weighed crucible and ignite with free access of air (or in a current of oxygen) until all carbon is consumed. Cool and weigh as insoluble siliceous material, unless barium sulphate has been found by qualitative test. The presence of barium sulphate is cause for rejection.

(d) **Calculation.** Add together the percentages of soluble mineral matter, volatile matter and insoluble siliceous matter and subtract the sum from 100; the remainder which is fixed carbon may be calculated as graphitic carbon if the appearance of the pigment (see "a") indicates that the carbon is graphitic.

Section 4116. Wood Preservatives.

4116.01 CREOSOTE OIL FOR PRESSURE TREATMENT OF WOOD BLOCKS.

Creosote oil shall be a distillate obtained wholly from coal gas tar or coke oven tar without admixture except that not more than 35 per cent may be refined and filtered coal gas or coke oven tar. It shall conform to the following requirements:

		Minimum	Maximum
1	Water by volume		3.0%
2	Matter insoluble in benzol		3.0%
3	Specific Gravity @ 38°C. compared to water @ 15.5°C.	1.07	1.14
4	Total distillate based on water-free oil: Up to 210°C. Up to 235°C.		5.0% 25.0% 10.0%
5	Coke residue		
6	Float test of residue above 355°C., if it exceeds 35%, at 70°C.		80 sec.

4116.02 CREOSOTE OIL FOR PRESSURE TREATMENT OF LUMBER, PILING AND POSTS. The creosote oil shall be a distillate obtained wholly from coal gas tar or coke oven tar without admixture. This oil shall also be used for brush treatment of cut or damaged surfaces of pressure-treated lumber or piling. It shall conform to the following requirements:

		Minimum	Maximum
1	Water by volume		3.0%
2	Matter insoluble in benzol		0.5%
3	Specific gravity at 38°C. compared to water at 15.5°C.	1.03	
4	Total distillate based on water-free oil: Up to 210°C. Up to 235°C.		5.0% 25.0%
5	Specific gravity at 38°C. compared to water at 15.5°C. Fraction from 235°C. to 315°C. Fraction from 315°C. to 355°C.	1.025 1.085	
6	Coke residue		2.0%
7	Float test of residue above 355°C., if it exceeds 5.0%, at 70°C.		50.0 sec.

4116.03 CREOSOTE OIL FOR BUTT TREATMENT OF POSTS. Creosote oil shall be a distillate obtained wholly from coal gas tar or coke oven tar. It shall be liquid at 15.5°C. and crystal free at 38°C. and shall conform to the following requirements:

		Minimum	Maximum
1	Water by volume		1.0%
2	Matter in insoluble in benzol		0.5%
3	Specific gravity at 38°C. compared to water at 15.5°C.	1.06	
4	Total distillate based on water-free oil:		
	Up to 210°C.		1.0%
	Up to 235°C.		10.0%
	Up to 355°C.	65.0%	
5	Specific gravity at 38°C. compared to water at 15.5°C.		
	Fraction from 235°C. to 315°C.	1.03	
	Fraction from 315°C. to 355°C.	1.09	
6	Coke Residue		2.0%
7	Float test of residue above 355°C., if it exceeds 10.0%, at 70°C.		50.0 sec.

4116.04 ANTIMONY TRICHLORIDE SOLUTION. The antimony trichloride solution shall conform to the following requirements and shall be furnished in the following proportions:

Antimony Trichloride2½ lb.
Benzol 7/8 gal.
Yieldapproximately one gallon of solution

The solution should be homogeneous and free from analine dyes or other coloring matter not inherent to the antimony trichloride or benzol.

The specific gravity of the solution at 15.5°C. compared with water at the same temperature as determined by the Westphal balance, shall be not less than 1.06 nor more than 1.08. When 2 to 3 cubic centimeters of the above solution is treated with 100 cubic centimeters of water and 100 cubic centimeters of ethyl alcohol, a white curdy precipitate shall be formed, and upon filtering through an asbestos mat in a Gooch crucible the resulting filtrate shall be clear and no further precipitation shall take place upon diluting with another 100 cubic centimeters of water.

The above solution is to be diluted at the place of treatment in the proportion of one gallon to 2½ gallons of kerosene. The resulting mixture shall be thoroughly stirred to homogeneity before the treatment is begun.

The antimony trichloride used shall be of the crystalline form. The purity of the antimony trichloride shall be determined by the melting point according to the following method:

Sufficient crystals shall be taken so that when melted they shall three-quarters fill a 4-ounce glass bottle of the salt mouth variety. Care must be taken during melting to avoid contact. The melting point is determined by allowing the melted sample to cool while stirring with a thermometer. The recalescence point shall be taken as the true melting point of the material. The thermometer shall be of similar shape, workmanship and appearance as the instrument described for the distillation of benzol (see Journal of Industrial and Engineering Chemistry, December, 1918, Page 1006) except that it shall be graduated every tenth of one degree C. between 65 and 75°C.

Antimony trichloride, when tested by this method, shall have a melting point of 70.0°C. or higher.

The benzol to be used in connection with the antimony trichloride shall be that known as "commercially pure" benzol, and shall comply with the following requirements:

The visible color of the benzol shall be not darker than a solution of 0.0030 gram of potassium bichromate in one liter of water, comparison to be made in 50 c.c. Nessler tubes.

The product shall distill from the start to dry within 2°C., within which degrees shall be included the true boiling point of pure benzol (80.2°C.). The method of distillation shall be in accordance with Method E-4, Journal Industrial and Engineering Chemistry, 10,1008 (1918).

The product shall contain no free acid.

The specific gravity at 15.5°C. shall lie between 0.875 and 0.886. The specific gravity shall be determined by the use of the Westphal balance.

The benzol shall have the usual characteristic odor of the aromatic hydrocarbons and shall have no pronounced foreign odor.

CAUTION. Antimony trichloride and benzol are **both poisonous**. Due caution should be observed and exercised in handling and working with these materials.

Benzol is inflammable.

Section 4117. Preservative Treatment.

4117.01 GENERAL REQUIREMENTS. Treated timbers, lumber, piles and posts furnished under these specifications shall be given preservative treatment in accordance with the following methods as specified in the plans or proposals.

4117.02 PRESSURE TREATMENT. When pressure treatment is required, the material shall be thoroughly seasoned and treated in accordance with the Standard Method for Preservative Treatment "Empty Cell Process with Initial Air Pressure" specified in the A. A. S. H. O. "Standard Specifications for Highway Bridges, Culverts and Incidental Structures." The Contractor's attention is called to the following particulars of the requirements for this process:

1. **Seasoning for Oil Treatment.** Green Douglas Fir must be seasoned in oil. Green Southern Pine must be steam seasoned.

2. **Preparation for Treatment.** Each cylinder charge shall consist of pieces approximately equal in size, moisture and sapwood content into which approximately equal quantities of preservative fluid can be injected. Pieces shall be so separated as to insure contact of steam and preservatives with all surfaces.

3. **Penetration.** The range of pressure, temperature, and time duration shall be controlled so as to result in a maximum penetration by the quantity of preservative injected. The vacuum requirements stipulated are in inches of mercury at sea level, and necessary corrections shall be made for altitude.

In Southern Yellow Pine the preservative shall permeate all of the sapwood and as much of the heartwood as practicable.

In Douglas Fir the minimum penetration for the specified amount of creosote oil shall be as follows:

	Specified amount of Creosote per Cu. Ft.	
	Ten Pounds or Less (Inch)	Twelve Pounds (Inch)
Piling	5/8	3/4
Timbers 12 inches by 12 inches and larger .....	.65	.75

For timbers less than 12 inches by 12 inches the required depth of penetration shall be determined by the formula:

$$P = P_s \frac{R}{R_s}$$

Where P = required penetration.

P_s = specified penetration for 12 inch by 12 inch timbers.

R = ratio of the volume of the piece in question to its superficial area.

R_s = ratio of the volume of a 12 inch by 12 inch timber to its superficial area.

The penetration of the preservative shall be based on black or dark oil, and in no case will light discoloration of the wood, due to treatment, be taken into consideration in measuring the depth of penetration.

Tests for penetration shall be made by taking borings with an increment borer, or

a 5/8 inch auger, all holes so bored to be plugged by the Contractor with tight-fitting creosoted plugs.

As many penetration tests of lumber and piling shall be made as is considered necessary by the inspector. In the case of piling, the holes shall be bored midway between the ends.

In the case of timber and lumber, every fourth stick of the charge may be bored.

(a) **Special Treatment for Guard Rail and Sign Posts.** Sign and guard rail posts which have been given preservative treatment with creosote oil, before removal from the cylinder, shall be further subjected to live steam at a maximum pressure of 30 pounds and following that to an additional period of vacuum to insure that the surface of the wood shall be free from accumulation of tarry material.

(b) **Preservatives.** The preservatives used shall be creosote distillate oil meeting the requirements of Paragraph 4116.02.

(c) **Boring and Framing.** All cutting, framing, boring or doming of treated material shall be performed before treatment.

(d) **Incising.** All sawn pieces of Douglas Fir with nominal thickness 3 inches or more shall be incised before treatment. The incising machine shall be equipped with power driven rolls which shall incise to uniform depth and continuity of predetermined pattern. Lumber 4 inches and over in thickness shall be incised on all 4 sides. Lumber 3 inches thick shall be incised on wide faces only. The incisions shall preferably be made by teeth designed to separate rather than cut the wood fibers with a minimum loss of structural strength.

The pattern of the incisions shall consist of successive parallel rows of punctures spaced not over one inch apart across the piece and not more than 2 1/2 inches between rows lengthwise of the piece. The rows shall be staggered so that in 3 successive rows 2 incisions fall between each 2 of the first row at approximately equal spaces.

The depth of the incision shall be such that a uniform penetration of the preservative is secured in accordance with the depth of penetration called for in the foregoing paragraphs.

(e) **Amount of Preservative.** It is contemplated that each charge will be composed of material of approximately equal size and heartwood content and into which approximately equal quantities of preservatives may be injected. When the quantity of any one size of timber to be treated on any order is too small to constitute an individual charge, mixed sizes may be treated. The amount of water-free oil retained in the wood shall not be less than the sum obtained by multiplying the volume of wood in pieces of each size in the charge by the final retention specified in the following table, and adding together the results obtained. The volume of the charge shall be computed on the nominal rough dimensions or the actual dressed dimensions of the pieces with no allowance for reduction of size due to boring or framing.

Pieces Composing the Charge	Amount of Preservative to be Retained Per Cu. Ft.
Timber with:	
Nominal thickness less than 5 inches	12 lb.
Nominal thickness 6 to 9 inches incl.	10 lb.
Nominal thickness 10 inches and over	8 lb.
Piling	10 lb.
Posts	8 lb.

Piling shall not be treated in the same charge with guard fence posts or timbers requiring lesser amounts of preservative per cubic foot.

4117.03 BUTT TREATMENT. The butt treatment of the posts with creosote oil shall conform to the requirements of the standard method of preservative treatment "Open Tank Method, Single or Hot Bath Treatment" of the A. A. S. H. O. "Standard

Specifications for Highway Bridges and Incidental Structures," 1931. The bottom 4½ feet of the post shall be treated with the preservatives. After treatment the posts shall be piled until dry in such a way that the part of the posts above the treated portion shall be free from creosote oil.

(a) **Preservative.** The preservative used in Butt Treatment shall conform to the requirements of Paragraph 4116.03 or 4116.04.

Section 4118. Wood Paving Blocks.

4118.01 GENERAL REQUIREMENTS. Wood blocks for use in wearing surfaces on bridge floors shall be Dense Southern Pine meeting the requirements of the A. S. T. M. "Standard Specification for Wood Paving Blocks for Exposed Pavements," Designation D52-20, supplemented by the following paragraphs:

(a) **Size of Blocks.** The blocks shall be from 5 to 8 inches in length, 3 inches in depth unless otherwise specified, and 4 inches in width. A variation of 1/16 inch shall be allowed in depth and 1/8 inch in width.

(b) **Creosote Oil.** The creosote oil used shall conform to the requirements of Paragraph 4116.01.

Section 4119. Treated Timbers.

4119.01 GENERAL REQUIREMENTS. All rough and dressed treated timbers and lumber furnished under these specifications shall conform to the following detailed requirements. The preservative treatment shall conform to the requirements of Section 4117 for "Full Pressure Preservative Treatment."

4119.02 SPECIES OF WOOD. Only Douglas Fir and Southern Pine will be admitted under these specifications for treated timbers and lumber.

4119.03 LENGTHS OF MATERIAL. All lengths of materials furnished shall be in multiples of 2 feet unless otherwise specified on the plans or in the contract.

4119.04 MINIMUM ACCEPTABLE SIZES. All material furnished shall conform to the dimensions specified for either "Rough" or "Surfaced" stock. Unless otherwise specified on the plans or in the contract, rough material shall be furnished. Materials covered by these specifications are classified as follows according to use:

Joist and Plank:

Nominal thickness.....	2 in., 3 in., and 4 in.
Nominal widths	4 in. and wider in multiples of 2 in.
Dressed thickness, S1S or S2S	3/8 in. off
Dressed widths, S1E or S2E	3/8 in. off for widths 4 in. to 7 in. incl. 1/2 in. off for widths 8 in. and over

Beams and Stringers:

Nominal thickness	5 in., 6 in., and thicker
Nominal widths	8 in. and wider in multiples of 2 in.
Dressed sizes, S1S, S1E, S2S or S4S	1/2 in. off

Posts and Timbers.

Nominal sizes	6 in. x 6 in. and larger in multiples of 2 in.
Dressed sizes, S1S, S1E, S2S, or S4S	1/2 in. off

(a) **"Rough Stock."** Rough material shall be well manufactured and shall be sawn to the full nominal dimension except that occasional slight variation in sawing will be permissible. This variation in sawing will be interpreted as a deviation from

the intended straight line of cut, which shall not exceed the following limits for the respective sizes:

Nominal Dimension	Allowable Variation in Sawing
2 in.	1/8 in. under
3 in. to 7 in.	3/16 in. under
8 in. and over	1/4 in. under

Not more than 20% of the pieces of any one size in any shipment shall be of the minimum dimensions. At least 80% of the pieces shall have the full nominal dimensions at some point.

(b) **“Surfaced Stock.”** Surfaced material shall be furnished S1E or S2E, and, or S1S or S2S, as specified in the proposals or the contract. The material shall be surfaced to the dressed dimensions specified in Paragraph 4119.04 and shall be clean except that occasional slight skips where the planer did not surface smooth but not exceeding 6 in. in length, will be permitted.

Floor plank furnished S1S shall be surfaced on the heart side.

When so specified on the plans or proposals, beams and stringers shall be daped to a specified depth for 2 feet on each end in lieu of surfacing the full length.

(c) **“Surfaced Hit or Miss.”*** When so specified in proposals or contract, material shall be furnished with “Hit or Miss” dressing subject to the following conditions:

In the production of this material the planer shall be set to surface one side and one edge of the piece at 1/8 inch less than the full nominal dimensions, and all stock of greater thickness and width dressed smooth. At least 80 per cent of the pieces of any one size in any shipment shall be surfaced on one side and one edge for the greater part of their length. That portion of each piece which remains unsurfaced shall not be less than the full nominal dimensions by more than 3/16 inch in thickness or 1/4 inch in width.

Note: *Material covered by this specification is best adapted to use as floor plank when a perfectly smooth surface is not necessary but the the maximum variation of “Rough” material is to be avoided.

(d) **Seasoning.** When thoroughly air seasoned stock is furnished in “Rough” material, a tolerance of 2.0 per cent of the minimum specified dimension, but not exceeding 1/8 inch for sizes 7 inches and narrower, nor more than 1/4 inch for sizes 8 inches and wider, will be accepted. No seasoning tolerance will be allowed in “dressed” material. In case of controversy regarding shrinkage of seasoned material and the resultant size of stock, the original green size of the material may be determined by soaking pieces in water.

4119.05 BORING, FRAMING AND INCISING. Unless specifically stated on the plans or proposals, all framing, and boring shall be done before treatment. Douglas Fir lumber shall be incised before treatment. Incising shall be performed in accordance with requirements of Paragraph 4117.02 (d).

4119.06 GRADING REQUIREMENTS. The terms used in these specifications shall be interpreted in accordance with the A. S. T. M. “Standard Definitions of Terms Relating to Structural Timber,” Designation D9-30.

The quality of the timbers shall conform to the requirements of the A. S. T. M. “Standard Specifications for Structural Wood Joists, Plank, Beams, Stringers and Posts,” Designation D245-30, and to the detailed requirements of the coded specifications for the various species as follows:

Use	Material	Grade	Coded Specifications	
			Number	Title
Beams & Stringers	Douglas Fir	Select	9	Beams & Stringers, Douglas Fir, Select, Sapwood wanted for treatment, Square Edges.
	Southern Pine	Dense Select	4	Beams & Stringers, Southern Pine, Dense Select, Sapwood wanted for treatment, Square Edges.
Joist & Plank	Douglas Fir	Select	34	Joist & Plank, Douglas Fir, Select, Sapwood wanted for treatment, Square Edges.
	Southern Pine	Dense Select	29	Joist & Plank, Southern Pine, Dense Select, Sapwood wanted for treatment, Square Edges.
Posts & Timbers	Douglas Fir	Select	59	Posts & Timbers, Douglas Fir, Select, Sapwood wanted for treatment, Square Edges.
	Southern Pine	Dense Select	54	Posts & Timbers, Southern Pine, Dense Select, Sapwood wanted for treatment, Square Edges.

Section 4120. Untreated Timbers and Lumber.

4120.01 GENERAL REQUIREMENTS. All rough and dressed timbers and lumber furnished under these specifications shall conform to the following detailed requirements as to size and quality for the grade and dimension called for on the plans or in the contract.

4120.02 LENGTHS OF MATERIAL. The lengths of all materials furnished under these specifications shall be in multiples of 2 feet unless otherwise specified on the plans or in the contract.

4120.03 MINIMUM ACCEPTABLE SIZES. All material furnished shall conform to the dimensions specified for either "Rough" or "Surfaced" stock. Unless otherwise specified on the plans or in the contract rough material shall be furnished. Materials covered by these specifications are classified as follows according to use:

Joist and Plank:

Nominal thickness	2 in., 3 in. and 4 in.
Nominal widths	4 in. and wider in multiples of 2 in.
Dressed thickness, S1S or S2S	3/8 in. off
Dressed widths, S1E or S2E.....	3/8 in. off for widths 4 in. to 7 in. incl. 1/2 in. off for widths 8 in. and over

Beams and Stringers:

Nominal thickness	5 in., 6 in. and thicker
Nominal widths	8 in. and wider in multiples of 2 in.
Dressed sizes, S1S, S1E, S2S or S4S	1/2 in. off

Posts and Timbers:

Nominal sizes	6 in. x 6 in. and larger in multiples of 2 in.
Dressed sizes, S1S, S1E, S2S or S4S	1/2 in. off

(a) "Rough Stock." Rough material shall be well manufactured and shall be sawn to the full nominal dimension except that occasional slight variation in sawing will be permissible. This variation in sawing will be interpreted as a deviation from the intended straight line of cut, which shall not exceed the following limits for the respective sizes:

Nominal Dimension	Allowable Variation in Sawing
2 in.	1/8 inch under
3 in. to 7 in.	3/16 inch under
8 in. and over	1/4 inch under

Not more than 20 per cent of the pieces of any one size in any shipment shall be

of the minimum dimensions. At least 80 per cent of the pieces shall have the full nominal dimensions at some point.

(b) **“Surfaced Stock.”** Surfaced material shall be furnished S1E or S2E, and, or S1S or S2S, as specified in the proposals or the contract. This material shall be surfaced to the size specified in the foregoing paragraph and shall be clean except that occasional slight skips where the planer did not surface smooth but not exceeding six inches in length, will be permitted.

Floor plank furnished S1S shall be surfaced on the heart side.

When so specified on the plans or proposals, beams and stringers shall be daped to a specified depth for 2 feet on each end in lieu of surfacing the full length.

(c) **“Surfaced Hit or Miss.”*** When so specified in proposals or contract, material shall be furnished with “Hit or Miss” dressing subject to the following conditions:

In the production of this material the planer shall be set to surface one side and one edge of the piece at $\frac{1}{8}$ inch less than the full nominal dimensions, and all stock of greater thickness and width dressed smooth. At least 80 per cent of the pieces of any one size in any shipment shall be surfaced on one side and one edge for the greater part of their length. That portion of each piece which remains unsurfaced shall not be less than the full nominal dimensions by more than $\frac{3}{16}$ inch in thickness or $\frac{1}{4}$ inch in width.

Note: *Material covered by this specification is best adapted to use as floor plank when a perfectly smooth surface is not necessary but the maximum variation of “Rough” material is to be avoided.

(d) **Seasoning.** When thoroughly air seasoned stock is furnished in either “Rough” or “Surfaced” material, a tolerance of 2.0 per cent of the minimum specified dimension, but not exceeding $\frac{1}{8}$ inch for sizes 7 inches and narrower, nor more than $\frac{1}{4}$ inch for sizes 8 inches and wider, will be accepted. The seasoning shall have been accomplished before the material is shipped or presented for inspection. In case of controversy regarding shrinkage of seasoned material and the resultant size of stock, the original green size of the material may be determined by soaking pieces in water.

4120.04 CLASSIFICATION. For the purpose of this specification all bridge timbers and lumber are classified as follows:

(a) **Class A.** Class A shall include all bridge timbers and lumber having a nominal thickness of 3 inches or more except material for handrail posts.

(b) **Class C.** Class C shall include all bridge lumber having a nominal thickness of less than 3 inches and also all material for handrail posts.

(c) **Class D.** Class D shall include lumber for maintenance work only. This grade of material is not suitable for use as beams and stringers where a definite supporting strength is required.

4120.05 SPECIES OF WOOD. The species of wood specified below may be furnished under these specifications:

(a) **Class A.** Douglas Fir or Southern Pine. For floor plank Oak may be furnished when specified.

(b) **Class C.** Douglas Fir, Southern Pine, Western Hemlock or Ponderosa Pine.

(c) **Class D.** Douglas Fir or Southern Pine.

4120.06 DEFINITION OF TERMS. The terms used in these specifications shall be interpreted in accordance with the A. S. T. M. “Standard Definitions of Terms Relating to Structural Timber,” Designation D9-30.

4120.07 GRADING RULES. The quality of all timbers and lumber furnished

under these specifications shall conform to the following grading rules for the class specified:

(a) **Class A.** All material in Class A shall conform to the requirements of the A. S. T. M. "Standard Specifications for Structural Wood Joist, Planks, Beams, Stringers, and Posts," Designation D245-30, and to the detailed requirements of the coded specifications as follows:

Use	Material	Grade	Coded Specifications	
			No.	Title
Beams & Stringers	Douglas Fir	Select	6	Beams & Stringers, Douglas Fir, Select, 85% Heartwood, Square Edges.
	Southern Pine	Dense Select	1	Beams & Stringers, South Pine, Dense Select, 85% Heartwood, Square Edges.
Joist & Plank	Douglas Fir	Select	31	Joist & Plank, Douglas Fir, Select, 85% Heartwood, Square Edges.
	Southern Pine	Dense Select	26	Joist & Plank, Southern Pine, Dense Select, 85% Heartwood, Square Edges.
Posts & Timbers	Douglas Fir	Select	56	Posts & Timbers, Douglas Fir, Select, 85% Heartwood, Square Edges.
	Southern Pine	Dense Select	51	Posts & Timbers, Southern Pine, Dense Select, 85% Heartwood, Square Edges.

For bridge floors when Oak is specified, only White Oak, Burr or Post Oak, may be furnished. The planks shall conform to the National Hardwood Lumber Manufacturers Association "Rules for Measurement and Inspection of Hardwood Lumber," (No. 1 Bridge Plank, page 73), effective January, 1933.

(b) **Class C.** All material furnished under this class shall conform to the following standards according to the species of material:

Species	Grade Designation	Standard
Douglas Fir) Western Hemlock)	No. 1 Common Dimension	Par. 195 West Coast Lumbermen's Ass'n., St'd. Grading & Dressing Rules, 1929.
	No. 1 Common Boards	Par. 187, West Coast Lumbermen's Ass'n., St'd. Grading & Dressing Rules, 1929.
Ponderosa Pine	No. 1 Common	Standard Grading & Dressing Rules, July 1, 1929. Western White Pine Ass'n.
Southern Pine	No. 1 Common) Dimension) No. 1 Common) Board)	Standard Specification for Grades of Southern Pine Lumber and Timbers, Sept., 1932, Southern Pine Association.

(c) **Class D.** All material of this class shall conform to the requirements of the A. S. T. M. "Standard Specifications for Structural Wood Joist, Plank, Beams, Stringers and Posts," Designation D245-30, and to the detailed requirements of the coded specifications as follows:

Use	Material	Coded Specifications	
		No.	Title
Joist & Plank	Douglas Fir or Southern Pine	48	Joist & Plank, Common, No Heartwood or Sapwood Requirements, Wane Permitted.
Posts & Timbers	Douglas Fir or Southern Pine	73	Posts & Timbers, Common, No Heartwood or Sapwood Requirements, Wane Permitted.

Material furnished under this specification shall show a mean average on one end of the piece of not less than 4 annual rings per inch when measured over the 3-inch

line located as specified for determining "Close Grain" or "Density" for Class A material.

Section 4121. Posts.

4121.01 GENERAL REQUIREMENTS. All posts furnished shall conform to the detailed requirements hereinafter stated for one of the classes listed below as specified on the plans and proposals:

Round Wood Posts
Sawed Wood Posts
Steel Angle Posts
Steel Tee Posts

4121.02 ROUND WOOD POSTS. All round wood posts shall be cut from sound and solid trees. They shall contain no unsound knots. Sound knots will be permitted provided the diameter of the knot does not exceed $\frac{1}{3}$ of the diameter of the piece at the point where it occurs or a maximum of $2\frac{1}{2}$ inches. They shall be free from decayed wood, rot, "red heart," ring shake or season checks which penetrate at any point more than $\frac{1}{4}$ the diameter of the piece or are more than $\frac{1}{4}$ " wide. Fir and pine posts shall be close grained, showing 6 to 20 annular rings per inch when measured as prescribed for close grain or density for untreated lumber, Class A, Section 4120. Spiral grain shall not exceed $\frac{1}{4}$ turn in 10 feet. Groups of knots or any defect or combination of defects which impair the strength more than the maximum knot shall not be accepted. All posts shall be peeled for their full length and all bark and inner skin removed. The part of the post which will remain out of the ground shall be shaved clean, and free from glazed surface left by dried sap. All knots and projections shall be shaved smooth and flush with the surface of the surrounding wood.

When so specified on the plans or proposals the tops of posts shall be shaped to a true hemispherical surface which shall have the same diameter as specified for the posts and whose axis shall coincide with the axis of the post.

(a) **Straightness.** All posts shall be free from short or reverse bends. Curvature or sweep in excess of $2\frac{1}{2}$ inches measured at its maximum deviation will not be permitted.

(b) **Size.** The size of posts will be specified on the plans or proposals by even inches of the diameter of the top. Posts will be accepted only when the top diameter equals the specified dimension or exceeds it by less than $\frac{1}{2}$ inch. This diameter may be determined from the circumference divided by 3.14.

(c) **Species.** The species of wood of posts furnished under these specifications shall be that called for on the plans or proposals with the following limitations:

(1) Posts which are to be given full pressure preservative treatment shall be Southern Pine, or Douglas Fir.

(2) Posts which are to be given preservative treatment on butts only shall be Cypress or White Cedar.

(3) Untreated posts shall be White or Burr Oak, Black Locust, Osage Orange or Red Cedar.

(d) **Preservative Treatment.** All posts when so stipulated on plans or proposals, shall be given preservative treatment in accordance with the methods specified in Section 4117, and with one of the preservatives specified in Section 4116.

(e) **Inspection.** The posts shall be inspected before being treated. The Contractor shall notify the Materials Department of the State Highway Commission at Ames, Iowa, of the name and location of the company furnishing the posts. If the posts are to be treated at the source of supply, such notice shall be given in advance of the date of treatment to allow for the selection and testing of samples of the preservative

which is to be used. The inspector shall have free access to all parts of the treating plant and the plant shall be equipped with instruments for accurate measurement of the treating process.

Posts which are to be butt-treated only may be treated after delivery at the site of the work.

4121.03 SAWED WOOD POSTS. Sawed wood posts for all construction other than sign posts and hand rails for bridges shall conform to the requirements of Section 4120, "Untreated Lumber, Class A."

Sign posts shall conform to the requirements listed in Paragraph 4121.04.

(a) **Size.** Posts shall conform to the shape and nominal dimensions specified on the plans or proposals.

(b) **Preservative Treatment.** All posts when so stipulated on plans or proposals, shall be given preservative treatment in accordance with the methods specified in Section 4117, and with one of the preservatives specified in Section 4116.

4121.04 WOOD SIGN POSTS. Wood sign posts shall be furnished either treated or untreated as specified in the proposals or contracts. They shall conform to the following requirements:

(a) **Species.** Wood sign posts may be furnished untreated in either Redwood or Red Cedar, and treated in either Southern Pine or Douglas Fir. They shall conform to the following requirements for the respective species as specified on the plans or proposals:

(1) **Redwood.** Redwood posts furnished under these specifications shall comply with the following requirements:

a. **Size of Knots.** Knots shall not exceed one-third of the width of face. Single pin knots will be admitted in any number or any position except in clusters. The number of sound, incased or pith knots on all 4 sides of the piece shall not exceed twice the length of the stick, in feet, and the total number of knots on any one face shall not exceed three-fourths of the length of the stick in feet. Clusters of knots will not be admitted.

b. **Shakes, Checks and Splits.** Shakes, checks and splits in green wood shall not exceed $\frac{1}{2}$ the width of the end. In seasoned wood they shall not exceed $\frac{3}{5}$ the width of the end.

c. **Slope of Grain.** In the middle $\frac{1}{3}$ of the length the slope of grain shall not exceed one to 15.

d. **Heartwood.** Pieces shall contain only heartwood.

e. **Close Grain.** Rate of growth shall not be less than 7 annual rings per inch.

(2) **Red Cedar.** Red Cedar posts shall comply with the requirements of Paragraph 451 for "Selected Common Red Cedar" of the West Coast Lumbermen's Association "Standard Grading and Dressing Rules No. 9," effective July 1, 1929, except that no piece shall show less than 75% heartwood on any face.

(3) **Southern Pine.** Southern Pine posts shall comply with the requirements for "No. 1 Longleaf Small Timbers" or "No. 1 Shortleaf Small Timbers" as given in the Southern Pine Association "Standard Specifications for Southern Pine Lumber and Timber," effective September 1, 1932, except that in the center half of the length the sum of the diameters of all knots on any one face shall not exceed the width of the face.

(4) **Douglas Fir.** Douglas Fir posts shall comply with the requirements of Paragraph 195 for "No. 1 Common Dimension Douglas Fir" of the West Coast Lumbermen's Association "Standard Grading and Dressing Rules," effective July

1, 1929, except that in the center half of the length the sum of the diameters of all knots on any one face shall not exceed the width of the face.

(b) **Size.** All wood sign posts shall be furnished to the nominal dimension of 4 in. x 4 in. surfaced four sides to not less than 3½ in. x 3½ in., in lengths 8 ft., 10 ft., 12 ft., as ordered. All posts shall be sawed square at both ends and shall be bored with 8 holes 7/16 in diameter. The first hole shall be 3 in. from one end and other holes at 6-inch spacing (cc). The spacing and alignment of the holes shall be within 1/16 inch of true centerline and distance.

(c) **Preservative Treatment.** All Douglas Fir and Southern Pine sign posts shall be given full pressure preservative treatment in accordance with the method specified in Section 4117, "Preservative Treatment for Timber," with the preservative specified in the proposal or the contract, which shall meet requirements of Section 4116, "Timber Preservatives."

(d) **Inspection.** Inspection of untreated wood posts will be made after delivery. Inspection of treated wood posts will be performed at the treating plant. Both the untreated material and the treating process will be inspected. The manufacturer shall advise the Department of Materials and Tests a sufficient time in advance of the treating date to allow for arrangements for inspection and testing preliminary samples of preservatives.

4121.05 STEEL ANGLE POSTS. Steel angle posts shall be furnished in 10-foot lengths, weighing approximately 2.44 pounds per foot. The cross section of the post shall be 2 in. x 2 in. x 3/16 in. angle. The moment of inertia shall not be less than 0.28 in. Bidders should submit a sample of their post prior to the letting. One leg of the angle shall be punched with 7/16 inch holes as follows: first hole 3 inches from the top, 7 more holes at 6-inch spacing. The spacing and alignment of the holes shall be within 1/16 inch of the true center lines and distance.

(a) **Zinc Coating.** After the posts are cut to length and punched, they shall be coated with a minimum of 2 ounces of zinc per square foot of surface. The zinc coating shall be applied by the hot-dip process. It shall be uniform in thickness, and shall be smooth and free from blister spots, scales, holes, or other imperfections not consistent with a sound coating.

Determination of the weight of zinc coating shall be made in accordance with the Hydrochloric Acid-Antimony Chloride Method as described in the A. S. T. M. "Standard Method for Determining Weight of Coating on Zinc Coated Articles," Designation A90-30.

The zinc used for the coating shall be any grade of zinc conforming to the requirements of the A. S. T. M. "Standard Specifications for Slab Zinc," Designation B6-18.

4121.06 STEEL TEE POSTS. Steel tee posts shall be made of rail steel 6½ ft. long and 1½ in. x 1½ in. tee section, or a section having a moment of inertia and area of projection not less than that of the specified tee section in both directions. The average weight of tee sections shall be not less than 8.75 pounds per post and no post shall weigh less than 8.50 pounds. They shall be sharpened on one end by shearing off both sides of the flange of the tee. Posts shall be punched with one 3/8-inch hole near the top.

(a) **Painting.** After shearing and punching, all posts shall be painted with an iron oxide paint and oven-dried in such a manner that the paint film will be uniform, hard and free from marks due to contact with other surfaces. The paint used shall have proper flowing and covering properties to suit the method of application. It shall contain not less than 40.0 per cent by weight, iron oxide pigment, and shall weigh not less than 10.0 pounds per gallon at the time of application.

Section 4122. Piling.

4122.01 STEEL PILING. Steel piling shall have the section shown on the plans. Steel piling shall be rolled from steel conforming to the requirements of Section 4113.

4122.02 CONCRETE PILES. Concrete piles shall be made of Class A concrete as specified in Section 2402. They shall have the form, dimensions and reinforcement shown on the plans and shall be constructed and cured as required in Paragraphs 2501.03 and 2501.04.

4122.03 UNTREATED WOOD FOUNDATION PILES. Untreated wood foundation piles shall be cut from sound and solid trees preferably during the winter season. To avoid deterioration and excessive season checks they should be cut within 12 months prior to delivery to the construction site. They shall contain no unsound knots. Sound knots will be permitted provided the diameter of the knot does not exceed $\frac{1}{3}$ of the diameter of the stick at the point where it occurs, with a maximum limit of 4 inches. They shall be free from decayed wood, rot, "Red Heart," ring shake and season checks which penetrate at any point more than $\frac{1}{4}$ the diameter of the pile or which are more than $\frac{1}{4}$ inch wide. Cypress piling showing peck over 5.0 per cent of either butt or tip will not be accepted. Fir and Pine piling shall be close grained showing 6 to 20 annular rings per inch when measured as prescribed for "close grain" or "Density" for untreated lumber, Class A, Section 4120. Groups of knots or any defects or combination of defects which will impair the strength more than the maximum knot will not be accepted.

Piles shall be cut above ground swell and shall taper uniformly from butt to tip. Both butt and tip shall be cut square. All knots shall be trimmed close to the body of the pile. All piles shall be peeled. On all species except Red Cedar all the outer bark and at least 75 per cent of the inner bark shall be removed. Red Cedar piles shall have at least 75 per cent of the outer and inner bark removed.

They shall also conform to the following requirements:

(a) **Species.** Untreated wood foundation piles may be White Oak, Burr Oak, Willow Oak, Post Oak, Red Cedar, Western or White Cedar, Cypress, Chestnut, Tamarack, Douglas Fir, Southern Pine, Norway Pine or other wood which will satisfactorily withstand driving.

(b) **Dimensions.** At least 95 per cent of piles in any one shipment shall conform to the following dimensions:

Length Feet	Circumference 3 ft. from Butt Inches		Tip Diameter Inches	
	Minimum	Maximum	Minimum	Maximum
Less than 40 ft.	(0.5L* + 23)	55.0	8.0	10.0
40 ft. and over	(0.5L* + 23)	60.0	7.0	9.0

*L = Length of pile in feet

The remaining 5 per cent of the lot may be deficient in minimum butt or minimum tip measurement by not more than 5 per cent of the specified dimension.

Piles will be furnished to the length called for in plans or proposals or as specified by the Engineer. These lengths will be specified in multiples of 2 feet for lengths of 20 feet and under, and in multiples of 5 feet for lengths over 20 feet.

(c) **Straightness.** The center of the pile shall not deviate more than 4 inches from a straight line drawn from the center of the tip to the center of the butt. In short bends the distance of the center of the pile from a line drawn from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4 per cent of the length of the bend or $2\frac{1}{2}$ inches.

4122.04 UNTREATED WOOD PILES FOR EXPOSED WORK. Untreated wood piles for exposed work or above ground water level shall conform to the foregoing requirements for foundation piling with the following additional requirements:

(a) **Species.** Piling shall be of one of the following species: White Oak, Burr Oak, Post Oak, Tennessee Red Cedar, Douglas Fir, Western Red Cedar or Southern Pine.

(b) **Heartwood.** The diameter of the heartwood at both butt and tip shall not be less than eight-tenths of the required diameter of the pile.

4122.05 TREATED WOOD PILES. Piles to be given preservative treatment shall conform to the requirements for Untreated Foundation Piles (Paragraph 4122.03) with the following additional requirements:

(a) **Species.** The piles shall be either Southern Pine or Douglas Fir.

(b) **Peeling.** All piles shall be peeled by removing all of the rough bark and at least 80 per cent of the inner bark. No strip of inner bark remaining on the pile shall be over $\frac{3}{4}$ inch wide or over 8 inches long, and there shall be at least one inch clean wood surface between any 2 such strips. Not less than 80 per cent of the surface of any circumference shall be clean wood.

(c) **Preservative Treatment.** The piles shall be given full pressure preservative treatment in accordance with the requirements of Section 4117. The preservative used shall be creosote oil conforming to the requirements of Paragraph 4116.02. Ring shakes, checks, "water bursts," or similar defects which develop during the treating process may be considered cause for rejection.

Section 4123. Snow Fence.

4123.01 GENERAL. Snow fence shall consist of wood slats tightly woven together with galvanized wire cables.

4123.02 SLATS. The actual dimensions of the slats shall be $1\frac{1}{2}$ in. by $\frac{1}{2}$ in. by 48 in. The slats shall be cut with square or pointed ends and shall be well seasoned before weaving. They shall be spaced 2 inches apart. Slats may be made of any durable wood except Cottonwood, Basswood, Poplar, Gum or Elm. The fence shall not contain over 3 per cent of weak slats caused by cross grain, knots or other defects.

4123.03 CABLES. The slats shall be tightly woven together by 4 or 5 cables, each cable to consist of 2 galvanized wires.

If 4 cables are used the wire shall be not less than 0.102 inches in diameter. If 5 cables are used the wire shall be not less than 0.095 inches in diameter. One cable shall be placed approximately 4 inches from each end of the slats and the other cables equally spaced between these two. Each wire shall have a continuous coating of zinc galvanizing of uniform thickness. The average amount of coating shall be not less than 0.50 ounce per square foot. No one specimen shall show less than 0.45 ounce per square foot of surface. Such limits shall apply to wire before fabrication. The coating shall be smooth and free from blister spots, scales, holes, or other imperfections, and shall not crack or spall when the wire is fabricated into snow fence.

4123.04 POSTS. The posts used shall be steel tee posts conforming to the requirements of Paragraph 4121.06.

4123.05 SAMPLING AND TESTING. Samples shall be taken from at least 10 per cent of the number of bundles of wire or snow fence in a shipment, each sample to consist of not less than 12 inches of wire, and not less than 12 wires shall be tested as the basis of computing the average amount of coating. The weight of coating shall be determined by the "Hydrochloric Acid-Antimony Chloride Method," of the A. S. T. M. "Standard Method of Determining Weight of Coating on Zinc-Coated Articles," Designation A90-30.

4123.06 PAINT. All fence shall be treated as manufactured by passing it through a red iron oxide paint. Such paint shall thoroughly cover the slats.

4123.07 PACKING. The fence shall be furnished in rolls containing 50 feet of fence.

Section 4124. Miscellaneous Materials.

4124.01 PARTING STRIPS. Parting strips for concrete pavements shall be one of the 3 following types:

(a) Metal parting strip shall be of 18-gauge U. S. S. G. coated or uncoated sheet metal, formed and punched according to the details given on the plans. Its width shall not vary by more than $\frac{1}{8}$ inch from the width shown on the plans.

(b) Pre-moulded bituminous parting strip shall be not less than $\frac{1}{8}$ inch thick and not less than $2\frac{1}{2}$ inches wide. It shall be of material complying with the requirements of Paragraph 4106.04, or other suitable material.

(c) Bituminous material for filling open center joints shall be asphalt complying with the requirements of Paragraph 4106.05.

4124.02 METAL EXPANSION TUBES. Expansion tubes to be used on dowel bars through expansion joints shall be non-collapsible tubes with one end closed. They shall be formed with a positive bar stop capable of withstanding a push of more than 20 pounds. The stop shall be located 6 inches from the open end of the tube. All tubes shall have an internal diameter $\frac{1}{16}$ inch larger than the nominal diameter of the bar. The length of that part of the tube having this diameter shall be equal to the length of bar projecting as shown on the plans, plus the thickness of the expansion joint.

4124.03 WIRE ROPE. Wire rope for guard rails shall have a diameter of $\frac{3}{4}$ inch or one inch as called for on the plans.

(a) **Three-quarter Inch Wire Rope.** Three-quarter inch wire rope shall be composed of 3 strands, each strand having 7 wires. The wires shall be of double galvanized annealed steel all of the same grade of steel and of uniform quality and free from scales, inequalities, flaws and splits. The diameter of the wires shall not be less than 0.117 inch nor more than 0.124 inch. The lay of the finished rope shall not be more than 7.5 inches. The lay of the wires in the strand shall not be more than 4.5 inches. The minimum tensile strength of the rope shall be 13,000 pounds.

(b) **One-inch Wire Rope.** One-inch wire rope shall be composed of 6 strands with a wire strand center; each strand having 7 wires. The wires shall be of double galvanized annealed steel, all of the same grade of steel and of uniform quality and free from scales, inequalities, flaws and splits. The diameter of the wires shall not be less than 0.105 inch nor more than 0.112 inch. The lay of the finished rope shall not be more than 10.0 inches. The lay of the wires in the strand shall not be more than 4.5 inches. The minimum tensile strength of the rope shall be 30,000 pounds.

(c) **Zinc Coating.** Each wire of the rope shall have a continuous coating of zinc of uniform thickness applied by the hot dip method. The weight of zinc coating shall not be less than 0.8 ounces per square foot of surface. The coating shall be strongly adherent to the surface of the wire and shall be free from blisters, scale, holes or other imperfections. The zinc coating shall be capable of withstanding 4 immersions in a standard testing solution of copper sulphate without showing any trace of metallic copper on the steel. The first 3 immersions shall be for a period of one minute each and the fourth immersion for a period of $\frac{1}{2}$ minute.

4124.04 GUARD RAIL FITTINGS. All guard rail fittings furnished under these specifications shall conform to the following requirements:

(a) **Zinc Coating.** All metal guard rail fittings except cast iron or malleable iron

dead men shall have a continuous zinc coating of uniform thickness applied by the "Hot Dip" method at the rate of not less than one ounce per square foot of surface on all surfaces except female threads. The coating shall be smooth and free from blister spots, scales, holes or other imperfections. The weight of coating shall be determined in accordance with the "Hydrochloric Acid-Antimony Chloride Method" as described in the A. S. T. M. "Standard Method of Determining Weight of Coating on Zinc-Coated Articles," Designation A-90-30.

(b) **Strength.** In all cases where stress is transmitted through eyebolts, clips, threads and nuts, turn-buckles or other fittings, the minimum tensile strength of such connections when assembled shall be at least that specified for the cable.

(c) **Dimensions.** The actual weight of all guard rail fittings shall be within 5 per cent of the theoretical weight for the nominal dimension shown on the plans.

4124.05 BRONZE METAL. Bronze shall conform to the requirements of the A. S. T. M. "Standard Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges," Designation B22-21. "Class B" metal will be admitted unless otherwise shown on the plans.

4124.06 HYDRATED LIME. Hydrated lime shall comply with the requirements of the A. S. T. M. "Standard Specifications for Hydrated Lime," Designation C6-24.

4124.07 CALCIUM CHLORIDE. Calcium chloride used for dust prevention or for an admixture in concrete shall comply with the requirements of the A. S. T. M. "Tentative Specifications for Calcium Chloride for Dust Prevention," Designation D98-30T.

4124.08 BURLAP FOR CURING CONCRETE. Burlap used for curing concrete pavements shall comply with the following requirements. The average dry weight shall not be less than 9 ounces per square yard. The ash based on the dry weight of the burlap shall not be more than 3 per cent. The burlap shall be composed of not less than 95 per cent jute and manila fibers. Burlap reclaimed from previous use for purposes other than the curing of concrete, shall be thoroughly washed to remove all trace of materials, such as sugar, which may injure the concrete.

4124.09 PAPER FOR CURING CONCRETE. Paper to be used for the curing of concrete pavements shall be of a type and quality approved by the Engineer. It shall be sufficiently strong and tough to permit its use under the conditions existing on highway paving work, without being torn or otherwise rendered unfit for the purpose during the curing period. The paper as prepared for use shall have such dimensions that a single unit will extend from one bottom corner of the slab to the opposite bottom corner of a slab of normal width with allowance for shrinkage of the paper, and cover a length of slab not less than 20 feet. Paper not manufactured in sizes which will provide the dimensions specified above shall be securely sewed or cemented together in such a way that joints in the paper will not separate during the curing period.

The paper used shall meet the requirements of Paragraph 2303.21 (c) as to the prevention of loss of moisture.

4124.10 BITUMINOUS TREATED PAPER FOR INSULATING SUBGRADE FOR CONCRETE PAVEMENT. Bituminous treated paper to be used for insulating the subgrade for concrete pavement shall meet the following requirements:

(a) **Kind of Paper.** The paper shall be kraft, mixed kraft and felted stock, or felted stock.

(b) **Saturant.** The saturant used shall be asphalt.

(c) **Weight.** The weight of the saturated paper shall be not less than 40.0 lbs. per 1000 sq. ft.

(d) **Evaporation Loss.** When heated for one hour at a temperature of 163°C., the paper shall lose not more than 7.5 per cent of its original weight.

(e) **Pliability.** The paper shall bend through 180 degrees around a mandrel 1/16 inch in diameter at a temperature of 70°F., without cracking or breaking.

(f) **Per Cent of Saturant.** The amount of saturant contained in the paper shall be not less than 50.0 per cent of the weight of the untreated paper.

(g) **Strength.** The paper shall meet the following strength requirements:

(1) **Bursting strength as determined by the Mullen Test:**

The paper as received Not less than 40 lb.

The paper after being immersed in water for one hour Not less than 20 lb.

(2) **Tensile strength as received:**

In the longitudinal direction Not less than 45 lb.

Across the paper Not less than 15 lb.

(h) **Diameter of Roll.** The diameter of the roll of paper shall not exceed 8 inches.

(i) **Width of Paper.** The width of paper used shall not be more than 48 inches, nor less than 12 inches.

PART IV

STANDARD FORMS

The following are the "Standard Forms" referred to herein, and these forms are applicable to all work done under these specifications.

1 Standard Form for Advertisement

Form No. 881

NOTICE TO BIDDERS

Sealed bids will be received by the Iowa State Highway Commission at its office in Ames, Iowa, until.....o'clock M. on, 193...., for the various items of construction work and/or materials and supplies listed below.

A certified check or cashier's check drawn upon a solvent Iowa bank to the amount listed below, and made payable to the Iowa State Highway Commission shall be filed with each proposal, which check in case of a bidder receiving an award, may be cashed and the proceeds retained by the State as liquidated damages if he fails to execute a contract containing the provisions required by the statutes of Iowa, and file an approved bond for the faithful performance thereof, within ten days after the acceptance of his bid.

Plans, specifications and proposal forms for the work may be seen and may be secured at the office of the Iowa State Highway Commission, Ames, Iowa.

All proposals filed must be on the form furnished by the Iowa State Highway Commission, sealed and plainly marked. Proposals containing any reservations not provided for in the forms furnished may be rejected, and the Iowa State Highway Commission reserves the right to waive technicalities and to reject any or all bids.

Bidders are advised that preference must be given to Iowa domestic labor, and that "by virtue of statutory authority, a preference will be given to materials, products, supplies, and other articles produced, manufactured, made or grown within the State of Iowa." (See Chapter 62B1 of the 1931 Code of Iowa.)

.....
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....., 193.....

Iowa State Highway Commission

PROPOSAL FORM

Type of Work..... County

Miles..... Proj. No.

Proposal of
(Name of Bidder)

of
(Name of Town) (State)

for work on..... Project Number..... located

.....

To

..... hereby certify that..... the only person, or persons, interested in this proposal as principals; that an examination has been made of the plans, specifications; and contract form, including the supplemental specifications contained herein, and of the site of the work, and..... understand that the quantities of work as shown herein are approximate only and are subject to increase or decrease, and further understand that all quantities of work, whether increased or decreased, are to be performed at the unit prices stipulated herein; propose to furnish all necessary machinery, equipment, tools, labor, and other means of construction and to furnish all materials specified, in the manner and the time prescribed, and to do the work at the prices hereinafter set out.

We further propose:

To do all "Extra Work" which may be required to complete the work contemplated, at unit prices or lump sums to be agreed upon in writing prior to starting such work, or if such prices or sums cannot be agreed upon, to perform such work on a force account basis, as provided in the Specifications.

To execute the formal contract within ten days from date, to begin work and complete same as follows:

Division No.	Date Begin	Date Complete

The interval of time between the dates specified herein for beginning and completing the work shall constitute the "contract time."

To furnish a contract bond in an amount not less than 75 per cent of contract award, as security for the construction and completion of the work awarded..... in accordance with the plans, specifications and contract.

Enclosed herewith find {Certified Check} in the amount of..... Dollars
 {Cashier's Check}

(\$.....) as a proposal guaranty which it is understood will be retained in the event the formal contract or bond is not executed, if award is made to the undersigned.

Date of Letting..... Signed.....

....., 19.....
Signatures are to comply with requirements of the specifications.

Project. No.

County

CONTRACT

THIS AGREEMENT made and entered by and between The Iowa State Highway Commission, Ames, Iowa, consisting of the following members:

party of the first part, and
of, party of the second part.

WITNESSETH: That the party of the second part, for and in consideration of Dollars (\$.....) payable as set forth in the specifications constituting a part of this contract, hereby agrees to construct in accordance with the plans and specifications therefor, and in the locations designated in the notice to bidders, the various items of work as follows:

Item No.	ITEM	Quantity	Unit Price	Amount

Said specifications and plans are hereby made a part of and the basis of this agreement, and a true copy of said plans and specifications are now on file in the office of the Iowa State Highway Commission under date of, 19.....

That in consideration of the foregoing, the party of the first part hereby agrees to pay to the party of the second part, promptly and according to the requirements of the specifications the amounts set forth, subject to the conditions as set forth in the specifications.

That it is mutually understood and agreed by the parties hereto that the notice to bidders, proposal, the specifications for Project No., County, Iowa, the within contract, the contractor's bond, and the general and detailed plans are and constitute the basis of contract between the parties hereto.

That it is further understood and agreed by the parties to this contract that the above work shall be commenced on or before the.....day of....., 19....., and shall be completed on or before the.....day of....., 19....., and that the time of commencing and completion of said work is the essence of this contract.

IN WITNESS WHEREOF the parties hereto set their hands for the purposes here-in expressed to this and three other instruments of like tenor, as of the.....day of....., 19.....

Iowa State Highway Commission
By

Party of the First Part

By

Party of the Second Part

Project. No.

County

CONTRACTOR'S BOND

KNOW ALL MEN BY THESE PRESENTS: That we,
..... of

(hereinafter called the Principal) and
..... of

(hereinafter called the Surety) are held and firmly bound unto the Iowa State Highway Commission and to the State of Iowa, in the penal sum of.....

Dollars

(\$.....) lawful money of the United States, to the payment of which sum, well and truly to be made, the Principal herein firmly binds himself (themselves), their heirs, executors, and administrators, and the said Surety binds themselves, their successors, assigns, executors and administrator, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, THAT whereas the above bounden Principal, did on the.....day of....., 193....., enter into a written contract with the Iowa State Highway Commission to

Copy of which contract, together with all of its terms, covenants, conditions, and stipulations is incorporated herein and made a part hereof as fully and completely as if said contract were recited at length, and

Whereas, the principal and sureties on this bond hereby agree to pay to all persons, firms, or corporations having contracts directly with the principal or with subcontractors, all just claims due them for labor performed or materials furnished, in the performance of the contract on account of which this bond is given, when the same are not satisfied out of the portion of the contract price which the public corporation is required to retain until completion of the public improvement, but the principal and sureties shall not be liable to said persons, firms, or corporations unless the claims of said claimants against said portion of the contract price shall have been established as provided by law.

Now if the principal shall in all respects fulfill his said contract according to the terms and tenor thereof, and shall satisfy all claims and demands incurred for the same, and shall fully indemnify and save harmless the Iowa State Highway Commission and/or the State of Iowa from all costs and damages which it may suffer by reason of failure to do so and shall fully reimburse and repay the Iowa State Highway Commission and/or the State of Iowa all outlays and expenses which it may incur in making good any such default, then the obligation is to be void and of no effect; otherwise to remain in full force and effect.

Every surety on this bond shall be deemed and held, any contract to the contrary notwithstanding, to consent without notice:
1. To any extension of time to the contractor in which to perform the contract, when each particular extension does not exceed sixty (60) days.

2. To any change in the plans, specifications or contract, when such change does not involve an increase of more than twenty per cent (20%) of the total contract price, and shall then be released only as to such excess increase.

3. That no provision of this bond or of any other contract shall be valid which limits to less than one year from the completion of the contract the right to sue on this bond for defects in workmanship or material not discovered or known to the Iowa State Highway Commission and/or the State of Iowa at the time such work is accepted.

4. That no provision of this bond or of any other contract shall be valid which limits to less than five years after the completion of the contract, the right to sue on this bond for defects in workmanship or materials in connection with or entering into paving or concrete work.

This bond is to be considered a performance bond and secures to the Iowa State Highway Commission and/or the State of Iowa the right to recover from the contractor on account of material or labor entered into the work or work performed not in accord with the contract, specifications or plans. The contractor does not by this obligation guarantee to maintain the work for five years.

IN WITNESS WHEREOF, we have hereunto set our hands and seals this.....
day of....., 193.....

Principal

By

This bond approved by the Iowa State Highway Commission this.....day

of, 193.....

Surety

By

Chairman

County

Project. No.

Kind of Work

EXTENSION OF CONTRACT TIME

To.....
Contractor

And to
Surety

It appearing that it will be impossible to complete the.....
(road or bridge)
work under contract dated....., 193.....,
Project No.....,County, within the original contract
time which expires....., 193....., the Iowa State Highway Commis-
sion, upon its own motion, hereby extends the contract time for a period of not ex-
ceeding 60 days, making the new date of completion, 193.....

Necessity for extension of time occasioned by

This extension of time is granted with the understanding that the contractor will maintain such rate of progress on the remaining work as to insure completion within the extended time and contractor and surety will govern themselves accordingly.

Iowa State Highway Commission

Dated at Ames, Iowa, this.....day of
....., 193.....

By

The granting of a sixty-day extension is recommended by.....

Resident Engineer

District Engineer

NOTE: No extension of time for a period exceeding 60 days will be granted without the consent of surety nor will the Highway Commission grant more than one 60-day extension of contract time upon its own motion. Further extension, if any, must be with consent of surety.

Engineer's Approval of Completed Work

....., Iowa,
....., 193.....
To....., Contractor

You are hereby notified that the following described part of your contract dated
....., 193....., Project No....., located in
County, Iowa, has been completed and approval as provided in the specifications is
hereby given. Barricades and red lights are no longer required on this part of the
work. You are also released from the responsibility of maintaining these sections,
such maintenance from this date to be assumed by the State.

Bridges or Culverts: Items Nos.

Roads: Type.....Sta..... to Sta.....

Pr. Rd. No.....Secs.....

Engineer

Contractor County

Surety Project

Certification as to Completion of Work

and

Final acceptance by Iowa State Highway Commission

This is to certify that work covered by contract of
dated, 193....., consisting of

On..... Project No.

.....County, Iowa, has been completed in accordance
with plans and specifications and is accepted by the Iowa State Highway Commission
as of the.....day of....., 193.....

Given under our hands on behalf of and acting for said Commission as of the date
last above written.

By
Resident Engineer
Division Maint. Engineer

By
District Engineer

By
Construction Engineer
Maintenance Engineer

By

Manufacturer's Guarantee and Certified Analysis

BASE METAL FOR CORRUGATED CULVERTS

We, _____, of _____,
(Name of Manufacturer) (City)
 _____, manufacturers of _____,
(State) (Trade Name)

base metal for use in corrugated metal culvert pipe under the Standard Specifications for Primary Road Construction, 1933 Series, in consideration of the approval of said base metal by the Iowa State Highway Commission, do hereby represent and guarantee:

1. That all base metal of the above trade name and bearing the trade mark or identification brand, a facsimile copy of which is attached, will conform to the detailed requirements of said specifications.
2. That the base metal so identified by us will conform to the following typical chemical analysis:

Typical Chemical Analysis of Base Metal

	Max. %	Min. %
Carbon	_____	_____
Phosphorus	_____	_____
Sulphur	_____	_____
Manganese	_____	_____
Silicon	_____	_____
Sum of foregoing Elements	_____	_____
Copper	_____	_____

3. That we will replace without cost any base metal manufactured by us under the above identification and sold in the State of Iowa for use under said specifications not in accordance therewith.

4. That this guarantee and agreement shall remain in full force and effect so long as we continue to furnish base metal under said specifications.

Signed _____
Name of Manufacturer

By _____
Title

State of _____ }
 County of _____ } **ss.**

Subscribed and sworn to before me by _____
 this _____ day of _____, 193_____

 Notary Public in and for
 _____ County _____

Approved:
 IOWA STATE HIGHWAY COMMISSION
 By _____
 Date: _____

covering the various kinds or classes of material herein specified, are and constitute the contract between the parties hereto, and that all material furnished shall comply with requirements thereof.

That the dates of delivery specified in the Proposal are of the essence of this contract and a failure to make delivery within days from the specified date of delivery shall constitute a breach of this contract, and the Party of the First Part may thereafter purchase such material at its option, and the difference in cost, if any, between the amounts so paid for the material and the contract price for the same, shall constitute the measure of damage to be paid by the Party of the Second Part to the Party of the First Part for such breach.

That in consideration of the foregoing, the Party of the First Part agrees to inspect all materials promptly upon delivery and to pay to the Party of the Second Part the sums as set forth in the contract promptly after the inspection and acceptance of the material.

IN WITNESS WHEREOF, the parties hereto have set their hands for the purpose herein expressed, to this and three other instruments of like tenor, this.....day of....., 193.....

IOWA STATE HIGHWAY COMMISSION
By
Party of the First Part

.....
By
Party of the Second Part

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