STRUCTURES

200 CONCRETE BRIDGES

200-1.1 Description. This item shall consist of concrete bridges, including also concrete substructures for steel, timber, log and composite bridges, all of which shall be built and completed as indicated on the plans in conformity with the lines, profile grades, dimensions and design shown, in accordance with these specifications and in full compliance with the specifications for "Excavation for Structures," "Concrete," "Reinforcing Steel," "Piling" and other specification or contract items which are to contribute to and constitute the complete structure or substructure in each case.

-2.1 Materials. The materials to be furnished and used shall be those prescribed for the several specification and/or contract items which are to constitute the structure, including primarily but not limited to "Concrete" and "Reinforcing Steel."

-3.1 Construction Methods. All foundations shall be prepared as hereinbefore specified under "Excavation for Structures," and concrete shall not be placed until the foundation area upon which it is to rest has been inspected and approved by the engineer. All foundations shall be poured in the "dry" except as provided for "Concrete Seals" or unless otherwise permitted in writing by the engineer. Cofferdams and concrete seals shall be furnished and prepared as prescribed under "Excavation for Structures."

-3.2 The tops of timber piles shall project not less than twelve inches into the concrete after all damaged wood has been removed.

-3.3 Drainage of Substructures. The filling material back of abutments and wing walls shall be drained thoroughly and effectively by means of a system of tiling, French drains or other adequate construction. Drains shall be so located that the stream water cannot wash away fill material through the openings. The drainage water shall be discharged through abutment, wing or pier walls in such manner and at such locations as to eliminate as far as possible any objectionable discoloration of exposed masonry surfaces. Drainage outlets shall be fitted with suitable screens where directed and the intakes shall be protected against clogging by means of screens, gratings or French drains.

-3.4 Ice Breakers. Ice breakers shall be constructed as shown on the plans, and when fitted with a steel angle or other metal nosing this shall be secured to the masonry effectively by means of suitable anchor bolts having countersunk heads, which shall be placed before the concrete is deposited. The metal nosing shall be painted 3 coats of approved structural steel paint, 2 coats prior to placing in the masonry and the third coat after all other work on the pier has been completed. The color of the nosing paint shall be as specified or as ordered by the engineer. Independent ice breakers shall be provided where required.

-3.5 Placing Anchor Bolts. All necessary anchor bolts in piers, abutments or pedestals shall be set carefully in portland cement mortar in accordance with the requirements specified under "Steel Bridges."

The holes may be drilled in accordance with the provisions of the above-mentioned item or, if in concrete masonry, may be formed by the insertion in the fresh concrete of oiled wooden plugs or metal pipe sleeves or other approved devices which are subsequently withdrawn after the concrete has partially set. When the holes are formed by the latter method, they shall be not less than 4 inches in diameter to allow for horizontal adjustment of the bolts.

In lieu of the above methods of placing, anchor bolts in concrete masonry may be set to exact location in the concrete when it is placed. In this case great care shall be exercised to insure the proper setting of the bolts and any inaccuracies which will be detrimental to the structure shall be corrected by suitable means.

-3.6 Setting Bed Plates. Bed plates, preferably, shall be set on a layer of canvas and red lead as specified under Steel Bridges.

When bed plates are set on portland cement mortar, no superstructure or other load shall be placed thereon until this mortar has been allowed to set for a period of at least 96 hours, adequate provision being made to keep it well moistened during this period.

-3.7 Placing Superstructures. No superstructure load shall be placed upon finished piers or abutments until the engineer directs. In general, a minimum time of 21 days shall be allowed for the hardening of concrete before any superstructure load is placed thereon.

The method and sequence of placing concrete for the various types of concrete bridge construction shall be as specified below for the particular types of construction involved.

-3.8 Reinforced Concrete Slab and Girder Bridges. Concrete, preferably, shall be deposited by beginning at the center of the span and working from the center toward the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers.

Concrete in girder haunches less than 3 feet in height shall be placed at the same time as that in the girder stems and the column or abutment tops shall be so shaped as to form seats for the haunches. Whenever any haunch or fillet has a vertical height of 3 feet or more, the abutment or columns, the haunch and the girder shall be placed in three successive stages; first, up to the lower side of the haunch; second, to the lower side of the girder; and third, to completion.

Concrete in slab spans shall be placed in one continuous operation for each span.

The floors and girders of through girder superstructures shall be placed in one continuous operation unless otherwise specified, in which case special shear anchorage shall be provided to insure monolithic action between girder and floor.

Concrete in T-beam or deck girder spans may be placed in one continuous operation or may be placed in two separate operations, each of which shall be continuous; first, to the top of the girder stems, and second, to completion. In the latter case, the bond between stem and slab shall be positive and mechanical, and shall be secured by means of suitable shear keys in the top of the girder stem. The size and location of these keys shall be as directed by the engineer. In general, suitable keys may be formed by the use of timber blocks approximately 2 by 4 inches in cross-section and having a length 4 inches less than the width of the girder stem. These key blocks shall be spaced along the girder stems as required, but the spacing shall be not greater than 1 foot center to center. The blocks shall be beveled and oiled in such manner as to insure their ready removal, and they shall be removed as soon as the concrete has set sufficiently to retain its shape.

Drainage. Transverse drainage of the roadway surface of slab and girder bridges shall be secured by means of a suitable crown in the floor slab.

The gutters shall be effectively drained by means of weep holes or scuppers constructed at the locations and in the manner shown on the plans.

The details of scuppers shall be such as to eliminate the tendency for drainage water to stain the exposed surfaces of girders and abutment walls. In general, drain pipes shall extend through the concrete slab to a distance of not less than 1 inch below the lower surface and if necessary, shall be connected to down-spouts which shall carry the drainage water to a suitable place of discharge.

The under surface of cantilever brackets and overhanging slabs shall be provided with a "V" groove ½ inch in depth at a point not more than 6 inches from the outside face for the purpose of arresting the flow of moisture and thus preventing staining.

Camber. Falsework and forms for multiple slab or girder spans shall be so constructed as to produce in the finished structure the camber indicated on the plans.

Unless otherwise specified, single slab or girder spans shall be constructed with a permanent camber at the center equal to 1/40 of an inch for each foot of span length.

Waterproofing. When called for by the Bid Schedule, the floor slabs of concrete slab or girder bridges shall be waterproofed with a membrane waterproofing constructed in accordance with the requirements specified under "Waterproofing."

-3.9 Concrete Viaducts. Where concrete viaduct construction consists of a series of reinforced concrete slab or girder spans supported on bents or towers composed of concrete columns suitably braced by means of longitudinal and transverse struts and sway braces, the superstructure shall be constructed in accordance with the requirements governing the construction of concrete slab and girder structures. The following provisions relate to the construction of the column substructure.

Column forms shall be composed of material not less than 1-1/4 inches in thickness after being dressed and shall be effectively braced. Forms shall be daylighted at intervals not greater than 10 feet vertically, the openings being sufficient to permit of free access to the forms for the purpose of inspecting, working and spading the concrete.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 12 hours before the caps are placed.

Unless otherwise permitted by the engineer, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be allowed to come upon the bents until they have been in place at least 21 days, unless otherwise permitted by the engineer.

-3.10 Arches. Arch centering shall be constructed according to centering plans approved by the engineer. Provision shall be made by means of suitable wedges, sand boxes or other device for the gradual lowering of centers and rendering the arch self-supporting.

When directed, centering shall be placed upon approved jacks in order to take up and correct any slight settlement which may occur after the placing of masonry has begun.

No centering shall be removed from beneath any arch until the masonry has been in place at least 28 days. A longer period may be required at the discretion of the engineer.

In general, centers shall be struck and the arch made self-supporting before the railing or coping is placed. This precaution is essential in order to avoid jamming of the expansion joints and variations in alignment. For filled spandrel arches, such portions of the spandrel walls shall be left for construction subsequent to the striking of centers as may be necessary to avoid jamming of the expansion joints.

Centers shall be lowered gradually and uniformly in such a manner as to avoid injurious stresses in any part of the structure. In arch structures of two or more spans, the sequence of striking centers shall be specified or approved by the engineer.

Waterproofing. When called for by the Bid Schedule the top of the arch ring and the interior faces of the spandrel walls of all filled spandrel arches shall be waterproofed with a membrane waterproofing constructed in accordance with the requirements specified under "Waterproofing."

Drainage. The roadway surface of arch structures shall be drained by means of weep holes or scuppers and suitable drain pipes, designed to prevent, as far as possible, the entrance of surface water into the spandrel fill. The fills of filled spandrel arches shall be drained effectively by a system of tile drains or French drains laid along the intersections of the spandrel walls and arch ring and discharging through suitable outlets in the piers and abutments. The location and details of the drainage outlets shall be such as to eliminate, as far as possible, the discoloration of exposed masonry faces by drainage water.

Filling. For filled spandrel arches, the filling shall be placed carefully in such manner as to load the ring uniformly and symmetrically. The filling material shall be acceptable to the engineer and shall be placed in horizontal layers carefully tamped and brought up simultaneously from both haunches. Wedge-shaped sections of filling material against spandrels, wings or abutments will not be permitted.

-3.11 Concrete Arches. The concrete in arch rings shall be placed in such a manner as to load the centering symmetrically.

Arch rings, preferably, shall be cast in transverse sections of such size that each section can be cast in a continuous operation. The arrangement of the sections and the sequence of placing shall be as approved by the engineer and shall be such as to avoid the creation of undue initial stresses in the reinforcement. The sections shall be bonded together by suitable keys or dowels. When permitted by the engineer, arch rings may be cast in a single continuous operation.

Particular care shall be exercised in order to produce a pleasing and uniform surface finish throughout the entire portion of the structure visible above the ground.

On filled spandrel arches the extrados of the rings shall be screeded to correct contour and finished with a wooden float unless extrados forms are used. The extrados and the interior faces of the spandrel walls shall be smooth if to receive waterproofing.

-3.12 Masonry Arches. Masonry arches shall be constructed in accordance with the requirements for masonry of the class called for in the Bid Schedule.

Arch Rings. The number of courses and the depth of voussoirs shall be as shown on the plans. Voussoirs shall be placed in the order indicated; shall be full size throughout and shall have bond not less than their thickness. Beds shall be roughly pointed to bring them to radial planes. Radial joints shall be in planes parallel to the transverse axis of the arch and, when measured at the intrados, shall not exceed 3/4 inch in thickness. Joints perpendicular to the arch axis shall not exceed 1 inch in thickness when measured at the intrados. The intrados face shall be dressed

sufficiently to permit the stone to rest properly upon the centering. Exposed faces of the arch ring shall be rock-faced with edges pitched to true lines.

The work shall be carried up symmetrically about the crown, the stone being laid in full mortar beds and the joints grouted where necessary. Pinning by the use of stone spalls will not be permitted.

Backing. Backing may consist of Class "B" concrete or of large stones shaped to fit the arch, bonded to the spandrels, and laid in full beds of mortar. The extrados and interior faces of the spandrel walls shall be given a finishing coat of 1:2½ cement mortar which shall be trowelled smooth to receive the waterproofing.

-3.13 Concrete Wearing Surface. Concrete wearing surface for concrete floors may consist either of an additional thickness of concrete placed monolithically with the floor proper or of a separately placed wearing surface of concrete.

For monolithic construction the additional floor thickness shall be not less than ½ inch and the entire floor slab shall be of Class "A" concrete. Separately placed concrete wearing surfaces shall be not less than 3 inches thick at the center and 2½ inches thick at the edges and shall be of Class "A" concrete.

-3.14 Concrete Railings and Parapets. In no case shall concrete railings be placed until the centering or falsework for the span has been released rendering the span self supporting. Concrete railings shall be of Class D concrete.

Railings Cast in Place. The portion of the railing or parapet which is to be cast in place shall be constructed in accordance with the requirements for "Concrete." Special care shall be exercised to secure smooth and tight fitting forms which can be rigidly held in line and grade and removed without injury to the concrete. All mouldings, panel work, and bevel strips shall be constructed according to the detail plans with neatly mitered joints and all corners in the finished work shall be true, sharp and clean cut and shall be free from cracks, spalls or other defects.

Precast Rails. Precast railing members shall be cast in mortar-tight forms. The precast members shall be removed from the moulds as soon as the concrete has set sufficiently to permit and shall then be kept covered with saturated burlap or tarpaulin for at least three days. After this the curing shall be completed by immersion in water or by spraying not less than twice a day, for a period of not less than seven days.

The method of storage and handling shall be such as to preserve true and even edges and corners, and any precast members which become chipped, marred or cracked before or during the process of placing shall be rejected and removed from the work.

In the construction of cast-in-place railing caps and copings built in connection with precast balusters, the balusters shall be protected from staining and disfigurement during the process of placing and finishing the concrete.

Expansion Joints. Expansion joints shall be so constructed as to permit freedom of movement. After all other work is completed, all loose or thin shells of mortar likely to spall under movement shall be carefully removed from all expansion joints by means of a sharp chisel.

-4.1 Method of Measurement. The quantities of concrete and of the various other pay items which constitute the completed and accepted structure shall be measured for payment according to the specifications for the several individual contract items. Only accepted work shall be included and the dimensions used shall be those shown on the plans or ordered in writing.

-5.1 Basis of Payment. The quantities, measured as provided above shall be paid for at the contract unit prices bid for the several pay items, which prices and payment shall be full compensation for furnishing, hauling, and placing all materials, and for all labor, equipment, tools and incidentals necessary to complete the work. Such payment shall constitute full payment for the completed structure, ready for use, and no additional allowance shall be made for cofferdam construction, falsework, form lumber, or other erection expenses.

201 STEEL BRIDGES

201-1.1 Description. This item shall consist of steel bridges including but not limited to superstructures to be placed on concrete or masonry substructures, all of which shall be built and completed as indicated on the plans in conformity with the lines, profile grades, dimensions and design shown, in accordance with these specifications and in full compliance with the specifications for "Excavation for Structures," "Structural Steel," concrete, wood, combination or other floor systems, and other specification or contract items which are to contribute to and constitute the complete structure in each case.

-2.1 Materials. The materials to be furnished and used shall be those prescribed for the several specifications and/or contract items which are to constitute the structure, including primarily but not limited to "Structural Steel."

-3.1 Construction Methods. The construction methods used shall be those prescribed for the several items which are to constitute the structure and in particular shall conform to the requirements for fabrication and erection, as hereinafter prescribed under "Structural Steel." No compensation for fabrication or erection of steel superstructure or structural steel shall be allowed save as provided under "Structural Steel" hereinafter.

-3.2 Erection of Structure. The contractor shall erect the metal work, remove the temporary construction, and do all work required to complete the bridge or bridges as covered by the contract, including the removal of the old structure or structures if stipulated, all in accordance with the plans and these specifications.

The contractor shall provide the falsework and all tools, machinery and appliances, including drift pins and fitting-up bolts, necessary for the expeditious handling of the work.

The contractor shall dismantle the old structure which, unless otherwise provided, shall remain the property of the Government, and shall dispose of it in the immediate vicinity of the bridge site as the engineer may direct. If the old structure is to be reerected, it shall be dismantled without unnecessary damage and the parts match-marked and carefully piled.

-3.3 Handling and Storing Materials. Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease and other foreign matter, and shall be protected as far as practicable from corrosion. It shall be kept properly drained.

Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection.

-3.4 The falsework shall be designed properly, constructed substantially and maintained for the loads which will come upon it. The contractor, if required, shall prepare and submit to the engineer for approval, plans for falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the contractor's plans shall not be considered as relieving the contractor of any responsibility.

-3.5 Before starting the work of erection, the contractor shall inform the engineer fully as to the method of erection he proposes to follow, and the amount and character of equipment he proposes to use, which shall be subject to the approval of the engineer. The approval of the engineer shall not be considered as relieving the contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done until such approval by the engineer has been obtained.

-3.6 Bearings and Anchorage. Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry. The bridge seat bearing area shall be swabbed thoroughly with red lead paint and then covered with three layers of 12 to 14-ounce duck, each layer being swabbed thoroughly on its top surface with red lead paint. The superstructure shoes or pedestals shall be placed in position while the paint is plastic.

The contractor shall drill the holes and set the anchor bolts, except where the bolts are built into the masonry. The bolts shall be set accurately and fixed with portland cement grout completely filling the holes. The location of the anchor bolts

in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

-3.7 Other details of field assembling, placing, erecting, adjusting, straightening bent material, bolting, field riveting and other connections and adjustments of misfits shall be performed by the contractor in all respects as specified under "Structural Steel."

-4.1 Method of Measurement. The quantities of structural steel and of the various other pay items, which constitute the completed and accepted structure shall be measured for payment according to the specifications for the individual contract items. Only accepted work shall be included and the dimensions shall be those on the plans or ordered in writing.

-5.1 Basis of Payment. The quantities of structural steel and of other pay items, measured as provided above, shall be paid for at the contract unit prices bid for the "Structural Steel" and the several other pay items, which prices and payments shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all structural steel and all other materials for the complete structure; for all shop work, painting and field work; for all labor, equipment, tools and incidentals necessary to complete the work. Such payment shall constitute full payment for the completed structure ready for use, and no allowance shall be made for cofferdam construction, falsework, or other erection expenses.

202 TIMBER BRIDGES

202-1.1 Description. This item shall consist of timber structures (not including log structures) built as indicated on the plans, in conformity with the lines, profile grades, dimensions and design shown, in accordance with these specifications and in full compliance with the detailed specifications for "Treated and Untreated Timber," "Piling," "Concrete," any masonry items, any flooring items and other specification and contract items which are to contribute to and constitute the intended complete structure. The contractor shall furnish all structural steel and iron and all hardware for the structure in each case.

-2.1 Materials. All timber and lumber shall be of the species called for on the plans and structural members, floor and rails of pieces of a given species shall meet all the specific requirements prescribed for that species for the given use, all as prescribed under the item "Treated and Untreated Timber," for the particular strength specified on the plan.

-2.2 All structural shapes, rods and plates shall be of structural steel or wrought iron, as specified or called for on the plans, meeting the respective requirements prescribed under "Structural Steel." All eyebars and castings shall conform to the requirements therefor prescribed under "Structural Steel." No welds will be permitted in truss-rods, or in main members of trusses or girders.

-2.3 Hardware. Machine bolts, drift-bolts and dowels may be either wrought iron or medium steel. Washers shall be cast ogee gray iron or malleable castings, unless washers cut from medium steel or wrought iron plate are called for on the plans.

Machine bolts shall have square heads and nuts, unless otherwise called for. Nails shall be cut or round of standard form. Spikes shall be cut, wire, or boat spikes.

All nails, spikes, bolts, dowels, washers, lag screws and other hardware shall be galvanized.

The design of ring or shear plate timber connectors shall be subject to the approval of the engineer. Such connectors shall be made of noncorrosive metal.

-3.1 Construction Methods. Storage of Materials. All lumber and timber on the site of the work shall be stored in piles. Untreated material shall be open-stacked at least 12 inches above the ground surface and piled to shed water and prevent warping. When required by the engineer, it shall be protected from the weather by suitable covering. Creosoted timber and piling shall be close-stacked, piled to prevent warping, and the tops of the stacks shall be covered with a 2-inch layer of earth. The ground underneath and in the vicinity of all material piles shall be cleared of weeds and rubbish.

-3.2 Workmanship. All framing shall be true and exact. Unless otherwise specified, nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for removal of the workman causing them. The workmanship on all metal parts shall conform to the requirements specified under "Steel Bridges."

-3.3 Treated Timber. Treated timber shall be framed before treatment and shall be handled carefully without sudden dropping, breaking of outer fibres, bruising or penetrating the surface with tools. It shall be handled with rope slings. Cant dogs, peaveys, hooks or pike-poles shall not be used. In water infested by marine borers, cutting and boring below high-water shall be avoided.

All cuts in treated piles or timbers, and all abrasions after having been carefully trimmed, shall be coated with two applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

Before driving bolts, all holes bored after treatment shall be impregnated with hot creosote oil by means of an approved bolt hole treater. Any unfilled holes, after being treated with creosote oil shall be plugged with creosoted plugs.

-3.4 Untreated Timber. In structures of untreated timber the following surfaces shall be coated thoroughly with two coats of hot creosote oil before assembling: Ends, tops, and all contact surfaces of posts, sills, caps, floor beams and stringers, and all ends, joints and contact surfaces of bracing and truss members. Timber bumpers, the back faces of bulkheads and all other timber which is to be in contact with earth shall be similarly treated. Where cedar, heart cypress or redwood is used, this treatment will not be required.

-3.5 Treatment of Pile Heads. Pile heads, after cutting to receive the caps and prior to placing the caps, shall be treated to prevent decay.

The heads of creosoted piles shall be treated as follows:

The sawed surface shall be covered with three applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or thoroughly brush coated with three applications of hot creosote oil and covered with hot roofing pitch. Upon this shall be placed a covering of medium weight roofing felt or galvanized iron, which shall be bent down over the sides of the pile to shed water. Edges shall be trimmed to present a workmanlike appearance.

The heads of untreated piles shall be given one of the following treatments, as may be specified or directed by the engineer:

1. The sawed surface shall be thoroughly brush coated with two applications of hot creosote oil.

2. The sawed surface shall be heavily coated with red lead paint, after which it shall be covered with cotton duck, of at least 8-ounce weight, which shall be folded down over the sides of the pile and firmly secured thereto with large-headed roofing nails. The edges of the duck shall be trimmed to give a workmanlike appearance. The duck shall then be waterproofed by being thoroughly saturated and coated with one or more applications of red lead paint.

-3.6 Holes for Bolts, Dowels, Rods and Lag Screws. Holes for round driftbolts and dowels shall be bored with a bit 1/16 inch less in diameter than the bolt or dowel to be used. The diameter of holes for square driftbolts or dowels shall be equal to the least dimension of the bolt or dowel. Holes for machine bolts shall be bored with a bit of the same diameter as the bolt. Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rod. Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

-3.7 Bolts and Washers. A washer of the size and type specified shall be used under all bolt heads or nuts which would otherwise come in contact with wood. Cast iron washers shall have a thickness equal to the diameter of the bolt, and a diameter of four times the thickness. For malleable or plate washers the diameters or side size of the square shall be equal to four times the diameter of the bolt, and the thickness of the washers shall be equal to half the diameter of the bolt. Cast iron washers shall be used when the timber is in contact with the earth. All bolts shall be checked effectually after the nuts have been finally tightened.

-3.8 Countersinking. Countersinking shall be done wherever smooth faces are required. Recesses formed for countersinking shall be painted with hot creosote oil, and, after the bolt or screw is in place, shall be filled with hot pitch.

-3.9 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. Mortises shall be true to size for their full depth and tenons shall fit snugly. No shimming will be permitted in making joints, nor will open joints be accepted.

-3.10 Pile Bents. The piles shall be driven as accurately as possible in the correct location and vertical or to the batter 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 at the contractor's expense. No shimming on tops of piles will be permitted.

The piles for any one bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. However, care shall be exercised in the distribution of piles of varying sizes to secure uniform strength and rigidity in the bents of any given structure.

Cut-offs shall be accurately made to insure perfect bearing between the cap and piles of a bent.

-3.11 Framed Bents. Untreated timber used for mud sills shall be of heart cedar, heart cypress, redwood, or other durable timber. Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place.

Concrete pedestals for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them. Dowels of not less than 3/4-inch diameter and projecting at least 6 inches above the tops of the pedestals, shall be set in them when they are cast, for anchoring the sills or posts.

Sills shall have true and even bearing on mud sills, piles or pedestals. They shall be drift-bolted to mud sills or piles with bolts of not less than 3/4-inch diameter and extending into the mud sills or piles at least 6 inches. When possible, all earth shall be removed from contact with sills so that there will be free air circulation around them.

Posts shall be fastened to pedestals with dowels of not less than 3/4-inch diameter, extending at least 6 inches into the posts.

Posts shall be fastened to sills by one of the following methods, as indicated on the plans:

(a) By dowels of not less than 3/4-inch diameter, extending at least 6 inches into posts and sills.

(b) By drift-bolts of not less than 3/4-inch diameter driven diagonally through the base of the post and extending at least 9 inches into the sill.

-3.12 Caps for All Bents. Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps shall be secured by drift-bolts of not less than 3/4-inch diameter, extending at least 9 inches into the posts or piles. The drift-bolts shall be approximately in the center of the post or pile.

-3.13 Bracing. The ends of bracing shall be bolted through the pile, post or cap with a bolt of not less than 5/8-inch diameter. Intermediate intersections shall be bolted, or spiked with wire or boat spikes, as indicated on the plans. In all cases spikes shall be used in addition to bolts.

-3.14 Stringers. Stringers shall be sized at bearings and shall be placed in position so that knots near the edges will be in the top portions of the stringers. Outside stringers may have butt joints but interior stringers shall be lapped to take bearing over the full width of floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least 1/2 inch for the circulation of air and shall be securely fastened by driftbolting where specified. When stringers are two panels in length the joints shall be staggered. Cross bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails at each end.

-3.15 Floors. Floors shall be of the type called for in the Bid Schedule and shall be constructed and paid for as prescribed under contract items therefor.

-3.16 Wheel Guards and Railings. Wheel guards shall be constructed as shown on the plans and shall be bolted to the outside stringers as shown on the plans. When the wheel guard is not blocked up from the floor, drain holes shall be provided at such intervals as to drain the roadway adequately. They shall be provided with galvanized iron lining and arranged so as to discharge free of the structure. They shall be surfaced one side and one edge (S1S1E).

Railings shall be built as shown on the plans and shall be constructed in a workmanlike and substantial manner. All railing material shall be untreated and shall be surfaced on four sides (S4S). All rails shall be squarely butt-jointed at the posts and the rails shall break joints.

-3.17 Trusses. Trusses, when completed, shall show no irregularities of line. Chords shall be straight and true from end to end in horizontal projection and, in vertical projection, shall show a smooth curve through panel points conforming to the correct camber. All bearing surfaces shall fit accurately. Uneven or rough cuts at the points of bearing shall be cause for rejection of the piece containing the defect.

-3.18 Truss Housings. The carpentry on truss housings shall be equal in all respects to the best house carpentry. The finished appearance of the housing is considered of primary importance and special care shall be taken to secure a high quality of workmanship and finish on this portion of the structure. Workmen wearing shoes with caulks will not be permitted on the roof.

-3.19 Erection of Housing and Railings. Unless otherwise directed by the engineer, housing and railings shall be built after the removal of the falsework and the adjustment of the trusses to correct alignment and camber.

-3.20 Painting. Rails and rail posts shall be painted with three coats of white paint. Other parts of the structure shall be painted when so designated on the plans.

-4.1 Method of Measurement. The quantities of timber and of the various other contract pay items which constitute the completed and accepted structure shall be measured for payment according to the specifications for the individual contract items. Only accepted work shall be included and the dimensions used shall be those shown on the plans or ordered in writing.

-5.1 Basis of Payment. The quantities, measured as provided above, shall be paid for at the contract unit prices bid for the several contract pay items, which prices and payments shall constitute full compensation for procuring, furnishing and delivering all lumber and timber, for preparing, framing, assembling, erecting and painting including also all structural steel, iron, castings, hardware and other metal parts, and for all labor, equipment, tools and incidentals necessary to complete the work. Such payment shall constitute full payment for the completed structure ready for use, and no allowance shall be made for cofferdam construction, falsework or other erection expenses.

Timber bumpers at the ends of concrete spans or steel spans with concrete decks shall not be measured or paid for directly. Such bumpers, including bolts, washers, painting, etc., shall be considered an incidental part of the work paid for under the bid price for "Concrete."

203 LOG BRIDGES

203-1.1 Description. This item shall consist of log trestle bridges, built as indicated on the plans conforming to the line, grade and dimensions shown and in accordance with these specifications.

-2.1 Materials. The logs used in constructing log bridges shall be of the species specified on the plans, or if not therein specified, as required by the engineer. The logs may be obtained and the tops and branches of trees shall be disposed of as provided in the specifications for clearing and grubbing, as hereinbefore given.

The logs shall be straight, sound, out of wind, and free from defects of all kinds and shall be cut from live trees not less than 30 days in advance of use, but not exceeding 1 year, and be allowed to season with the bark on. Immediately before use in the work all bark shall be peeled and the logs trimmed smooth of all knots and projections.

All lumber for flooring, railings, etc., shall be of the kind and dimensions indicated on the plans and shall conform to the applicable requirements stipulated in the specifications for "Treated and Untreated Timber," as hereinbefore given.

The contractor shall furnish all necessary bolts, driftbolts, spikes, nails, and other material or hardware called for on the plans or in the specifications. All hardware, including nails, spikes, bolts, nuts, washers, etc., shall be galvanized.

-3.1 Construction Methods. The contractor shall provide ample and suitable equipment and tools for performing the work and shall follow only well recognized methods in preparing the timber and framing and erecting the structure. Where concrete or masonry piers or abutments are called for on the plans, they shall be constructed in accordance

with the requirements of the plans and of the specifications herein given for the particular kind of concrete or masonry called for.

The provisions for preservative treatment, if called for, painting bridge iron and rail, and construction methods as specified for "Timber Bridges" and for "Treated and Untreated Timber," shall apply to log bridges and log trestles.

Log abutments shall be built according to the specifications for log cribbing and as shown on the plans.

-4.1 Method of Measurement. The quantities to be paid for under this item shall be the number of log trestle spans of the several lengths shown on the plans, the number of linear feet of logs in log bents, the number of square feet of log cribbing and the number of thousand feet board measure of sawn timber in bents, flooring, railings, etc., all complete and accepted. Each log trestle span shall include caps and all parts of the bridge except abutments, piers and timber bents and except supplementary floor wearing tops otherwise provided for. The quantity of logs in log bents paid for shall be the linear feet of logs used in bents as sills, columns, posts and bracing as shown on the plans.

-5.1 Basis of Payment. The quantities, measured as provided above, shall be paid for at the contract unit prices per unit specified bid for "Log Trestle Spans Complete" of the several lengths and "Logs in Log Bents," respectively, which prices and payments shall be full compensation for the substructures and superstructures complete in place including all preservative treatment and painting and all materials, labor, equipment, tools and incidentals necessary to complete the item, except sawn timber and log cribbing, concrete or masonry piers and abutments or other similar items for which separate payment is specified.

-5.2 Sawn timber shall be measured and paid for as provided under the item "Treated and Untreated Timber."

-5.3 Log Cribbing shall be measured and paid for as provided under the item "Timber and Log Cribbing."

204 LOG CULVERTS

204-1.1 Description. This item shall consist of log culverts, built as indicated on the plans, conforming to the line, grade and dimensions shown, and in accordance with these specifications.

-2.1 Materials and -3.1 Construction Methods shall be as prescribed for log bridges and log cribbing.

-4.1 Method of Measurement. The quantity to be paid for under this item shall be the number of linear feet, of over-all length measured along the centerline of the barrel, of culverts of the several sizes, completed and accepted.

-5.1 Basis of Payment. The footage, determined as provided above, shall be paid for at the respective contract unit prices per linear foot bid for "Log Culverts" of the several sizes, which prices and payment shall be full compensation for the completed structures, including furnishing and placing all material, and all labor, equipment, tools and incidentals necessary to complete the item. Wings or end walls of less than fifty square feet area shall not be measured or paid for directly but shall be considered an incidental part of the work paid for under the contract price bid for "Log Culverts." Wings or end walls of fifty square feet area or more shall be measured and paid for as "Log Cribbing."

205 CULVERTS AND RETAINING WALLS

205-1.1 Description. This item shall consist of concrete and masonry culverts, pipe culverts, end walls and retaining walls all of which shall be built and completed as indicated on the plans in true conformity with the lines, profile grades, dimensions and designs shown, in accordance with these specifications and in full compliance with the specifications for "Concrete," with any masonry or culvert pipe items involved and with any other specification or contract items which are to contribute to and constitute the complete structure in each case.

-2.1 Materials. The materials to be furnished and used shall be those prescribed for the several specification and/or contract items which are to constitute the complete structures. The materials and the composition and proportions for the concrete used in this item shall meet all the requirements specified under "Concrete" for the particular class or classes of concrete shown on the plans.

-3.1 Construction Methods. All excavation involved shall be performed and all foundations and beddings shall be prepared as specified under "Excavation for Structures."

-3.2 The backfilling for all structures shall be as prescribed under "Backfill for Structures other than Pipe Culverts" and "Bedding and Backfill for Pipe Culverts."

-3.3 The construction of concrete and masonry culverts and retaining walls, the installation of pipe for pipe culverts and the construction of headwalls shall be performed in accordance with the respective specifications for "Concrete," the several masonries and the several types of culvert pipe.

-3.4 Concrete used in this item shall be batched, mixed, placed and completed in accordance with all the requirements in "Concrete" for the respective classes.

-4.1 Method of Measurement. The quantities of the various contract pay items which constitute the completed and accepted structures shall be measured for payment according to the specifications for the several individual contract items. Only accepted work will be included and the dimensions used will be those shown on the plans or ordered in writing.

-5.1 Basis of Payment. The quantities, measured as provided above, shall be paid for at the contract unit prices bid for the several contract pay items, which prices and payments shall be full compensation for furnishing, hauling and incorporating all prescribed and necessary material in the structures, and for all labor, equipment, tools and incidentals necessary to complete the work. Such payment shall constitute full payment for the completed structures, ready for use, and no additional allowance will be made for cofferdam construction, falsework, farm lumber or other erection expenses.

206 CONCRETE

206-1.1 Description. This item shall consist of concrete masonry composed of approved portland cement, fine aggregate, coarse aggregate and water, prepared and constructed in accordance with these specifications at the locations, and of the form, dimensions and class shown on the plans or directed in writing by the engineer.

-1.2 Classification. Concrete will be classified as Class A, Class B, Class D or Class S. Each class of concrete shall be used in that part of the structure in which it is called for on the plans, or where directed. The following requirements shall govern unless otherwise shown on the plans:

Class A concrete shall be used (except where Class D is required) for all superstructures and all arch rings, and for all parts of substructures having a least dimension less than one foot and for all reinforced concrete except footings.

Class B concrete shall be used (except as provided above and except where Class S is required) for substructures, for footings and for unreinforced concrete.

Class D concrete shall be used for railings, posts, slabs, beams, girders, and curbs.

Class S concrete shall be used for all concrete deposited under water.

-1.3 Composition of Concrete and Proportioning. The contractor shall put into each batch the designated number of bags of cement and amount of water, and weigh into each batch the respective weights of fine and coarse aggregate designated by the engineer for the particular job materials and class of concrete being used, provided, however, that for batching aggregates for structures of less than 50 cubic yards the contractor may substitute approved volumetric measuring devices, in which case the volumes of coarse aggregate and of fine aggregate in each batch shall be those designated by the engineer.

The engineer, subject to the requirements of the "Master Proportion Table" will designate the respective amounts of the job materials to be used in the batch. He will fix the amount of water. The sum of the weights of fine and coarse aggregate designated for each class of concrete shall equal the "FIXED" weights shown in the "Total Aggregate" column for the respective types of material. Within the ranges of the table, the engineer shall designate the weight of fine aggregate which, using the materials furnished, will produce a workable mix of the consistency hereinafter specified with the least amount of water. In the event that volumetric measurement is to be used the engineer shall determine the weights per cubic foot of the aggregates under job conditions and convert the designated batch weights into cubic feet. If, during construction, the concrete at any time is found unsatisfactory, the contractor shall readjust his batch subject to requirements of the Master Table tabulated below, as ordered by the engineer, until the consistency of the mix actually being used on the job complies with the consistency requirements.

MASTER PROPORTION TABLE

Class	When coarse aggregate used is:	Weight of fine aggregate per bag of cement		Weight of total aggregate per bag of cement FIXED
		minimum	maximum	
		pounds	pounds	pounds
A	Gravel	180	220	580
	Stone	216	264	
B	Gravel	216	264	750
	Stone	270	330	
D	Gravel	135	165	470
	Stone	170	210	
S	Gravel	120	140	430
	Stone	155	185	

For each class of concrete the pounds of coarse aggregate per bag of cement shall be the difference between the "FIXED" pounds, shown in the "Total Aggregate" column above for the type of coarse aggregate to be used, and the pounds of fine aggregate as designated by the engineer.

The above tabulation is based on an apparent specific gravity of 2.65 for both fine and coarse aggregate. Corrections shall be made for variations therefrom in the job materials of more than .05 up or down. The weights are weights of dry aggregates.

The determination of proportions, as stipulated above will be based on representative samples of the materials to be used. No change in the source, character or grading of the materials shall be made without due notice to the engineer and no work shall proceed using such changed or new materials, or using any materials not possessing all the qualities and properties upon which the designated mix and proportions have been based, until the engineer has determined and designated an appropriate mix based on the new or altered material. All materials shall meet the requirements for "Materials" as prescribed hereinafter.

In all cases reference to coarse aggregate shall be taken to mean all the aggregate in the mix which under test would be retained on the No. 4 sieve, and fine aggregate shall be taken to mean all aggregate in the mix which would pass the No. 4 sieve. In the event that either or both aggregates contain more than 10 percent of material, which under the above definition would be classed as the other aggregate, adjustment in the batch weight shall be made.

-2.1 Materials. Cement. The cement used in the work shall be a standard brand of portland cement or a standard brand of High-Early-Strength cement. Portland cement shall

conform to Federal Specification SS-C-191. High-Early-Strength cement shall conform to A.A.S.H.O. Standard Specification M-39. Only one brand of each shall be used in any one contract, except by specific written permission of the engineer. In curing concrete made with high-early-strength cement, in lieu of the twenty-one day period as hereinafter required, the period shall be seventy-two hours, and in lieu of the seventeen-day period as hereinafter required, the period shall be forty-eight hours.

Where so indicated on the plans or required by the Special Provisions high-early-strength cement shall be used in lieu of portland cement and in such cases concreting operations shall not be carried on when the atmospheric temperature is at or may be expected to drop to 60°F. except by written approval of the engineer, provided that where the contractor, in order to facilitate his own operations, chooses to use high-early-strength cement in portions of the work other than those where its use is required, permission must be secured from the engineer in writing. Payment for the use of high-early-strength cement will not be made directly but shall be considered as included in the price bid for the various classes of concrete specified.

The contractor shall provide suitable means for storing and protecting the cement against dampness. Different brands or grades of cement shall be stored separately, and shall not be mixed nor used alternately.

Bags of cement, which for any reason have become partially set, or which contain lumps of caked cement, shall be rejected. Use of cement salvaged from discarded or used bags will not be permitted.

-2.2 Water. All water used in concrete shall be subject to the approval of the engineer, shall be reasonably clear and free from oil, acid or alkali and vegetable substances and shall not be brackish or salty. Water of doubtful quality shall be tested in comparison with distilled water by making standard soundness, time-of-setting, and 1:3 mortar-strength tests with standard sand, using the same cement of standard quality with each water. Limits for these tests are as follows. Any indication of unsoundness, marked change in time of setting, or a variation of more than 10 percent in strength from results obtained with mixtures containing distilled water shall be sufficient cause for rejection of the water under test.

-2.3 Fine Aggregate. The fine aggregate for concrete shall consist of sand, or other approved inert materials, composed of clean, hard, strong, durable grains, reasonably free from dust, coatings, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances.

When subjected to a sodium sulphate soundness test, using A.A.S.H.O. Method T-75, the fine aggregate shall have a total loss not greater than 10 percent by weight. In lieu of the above soundness test the contractor may provide evidence, satisfactory to the engineer, that the fine aggregate has been exposed to natural weathering, either directly or in concrete, for a period of at least five years without appreciable disintegration.

Fine aggregate shall contain not more than 3 percent of material removable by a decantation test using A.A.S.H.O. Method T-11 nor more than 1 percent of clay lumps.

The percentage of clay lumps shall be determined by examining the various fractions which remain after the test for grading. Any particles that can be broken up with the fingers shall be classified as clay lumps and the total percentage by weight of all clay lumps shall be determined on the basis of the total original weight of the sample.

The fine aggregate shall be well graded from fine to coarse and when tested by laboratory sieves shall meet the following requirements using A.A.S.H.O. Method T-27.

Total passing	Percent by weight
No. 4 sieve	95 - 100
No. 16 sieve	45 - 80
No. 50 sieve	5 - 30
No. 100 sieve	0 - 10

Mortar specimens made with the fine aggregate shall have a compressive strength, using A.A.S.H.O. Method T-71, at 28 days of at least 90 percent of the strength of similar specimens made with Ottawa sand having a fineness modulus of 2.40±0.10.

For the purpose of controlling the grading of fine aggregate from any one source, the contractor shall, prior to actual deliveries, submit a preliminary sample which shall be representative of the material which he proposes to furnish. Any shipment of fine

aggregate made during the progress of the work which shows a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the preliminary sample shall be rejected or, at the discretion of the engineer, may be accepted subject to such changes in the proportions used as he may direct.

The fineness modulus of fine aggregate shall be determined by adding the total percentages by weight retained on U.S. Standard Sieves Nos. 4, 8, 16, 30, 50, 100, and dividing by 100.

-2.4 Coarse Aggregate. The coarse aggregate for concrete shall consist of crushed stone, gravel, slag or other approved inert materials, conforming to the following requirements.

Crushed Stone. Crushed stone shall consist of clean, hard, tough, durable, uncoated fragments, reasonably free from an excess of flat, elongated, soft or disintegrated pieces, organic or other objectionable matter and shall be free from lumps of clay. When subjected to the abrasion test for stone using A.A.S.H.O. Method T-3 the loss by abrasion shall be not more than 7 percent. The crushed stone shall not show evidence of disintegration nor show a total loss greater than 15 percent when subjected to five alternations in the sodium sulphate accelerated soundness test using A.A.S.H.O. Method T-76.

Gravel. Gravel shall consist of clean, tough, durable stone of high resistance to abrasion, reasonably free of clay or coatings of any character. "Run of Bank" gravel or gravel which contains disintegrated or soft pieces shall not be used. When subjected to the abrasion test for gravel using A.A.S.H.O. Method T-4 the loss by abrasion shall be not more than 15 percent. The gravel shall not show evidence of disintegration nor show a total loss greater than 15 percent when subjected to five alternations in the sodium sulphate accelerated soundness test using A.A.S.H.O. Method T-76.

Slag. Slag shall be air cooled, blast furnace slag, and shall consist of angular fragments reasonably uniform in density and quality and reasonably free from thin, elongated or glassy pieces, dirt or other objectionable matter. The slag shall have a weight per cubic foot of not less than 70 pounds, using A.A.S.H.O. Method T-19.

In lieu of the abrasion and soundness tests specified above for crushed stone and gravel the contractor may provide evidence, satisfactory to the engineer, that the crushed stone or gravel has proved satisfactory as coarse aggregate in concrete which has been subjected for a period of five years to essentially the same conditions, service and exposure as the structure in which the material is to be used.

The coarse aggregate shall not have more than 1 percent of material removable by the decantation test, using A.A.S.H.O. Method T-11, nor more than 5 percent of soft fragments, using A.A.S.H.O. T-8, nor more than 1/4 percent of clay lumps.

Mixing Different Materials. Different types of coarse aggregate, even if tested and approved, shall not be mixed during use nor used alternately in any one class of construction.

Coarse aggregate of the sizes designated shall conform to the following requirements, using A.A.S.H.O. T-27.

Designated sizes	Percentage by weight passing laboratory sieves having square openings							
	2-1/2 inch	2 inch	1-1/2 inch	1 inch	3/4 inch	1/2 inch	3/8 inch	No. 4
1 to 2 inches	100	90-100	35- 70	0- 15				
3/4 to 1-1/2 inch		100	90-100	20- 55	0- 15			
No. 4 to 2-1/2 inch	100	70- 85		40- 75				0- 5
No. 4 to 2 inches	100	95-100		35- 70		10- 30		0- 5
No. 4 to 1-1/2 inch		100	95-100		35-70		10-30	0- 5
No. 4 to 1 inch			100	90-100		25- 60		0-10
No. 4 to 3/4 inch				100	90-100		20-35	0-10
No. 4 to 1/2 inch					100	90-100		0-15

In the No. 4 to 1/2-inch size not more than 5 percent shall pass a No. 8 sieve. The shape of aperture specified for determining compliance with specifications for size of coarse aggregate has no relation to the size or shape of aperture or type of screen used in the production of the material.

The following sizes of coarse aggregate shall be used for the various classes of concrete.

Class A - No. 4 to 1½ inches
Class B - No. 4 to 2½ inches
Class D - No. 4 to 1½ inches
Class S - No. 4 to 1½ inches

If the contractor so elects the No. 4 to 3/4 inch size or the No. 4 to 1-inch size aggregate may be used for Class A concrete and the No. 4 to 1½-inch size or the No. 4 to 2-inch size coarse aggregate may be used for Class B concrete, provided that the amount of cement used in the mix is increased as directed by the engineer. Such increase shall be at the expense of the contractor. For railings and sections less than 8 inches thick, the No. 4 to 3/4-inch size shall be used when required by the engineer. When separated sizes of coarse aggregate are to be used, the sizes to be combined for the various classes shall be as designated in the special provisions. The contractor may at his option use Class A concrete instead of Class B concrete, but in all cases payment will be made at the contract unit price for the specified class.

-2.5 (a) Rubber Expansion Joint Filler. Rubber expansion joint filler shall consist of preformed strips composed essentially of a durable elastic rubber compound, which may be reinforced on each side with a layer of asphalt treated felt. The strips shall be of such character that the filler will not be deformed or broken by twisting, bending or other ordinary handling after having been subjected for 12 hours to a temperature of 125°F., or when subjected to freezing temperatures. The joint shall weigh not less than 40 nor more than 50 pounds per cubic foot. It shall also conform to the requirements specified hereinafter.

(b) Cork Expansion Joint Filler. Cork expansion joint filler shall consist of preformed strips composed essentially of a durable elastic compound of cork. The joint filler shall be formed from clean particles bound together by a synthetic resin of an insoluble nature, the particles being present in their original state. They shall not have been exposed to a temperature exceeding 300°F. during the process of manufacture. The joint filler shall withstand boiling for 1/2-hour in concentrated hydrochloric acid without showing any indication of disintegration. Discoloration or a small amount of swelling shall not be considered failure. The joint filler shall meet the requirements hereinafter, both when tested as received, and when tested after having been maintained for a period of 120 hours at a temperature of 165°F.

(c) Cork-Rubber Expansion Joint Filler. Cork-Rubber expansion joint filler shall consist of preformed strips formed from clean cork particles securely bound together by a durable elastic rubber compound. The cork particles contained in this filler shall be in their original state and shall not have been exposed in the process of manufacture to a temperature exceeding 325°F. and shall meet the test requirements hereinafter specified.

-2.6 Sampling and Testing of Cork, Rubber and Cork-Rubber Fillers. Size of Samples. Each test sample shall consist of at least one square foot in area and of the full thickness required.

Number of Samples. One representative sample shall be selected from each shipment of 1,000 linear feet or less of each thickness ordered.

Preparation of Test Specimens. Test specimens shall be free from warping, bending or localized protrusions. They shall measure 4 x 4 inches $\pm$ 0.10-inch and shall be freshly and squarely cut immediately prior to test from the sample furnished for test. The original thickness shall be determined when the test specimen is subjected to a load of not over 0.025 pound per square inch.

Tests for Recovery, Compression and Extrusion. The test specimen prepared as described above shall be placed in a suitable steel mold so constructed as to confine the lateral movement of the specimen under compression to one side only. The specimen shall then be covered with a 1/2-inch metal plate which will fit snugly but without binding within the three restraining sides of the steel mold. A metal cylinder or other suitable device for transferring the load from the moving head of the testing machine around the measuring apparatus to the plate covering the specimen shall be placed upon the plate and a spherical bearing block mounted between the upper end of the cylinder and the moving head of the testing machine.

The dead weight of the load transferring apparatus and the spherical bearing block may compress the test specimen to a noticeable extent. This initial compression shall be considered as a portion of the 50 percent compression to which the test specimen shall be subjected during the test. Correction for this initial compression shall be made in the measuring apparatus so that the thickness to which the specimen is compressed shall be 50 percent of the original thickness of the material.

For the determination of the percentage of recovery the specimen shall be given three applications of a load sufficient to compress it to 50 percent of its original thickness. The load shall be applied without shock and at such a rate that the specimen will be compressed approximately 0.05-inch per minute. After the first and second applications the load shall be immediately released and the specimen permitted to recover 5 minutes before again applying the load. After the third application the specimen shall again be measured by the method used for original thickness. The percentage of recovery shall be computed as follows:

$$\text{Recovery} = \frac{t'}{t} \times 100,$$

in which t = the thickness of the specimen before test and t' = the thickness one hour after the completion of the third application of load.

The total maximum load in pounds required for the first application as specified above shall be recorded and the unit compression calculated in pounds per square inch from the cross-sectional area of the specimen.

The amount of extrusion in inches shall be determined by measuring the movement of the free edge of the test specimen during the first application of load made as hereinbefore specified. The extrusion shall be measured by means of a dial or other suitable device reading to 0.001 inch.

Recovery Test. One hour after the release of the third application of load, when tested as described above, the specimen shall have recovered to at least 90 percent of its original thickness.

Compression Test. When the test specimen is compressed to 50 percent of its original thickness the load upon the specimen or sample shall be not less than 100 nor more than 750 pounds per square inch.

Extrusion Test. When the test specimen is compressed to 50 percent of its original thickness, the extrusion shall be not more than 50 percent of the original thickness of the sample. During the test the specimen shall not show appreciable continued extrusion under constant pressure. It shall not show any breaking or deterioration after the test.

-2.7 Bituminous Expansion Joint Filler. Bituminous expansion joint shall be of asphaltic or tar composition of approved quality. It shall be of such character that it will not be deformed by ordinary handling during the hot summer months or become hard and brittle in cold weather. Thin strips of stiffener will be allowed. The bitumen shall be uniformly impregnated with suitable filler, to reduce its brittleness at low temperatures to a minimum.

Physical Properties. It shall conform to the following requirements:

Absorption, not more than five percent
Distortion, not more than one inch
Brittleness, shall not crack or shatter when subjected to brittleness test

Sampling and Testing. Sampling and testing shall be in accordance with A.A.S.H.O. Method T-42.

-2.8 Metal Expansion Joints. Metal expansion joints shall consist of folded metal sheets of the form, dimensions and design shown on the plans. The folded metal sheets shall be made of twenty-four oz. copper or of twelve oz. zinc; the weight of thin spots shall be at least ninety percent of that specified and the total weight of a strip shall be at least ninety-five percent. Sheet lead used in joints shall be at least one-eighth inch thick. Metal expansion joints through bridge floors shall be of copper or zinc of the weight given above.

All metal joints shall be placed in such manner as to be free from kinks and the resulting joint shall be water-tight, and shall be so arranged as to lead all drainage water to a point of discharge so as to prevent staining of the exposed concrete surfaces. Joints shall be riveted and soldered. At bends the strip shall be preferably one piece.

All stones, forms or other foreign material that would in any way interfere with the efficiency of the joint shall be removed.

-3.1 Construction Methods. Falsework. Falsework for supporting concrete work shall be built on foundations of sufficient strength to carry the loads without appreciable settlement. Falsework which cannot be founded on solid footings must be supported by ample falsework piling. Falsework shall be designed to carry the full loads coming upon
All spans shall be given a temporary camber of 1/40 inch per foot of clear span to

allow for shrinkage and settlement. Bridges shall have a permanent camber only when shown on the plans. If appreciable settlement occurs in the falsework, the work shall be stopped, any masonry affected shall be removed and the falsework rebuilt. In general, double wedges or other suitable means shall be provided for constructing and maintaining falsework and forms to correct lines.

If requested by the engineer, detail drawings of the falsework shall be submitted to the engineer for approval, but such approval shall not operate to relieve the contractor of any of his responsibility under the contract for the successful completion of the improvement. Arch centering shall be so constructed as to permit of its being lowered gradually and uniformly or released after pouring the arch ribs or rings.

-3.2 Forms. Forms shall be so designed and constructed that they may be removed without injuring the concrete.

Forms for exposed surfaces shall be made of sized and dressed tongue and groove or shiplap lumber or metal in which all bolt and rivet holes are countersunk so that in either case a plane smooth surface of the desired contour is obtained. Rough lumber may be used for backing or for surfaces which will not be exposed in the finished structure. All lumber shall be free from knot holes, loose knots, cracks, splits, warps, or other defects affecting the strength or appearance of the finished structure. Form lumber shall be free from bulge or warp, and shall be cleaned thoroughly if used a second time.

In designing forms and centering, the concrete shall be treated as a liquid weighing 150 pounds per cubic foot for vertical loads, and not less than 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 forms shall be so designed that portions where finishing is required may be removed without disturbing portions of forms which are to be removed later, and, as far as practicable, so that form marks will conform to the general lines of the structure. Column form marks shall be vertical and symmetrically placed.

When possible forms shall be daylighted at intervals not greater than 10 feet vertically, the openings being sufficient to permit of free access to the forms for the purpose of inspecting, working, and spading the concrete.

The forms shall be built to line and braced in a substantial and unyielding manner. Wires for tying forms shall not extend through faces of concrete that will be exposed in the finished work. In general, forms shall be tied together with bolts that can be removed. The forms shall be mortar tight and, if necessary to close cracks due to shrinkage, shall be soaked thoroughly with water. Forms for reentrant angles shall be chamfered and for edges shall be filleted. The interior surfaces of forms shall be adequately oiled, greased, or soaped to insure nonadhesion of mortar. Forms shall be inspected by the engineer immediately prior to placing concrete. Dimensions shall be checked carefully and any bulging or warping shall be remedied and all dirt, sawdust, shavings, or other debris within the forms shall be removed. Special attention shall be paid to ties and bracing, and where forms appear to be insufficiently braced, or unsatisfactorily built, either before or during construction, the engineer shall order the work stopped until the defects have been corrected to his satisfaction. Forms shall be so constructed that the finished concrete shall be of the form and dimension shown on the plans, and true to line and grade. Cleanout ports shall be provided at the top surface of concrete where a stoppage of placing occurs.

-3.3 Handling, Measuring, and Batching Materials. Concrete of the class indicated shall be made up of accepted material batched in the proportions set by the engineer for the specific materials. Corrections necessitated by variations from day to day in the moisture content of the raw materials or for other similar reasons shall be made as directed by the engineer.

The coarse and fine aggregate shall be handled and measured separately. No batch shall be run requiring fractional bags of cement.

Cement shall be measured by the bag as packed by the manufacturer.

Water shall be measured either by volume or by weight. The allowable error in accuracy of water measuring equipment on the mixer shall be not more than 2 percent. The equipment should preferably include an auxiliary tank from which the measuring tank shall be filled, and in any case shall be so arranged that the accuracy of measurement will not be affected by variations in pressure in the water supply line.

The allowable error in accuracy of weighing equipment for aggregates shall be not more than 1/2 of 1 percent for all loads.

All weighing equipment shall be arranged so as to permit making compensation for changes in the weight of moisture contained in the aggregates and to permit the convenient removal of excess material from the weighing hopper.

Weighing equipment shall be so arranged that the operator has convenient access to all control levers and cables. The weighing beam and auxiliary weighing device shall be in full view of the operator when manipulating the gates which deliver material to the weighing hopper.

The scales shall be of either the beam or springless dial type. A suitable device consisting of a graduated beam or dial shall be used to register at least the last 100 pounds of either of the aggregates required for the batch. The value of the minimum graduation shall not be greater than 2 pounds. If the aggregate is measured by volume the contractor shall use satisfactory hoppers or boxes which when filled and struck off will give the exact volume of aggregate specified. In no case will wheelbarrow measurement be permitted.

-3.4 Consistency. The quantity of mixing water used shall not be changed without the consent of the engineer. The consistency of the various classes of concrete shall be such as to have slumps within the following ranges using A.S.T.M. Method D 138-32T:

Class A	2	-	4 inches slump
Class B	1½	-	3 inches slump
Class D	4	-	6 inches slump
Class S	6	-	8 inches slump

The above ranges represent the extreme limits of allowable slump. In all cases the amount of water used shall be the minimum necessary to secure the required workability of the concrete, within the ranges of slump specified.

-3.5 Mixing. The concrete shall be mixed only in such quantities as are required for immediate use. No retempering of concrete will be allowed. Aggregates or bags of cement containing lumps or crusts of hardened material shall not be used.

Concrete shall be mixed thoroughly in a batch mixer of approved type and capacity for a period of not less than one and one-half minutes after all materials, including water, are in the drum.

During such period, the drum shall be operated at drum speeds specified by the mixer manufacturer and shown on his nameplate on the machine. The entire contents of the mixer shall be removed from the drum before materials for the succeeding batch are placed therein and the mixer preferably shall be equipped with mechanical means for preventing the addition of aggregates after mixing has commenced.

The mixer shall be equipped with an approved timing device which will automatically lock the discharging device so as to prevent the emptying of the mixer until the materials have been mixed the minimum specified time. No mixer shall be operated above its rated capacity and no mixer shall be used which has a rated capacity of less than a one-bag batch.

The first batch of concrete material placed in the mixer shall contain an additional quantity of sand, cement and water sufficient to coat the inside surface of the drum without diminishing the mortar content of the mix. Upon the cessation of mixing for any considerable length of time, the mixer shall be cleaned thoroughly.

Hand mixing will not be permitted, except in case of emergency and with the written permission of the engineer. When permitted, it shall be done only on water-tight platforms. The sand shall be spread evenly over the platform and the cement spread upon it. The sand and cement shall then be mixed thoroughly while dry by means of shovels until the mixture is of a uniform color, after which it shall be formed into a "crater" and water added in an amount necessary to produce mortar of the proper consistency. The material upon the outer portion of the "crater" ring shall then be shoveled to the center and the entire mass turned and sliced until a uniform consistency is procured. The coarse aggregate shall then be wetted thoroughly and added to the mortar and the entire mass turned and re-turned at least six times and until all of the stone particles are covered thoroughly with mortar and the mixture is of a uniform color and appearance. Hand mixed batches shall not exceed 1/2 cubic yard in volume. Hand mixing will not be permitted for concrete to be placed under water.

-3.6 Placing Concrete. Concrete shall be placed in the forms immediately after mixing and in no case shall concrete be used which does not reach final position in the forms within 30 minutes after water is first added to the mix. The method of placing shall be such as to avoid segregation of the aggregates or displacement of reinforcement.

Use of long chutes for conveying concrete from mixing plant to forms will not be permitted. Troughs, pipes or short chutes used as aids in placing concrete shall be arranged and used in such a manner that the ingredients of the concrete are not separated. Where steep slopes are required, troughs and chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. When pipes are used they shall be kept full of concrete and have their lower ends kept buried in fresh concrete as required when a tremie is used. All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by flushing thoroughly with water after each run. Water used for flushing shall be discharged clear of the concrete in place. Troughs and chutes shall be either of metal or metal lined and shall extend as nearly as possible to the point of deposit. When the discharge must be intermittent, a hopper or other device for regulating the discharge shall be provided.

Dropping the concrete a distance of more than 5 feet or depositing a large quantity at any point and running or working it along the forms will not be permitted.

Placing of concrete shall be so regulated that the pressures caused by the wet concrete shall not exceed those used in the design of the forms.

Special care shall be taken to fill each part of the forms by depositing concrete directly as near final position as possible, to work the coarser aggregates back from the face and to force the concrete under and around the reinforcement bars without displacing them. After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcement.

Concrete shall be compacted by continuous working with suitable tools or suitable vibrating equipment in a manner acceptable to the engineer. In general, slab and girder work, arch ribs and thin section work shall be vibrated. All faces shall be vibrated well or the mortar shall be flushed to the surface of the forms by continuous working in a manner acceptable to the engineer.

The placing of concrete shall be done in such manner that the steel reinforcing is not coated with cement before its final embedment. In depositing concrete around steel shapes and closely spaced reinforcing bars the concrete shall be deposited on one side of the steel and worked until it flushes under the steel to the opposite side before any concrete is placed on the opposite side or over the steel. In all cases where, on account of the obstructions produced by reinforcement metal, shape of forms, or any other condition, difficulty is encountered in puddling the concrete adjacent to the forms, the mortar content of the mix shall be brought into proper contact with interior surfaces by vibrating the forms and/or the concrete. The vibrations shall be produced by the use of suitable vibrating equipment or by striking the outside surfaces of the forms with wooden mallets or by other means satisfactory to the engineer.

Concrete shall be placed in each section of the work in a continuous operation working day and night, if necessary, to avoid stoppage planes. It shall be deposited in horizontal layers, placing thin layers at first that can be thoroughly worked into intimate contact with the concrete beneath. After a depth of 6 inches has been built up in this manner the thickness of the layers may be increased to a maximum of 12 inches. The depth of layers used shall be such that the succeeding layer is placed before the previous layer has attained initial set. Each layer shall be compacted in a manner that will break up and obliterate any tendency to form a place of separation between the layers. If it is necessary, by reason of an emergency, to stop placing concrete before any section is completed, bulkheads shall be placed as the engineer may direct. Any place where the placing of concrete is discontinued for a sufficient time to allow the concrete to take initial set shall be deemed a construction joint and treated as hereinafter described under "Forming Joints."

Horizontal layers so located as to produce a construction joint at a location wherein a "featheredge" might be produced in the succeeding layer, shall be formed by inset work so that the succeeding layer will end in a body of concrete having a thickness of not less than 6 inches.

In no case shall the work on any section or layer be stopped or discontinued temporarily within 18 inches below the top of any face, unless the details of the work provide for a coping having a thickness of less than 18 inches, in which case, at the option of the engineer the construction joint may be made at the under side of the coping.

After the concrete in finished surfaces has begun to set, it shall not be walked upon or otherwise disturbed in less than 48 hours.

The method and manner of placing concrete shall be so regulated as to place all construction joints across regions of low shearing stress and in such locations as will be hidden from view to the greatest possible extent. The method and sequence of placing concrete for the various types of concrete bridge construction shall be as specified below for the particular type of construction involved.

-3.7 Depositing Concrete under Water. Concrete shall not be exposed to the actione of water before setting, or deposited in water, except with the approval of the engineer and under his immediate supervision. When concrete is so deposited, the method and manner of placing shall be as hereinafter designated.

All concrete deposited under water shall be mixed in the proportions designated for Class S concrete.

Concrete deposited under water shall be placed carefully in a compacted mass in its final position by means of a tremie, a closed bottom dump bucket or other approved methods and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. No concrete shall be placed in running water and all form work designed to retain concrete under water shall be water-tight. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. Each seal shall be placed in one continuous operation.

When a tremie is used it shall consist of a tube having a diameter of not less than 10 inches, constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit free movement of the discharge end over the entire top of the work and to permit its being lowered rapidly when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow is then stopped by lowering the tremie. The flow shall be continuous and in no case shall be interrupted until the work is completed.

When concrete is placed by means of a bottom dump bucket, the bucket shall have a capacity of not less than 1/2 cubic yard. The bucket shall be lowered gradually and carefully until it rests upon the concrete already placed. It shall then be raised very slowly during the discharge travel, the intent being to maintain, as nearly as possible, still water at the point of discharge and to avoid agitating the mixture.

-3.8 Forming Joints. When the work of placing concrete is delayed until the concrete has taken initial set, the point of stopping shall be deemed a construction joint. The location of construction joints shall be planned in advance and shall be subject to approval by the engineer. The placing of concrete shall be carried continuously from joint to joint. These joints shall be perpendicular to the principal lines of stress and in general be located at points of minimum shear.

At all horizontal construction joints and at other locations, when directed, a gage strip not less than 2 inches thick shall be placed inside the forms along all exposed faces to give the joint a straight line and eliminate wedge shaped particles of concrete that might chip off. In placing concrete up to construction joints the forms shall be "over filled" at least one inch and all excess material removed, including all laitance.

In joining fresh concrete to concrete that has already set, the forms shall be drawn tight against the face of the set concrete and all gage strips and key forms removed. The surface of the set concrete to be contacted shall then be cut over with suitable tools to remove all residual laitance, and loose and foreign material. This surface shall then be washed and scrubbed with wire brooms, drenched with water until saturated and kept saturated until the new concrete is placed. Immediately prior to placing new concrete, the old surface shall be coated thoroughly with a very thin coating of neat cement mortar.

In order to bond successive courses, suitable keys shall be formed at the top of the upper layer of each day's work and at other levels where work is interrupted. These keys shall be formed by the insertion and subsequent removal of beveled wood strips which shall be saturated thoroughly with water prior to insertion. Rough stone or steel dowels may, at the discretion of the engineer, be used in lieu of keys. All construction joints shall be keyed or doweled as shown on the plans or directed by the engineer.

Sliding joints shall be true planes parallel to the direction of movement. Where sliding joints are to be provided at the ends of slabs, girders or beams, or between walls, etc., the surface of the supporting concrete shall be given a smooth finish and covered with two layers of three-ply roofing felt to separate the concrete.

Metal expansion joint fillers shall be used, where shown on the plans, otherwise, expansion joints shall be filled with either rubber, cork, or corb rubber filler, at the choice of the contractor, meeting the requirements hereinbefore prescribed.

The thickness of expansion joints shall be 1/4 inch where the length of the moving concrete is 20 feet or less, 1/2 inch for lengths 21 to 36 feet, and 3/4 inch for lengths of 37 to 50 feet unless otherwise shown on the plans. The joint filler shall be cut to the same shape as the area to be covered but 1/4 inch smaller along all surfaces that will be exposed in the finished work. It shall be fixed firmly against the surface of the concrete already in place in such manner that it will not be displaced when the concrete is deposited against it. Where necessary to use more than one piece to cover any surface, the abutting pieces shall be placed in close contact and the joint between the separate pieces shall be covered with a layer of two-ply roofing felt, one side of which shall be covered with hot asphalt to insure proper retention. The 1/4-inch space along the edges at exposed faces shall be filled with wooden strips of the same thickness as the joint material. These wooden strips shall be saturated with oil and have sufficient "draft" to make them readily removable after the concrete is placed. Immediately after the forms are removed the expansion joints shall be inspected carefully. Any concrete or mortar that has sealed across the joint shall be cut neatly and removed.

Special water-tight and flashed expansion joints shall be constructed as shown on the plans.

-3.9 Cold Weather Concreting. Except by written authorization, concreting operations of mixing and placing shall not be continued when a descending atmospheric temperature in the shade and away from artificial heat falls below 40°F. nor resumed until an ascending atmospheric temperature in the shade and away from artificial heat reaches 35°F. If such authorization is granted, the aggregates shall be heated by either steam or dry heat to a temperature of not less than 70°F. nor more than 150°F. The water shall be heated to a temperature of between 130°F. and 150°F. The temperature of the mixed concrete shall be not less than 60°F. nor more than 100°F. at the time of placing it in the forms. Neither salt nor chemical admixtures shall be added to the concrete to prevent freezing. When directed by the engineer the contractor shall furnish sufficient canvas and framework, or other type of housing, to enclose and protect the structure in such a way that the air surrounding the fresh concrete can be kept at a temperature above 50°F. for a period of 5 days after the concrete is placed. Sufficient heating apparatus, such as stoves, salamanders or steam equipment, and fuel to furnish all required heat, shall be supplied. The heating apparatus shall be such as to heat the mass uniformly and preclude the possibility of the occurrence of hot spots which will burn the material.

The contractor shall assume all risk in connection with placing concrete in cold weather and permission given to place concrete under the above conditions shall in no way relieve the contractor of responsibility for proper results. Should concrete placed under such conditions prove unsatisfactory it shall be removed and replaced at the contractor's expense.

-3.10 Curing Concrete. Careful attention shall be given by the contractor to the proper curing of concrete handrails, floors and finished surfaces. Such surfacing shall be protected from the sun and the whole structure shall be kept wet for a period of at least 7 days. All concrete floors shall be covered as soon as possible with sand, earth or other suitable material and kept thoroughly moistened for a period of at least 10 days by sprinkling each morning and evening, or more frequently if deemed necessary by the engineer. The covering material shall not be cleared from the surface of the concrete floor for a period of at least 14 days.

Unless otherwise permitted by the engineer, concrete bridge floors shall be closed to traffic for a period of at least 28 days after placing and for such additional time as may be deemed advisable.

-3.11 Removal of Forms and Falsework. In order to facilitate finishing, forms on ornamental work, railings, parapets and exposed vertical surfaces shall be removed in not less than 12 or more than 48 hours, depending upon weather conditions. Forms under slabs, beams, girders and arches shall remain in place at least 21 days in warm weather and in cold weather at the discretion of the engineer. Forms shall always be removed from columns before removing shoring from beneath beams and girders in order to determine the condition of concrete in the columns.

No forms whatever shall be removed at any time without the consent of the engineer. Such consent shall not relieve the contractor of responsibility for the safety of the work. 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. As soon as the forms are removed all projecting wire or other metal devices used for holding the forms in place and which pass through the body of the concrete shall be removed or cut back at least 1/4 inch beneath the surface

of the concrete and the holes or depressions thus made, and all other holes, depressions and small voids which show upon the removal of the forms, shall be filled with cement mortar mixed in the same proportions as that which was used in the body of the work. Lips of mortar and all irregularities caused by form joints shall be removed. The presence of excessive honeycomb areas may be considered sufficient cause for the rejection of the structure, and upon written notice from the engineer the contractor shall remove and rebuild the structure in part or in whole as specified, at his own expense. In patching holes or porous spots, all coarse or broken material shall be chipped away until a dense uniform surface of concrete exposing solid coarse aggregate is obtained. Feathered edges shall be cut away to form a face perpendicular to the surface being patched. All surfaces of the cavity shall be saturated thoroughly with water, after which a thin layer of neat cement mortar shall be applied. The cavity shall then be filled with a thick, dry mortar composed of one part of portland cement to two parts of sand which shall be tamped into place thoroughly. The surface of this mortar shall be floated with a wooden float before initial set takes place and shall present a neat and workmanlike appearance. The patch shall be kept wet for a period of 5 days.

For patching large or deep areas, coarse aggregate shall be added to the patching material and special precautions shall be taken to insure a dense, well bonded and properly cured patch, all as required by the engineer.

Falsework shall not be removed at any time without the consent of the engineer. Such consent shall not relieve the contractor of responsibility for the safety of the work. Falsework shall remain in place after concreting is completed at least 21 days in warm weather and in cold weather at the discretion of the engineer.

Falsework and centering for arches shall not be struck until the fill back of the abutments has been placed up to the spring line. Falsework for rigid frame structures shall not be removed until the fill has been placed back of the vertical legs.

-3.12 Finishing Concrete. All concrete surfaces exposed in the completed work shall comply with the requirements of the clause defining "Ordinary Finish" except as provided below for "Concrete Floors," for "Curbs and Sidewalk Surfaces" and for "Rubbed Finish," in which cases the type of finish will be indicated on the plans.

Ordinary Finish. An "Ordinary Finish" is defined as the surface left by the removal of the forms with all holes left by form ties filled and all defects repaired. The surface shall be true and even, free from stone pockets, depressions or projections beyond the surface. All surfaces which can not be repaired to the satisfaction of the engineer shall be given a "Rubbed Finish."

Concrete Floors. Concrete floors shall be struck off with a templet immediately after pouring to provide the proper crown and shall be hand finished to a smooth even surface by means of both longitudinal and transverse wooden floats, or other suitable means. The finished surface shall not show a variation of over 1/8 inch in 10 feet using a 10-foot straightedge placed parallel to the center line of roadway and no variations will be permitted that will tend to prevent complete drainage on all parts of the deck. The concrete in bridge seats and tops of walls shall be brought flush with the finished top surface, struck off with a straightedge and floated.

Curbs and Sidewalk Surfaces. Exposed faces of curbs and sidewalks shall be finished to true surfaces having the lines and grades shown on the plans. Concrete shall be worked until the coarse aggregate is forced down into the body of the concrete and a layer of mortar 1/4 inch thick is flushed to the top. The surface shall then be floated to a smooth but not slippery finish. The junction of the sidewalk with masonry parapets shall be finished with a fillet of 3/4-inch radius. Walk surfaces shall be laid out in blocks with a grooving tool as shown on the plans or directed by the engineer.

Rubbed Finish. When forms can be removed while the concrete is still green the surface shall be wetted and rubbed with a wooden float until all irregularities and form marks are removed and the surface is covered with a lather composed of the cement and water. If permitted by the engineer a thin grout composed of one part cement and one part fine sand may be used in the rubbing. This lather shall be allowed to set for at least 5 days. The surface shall then be smoothed by rubbing lightly with a fine carborundum stone. When the concrete has hardened before being rubbed a carborundum stone shall be used covering the surface in the following manner. A thin grout composed of one part cement and one part fine sand shall be spread over a small area of the surface and rubbed immediately with the stone until all form marks and irregularities are removed and the surface is covered with a lather, after which it shall be finished as described for green concrete. The surface shall be smooth and uniform in texture and appearance. Building up depressions will not be permitted. A cement wash or plaster coat shall not be used.

-3.13 Drainage and Weep Holes. Drainage and weep holes shall be constructed in the manner and where indicated on the plans or directed by the engineer. Drains and weep holes in the faces of the abutments shall be connected with the roadway drains wherever indicated on the plans. Ports or vents for equalizing hydrostatic pressure shall be placed below low water. Weep holes shall be placed at the elevations shown or directed.

Forms for weep holes through concrete may be clay pipe, concrete drain pipe, or wooden boxes. If wooden forms are used they shall be removed after the concrete is placed. Where weep holes pass through stone masonry the outlet through the masonry shall be rectangular in shape, from 2 to 3 inches in width and from 6 to 8 inches in height. Drain pipes embedded in concrete shall be standard light weight cast iron water pipe or wrought iron pipe. The pipe shall be held rigidly against displacement during the placing of the concrete.

No direct compensation will be allowed for drainage and weep holes and incidental work in connection therewith. The cost shall be considered as included in the unit prices bid for the various classes of concrete. No deduction will be made in the volume of concrete or masonry for the space occupied by drains and weep holes.

-3.14 Pipes, Conduits and Ducts. Pipes, conduits and ducts which are to be encased in the concrete, shall be installed by the contractor as the concrete is being placed.

No direct compensation will be allowed for furnishing and installing all pipes and conduits shown on the plans unless an item therefor is included in the Bid Schedule. The cost of furnishing, installing and incidental work in connection therewith shall be considered as included in the unit prices bid for the various classes of concrete.

-4.1 Method of Measurement. The yardage to be paid for shall be the number of cubic yards of concrete of the several classes, complete in place and accepted. In computing the concrete yardage for payment the dimensions used shall be those shown on plans or ordered in writing by the engineer. No measurements or other allowances will be made for forms, falsework, cofferdams, pumping, bracing, etc. No deductions will be made for the volume of timber bumpers, small pipes and conduits, or pile heads imbedded in concrete.

The area of metal structural expansion joints to be paid for shall be the number of square feet of metal expansion material complete in place and accepted.

-5.1 Basis of Payment. The yardage, determined as provided above, shall be paid for at the contract unit price per cubic yard bid for "Class A, Class B, Class D or Class S Concrete," as the case may be, which price and payment shall be full compensation for the concrete, for all materials, including expansion joint filler, expansion joint angles and bolts, water-stops, weep holes, drains, pipes and conduits indicated on the plans, and for installation of all joints, weep holes, drains, pipes and conduits and for all timber bumpers, forms, falsework, placing and finishing, and for all labor, equipment, tools and incidentals necessary to complete the item, but shall not constitute payment for reinforcing steel nor for metal structural expansion joints.

The quantity of metal structural expansion joints measured as provided above, shall be paid for at the contract unit price per square foot bid for "Metal Structural Expansion Joints" complete in place, which price and payment shall be full compensation for all material and for all labor, equipment, tools and incidentals necessary to complete the item.

Reinforcing steel shall be paid for under the pay item of that name.

207 REINFORCING STEEL

207-1.1 Description. This item shall consist of furnishing and placing reinforcing steel of the quality, type, size and quantity designated in accordance with these specifications and as shown on the plans. When deformed bars are specified, the form of the bars used must be approved by the engineer and shall be such as to provide a net section at all points equivalent to that of a plain square or round bar of equal nominal size. The use of cold-twisted bars will not be permitted. Steel mesh and expanded metal shall only be used when specified and shall be of the type shown on plans and approved by the engineer.

-2.1 Materials. Reinforcing bars shall conform to Federal Specification for Concrete Reinforcement Bars QQ-B-71, Billet Steel, type A or B, grade 1 or 2, or Rail Steel, type A or B, grade 4 or intermediate car axle, steel type A or B, grade 5, provided that grade 4 bars shall not be produced by the "piling" method and shall be shop bent.

If purchased from warehouse in small lots, reinforcement may, at the direction of the engineer, be accepted subject to the bending test.

Steel wire reinforcement to be used as such or in fabricated form shall conform to the standard specification A.S.T.M. A 82-34. Wire, wire mesh, and expanded metal, when used for concrete reinforcement shall be of a type and quality approved by the engineer.

-3.1 Construction Methods. When placed all reinforcement shall be free from dirt, oil, paint, grease, mill scale and loose or thick rust.

When bending is required, it shall be accurately done without the use of heat, and bars having cracks or splits at the bends shall be rejected. All reinforcement shall be placed in the exact position shown on the plans, and shall be so securely held in position by wiring and blocking from the forms and by wiring together at intersections that it will not be displaced during the depositing and compacting of the concrete. Precast concrete blocking or metal chairs should be used where applicable. The use of pebbles for blocking is prohibited.

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

When bar-bending diagrams are not shown on the contract plans, detail plans showing the bending of reinforcing bars shall be submitted to the engineer for approval.

-3.2 Splicing Reinforcement. Whenever it is necessary to splice reinforcement at points other than those shown on the plans, drawings showing the location of each splice shall be submitted and approved by the engineer before the reinforcing steel is ordered. Splices shall be avoided at points of maximum stress; they shall, where possible, be staggered, and shall be designed to develop the strength of the steel without exceeding the allowable unit bond stress. When sheets of metal mesh or expanded metal are used they shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the edges.

-4.1 Determination of Weight. The weight of steel to be paid for shall be the number of pounds, theoretical weight, of the steel placed as shown on the plans and accepted. The unit weight used for deformed bars shall be the weight of plain square or round bars, as the case may be of equal nominal size. If steel mesh or expanded metal is required, the weight per square foot will be shown on plans.

-5.1 Basis of Payment. The weight of steel thus determined as provided above shall be paid for at the contract unit price per pound bid for "Reinforcing Steel," which price and payment shall be full compensation for furnishing and placing all the materials, and for all labor, equipment, tools and incidentals necessary to complete the item. No allowance will be made for the clips, wire, separators, or other material used for fastening the reinforcing steel in place.

220 STRUCTURAL STEEL

220-1.1 Description. This item shall consist of furnishing, fabricating, preparing,e assembling, erecting and painting (both shop and field) all structural steel, wrought iron, steel castings and forgings, rivet and eyebar steel, gray iron and malleable iron castings, anchor plates and anchor bolts, steel plates and shapes for expansion joints and pier protection and metal scuppers, pipes and drains in steel superstructures and in floors thereof except for those features for which other payment is provided; all in accordance with these specifications and with applicable requirements prescribed for "Concrete Bridges" and "Steel Bridges," and in conformity with the dimensions, shapes and designs shown on the plans.

-2.1 Materials. All structural eyebar and rivet steel, except where alloy steele is specified, shall comply with and meet the Standard Specifications for Highway Bridges (1935) of the A.A.S.H.O., Division II, Section 7. Structural steel piling shall contain not less than 0.20 percent nor more than 0.35 percent of copper.

-2.2 Silicon and copper bearing structural steel shall comply with and meet thee requirements of Division II, Section 8 of the said A.A.S.H.O. Specification. These alloy steels shall be plainly marked at frequent intervals for identification. These marks shall be made during or immediately after rolling, and shall be of such nature and spacing that they will be visible on practically all pieces cut during fabrication and shall be visible after shop and field paints have been applied.

-2.3 Steel forgings, wrought iron, steel castings, gray iron castings and malleablee castings shall conform respectively to Division II, Sections 9, 10, 11, 12 and 13 of the said A.A.S.H.O. Specification.

-2.4 Schedule of Paint Coats for Metals. Steel structures, including hand rail, shall be painted with three coats of paint, as follows. The particular "Alternate" to be used shall be as directed by the engineer.

1. Shop Coat - Red-Lead Paint.

2. First Field Coat - Red-lead paint, tinted light brown as required with lampblack in an amount not more than 1/4 pound per gallon of linseed oil. Alternate:- White-lead Zinc-oxide paint tinted light gray with lampblack.

3. Second Field Coat - Aluminum paint (to be used when first field coat is red-lead). Alternate:- White-lead Zinc-oxide paint (to be used when first field coat is white-lead), tinted with lampblack to a light gray of a different shade from that of the first field coat.

-2.5 Composition of Paints. The composition of red-lead paints shall be in thee proportion of:

Using Dry Pigment	Using Paste
20 pounds, dry red-lead pigment	20 pounds, red-lead paste
5 pints, raw linseed oil	3 pints, raw linseed oil
2 gills, turpentine	2 gills, turpentine
2 gills, liquid drier	2 gills, liquid drier

-2.6 The composition of white-lead zinc-oxide paint shall be in the following proportion of:

Using Turpentine	Using Mineral Spirits (Vol).
75 pounds white-lead	75 pounds white-lead paste
25 pounds zinc-oxide paste	25 pounds zinc-oxide paste
3 to 4 gallons raw linseed oile	3 to 4 gallons raw linseed oil
½ to 3/4 gallons turpentine	½ to 3/4 gallons spirits
2 to 3 pints drier	2 to 3 pints drier

-2.7 The composition of aluminum paint shall be in the proportion of two pounds of aluminum powder to one gallon of varnish. Aluminum paint shall be mixed the same day it is used.

Where ready-mixed aluminum paint is furnished, composed of aluminum powder and varnish meeting the requirements for these materials herein specified and which retains its "leafing" properties for a period of two weeks after mixing, it may be accepted under these specifications provided it is used within two weeks after mixing.

-2.8 Raw Materials for Paints. These materials shall conform to Federal Specifications, as follows:

Red-lead, Dry or Paste, TT-R-191, 95 percent grade
Basic Carbonate White-lead, TT-W-251, Type A or Type B
Zinc-oxide, TT-Z-301, Dry or Paste
Aluminum Powder, TT-A-476
Lampblack, TT-L-71
Linseed Oil, Raw, JJJ-O-336
Linseed Oil, Boiled, JJJ-O-331
Turpentine, LLL-T-791
Mineral Spirits, TT-T-291a
Drier, TT-D-651
Varnish, for Aluminum Paint, TT-V-81

-2.9 Packing and Shipping Paint. All paint furnished must be shipped in strong, substantial containers, plainly marked with the name, weight and volume of the paint content, together with the color, formula and the name and address of the manufacturer.

-3.1 Construction Methods. The contractor shall furnish all shop detail plans and any material ordered prior to the approval of these plans shall be at the contractor's risk. These details must conform to the general drawings, stress sheet and specifications, and no deviation from the approved shop plans will be allowed without the written consent of the engineer. The contractor shall be responsible for the correctness of the drawings and for shop fits and field connections even though the drawings have been approved by the engineer.

The shop drawings shall be 22 inches by 36 inches in size. Three sets of blueprint copies shall be submitted to the engineer for checking, one of which will be returned with either approval or required revisions noted thereon. After final corrections and approval, three additional sets of blueprints shall be furnished the engineer. Upon completion of fabrication, the original tracings shall be furnished the engineer. No additional payment will be made for these plans; the cost thereof shall be considered as included in the bid price for steel.

-3.2 Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease and other foreign matter, and shall be protected as far as practicable from corrosion. It shall be kept properly drained.

Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends may be cause for rejection of the material.

Portions of the work exposed to view shall be finished neatly. Shearing and chipping shall be done carefully and accurately.

-3.3 If general reaming is not required, all main material, forming parts of a member composed of not more than 5 thicknesses of metal, may be punched with a punch 1/16 inch larger than the nominal size of the rivets, whenever the thickness of the metal is not greater than 3/4 inch. When there are more than 5 thicknesses, or when any of the main material is thicker than 3/4 inch, all of the holes shall be punched with a punch 3/16 inch smaller, and after assembling reamed 1/16 inch larger than the nominal size of the rivets, except that when the metal is thicker than the size of the rivet, the holes shall be drilled.

Holes punched full size shall be 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 3/32 inch. Holes shall be clean cut and without torn or ragged edges.

The punching of holes shall be done so accurately that, after assembling the component parts of a member, a cylindrical pin 1/8 inch smaller than the nominal diameter of the punched hole may be passed through at least 75 of any group of 100 contiguous holes, or in like proportion for any smaller group of holes. If this requirement is not fulfilled, the badly punched pieces may be rejected. If 10 percent of any group of 100 or fewer holes will not pass a pin 3/16 inch smaller than the nominal diameter of the punched hole, the mispunched pieces may be rejected.

General reaming will be required if provided for in the contract. If general reaming is required, holes shall be sub-punched and reamed in material forming a part of the section of main members if the thickness of the material is not greater than the nominal diameter of the rivet. Holes may be punched full size in material used for lateral, longitudinal and sway bracing, lacing bars, stay plates and diaphragms, not forming a part of the section of main members if the thickness of the material is not

greater than the nominal diameter of the rivet. Holes shall be drilled in material, the thickness of which is greater than the nominal diameter of the rivet.

Sub-punched and reamed holes for rivets having diameters greater than 3/4 inch shall be punched 3/16 inch smaller than the nominal diameter of the rivet. For rivets having diameters 3/4 inch, the holes shall be punched 11/16 inch in diameter. For rivets having diameters of 5/8 inch or less, the holes shall be punched full size and spear-reamed. The punch and die shall have the same relative sizes as specified for full size punched holes. After assembling, sub-punched holes shall be reamed to a diameter 1/16 inch larger than the nominal diameter of the rivet.

Reaming shall be done after the pieces forming a built member are assembled and firmly bolted together. Reamed parts shall not be interchanged.

Reaming of rivet holes shall be done with twist drills or with short taper reamers. Reamers preferably shall not be directed by hand. If oil or grease is used as a lubricant when reaming, it shall be applied so as not to soil surfaces which are to be painted. Burrs resulting from reaming shall be removed.

Drilled holes shall be 1/16 inch larger than the nominal diameter of the rivet. Burrs on the outside surfaces shall be removed. If members are drilled while assembled, the parts shall be held securely together while the drilling is being done.

Reamed or drilled holes shall be cylindrical and perpendicular to the member. After reaming or drilling, 85 of any group of 100 contiguous holes, or in like proportion for any smaller groups of holes, shall not show an offset greater than 1/32 inch between adjacent thicknesses of metal.

-3.4 Shop Assembly. Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned and firmly drawn together with bolts before reaming or riveting is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends and other deformation.

Preparatory to the shop riveting of full sized punched material, rivet holes, if necessary, shall be spear-reamed for admission of rivets. The reamed holes shall not be more than 3/32 inch larger than the nominal diameter of the rivets. End connection angles, stiffener angles and similar parts shall be adjusted carefully to correct position and bolted, clamped, or otherwise held firmly in place until riveted. Parts not completely riveted in the shop shall be secured by bolts insofar as practicable to prevent damage in shipment and handling. The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

If general reaming is required, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, holes for field connections drilled or reamed while so assembled and holes or other field connections, except those in lateral, longitudinal and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled, or else drilled or reamed to a metal templet without assembling. The field connections in punched work, except those for lateral, longitudinal and sway bracing, shall be reamed to a metal templet or else with the parts assembled.

Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match-marked and a diagram showing such marks shall be furnished to the engineer.

Rivets before driving shall be of the diameter specified. They shall be free from furnace scale. Rivet heads shall be of approved shape, concentric with the shank, true to size, full, neatly formed and free from fins. Field rivets shall be furnished in excess of the nominal number required to the amount of ten percent plus ten rivets for each diameter and length.

Bolted connections shall be not used unless specifically authorized. If bolted connections are permitted, the bolts shall be unfinished bolts, or turned bolts, as specified. Bolts shall have hexagonal heads and nuts and shall be of such length that they will extend entirely through the nut but not more than 1/4 inch beyond. Bolts in tension shall have two nuts. Unfinished bolts in shear shall have not more than one thread within the grip. The diameter of the unfinished bolt shall not be more than 1/16 inch smaller than the diameter of the hole. The threads of turned bolts shall be entirely outside the grip. The bolts shall be given a finishing cut. Approved nut locks or flat washers 1/4 inch thick shall be furnished, as required. The holes

for turned bolts shall be reamed and their diameters shall be not more than 1/32 inch greater than the diameter of the finished bolt.

Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale and other adhering matter. When driven, they shall completely fill the holes. The heads shall be of approved shape, full size, neatly formed, concentric with the shank, free from fins, and in full contact with the surface of the member. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal, and, if necessary, they shall be drilled out. Caulking or recupping will not be permitted. Rivets shall be driven with a pneumatic hammer and a pneumatic bucker shall be used if practicable.

-3.5 Member Details. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stress shall be planed to a depth of 1/4 inch. Re-entrant cuts shall be filleted before cutting.

The top and bottom surfaces of steel slabs and base plates and cap plates of columns and pedestals shall be planed, or else the plates or slabs hot straightened and annealed. Parts of members in contact with them shall be faced.

Sole plates of beams and girders shall have full contact with the flanges. Sole plates and masonry plates shall be planed or hot straightened. Cast pedestals shall be planed on surfaces to be in contact with steel and shall have the surface to be in contact with masonry rough finished. In planing the surfaces of expansion bearings the cut of the tool shall be in the direction of expansion.

Abutting joints in compression members and girder flanges, and in tension members where so specified on the drawings, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/4 inch.

Floorbeams, stringers and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angles shall be not less than that shown on the detail drawings. The ends of lacing bars shall be rounded neatly unless another form is required. Finished members shall be true to line and free from twists, bends and open joints.

In girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than 1/8 inch below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be 1/2 inch less in width than the distance back to back of the flange angles.

At web splices, the clearance between the ends of the web plates shall not exceed 3/8 inch. The clearance at the top and bottom ends of web splice plates shall not exceed 1/4 inch.

End stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange angles. Intermediate stiffener angles shall fit sufficiently tightly to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

Eye-bars shall be straight, true to size, and free from twists, folds in the neck and head, and other defects. The heads shall be made by upsetting and rolling or forging, and not by welding. The form of the heads will be determined by the dies in use at the works where the eye-bars are made, if they are satisfactory to the engineer. The thickness of the head and neck shall not overrun more than 1/16 inch. Eye-bars that are to be placed side by side in the structure shall be bored so accurately that upon being placed together, pins 1/32 inch less in diameter than the pin holes will pass through the holes at both ends at the same time without driving.

Before boring, eye-bars shall be annealed to produce the required physical qualities and shall be straightened. Proper instruments shall be provided for determining at any time the temperature of the bars. Other steel that has been heated partially shall be annealed, unless it is to be used in minor parts. Crimped stiffeners need not be annealed.

Pins and rollers shall be turned accurately to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. The final surface shall be produced by a finishing cut. Pins more than 7 inches in diameter shall be forged and annealed. In pins larger than 9 inches in diameter, a hole not less than 2 inches in diameter shall be bored full length along the axis.

Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut. The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than 1/32 inch. Boring of holes in built up members shall be done after the riveting is completed. The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter, or 1/32 inch for larger pins.

Welding of steel shall not be done except where shown on plans for minor details or to remedy minor defects and then only with the approval of the engineer. Defects may be corrected as and to the extent hereinbefore permitted. Structural welding, when contemplated in the fabrication, shall conform to the A.A.S.H.O. Standard Specifications (1935) for Arc Welding Metal Bridge Structures.

Screw threads shall make close fits in the nuts and shall be U.S. Standard, except that for pin ends of diameters greater than 1-1/2 inches, they shall be made with 6 threads to the inch. Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

-3.6 Mill and Shop Inspection. The contractor shall give the engineer ample notice of the beginning of work at the mill or in the shop, so that inspection may be provided. The term "mill" means any rolling mill or foundry where material for the work is to be manufactured. No material shall be manufactured or work done in the shop before the engineer has been so notified. The contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and the inspectors shall be allowed free access to the necessary parts of the works.

The inspector shall have the authority to reject any material or work which does not meet the requirements of these specifications.

The contractor shall furnish the engineer with duplicate copies of mill orders and triplicate copies of shipping statements as the engineer may direct. The weights of the individual members shall be shown on the statements. Shop scale weights shall be determined in the presence of the shop inspector, who shall certify thereto on the statement. The contractor shall furnish test specimens, as specified herein, without extra charge; also the labor, testing machines and tools necessary to make the specimen and full size tests.

The acceptance of any material or finished members by the inspector shall not be a bar to their subsequent rejection, if found defective.

Full Size Tests of Eye-bars. If tests of full size eye-bars are required, they shall be made under the following conditions and requirements:

The number and size of the bars to be tested shall be stipulated by the engineer before the mill order is placed. The number shall not exceed 5 percent of the whole number of bars ordered, with a minimum of two bars. The test bars shall be of the same section as the bars to be used in the structure and of the same length, if within capacity of the testing machine. They shall be selected by the inspector from the finished bars. Test bars representing bars too long for the testing machine shall be selected from the full length bar material after the heads on one end have been formed. They shall then be cut and the second head formed, making a bar of the greatest length that can be tested.

Full size tests of eye-bars shall show a yield point of not less than 33,000 pounds per square inch, an ultimate strength of not less than 60,000 pounds per square inch, and an elongation, including the fracture, of not less than 12 percent in a length of 18 feet measured in the body of the bar. The fracture shall show a uniform silky or fine granular structure throughout.

If a bar fails to fulfill the specified requirements, two additional bars of the same size and from the same mill heat shall be tested. The bars represented by the test may be reannealed before the additional bars are tested. If two of the three bars tested fail, the bars of that size and mill heat shall be rejected. A record of the annealing furnace charges, showing the bars in each charge and the details of the treatment as to temperature and time, shall be furnished to the engineer.

-3.7 Shop Painting. The painting of metal structures shall include the preparation of the metal surfaces, the application, protection and drying of the paint coatings, and the supplying of all tools, tackle, scaffolding, labor and materials necessary for the entire work.

All paint shall be mixed thoroughly before applying and during application shall be stirred frequently so that the pigments are kept in suspension and the proper consistency maintained. Paint shall not be applied when the atmospheric temperature is below 40°F., or when the air is misty, or when, in the opinion of the engineer, conditions are otherwise unsatisfactory for the work. It shall not be applied upon damp or frosted surfaces. Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting shall not be done when the metal is hot enough to cause the paint to blister and produce a porous paint film. If it is necessary in cool weather to thin the paint on account of congealing, this shall be done only by heating.

Painting shall be done in a neat and workmanlike manner. Brushes preferably shall be round or oval in shape, but if flat brushes are used they shall not exceed 4 inches in width. The paint when applied shall be so manipulated under the brush as to produce a uniform, evan coating in close contact with the metal or with previously applied paint and shall be worked into all corners and crevices. In the application of aluminum paint by brushing, the finish strokes shall generally be made in the same direction. On surfaces which are inaccessible to paint brushes, the paint shall be applied with sheepskin daubers specially constructed for the purpose. If the painting is unsatisfactory to the engineer, the paint shall be removed and the metal cleaned thoroughly and repainted.

Surfaces of metal to be painted shall be cleaned thoroughly, removing rust, loose mill scale, dirt, oil or grease, and other foreign substances. The removal of rust, scale and dirt shall be done by the use of metal brushes, scrapers, chisels, hammers or other effective means. Oil and grease shall be removed by the use of gasoline or benzine. Bristle brushes shall be used for removing loose dirt.

Surfaces to be riveted in contact either in the shop or field shall not be painted. Surfaces not in contact but which will be inaccessible after assembly or erection shall be painted two coats.

When fabrication is complete and the work has been accepted, surfaces not painted before assembling, except surfaces to be in contact after erection, shall be painted one coat. Material shall not be loaded for shipment until the paint is dry.

Erection marks shall be painted on painted surfaces.

With the exception of abutting chord and column splices and column and truss shoe bases, machine-finished surfaces shall be coated as soon as practicable after being accepted, and before removal from the shop, with a hot mixture of white-lead and tallow. Surfaces of iron and steel castings, machine-finished for the sole purpose of removing scales, scabs, fins, blisters or other surface deformations, shall be given the shop coat of paint.

The composition used for coating machine-finished surfaces shall be mixed in the following proportions: 4 pounds tallow, 2 pounds white-lead and 1 quart linseed oil.

-3.8 Plates and angles or other shapes which have become bent or buckled shall be straightened by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry-red color. After heating, the metal shall be cooled as slowly as possible.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

-3.9 Field Assembling. The parts shall be accurately assembled as shown on the plans and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are riveted fully and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before riveting. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled. The steel structures shall be entirely riveted and swung before any concrete in the deck is poured.

Fitting-up bolts shall be of the same nominal diameter as the rivets, and cylindrical erection pins shall be 1/32 inch larger.

Pneumatic hammers shall be used for field riveting, except when the use of hand tools is permitted by the engineer. Rivets larger than 7/8 inch in diameter shall not be driven by hand. Cup-faced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be fitted up accurately and securely before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out.

In bolted connections, the bolts shall be drawn up tight and the threads burred at the face of the nut with a pointed tool.

Pilot and driving nuts shall be used in driving pins. Nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

-3.10 Cleaning-up. Upon completion and before final acceptance, the contractore shall remove all falsework, excavated or useless materials, rubbish and temporary buildings, replace or renew any fences damaged and restore in an acceptable manner all property, both public and private, which may have been damaged during the prosecution of the work, and shall leave the bridge site and adjacent highway in a neat and presentable condition satisfactory to the engineer. All excavated material or falsework placed in the stream channel during construction shall be removed by the contractor before final acceptance.

-3.11 Field Painting. The following requirements, in addition to those prescribed for shop painting, shall apply to field painting.

The contractor shall protect pedestrian, vehicular and other traffic upon or underneath the bridge and also all portions of the bridge superstructure and substructure against damage or disfigurement by spatters, splashes and smirches of paint or paint materials.

Field painting shall consist of two coats applied after erection. The color of the paint shall be determined by the engineer and the coats shall be sufficiently different in color to permit detection of incomplete application.

As soon as the field cleaning has been done to the satisfaction of the inspector, the heads of field rivets and bolts, and any surfaces from which the shop coat of paint has been worn off or has become otherwise defective shall be covered with one coat of the same paint as was used in the shop. When the paint applied for touching up rivet heads and abraded surfaces has become dry the first field coat may be applied. In no case shall a coat be applied until the previous coat had dried throughout the full thickness of the paint film.

Small cracks and cavities which have not been sealed in a water-tight manner by the first field coat shall be filled with red-lead paste before the second field coat is applied.

Where timber decks are provided, the top flanges of all stringers and floor beams shall be protected by a covering composed of a heavy layer of bituminous material (tar, asphalt or pitch) applied hot and one thickness of two-ply tar paper wide enough to project three inches beyond the edges of the members. These edges shall be bent down at an angle of 45 degrees.

-4.1 Method of Measurement. The quantity to be paid for under this item shall be the number of pounds of metal in the fabricated structure completed and accepted, which weight shall include the weight of the actual number of field rivets shipped. The weight of erection bolts, field paint and all boxes and crates or other containers used for packing, together with sills, struts and rods used for supporting members during transportation, shall be excluded. For the purpose of measurement for payment, steel and iron castings, silicon steel, anchor plates, steel plates and shapes for expansion joints and pier protection, all metal conduits, scuppers, pipes and drains in the superstructure and all zinc and other similar metals required in the superstructures shall be considered as structural steel. Bridge hardware connectors for joining timber members, nails, spikes and bolts, except anchor bolts, shall not be included in the poundage, or paid for.

The weights paid for shall be shop scale weights unless otherwise provided. Finished work shall be weighed in the presence of the engineer's shop inspector if practicable. The contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various parts. When it is not practicable to obtain the shop scale weights of the individual members in the presence of the inspector,

and it is so ordered, payment will be based on the computed weight. In any case, if the total scale weight of any structure exceeds the computed weight by more than 2 percent, thee weight in excess of 2 percent over the computed weight shall not be paid for.

If the weight of any member is less than 97 percent of the computed weight it shalle be cause for rejection at the option of the engineer.

The computed weight shall be calculated in accordance with the following provisions and shall be based on the following assumptions.

The weight of steel shall be assumed at 490 pounds per cubic foot. The weight ofe rolled shapes, and of plates up to and including 36 inches in width, shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts and open holes. The weights of plates wider than 36 inches shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts, copes and open holes, to this shall be added one-half ofe the allowed percentages of overrun in weight hereinbefore permitted. The weight of headse of shop driven rivets shall be included in the computed weight, assuming the weights toe be as follows:

Diameter of Rivet Inche	Weight for 100 Button Heads Pounds
1/2	4.4e
5/8	9.0
3/4	15.0e
7/8	23.0
1	33.0

The weight of castings shall be computed from the dimensions shown on the approved shop drawings, with an addition of 10 percent for fillets and overrun based on an assumed weight of 450 pounds per cubic foot. To the total computed weight of metal may be addede an allowance of 0.4 of one percent for shop paint.

-5.1 Basis of Payment. The weight, determined as provided above, of steel ande metal of the various categories comprised in this item shall be paid for at the contracte unit price per pound bid for "Structural Steel," which price and payment shall constitute full compensation for furnishing, fabricating, delivering, erecting and painting all the steel and other metal and for all labor, equipment, tools and incidentals necessary toe complete the item. Where it is desired to pay for certain selected alloy steels, forgings, castings or other specific categories of metal herein above by the terms of this specification, included under the pay-name "Structural Steel," the weight of such selected material shall be determined and segregated and duly paid for at the contract unit price per pound bid for "Structural Steel (Alloy Steel, forgings, castings or other category named in the Bid Schedule, as the case may be)."

230 TREATED AND UNTREATED TIMBER

230-1.1 Description. This item shall consist of furnishing lumber of the sizese and grade specified, and of furnishing timber of the stress-grade, sizes and dimensionse for the different uses specified, treated or untreated as called for in the Bid Schedule, and of preparing, framing, assembling and erecting the same including painting wheree specified, and including also all structural steel, iron, castings and other metal parts, all hardware required by the specifications and plans, all in accordance with thesee specifications and in conformity with the structure design and details as shown on thee plans or directed by the engineer.

The contractor shall furnish lumber of the species called for on the plans; hee shall furnish timber of the species called for and of the stress-grade quality stipulated on the plan for the several usages or for the specific component members of the structure.e

-1.2 Treated Timber. Treated timber shall be interpreted to mean timber of thee species called for, treated by a pressure method to retain the minimum quantity per cubic foot of the specified preservative stipulated in Table I. The type of preservative used shall be the type called for in the Bid Schedule. Where more than one type ise included in the contract, each type shall be used as indicated by the plans.e

TABLE I

	Minimum Absorptions of Preservative - Pounds of Preservative per Cubic Foot of Wod					
	Creosote Oil or Creosote Coal Tar Solution		50-50 Creosote: Petroleum Oil Blend	1/ Zinc Chloride or 2/ Chromated Zinc Chloride	Zinc-Meta-Arsenite	Wolman Salts (Triolith or Tanalith)
	Empty Cell	Full Cell	Empty Cell			
General Bridge Construction except Marine Use	8		10	See special provisions	See special provisions	See special provisions
Timber for Marine Use						
Southern Pine		20				
Douglas Fir		15				
Poles	8		10	See special provisions	0.3	0.3
Posts	6		7-1/2	1/ 1 2/ 3/4	1/4	1/4
Lumber to be Painted or for Dry Use				1/2	1/4	1/4

-2.1 Materials. All lumber and timber shall meet the Standard Specifications for Highway Bridges (1935) of the A.A.S.H.O., Division II, Section 20, and shall be of a species recognized in Article 2.20.1 thereof, as limited by Article 2.20.2. "Lumber" shall be graded as provided in Article 2.20.3 "Grading of Yard Lumber" of the said Section 20. For sizes over 5 inches (least dimension) and for all structural uses involving specified strength the material furnished shall meet the requirements of the said Section 20 for "Timber" of the respective stress-grades stipulated on the plans for the several members and uses.

-2.2 Where the specifications and/or plans call for "standard" stress-grades for the various structural purposes, material of the grades specified for the various uses in Table II shall be furnished, and it shall be the understanding that in the design unit stresses corresponding to Table II have been assumed, and that, where choices appear in Table II, the choice shall be as noted on the plans.

TABLE II
(On next page)

TABLE II

Structural Purpose	Size of Member	Standard Stress Grade
(a) Truss members, tension Floor beams Stringers Other floor members	5" x 8" and larger	1800#f, 1600#f, or 1400#f structural beams and stringers
(b) Caps Posts, bridge and guard rail Sills Mud sills Nailing strips Truss members, compression Timbers (culverts)	6" x 6" and larger	1200#c or 1100#c structural posts and timbers
(c) Joist Decking, wearing Other floor members Rails Rail posts Nailing strips Truss members, compression and tension Guard rail	4" and thinner	1600#f or 1400#f structural joist and plank
(d) Wheel and felloe guards	6" x 6" and larger	1100#c structural posts and timbers
(e) Sub-decking, flat Sub-decking, laminated Bracing, sway, sash, and longitudinal Girts Bulkhead plank Scupper blocks Cleats Grillage	4" and thinner	1200#f or 1100#f joist and plank
		Yard Lumber Grade
(f) Cross-bridging Sidewalk Firestops	2" and 3" thick	No. 1 dimension
(g) Truss housing Inside sheathing	1"&1-1/4" thick	D select finish, or No. 1 boards

(h) For temporary structures which are for use only during erection or for emergency use, the grades of 1200#f or 1100#c may be substituted for 1800#f, 1600#f, 1400#f, or 1200#c where specified above; No. 1 Dimension for 1200#f and 1100#f, and No. 1 timbers for 1100#f.

-2.3 The preservative shall meet the requirements given below for the particular type used. The creosote oils shall be distillates of coal-gas tar or coke-oven tar. The creosote-coal-tar solution shall be a coal-tar product, of which at least 80 percent shall be a distillate of coal-gas tar or coke-oven tar, and the remainder shall be refined or filtered coal-gas tar or coke-oven tar.

	Creosote Oils Grade 1	Grade 2	Grade 3	Creosote-Coal-tar Solution
It shall not contain water in excess of ___ percent	3	3	3	3
It shall not contain matter insoluble in benzol in excess of, %	0.5	0.5	0.5	2
The specific gravity at 100/60°F. shall not be less than	1.03	1.03	1.03	1.05 to 1.12
The distillate, based on water-free oil shall be within the following limits:				
Up to 410°F. not more than, %	5	8	10	5
Up to 455°F. not more than, %	25	35	40	25
The float test of residue above 671°F. shall not exceed 50 seconds at 158°F. if the distillation residue above 671°F. exceeds, %	5	5	5	26
Coke residue of oil shall not exceed, %	2	2	2	6

An increase of 1 percent in matter insoluble in benzol shall be permitted for used oil in the working tanks, provided it can be shown that the oil when fresh was of the quality specified.

A blend of 50 percent creosote and 50 percent petroleum oil of suitable character may be used if approved in writing by the engineer in cases where such considerations as delayed or reduced checking indicate its use to be advantageous. Petroleum oil so used shall have an asphalt base, a flash point not less than 220°F. (Cleveland Cup), a viscosity Furol at 180°F. of 60 to 180 seconds, and at 100°F. of not more than 1300 seconds, and shall not contain more than one percent of water. When mixed with an equal volume of creosote, the resulting mixture shall be free from sludge and shall have a viscosity Furol at 180°F. of not over 70 seconds.

Zinc Chloride. Zinc chloride shall be acid-free and shall contain not more than 0.1 percent iron. Fused or solid zinc chloride shall contain at least 94 percent chloride of zinc. Concentrated zinc chloride shall contain at least 50 percent chloride of zinc.

Chromated Zinc Chloride. Chromated zinc chloride shall contain not less than 81.5 percent of zinc chloride as defined above, and not more than 18.5 percent sodium bichromate, which shall be commercial bichromate of sodium $Na_2Cr_2O_7-2H_2O$. Concentrated chromated zinc chloride shall contain not less than 50 percent of chromated zinc chloride.

Wolman Salts. Wolman Salts shall be either Triolith or Tanalith as specified or called for on the plans.

Triolith and tanalith shall conform approximately to the following requirements:

	Minimum, Percent
Triolith - (To resist decay)	
Sodium fluoride	50.88
Potassium dichromate	32.37
Dinitro-phenol	9.25
Insolubles, in hot water	0.50
Tanalith - (To resist decay and termites)	
Sodium fluoride	23.12
Arsenate	23.13
Dichromate	34.68
Dinitro-phenol	11.57
Insolubles, in hot water	0.50

Zinc Meta-Arsenite. Zinc meta-arsenite shall be in aqueous solution. The strength acidity, etc., in the solution shall be such as to insure the required penetration and absorption of the preservative in the quantity required.

The zinc meta-arsenite shall be used in approximately the following proportions:

Arsenious Acid (As_2O_3)	120 parts
Zinc Oxide (ZnO)	80 parts
Acetic Acid	Sufficient to keep the zinc meta-arsenite in solution.

-2.4 Sampling and Testing. Creosote Oils. Preservative oils shall be sampled using A.A.S.H.O. Method Test T-60. Coke residue shall be determined using A.A.S.H.O. Method Test T-61.

Zinc Chloride. Zinc chloride shall be tested using A.S.T.M. Method D 199-27.

Chromated Zinc Chloride. Chromated zinc chloride shall be tested as described above for zinc chloride for determination of zinc. For the determination of sodium bichromate the method shall be as follows:

Solutions Required:

Standard N/10 Sodium Thiosulphate
20% Solution C.P. Potassium Iodide
Starch Solution
Concentrated C.P. Hydrochloric Acid

The starch solution is best prepared by mixing 1 gm. soluble starch to a paste with a little distilled water and adding to 200 c.c. boiling distilled water. In case of solid chromated zinc chloride a sample of approximately 6 gm. should be taken, and in case of 50 percent chromated zinc chloride a sample of about 12 gm. The sample is accurately weighed in a closed weighing bottle, dissolved in distilled water, volume made up to 500 c.c. in a standard flask adding a little hydrochloric acid to remove any turbidity, and a 25 c.c. aliquot taken for titration. In case of treating solutions, 2% - 6%, a sample of 5 to 10 grams is weighed and taken directly for titration. The precision of the method is highest with a titration of 10 c.c. to 15 c.c. of N/10 thiosulphate. The aliquot or sample taken for titration is diluted to approximately 300 c.c. in a beaker or Erlenmeyer flask. Five c.c. of concentrated hydrochloric acid are added and the solution cooled a little below room temperature. Ten c.c. of the 20% potassium iodide solution are added and the sample allowed to stand 10 minutes. The liberated iodine is then titrated with the N/10 thiosulphate until the yellow color of iodine almost disappears. Two c.c. of starch solution are added and titration continued until the blue color just disappears. The percent of sodium bichromate is calculated as follows:

$$\frac{\text{c.c.'s of N/10 thiosulphate} \times 0.4966}{\text{weight of aliquot sample}} = \text{percent } Na_2Cr_2O_7\text{-}2H_2O$$

in original sample.

Wolman Salts. Procedure for Analysis. For the Dichromate. Precipitate as barium chromate by the addition of barium acetate. After filtering and washing, dissolve with warm hydrochloric acid, add potassium iodide and titrate against N/10 sodium thiosulphate.

For the Disodium Hydrogen Arsenate. After treating with sulphuric acid and potassium iodide, followed by continued boiling until all liberated iodine is driven off, the solution is neutralized with solid sodium bicarbonate, then with addition of starch solution titrated to N/10 iodine solution.

For Sodium Fluoride. After removal of other ingredients by silver nitrate, followed by sodium chloride, the filtrate is exactly neutralized to litmus and the fluorine precipitated by calcium chloride, which after vigorous boiling is filtered through the asbestos mat of a gooch crucible, dried and weighed as calcium fluoride.

For Dinitro-phenol. To the dry salts or to the residue of a solution evaporated nearly to dryness, add a little water and then concentrated sulphuric acid. Place in a separatory funnel and extract the dinitro-phenol with ether, drawn off into a small weighed flask. About four extractions of each sample will suffice. Evaporate with care over waterbath, with very slow final drying in a dessicator. Weigh as dinitro-phenol, with a tolerance determined for the exact method employed.

-2.5 Paint for Rails and Rail Posts. White paint for rails and rail posts shall consist of 100 percent white lead, uniformly mixed with pure linseed oil to the required consistency for priming and second coat. The finish coat shall consist of 3 parts by weight of white lead to one part by weight of zinc oxide, uniformly combined and mixed with pure linseed oil to the required consistency. Turpentine drier may be added to the paint but shall not exceed an average proportion of ½ pint of drier to one gallon of paint.

The white lead and zinc oxide shall meet the requirements for these materials specified under "Structural Steel," and shall be delivered separately on the project in the original containers before being opened and mixed with the linseed oil.

-3.1 Construction Methods. Lumber and timber on the site of the work shall be stored in piles. Untreated material shall be openstacked at least 12 inches above the ground surface and piled to shed water and prevent warping. When required by the engineer, it shall be protected from the weather by suitable covering. Creosoted timber and piling shall be close-stacked, piled to prevent warping, and the tops of the stacks shall be covered with a 2-inch layer of earth. The ground underneath and in the vicinity of all material piles shall be cleared of weeds and rubbish.e

All cutting, framing and boring of treated timber shall be done before treatment. The timbers shall be handled carefully without sudden dropping, breaking of outer fibres, bruising or penetrating the surface with tools. It shall be handled with rope slings. Cant dogs, peaveys, hooks or pike-poles shall not be used. In water infested by marine borers, cutting and boring below high-water shall be avoided.

All cuts in treated timbers, and all abrasions after having been carefully trimmed, shall be coated with two applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch, or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

Before driving bolts all holes bored after treatment shall be impregnated with hot creosote oil by means of an approved bolt hole treater. Any unfilled holes, after being treated with creosote oil shall be plugged with creosoted plugs.

-3.2 All construction involving timber or lumber shall be in accordance with thee requirements given under "Construction Methods" in the item "Timber Bridges."

-3.3 Seasoning and Other Preparation for All Timber Treatment. Seasoning ande other preparation for timber treatment shall be in accordance with the "Standard Specifications for Highway Bridges" (1935) of the A.A.S.H.O., Division III, Section 17, Articles 3.17.2 and 3.17.3, except that in the last sentence of Article 3.17.2 the requirement ofe 1/10 pound per cubic foot condensation per hour shall be changed to 1/6 pound per cubice foot per hour.e

-3.4 Plant Equipment. Treating plants shall be equipped as specified ine Article 3.17.4 of Section 17 cited above.

-3.5 Penetration of Treatments. The depth of penetration of treatments and thee methods of determining the same shall comply with Article 3.17.5 of Section 17 cited above, except that any penetration exceeding two inches in depth shall be considered as full sapwood penetration. In the case of sawn timbers, the location of the test boring shall be selected at the point of maximum sapwood thickness. In no case shall the penetration be less than one-half inch. In gaging the depth penetrated by preservatives other than creosote oil the method used shall be such as will enable the engineer to determine, to his satisfaction, the actual depth penetrated.

-3.6 Methods for Timber Treatment. (a) Oil Treatments. Oil treatments ofe Southern pine shall comply with Article 3.17.7 (a), (b) and (c) of Section 17 cited above.

Oil treatments of Douglas fir shall comply with Article 3.17.8 of Section 17 cited above.

(b)e Zinc Chloride Treatments. Zinc chloride and chromated zinc chloride treatments of pine material shall comply with Article 3.17.7 (d) of Section 17.

Zinc chloride and chromated zinc chloride treatments of Douglas fir shall comply with Article 3.17.7 (d) of Section 17 cited above, except that green material shall be steam-seasoned at a pressure of not more than 20 pounds per square inch for a period not exceeding 6 hours at not more than 260°F. which pressure and temperature maxima shall not be reached in less than 2 hours.

(c)e Wolman Salts Treatments. Treatment with Wolman Salts shall be by the fulle cell process; and the ranges of temperature, pressure and time duration shall be controlled so as to result in the maximum penetration by the quantity of preservative solution injected.

In general, the material to be treated shall have been seasoned by air drying, or kiln drying or a combination of them until the moisture content in the treatable areas of the wood has been reduced to not more than 20 percent of the oven-dry weight of the wood. When it is necessary to treat lumber or timber with a greater moisture content than 20

percent such material shall be artificially seasoned in the retort by alternate steam bath and vacuum of such intensity and duration and such number of cycles as will prepare the material for a minimum absorption of solution to provide the stipulated net dry salt retention. In no case, shall the steam pressure be such as to exceed a maximum temperature in the retort of 240°F.; and for Douglas fir and other more sensitive woods the maximum pressure shall be not more than 20 pounds per square inch and the steaming period shall not exceed 6 hours, which pressure and temperature maxima shall not be reached in less than 2 hours. The retort shall be relieved of condensate and wood extracts continuously during both the steaming and the vacuum periods and after the final vacuum the treating solution shall not be admitted to the retort until all such condensate and wood extracts have been evacuated thoroughly.

The concentration of Wolman Salts in the solution shall be so adjusted that the injected quantity of solution, after the carrier water has dried out, shall leave not less than 90 percent nor more than 110 percent of the stipulated dry salt retention, in any one charge.

Concentration of the treating solution shall be taken as the percentage of weight of dry salt related to the total weight of the solution, the weight of water being taken as 62.37 pounds per cubic foot at a temperature of 60°F. When the quantity of impregnated solution is determined by volume, the corresponding weight of the solution shall be corrected by the proper factor for any temperature other than 60°F., at which the readings for volume may have been taken. Due to the expansion occurring when these salts are dissolved, the weight of the resulting solutions has been found to be equal to the weight of the water plus 5/6 of the weight of the added salts, and in determining the weight of impregnated solution from measurements of volume, such weight shall be determined on this basis.

Before and after each charge the density of the treating solution may be observed by means of a calibrated hydrometer, and the concentration of salts in the solution calculated from the above given data.

The temperature of the treating solution may be varied according to the character of the wood being treated and the purpose for which it is to be employed, from a minimum of 120°F., up to a maximum of 200°F. With very resinous wood temperatures in excess of 120°F. may cause an objectionable movement and exudation of pitch, such as to interfere with satisfactory painting of the treated material.

Refractory woods such as Douglas fir, larch, tamarack, green timber or partly seasoned timber or heartwood lumber, for which the heavier concentrations of treating solution are required, shall not be placed for treatment in the same charge with non-refractory woods. For either class of material the concentration of treating solution shall be made up or adjusted to provide for the net dry salt retention stipulated, with the largest amount of absorption practicable for the kind of material to be treated.

Impregnation. The properly conditioned material, closed off in a tightly sealed retort, shall be subjected to an initial vacuum of not less than 27 inches for not less than 15 minutes after the maximum has been reached. Then, with the vacuum apparatus remaining in operation so that the vacuum is fully maintained until the material to be impregnated has been wholly submerged, the treating solution shall be admitted to the retort, continuing until the retort is completely filled. Thereafter additional solution shall be forced into the retort by a pressure pump as rapidly as it is absorbed by the wood, and in such volume as gradually to build up the pressure of the solution within the retort to a maximum of 150 pounds per square inch for yellow pine, and to a maximum of 175 pounds per square inch for Douglas fir and other similar refractory kinds of wood.

The pumping may be discontinued at intervals to observe the rate of absorption. The pressure shall be finally raised to the maximum and maintained until the amount of preservative solution required to comply with stipulated net retention has been injected, or until less than 5 percent of the total quantity required has been injected during the latter half of one hour throughout which the rate of absorption has steadily decreased while the pressure has been maintained at the maximum.

The temperature of the treating solution shall be brought to not less than 100 degrees F., during the pressure period, preferably to 120 degrees F., or more, but not to exceed 200 degrees F., if the character of the material being treated and the purpose for which it is to be used is not such that there would be an objectionable effect brought about by the higher temperatures.

After the pressure period the retort shall be emptied of preservative solution and the charge may be left in the retort of a final vacuum applied or a two or three stage final air pressure used so that when the charge is removed it will be free from drip or further loss of impregnated solution. All drip in the retort or solution

extracted by final vacuum, shall be returned to the work tank before the readings are taken to determine the amount of absorption of the preservative solution.

Volumetric and temperature readings shall be taken by means of suitable accurate device on the work tank before introduction of solution into the charged retort, at the start of the pressure pumping, after the first return of solution from the retort and after the final return, for use in calculation of the initial absorption, kickback and total remaining solution that has been injected into the charge.

(d)e Zinc Meta-Arsenite Treatments. Only properly conditioned material shall bee treated. Treatment with zinc meta-arsenite shall conform to the following: No charge shall retain less than 90 percent of the quantity of preservative specified, but the average retention of preservative by the material treated under any contract or order shall be at least 100 percent of the quantity specified. The amount of preservative retained shall be calculated on the basis of preservative at 60°F. The net amount of preservative retained in the wood shall be the difference between the salt in the measuring or weighing tank at the start and at the end of the treatment, after the solution from the cylinder, including all drip from the wood at the conclusion of the final vacuum period, has been returned to the measuring or weighing tank. This net retention shall be determined from the initial and final readings on the measuring or weighing tank using suitable accurate devices thereon and from an analysis of the solution in the tank at the start and at the end of the treatment.

The preservative solution shall have such a strength that the material to be treated shall obtain the required retention of preservative with the largest volumetric absorption practicable.

Full-Cell Process. The wood shall be subjected to a vacuum of sufficient intensity and duration to insure that the wood is as dry and free from air as practicable, and to permit a retention of the specified amount of preservative per cubic foot of wood.

The preservative shall be introduced at atmospheric temperatures at not less than 60°F., and the cylinder filled without breaking the vacuum. The pressure shall then be raised to and maintained at a minimum of 100 pounds per square inch or until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or until the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not more than 110°F. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 inches promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

-4.1 Method of Measurement. The quantity to be paid for shall be the number ofe thousand feet board measure of lumber and timber, complete in place and accepted. Measurements of lumber and timber will be computed from the net dimensions shown on the plans, unless changes in such dimensions have been authorized in writing by the engineer. The dimensions on the plans shall be interpreted as standard sizes. The standard size dimensions shall be used in the computations even though the actual size be scant in the amount provided above. The measurement of timber will include only such timber as is a part of the completed and accepted work, and will not include timber used for erection purposes, such as falsework, bracing, sheeting, etc.

-5.1 Basis of Payment. When the pertinent quantities, determined as provided above, do not include any bridge iron they shall be paid for at the contract unit prices per thousand feet board measure bid for "Untreated Timber," "Treated Timber, Creosote Preservative," "Treated Timber, Zinc Chloride Salts Preservative," "Treated Timber, Wolman Salts Preservative," and "Treated Timber, ZMA Preservative," as the case may be, which prices and payment shall be full compensation for procuring, furnishing and delivering all lumber and timber, including any preservative treatment required, for preparing, framing, assembling, erecting and painting and for all labor, equipment, tools and incidentals necessary to complete the item.

When the pertinent quantities, determined as provided above, include bridge iron they shall be paid for at the contract unit prices per thousand feet board measure bid for "Untreated Timber-Including Bridge Iron," "Treated Timber, Creosote Preservative-Including Bridge Iron," "Treated Timber, Zinc Chloride Salts Preservative-Including Bridge Iron," "Treated Timber, Wolman Salts Preservative-Including Bridge Iron," and "Treated Timber, ZMA Preservative-Including Bridge Iron," as the case may be, which prices and payments shall be full compensation for procuring, furnishing and delivering all lumber and timber, including any preservative treatment required, all structural steel, iron, castings, hardware and other metal parts used in the item, for preparing, framing, assembling, erecting and painting and for all labor, equipment, tools and incidentals necessary to complete the item.

Masonry, piling and floors called for in the Bid Schedule will be paid for as prescribed in the respective contract item.

GENERAL SPECIFICATION FR-50 1935

240 CLASS A CEMENT STONE MASONRY

240-1.1 Description. This item shall consist of approved stones laid in mortar and shall be constructed in accordance with these specifications and in conformity with the requirements shown on the plans. Class A cement stone masonry shall be used for walls supporting cut slopes, for the ends of box culverts, and at other locations where called for on the plans or directed in writing by the engineer.

-2.1 Materials. The stones shall be clean, hard, of a kind known to be durable, and preferably native to the vicinity of the construction. Individual stones shall in general have a thickness of not less than 5 inches, a width of not less than 1-1/2 times the thickness with a minimum of 12 inches, and a length of not less than 1-1/2 times their width. Where one or more dimensions of a stone are shown on the plans, it shall be of the size as shown.

There shall be a variety in the size of the stones and as a general rule not more than 10 percent shall be of equal size.

Mortar shall conform to all the specifications and requirements for "Mortar for Masonry."

-3.1 Construction Methods. Quarry. All quarry locations shall be subject to the approval of the engineer.

Quarry sites may not be opened within clear view from the roadway, except where widening of roadway cuts or quarry from the road prism is authorized and designated in writing by the engineer. Where quarries are located out of sight of the roadway, upon the completion of operations, the area shall be neatly trimmed up and all refuse and stripping shall be thrown over the bottom of the quarry and roughly spread to produce a neat appearance and so left that the whole area will drain.

Quarry From the Road Prism. Quarry from the road prism may be authorized by the engineer and will be required when called for on the plans or in the special provisions. All operations pertaining to quarry from the road prism, including stock piling of materials, shall be confined within the staked limits of the roadway. Refuse and stripping from such quarry shall be used to widen or flatten fills uniformly within 1000 feet from the site of such quarry operation or disposed of as otherwise directed by the engineer.

Suitable stone from the excavation other than the area or areas designated for quarry within the road prism may be saved when approved by the engineer and shall be stock piled within the cleared limits of the roadway.

-3.2 The finished stone work shall present a good architectural appearance, corresponding with the representation for Class A cement stone masonry as shown upon the architectural drawings. The masonry shall be constructed by experienced workmen. The contractor shall build at a site designated by the engineer, an L-shaped sample section of wall not less than 5 feet high and 8 feet long, showing examples of face wall, end wall, top wall, method of turning corners and method of forming joints, which shall be subject to the approval of the engineer, and no masonry, other than foundation masonry shall be laid prior to the approval of such sample.

-3.3 Quarrying operations and delivery of stone to the work shall be so organized as to insure this work keeping well ahead of masonry operations, and a surplus of weathered and unweathered stones shall be kept on hand at all times to allow adequate selection to be made.

-3.4 Face stones shall be hammer dressed to conform in general to the dimensions and face areas shown on the drawings and shall be principally of stones with weathered surfaces or stones with pronounced mineral stains on lines of cleavage. Unweathered stones where used in wall surfaces shall be distributed in relation to the entire wall area to avoid the appearance of patches of unweathered surfaces in an area of weathered surfaces.

-3.5 Care shall be taken to eliminate the bunching of either small stones or stones of the same color or size. Stones shall be selected for variations of color and texture, in both weathered and unweathered surfaces. Drill marks, dog holes or other marks caused by quarrying or handling will not be permitted on surfaces exposed in the completed work. In no case shall the 4 corners of adjacent stones be contiguous.

-3.6 Large flat stones shall be selected for the bottom course. Extra large stones shall be used in the corners. Stones in top courses shall range larger than those immediately below, shall be not less than 6 inches thick, from 1-1/2 to 4 feet long, and shall be wide enough to cover the top of the wall, unless otherwise shown on the plans. Headers shall be distributed uniformly throughout the walls of structures so as to form at least 1/5 of the exposed faces. They shall be of such lengths as to extend through the face of the wall into the backing at least 12 inches and where a wall is less than 18 inches in thickness the headers shall extend entirely through from front to back face.

-3.7 All stones shall be wet prior to laying and the beds which are to receive them shall be cleaned and moistened. All stones shall be fully bedded in mortar, and shall be so placed as to break joints at least 6 inches and beds at least 2 inches and form a firm bond. All joints shall be completely filled with mortar.

Unless otherwise shown or directed horizontal joints in the face shall be approximately level. They shall not exceed 1 inch in thickness and shall not extend through more than 6 stones. Vertical joints in the face shall not exceed 1-1/2 inches in width and shall not extend through more than 2 stones. No spalls shall be used in the face of the wall. Unless otherwise required, all mortar in exposed face joints and beds shall be raked out squarely to a depth of 1 inch before the mortar has set hard. When weather joints are required, the beds shall be weather struck, the joints slightly raked to conform to the bed weather joints and in no case shall the mortar be flush with the faces of the stones. If required by the engineer, they shall be wetted and pointed with mortar. Joints on top surfaces shall be raked out toea depth of 1 inch at the edges and be crowned to drain.

-3.8 The backing shall consist chiefly of large stones laid in full mortar beds, well bonded with each other and with the face stones. All spaces and interstices shall be filled completely with mortar or spalls surrounded completely with mortar.

-3.9 The stones shall be handled in a manner that will not jar or displace stones already set. Rolling or turning of stones on the wall will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone relaid with fresh mortar. Suitable equipment shall be provided for setting stones larger than two-man stones.

-3.10 Arch ring stones shall be the size indicated on the drawings and bee dressed to form radial joints not more than 1 inch in width. On the face and soffit the joints shall be cut "hard" for a distance of at least 3 inches from which point they may fall off not to exceed 1 inch in 12 inches. The joints shall be completely filled with mortar; if necessary, they shall be grouted. An anchor composed of a 1/2-inch square bar bent into an elongated letter "S" shall be placed in each voussoir joint extending at least 12 inches into the concrete of the slab and to within 3 inches of the face of the stone.

-3.11 Care shall be taken at all times to keep the surfaces of all stones freee from mortar stains. Immediately after laying, all face stones shall be cleaned thoroughly of all mortar stains, and shall be kept clean until the work is completed. Before final acceptance, if ordered by the engineer, the surface of the wall shall be cleaned, using wire brushes, and acid if necessary.

-3.12 No work shall be done in freezing weather except by written permission of the engineer and the use of such methods as he may prescribe for protecting the work. Such permission and the observance of the methods prescribed shall not, however, release the contractor from his obligation to build a satisfactory structure and all work damaged by cold weather shall be removed and replaced. In hot or dry weather the masonry shall be satisfactorily protected from the sun and kept wet for a period of 3 days after completion. Walls shall be provided with weep holes at the locations called for on the plans or directed by the engineer.

-4.1 Method of Measurement. The yardage to be paid for shall be the number ofe cubic yards of Class A cement stone masonry complete in place and accepted. In computing the yardage for payment, the dimensions used shall be those shown on the plans or directed in writing by the engineer. Projections forming the rock face shall not be included in the pay volume. No deduction of volume will be made because of weep holes.

-5.1 Basis of Payment. The yardage, determined as provided above, shall bee paid for at the contract unit price per cubic yard bid for "Class A Cement Stone Masonry," which price and payment shall constitute full compensation for the cement mortar, for all weep holes, for furnishing all materials and for all labor, equipment, tools and incidentals necessary to complete the item.

241 CLASS B CEMENT STONE MASONRY

241-1.1 Description. This item shall consist of approved stones laid in mortar and shall be constructed in accordance with these specifications and in conformity with the requirements shown on the plans. It shall include all cement stone masonry not designated as to be Class A.

-2.1 Materials. The stones shall be clean, hard, and of a kind known to be durable. They shall be as large as can be obtained on or near the site. The individual face stones shall vary in size, and at least 50 percent of them shall be over 2 feet in length. The minimum length of an exposed face shall be 1-1/4 times the rise and not less than 50 percent of the stone shall have a length of at least 2 times the rise. The width of bed shall be not less than 1-1/2 times the rise with a minimum of 12 inches.

Mortar shall conform to all specifications and requirements for "Mortar for Masonry."

-3.1 Construction Methods. The requirements set out in Article -3.1 under "Class A Cement Stone Masonry" shall apply equally in connection with "Class B Cement Stone Masonry." The finished stone work shall present a good architectural appearance corresponding, except as specified, with the representation of Class B cement stone masonry as shown on the architectural drawings. The masonry shall be constructed by experienced workmen. No trimming or shaping of wall stones will be required, except to get a face varying not more than 3 inches from a true plane, and to form beds and joints that will produce sound substantial masonry. In general, bed surfaces shall be practically perpendicular to the face of the stone for about 4 inches from which point they may be irregular and fall off not to exceed 3 inches in 12 and shall be free from depressions or projections that might impair the strength of the stone or hinder the securing of full bearing on the mortar.

-3.2 The larger stones shall be used in the bottom of the wall graduating smaller toward the top, but stones of various sizes shall be uniformly distributed throughout, care being taken to eliminate the meeting or bunching of either small stones or stones of the same size. Selected stones, roughly pitched to lines, shall be used at all angles and ends of walls.

The top course shall consist of carefully selected large stones of random lengths and thickness and as wide as the top of the wall is thick. They shall have a flat top surface and be pitched to line along the top edges.

-3.3 Headers shall be distributed uniformly throughout the walls so as to form at least 1/5 of the exposed faces. They shall be of such lengths as to extend through the face wall into the backing at least 12 inches and where the wall is 18 inches or less in thickness, they shall extend entirely through from front to back face, unless otherwise shown on the plans.

-3.4 Beds in the face of the work shall not be less than 1/2 inch nor more than 1-1/2 inches in thickness. They shall in general be "eye level" and shall not extend in an unbroken line through more than 4 to 6 stones as may be directed. Joints may make varying angles with the beds. They shall be not less than 1/2 inch nor more than 2 inches in width and shall not extend through more than 2 stones. In no case shall the 4 corners of adjacent stones be contiguous. No spalls shall be used in the face of the wall. The end joints shall be uniform in width and shall not exceed 1-1/2 inches in width.

-3.5 Before the mortar has set hard all joints and beds in exposed faces shall be raked out squarely to a depth of 1/2 inch unless otherwise required or directed by the engineer. When weather joints are required, the beds shall be weather struck, the joints slightly raked to conform to the bed weather joints and in no case shall the mortar be flush with the faces of the stones. Joints on top surfaces shall be raked out to a depth of 1 inch at the edges and be crowned to drain.

-3.6 The stones shall be handled ~~in~~ a manner that will not jar nor displace stones already set. Rolling or turning of stones on the wall will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone relaid with fresh mortar. Suitable equipment shall be provided for setting stone larger than two-man stones.

All stones shall be wet prior to laying and the bed which is to receive them shall be cleaned and moistened. They shall be laid in full beds of mortar and be so placed as to break joints and form a firm bond.

-3.7 The backing shall be built up in a workmanlike manner. The individual stones composing it shall be well bonded with the stones of the face wall and with each other. All interstices shall be filled completely with mortar or spalls surrounded completely with mortar.

-3.8 Immediately after laying and while the mortar is fresh all face stones shall be cleaned thoroughly of all mortar stains and shall be kept clean until the work is completed. Before final acceptance, if ordered by the engineer, the surface of the wall shall be cleaned, using wire brushes and acid if necessary.

-3.9 No work shall be done in freezing weather except by written permission of the engineer and the use of such methods as he may prescribe for protecting the work. Such permission and the observance of the methods prescribed shall not, however, release the contractor from his obligation to build a satisfactory structure and all work damaged by cold weather shall be removed and replaced. In hot or dry weather the masonry shall be satisfactorily protected from the sun and kept wet for a period of 3 days after completion.

-3.10 All walls shall have weep holes spaced 10 feet center to center and located at the lowest point where free outlets may be obtained unless otherwise shown on the drawings or directed by the engineer.

-4.1 Method of Measurement. The yardage to be paid for shall be the number of cubic yards of Class B Cement Stone Masonry complete in place and accepted. In computing the yardage for payment, the dimensions used shall be those shown on the plans or ordered in writing by the engineer. Projections forming the rock face will not be included in the pay volume. No deduction in volume will be made because of weep holes.

-5.1 Basis of Payment. The yardage, determined as provided above, shall be paid for at the contract unit price per cubic yard bid for "Class B Cement Stone Masonry," which price and payment shall be full compensation for the cement mortar, for all weep holes, for furnishing all materials and for all labor, equipment, tools and incidentals necessary to complete the item.

242 CEMENT RUBBLE MASONRY

242-1.1 Description. This item shall consist of cement rubble masonry composed of approved stones laid in mortar and be constructed in accordance with these specifications and in conformity with the requirements shown on the plans or directed in writing by the engineer.

-2.1 Materials. The mortar shall conform to the requirements given for "Mortar for Masonry," except as to proportions.

The stone for rubble masonry shall be clean, hard and of a kind known to be durable. The individual stones, except for filling joints, shall have a thickness of not less than 5 inches and a width of not less than one and one-half times the thickness with a minimum width of 12 inches. No stone, except headers, shall have a length less than one and one-half times its width.

-3.1 Construction Methods. All rubble masonry shall be constructed by experienced workmen. Footings shall be carried to a stable foundation and bed planes shall be constructed as directed to resist both sliding and overturning. A surplus supply of suitable size stone shall be maintained at the site to permit an adequate selection.

-3.2 Selected stones, roughly squared and pitched to lines, shall be used at all angles and ends of walls. All stones shall be cleaned thoroughly and wet prior to laying and be laid in practically horizontal beds. Large flat stones shall be selected for the bottom course. All stones shall be fully bedded in portland cement mortar, mixed in the proportion of one part cement to three parts of sand, and shall be so placed as to break joints at least 6 inches and form a firm bond.

-3.3 Headers shall be distributed uniformly through the walls of the structures so as to form at least one-fifth of the exposed faces. They shall be of such lengths as to extend through the face wall into the backing at least 12 inches and where a wall is less than 18 inches in thickness the headers shall extend entirely through from front to back face.

-3.4 The interior of the walls shall be built up so that the stones of which it is composed will be bonded, and so that no open spaces will be left. Horizontal joints in the face shall not exceed one inch in thickness and vertical joints shall not exceed 2 inches in width. No spalls shall be used in the face of a wall and the

face stones shall be so well bedded that none will be needed. Walls shall be provided with weep holes wherever called for on the plans or directed by the engineer. If a stone is loosened after the mortar has set it shall be removed, the mortar cleaned off, and the stone relaid with fresh mortar.

-3.5 This class of masonry shall be finished with a concrete coping or with a top course consisting of roughly shaped stones. Bridge seats and back walls, unless otherwise specified, shall be of Class A concrete, which shall be not less than 8 inches thick and wide enough to cover the full width of the wall and shall be cast in place. If a stone coping is specified, the stones shall be not less than 8 inches thick, from 1-1/2 to 4 feet long and wide enough to cover the top of the wall, set in full mortar beds as shown on the plans.

-3.6 Before the mortar sets, the joints shall be raked carefully to a depth of one inch and the adjacent stone surfaces cleaned of all mortar stain. Pointing, if required on the plans or in the special provisions, shall be done with portland cement motrar, mixed in the proportion of one part of cement to two parts of sand. No pointing shall be done in freezing weather, and any work damaged by frost shall be removed and replaced. In hot or dry weather the pointed masonry shall be satisfactorily protected from the sun and kept wet for a period of three days after completion.

-3.7 No masonry shall be laid in freezing weather without the permission of the engineer and the use of such precautions as he may direct to be taken. In hot or dry weather the masonry shall be protected from the sun for at least three days after laying.

-4.1 Method of Measurement. The yardage to be paid for shall be the number of cubic yards of cement rubble masonry complete in place and accepted. In computing the yardage for payment, the dimensions used shall be those shown on plans or ordered in writing by the engineer. The volume of the coping will be included.

-5.1 Basis of Payment. The yardage of masonry, determined as provided above, shall be paid for at the contract unit price per cubic yard bid for "Cement Rubble Masonry," which price and payment shall be full compensation for furnishing and placing all material, including the coping and all weep holes, and for all labor, equipment, tools and incidentals necessary to complete the item.

243 DRY RUBBLE MASONRY

243-1.1 Description. This item shall consist of approved stones laid without mortar and so as to fit neatly and firmly, constructed in accordance with these specifications and in conformity with the requirements shown on the plans or directed in writing by the engineer.

-2.1 Materials. The stones shall be sound, durable, free from structural defects and rounded or worn surfaces and clean of earth, clay or other foreign substances. No stone shall be used which has a minimum thickness of less than 5 inches, a minimum width of less than 12 inches, or which is less than 1/2 cubic foot in volume. In the lower course of a dry rubble wall no stone shall be used which has a volume of less than one cubic foot. Small stones may be used for pinning and filling interstices in the heart of the wall.

-3.1 Construction Methods. All dry rubble masonry shall be constructed by experienced workmen. The stone shall be roughly dressed on beds and joints and laid on natural beds, being well bonded and breaking joints at least 6 inches. Walls need not be built in courses but shall be so constructed that no part is materially in advance of the other. In all cases the base thickness of dry walls shall be at least one-half the height, which shall not exceed 8 feet. Headers shall be distributed uniformly throughout the wall so as to form approximately one-fifth of the exposed faces and shall extend through the face wall and into the backing at least 12 inches. Where a wall is less than 18 inches in thickness, the headers shall extend entirely through from front to back face. Where the wall is more than 18 inches thick, the headers shall either extend entirely through or overlap at least 6 inches. Walls shall be built up so as to leave no appreciable open spaces and only sufficient spalls shall be used to wedge the larger stones in place. This class of masonry shall be finished with a top course or coping consisting of roughly shaped stones not less than 6 inches thick, from 1-1/2 to 4 feet long, and wide enough to cover the top of the wall, carefully laid in solid beds.

-4.1 Method of Measurement. The yardage to be paid for shall be the number of cubic yards of dry rubble masonry complete in place and accepted. In computing the masonry yardage for payment the dimensions used shall be those shown on the plans or ordered in writing by the engineer. The volume of the coping will be included.

-5.1 Basis of Payment. The yardage, determined as provided above, shall be paid for at the contract unit price per cubic yard bid for "Dry Rubble Masonry," which price and payment shall be full compensation for furnishing and placing all materials, including the coping, and for all labor, equipment, tools and incidentals necessary to complete the item.

244 MORTAR FOR MASONRY

244-1.1 Description. This item shall consist of furnishing mortar made in accordance with these specifications, for the various classes and kinds of masonry where its use is required.

-2.1 Materials. Portland cement, fine aggregate and water shall conform to the respective requirements for these materials as contained in the specifications hereinbefore given for "Concrete" except that the fine aggregate shall all pass a No. 8 sieve, not less than 15 nor more than 40 percent shall pass a No. 50 sieve and not more than 10 percent shall pass a No. 100 sieve. Masonry cement, subject to the restriction in the specifications therefor, may be substituted for portland cement.

-3.1 Construction Methods. The mortar shall be composed of 1 part of portland cement and 2 parts of sand, by volume and sufficient water to make a mortar of such consistency that it can be easily handled and spread with a trowel. Mortar shall be mixed only in quantities required for immediate use. Unless an approved mortar mixing machine is used, the sand and cement shall be mixed dry in a tight box until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains the proper consistency. Mortar which is not used within 45 minutes after water has been added shall be wasted. Retempering of mortar will not be permitted.

-4.1 Compensation. The work and material prescribed under this item shall not be measured or paid for directly. The work and material shall be considered as necessary and subsidiary parts of the work comprised and in effect paid for under the contract unit prices bid for "Class A Cement Stone Masonry," "Class B Cement Stone Masonry," "Cement Rubble Masonry" and other classes of cement masonry wherein portland cement mortar is specified.

245 MASONRY CEMENT

245-1.1 Description. This item shall consist of furnishing masonry cement for the various kinds and classes of masonry in accordance with these specifications.

-2.1 Materials. Masonry cement conforming to the following requirements may be substituted for portland cement in mortar for masonry used in the construction of tree wells, headwalls for pipe culverts, headwalls and barrels of standard box culverts and retaining walls of height not exceeding 6 feet. For other construction masonry cement may be used if and as shown on the plans.

Fineness:	Residue on the standard No. 200 sieve, not more than 10.0%
Setting time:	Initial set, not less than . . . . . 45 min. Final set, not more than . . . . . 24 hr.
Soundness:	A pat of neat cement shall remain firm and hard and show no sign of distortion, cracking, checking or disintegration in the steam test for soundness.
Crushing strength:	The average crushing strength in pounds per square inch of not less than three 2-inch mortar cubes, composed of 1 part cement and 3 parts standard Ottawa sand by weight shall be equal to or greater than the following:

Age at Test Days	Storage of Specimens	Crushing Strength lb. per sq.in.
7	1 day in moist air, 6 days in water	600
28	1 day in moist air, 27 days in water	900

The average strength at 28 days shall be higher than the strength at 7 days.

Methods of Testing: Tests shall be made using Federal Specification SS-C-191, except as follows:

(1) Table 1 of Specification SS-C-191 shall be extended as follows in order to provide for testing cements of this type.

Percentage of water for neat cement paste of normal consistency	Percentage of water for one cement, three standard Ottawa sand
30	11.5
31	11.7
32	11.8
33	12.0
34	12.2
35	12.3
36	12.5
37	12.7
38	12.8
39	13.0
40	13.2

(2) Mixing. The quantities of dry materials to be mixed at one time shall be not less than 2,000 grams nor more than 2,200 grams.

(3) Molding. Immediately after mixing, the molds shall be filled in 2 equal layers, pressing the mortar with the thumbs with only sufficient effort to insure uniform filling of the mold. No ramming or tamping shall be used, nor any troweling in excess of that required to smooth off the specimens.

(4) Testing. Load shall be applied at right angles to the direction of molding. No cushioning or bedding materials shall be used but the bearing faces may be ground to plane surfaces if necessary. With screw type testing machines, load shall be applied with a free head speed of 0.05 inch per minute. With hydraulic testing machines, load shall be applied at a rate of approximately 1,000 pounds per square inch per minute.

(5) Computations. Cubes that are manifestly faulty or which give strengths differing more than 10 percent from the average value of all test specimens made from the same sample and test at the same period shall not be considered in determining the average strength.

-4.1 Compensation. Masonry cement shall not be measured or paid for directly, but shall be considered a necessary and subsidiary part of the work comprised and in effect paid for under the specifications for masonry in the cases where this cement is permitted.

250 REINFORCED CONCRETE CULVERT PIPE

250-1.1 Description. This item shall consist of furnishing reinforced concrete pipe conforming to these specifications and of the classes, sizes and dimensions required on the plans, and installing such pipe at such places as are designated on the plans or by the engineer and in conformity with the lines and grades given.

This item shall include the furnishing and construction of such joints and such connections to existing pipes, catch basins, endwalls, etc., as may be required to complete the work as shown on the plans.

Pipe furnished under this specification shall be of the class or classes called for in the Bid Schedule - "Standard Reinforced Concrete Culvert Pipe" and "Extra Strength Reinforced Concrete Culvert Pipe."

-2.1 Materials and Manufacture. The pipe shall conform to the A.A.S.H.O. Standard Specification M-41 for Reinforced Concrete Culvert Pipe, except with respect to ultimate load.

Pipe of "Standard" class shall withstand an ultimate load of 2000D and pipe of "Extra Strength" class shall withstand an ultimate load of 3000D under the three-edge bearing test.

The engineer reserves the right to inspect and test the pipe after delivery on the work. Injurious defects revealed subsequent to acceptance of pipe at the manufacturer's plant will be cause for rejection.

-3.1 Installation. The formation of the bed for the pipe and the backfilling, after the placing of the pipe as prescribed below, shall be as provided under the item "Bedding and Backfill for Pipe Culverts."

-3.2 Placing Pipe. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. The pipe shall be laid carefully, hubs upgrade, ends fully and closely jointed, and true to lines and grades as given. Each section shall be securely attached to the adjoining sections by the method contemplated by the type of joint used. All joints, unless otherwise provided, shall be filled with stiff mortar composed of one part portland cement and two parts sand. These materials shall conform to the appropriate requirements prescribed under Federal Specification SS-S-61. The mortar shall be placed so as to form a durable watertight joint. After any section of pipe is laid and before any succeeding section is laid the lower portion of the hub of the preceding section shall be plastered thoroughly on the inside with the mortar to such depth as to bring the inner surfaces of the abutting pipes flush and even. After the section is laid, the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a thoroughly wetted earth or burlap cover. Any pipe which is not in true alignment or which shows any undue settlement after laying, or is damaged, shall be taken up and relaid without extra compensation.

-4.1 Method of Measurement. The footage to be paid for shall be the actual number of linear feet of pipe of the several classes and sizes measured as installed in place, completed and accepted.

-5.1 Basis of Payment. The footages, determined as provided above, shall be paid for at the contract unit prices per linear foot bid for "Standard Reinforced Concrete Culvert Pipe," and "Extra Strength Reinforced Concrete Culvert Pipe," of the several sizes, as the case may be, which prices and payments shall constitute full compensation for furnishing or manufacturing, hauling and installing pipe, including jointing and joint materials, and for all materials, labor, equipment, tools and incidentals necessary to complete the item but shall not constitute payment for concrete or masonry headwalls or for excavation.

251 CAST IRON CULVERT PIPE

251-1.1 Description. This item shall consist of furnishing cast iron pipe conforming to these specifications and of the types, classes, sizes and dimensions required on the plans and installing such pipe at such places as are designated on the plans or by the engineer and in conformity with the lines and grades given.

This item shall include the furnishing and installation of such specials; joints and connections to other pipes, catch basins or endwalls, etc., as may be required to complete the work indicated on the plans.

-1.2 The pipe shall be of the type and class named in the proposal and indicatede on the plans. Where the proposal and plans do not name the type the contractor shall furnish the types of his choice, except that, throughout any one contract, for each class required only one type shall be furnished for any one size of pipe. The types are identified as "Smooth," "Corrugated" and "Ribbed." The classes are identified as "Standard," "Heavy" and "Extra Heavy" and shall meet the respective classified requirements hereinafter prescribed. The sizes are identified by the nominal inside diameter of the pipe. The 12-inch nominal size is the minimum size covered by this specification.

-1.3 Each length of pipe shall be cast as a unit and shall have a full circulare cross section with outside and inside circumferences concentric. All pipe shall be cast with hub and spigot joints or be designed with an effective type of mechanical lock joint which shall be of sufficient strength to bind together securely each section of pipe true to the designed center line and the locks shall be free from any burrs or roughness preventing complete travel of the locking lugs in the slots, or spirals.

-2.1 Materials and Manufacture. The pipe shall be manufactured of cast irone of good quality and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to permit satisfactory drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal and shall be remelted in a cupola, air furnace or electric furnace.

-2.2 The pipe may be cast vertically or horizontally in dry or green sande molds or by centrifugal processes.

-2.3 All pipe shall be coated inside and out by dipping in coal-tar pitch varnishe to which sufficient oil shall have been added to make a smooth coating. This coating must be of such a nature that it will be tough and tenacious when cold and not tacky or brittle nor with any tendency to scale off. Prior to dipping, the pipe shall be cleaned thoroughly of rust, scale, grease and dirt.

-2.4 The iron shall conform to the following ladle analysis requirements ase to chemical composition.

Phosphorous, maximum, percent 0.90e
Sulphur, maximum, percent 0.12e

The manufacturer shall maintain a daily record of chemical analyses, which record shall be open to authorized inspection at all times.

-2.5 Strength Test. The pipe shall not fail or develop any crack when testede under the following loads by the three-edge bearing method.

Class of Pipe	Load in pounds per foot of Laying Length
Standard pipe	2000 D
Heavy pipe	3000 D
Extra heavy pipe	4000 D

D = Nominal inside diameter of the pipe specimen in feet.

Pipe specimens tested for strength shall not be tested to destruction if they will sustain, without cracking, a load 10 percent in excess of the specified load. If tests to destruction are required on pipe meeting these strength requirements without cracking, payment will be made for the pipe so tested.

Testing Smooth Pipe. The lower bearing for the pipe shall consist of two wooden strips with vertical sides having their interior corners rounded to a radius of approximately 1/2 inch. The strips shall be straight and shall be fastened securely to a rigid block with the interior vertical faces spaced at a distance apart not less than 1/2 inch

nor more than one inch for each foot of nominal pipe diameter, with a minimum spacing of one inch for any size of pipe. The upper bearing shall be a rigid wooden block, straight and true from end to end. The upper and lower bearings shall extend the full length of the outside of the barrel of the pipe exclusive of the hub, if any. The pipe shall be placed symmetrically between the two bearings and the center of the application of load shall be at the center of the length of pipe. In testing pipe which is "out of line" the lines of the bearing chosen shall be from those which appear to give the most favorable conditions for fair test. In testing pipe, the specimen shall be placed so that the upper bearing will be along the thinnest element.

Testing Corrugated or Ribbed Pipe. For corrugated or ribbed pipe the methods in making the 3-edge bearing test shall be the same as prescribed above for smooth pipe except as follows: In the case of corrugated pipe the bearing blocks shall be placed in contact with the outside crest of the corrugations. In the case of ribbed pipe, the bearing blocks shall be placed in contact with the tops of the transverse ribs. If the ribbed pipe has longitudinal ribs, the pipe shall be placed so that the bearing blocks will be, as nearly as possible, midway between the longitudinal ribs.

Testing Apparatus. Any mechanically driven or hand-power device, which meets the following requirements may be used.

It shall be substantially built and rigid throughout so that the distribution of the load to the specimen will not be affected appreciably by the deformation or yielding of any part.

It shall provide for an approximately continuous application of load by means of a head which, during the test, moves at an approximately uniform rate not to exceed -

0.05 in. per minute for pipe less than 24 in. in diameter
0.10 in. per minute for pipe 24 to 36 in. in diameter
0.20 in. per minute for pipe more than 36 in. in diameter.

It shall provide means for the determination of load with an error not greater than 2 percent.

Test Specimens. Strength tests will be required in such numbers as may be deemed necessary, provided that if the pipe meets the requirements as to shell thickness and weight, the number of specimens tested shall not exceed three pipes or 5 percent, whichever may be larger, of each size in each class of each manufacture furnished.

All pipe for purpose of tests will be selected at random from the stock of the manufacturer, or from the pipe as delivered to the work, and shall be pipe which would not otherwise be rejected under these specifications.

The laying length of test specimens of pipe shall be not less than 3 nor more than 4 feet. If the manufacturer proposes to furnish, for use in the work, pipe having a length greater than 4 feet, he shall furnish for the required tests, a sufficient number of test specimens of a length within the above tolerance.

Pipe specimens shall be tested under a load 10 percent in excess of the load specified for the particular class of pipe. Shipments represented by specimens which sustain the specified load without the development of cracks will be accepted as fulfilling the strength requirements. Specimens of pipe which meet all other requirements of the specifications and which sustain a load of 10 percent in excess of that specified without the development of cracks will be accepted for use. Payment will not be made for specimens which are cracked under the specified load, or a load 10 percent in excess of that specified.

A test specimen which has been accepted for use shall be marked with a suitable identification symbol.

Retests. Pipe will be acceptable under strength tests when all test specimens fulfill the strength test requirements. Should any pipe fail to meet the test requirements, then the contractor will be allowed a retest on two similar specimens for each specimen that failed, and the pipe shall be acceptable only when all of these retest specimens fulfill the test requirements. No further retests shall be permitted.

-2.6 Pipe Design. For any pipe the minimum inside diameter at any point shall be not less than the nominal diameter by more than 1/8 inch.

Unless otherwise specified pipe shall have a minimum laying length of 3 feet. Cutting for closures may be permitted by the engineer.

The shell thickness and weight per linear foot for pipe of the several types, classes and sizes shall conform to the requirements given in Tables I and II. The shell thickness shall refer to the thickness of shell along the barrel. The shell thickness of ribbed pipe shall refer to the thickness of plate between ribs. The shell thickness of smooth bore corrugated pipe shall refer to the minimum thickness between the bore and the valleys of the corrugations. In Tables I and II the weights are per foot of barrel exclusive of hub. For any pipe the shell thickness at any point shall be not less than 85 percent of the thickness specified in Tables I and II. The weight of any section of pipe shall be not less than 95 percent of the weight specified in Tables I and II.

Table I - Nominal Dimensions and Weights of Smooth Cast Iron Culvert Pipe

Diameter	Standard Pipe (2000 D)		Heavy Pipe (3000 D)		Extra-heavy Pipe (4000 D)	
	Shell Thickness,	Weight per foot of Barrel,	Shell Thickness,	Weight per foot of Barrel,	Shell Thickness,	Weight per foot of Barrel,
Inches	Inches	Pounds	Inches	Pounds	Inches	Pounds
12	0.37	45	0.37	45	0.40	49
14	0.37	52	0.40	57	0.46	65
16	0.40	64	0.46	74	0.53	86
18	0.42	76	0.52	95	0.60	110
20	0.47	94	0.57	115	0.66	134
24	0.56	135	0.69	167	0.80	195
30	0.70	211	0.86	261	1.00	304
36	0.84	304	1.03	374	1.20	438
42	0.98	414	1.20	509	1.40	597
48	1.12	540	1.38	669	1.60	779

Table II - Nominal Dimensions and Weights of Corrugated Cast Iron Culvert Pipe and Ribbed Cast Iron Culvert Pipe (Including Smooth Bore Corrugated Pipe)

Diameter	Standard Pipe (2000 D)		Heavy Pipe (3000 D)	
	Shell Thickness,	Weight per foot of Barrel,	Shell Thickness,	Weight per foot of Barrel
Inches	Inches	Pounds	Inches	Pounds
15	0.18	32	0.18	32
18	0.18	41	0.18	41
24	0.23	67	0.23	67
30	0.28	94	0.28	94
36	0.30	128	0.30	128

-2.7 Waiver of Further Strength Tests. After the strength, shell thickness and weight of pipe of a particular type, class and size furnished by the manufacturer have been established by tests, further strength tests may be waived and the pipe of that particular type, class, size and manufacture accepted on the basis of the shell thickness and weight thus established, subject to tolerances of not more than 15 percent in thickness and 5 percent in weight. In no case shall the acceptability of larger sizes of pipe be based on the results of strength tests on smaller sizes.

-2.8 Individual Requirements. The following requirements for specific types of pipe, are additional to the above requirements.

(a) Corrugated Cast Iron Pipe shall be cylindrical in form. The spiral style shall consist of two members, viz., the pipe member and the cuff member. The pipe member shall screw into the cuff member at least one complete turn. The pipe shall be marked so as to indicate when the lap is taken up. This type of pipe includes the smooth bore as well as the corrugated bore. The combined hub and spigot joint with interlocking feature may be used. No mortar will be required in jointing this type of pipe in any of the styles mentioned.

(b) Ribbed Cast Iron Pipe shall be cast so that the exterior longitudinal and transverse ribs are integral with the cast iron shell of the pipe. The pipe shall be true, whole, concentric cylinders of smooth interior bore which after joining shall present a true, smooth surface, free from intrusions within the diameter. If the joint design includes a satisfactory locking feature no mortar will be required in the joints.

-2.9 Visual Inspection. All pipe shall be examined carefully for defects and sounded with a hammer before shipment. No fillings with metal, cement or other material, or so-called "burning on" of iron will be permitted.

Pipe sections shall be practically straight and of true circular cross section. They shall be sound, smooth and free from cracks, scales, lumps, blisters, sand holes, "cold shuts," or other defects which would render them unfit for the use intended.

If required, each pipe shall be weighed and, after coating, the weight plainly marked thereon.

The brand of the manufacturer shall be legibly marked on each pipe.

The engineer reserves the right to inspect and test the pipe after delivery on the work. Injurious defects revealed subsequent to acceptance of pipe at the manufacturer's plant will be cause for rejection.

-3.1 Installation. The formation of the bed for the pipe and the backfilling, after the placing of the pipe as described below, shall be as provided under the item "Bedding and Backfill for Pipe Culverts."

-3.2 Placing Pipe. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. The pipe shall be laid carefully, hubs upgrade, ends fully and closely jointed, and true to lines and grades as given. Each section shall be attached securely to the adjoining sections by the method contemplated by the type of joint used. All joints, unless otherwise provided, shall be filled with stiff mortar composed of one part portland cement and one and one-half parts clean, appropriately graded sand. The mortar shall be placed so as to form a durable watertight joint. After any section of pipe is laid and before any succeeding section is laid the lower portion of the hub of the preceding section shall be plastered thoroughly on the inside with the mortar to such depth as to bring the inner surfaces of the abutting pipes flush and even. After the section is laid the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set the mortar on the outside shall be protected from the air and sun with a thoroughly wetted earth or burlap cover. Any pipe which is not in true alignment or which shows any undue settlement after laying, or is damaged, shall be taken up and relaid without extra compensation.

-4.1 Method of Measurement. The footages to be paid for shall be the actual number of linear feet of pipe of the several types, classes and sizes measured as installed in place, completed and accepted.

-5.1 Basis of Payment. The footage determined as provided above shall be paid for at the contract unit prices per linear foot bid for "Cast Iron Culvert Pipe of the several types, classes and sizes," as the case may be, which prices and payment shall constitute full compensation for furnishing, hauling and installing the pipe including jointing and joint materials, and for all materials, labor, equipment, tools and incidentals necessary to complete the item but shall not constitute payment for concrete or masonry endwalls, nor for excavation.

252 CORRUGATED GALVANIZED SHEET METAL PIPE

252-1.1 Description. This item shall consist of furnishing sheet metal pipe conforming to these specifications and of the sizes and dimensions required on the plans, and installing such pipe at such places as are designated on the plans or by the engineer and in conformity with the lines and grades given.

This item shall include the furnishing and construction of such joints, and such connections to existing pipes, catch basins, endwalls, etc., as may be required to complete the work as shown on the plans.

Pipe furnished under this specification shall be of the full circle, riveted type, with lap joint construction, and shall be perforated when specified by the engineer.

-2.1 Materials and Manufacture. Corrugated metal pipe culverts shall be fabricated from corrugated galvanized sheets, the base metal of which shall be made by either the open hearth process or a process which produces genuine wrought iron. The base metal shall conform to one of the following chemical requirements.

Elements	Chemical composition by ladle analysis (Position of base metals does not indicate preference) Kind of Base Metal						Tolerance by check analysis of finished sheets
	Pure iron	Copper bearing pure iron	Copper iron	Copper molyb-denum iron	Copper steel	Genuine wrought iron	
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Carbon - Max.	-	-	-	-	-	.05	.01
Manganese - Max.	-	-	-	-	-	.06	.01
Phosphorus - Max.	.015	.015	.015	.015	-	.12	-
Sulphur - Max.	.040	.040	.040	.040	.050	.04	.01
Silicon - Max.	-	-	-	-	-	.15	-
Copper - Min.	-	.20	.20	.40	.20	-	.02
Molybdenum - Min.	-	-	-	.05	-	-	-
Sum of first five elements - Max.	-	.10	.25	.25	.70	.42	.04
Sum of first six elements - Max.	.10	-	-	-	-	-	.04

All rivets shall be of the same material as the base metal specified for the corrugated sheets. They shall be thoroughly galvanized or sherardized.

The base metal sheets shall be galvanized on both sides by the hot-dip process, after which these sheets may be sheared to proper sizes. Sheets perforated for drainage shall be galvanized after drainage perforations have been punched. A coating of prime western spelter or equal shall be applied at the rate of not less than two ounces per square foot of double exposed surface. If the average spelter coating as determined from the required samples is less than two ounces of spelter per square foot, or if any one specimen has less than 1.8 ounces of spelter per square foot of double exposed surface, the lot sampled shall be rejected. The finished sheets shall be of first class commercial quality, free from injurious defects, such as blisters, flux and uncoated spots.

No metal will be accepted under this specification and no bids will be considered for the materials above described until after the sheet manufacturer's certified analysis and manufacturer's guarantee have been passed upon by the engineer and accepted. Misbranding or other misrepresentation, and non-uniformity of product will each be considered a sufficient reason to discontinue the acceptance of any brand under this specification, and notice sent to the sheet manufacturer of the discontinuance of acceptance of any brand will be considered to be notice to all culvert companies which handle that particular brand. The kind of base metal which it is proposed to furnish shall be designated by the bidder. One brand, and one brand only shall be approved for each kind of base metal furnished by each of the actual manufacturers of the sheets.

The manufacturer of each brand shall file with the engineer a certificate setting forth the name or brand of metal to be furnished and a typical analysis showing the percentage of carbon, manganese, phosphorus, sulphur, silicon, and copper; also molybdenum, when provided for under the particular kind of base metal. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company.

-2.2 Sheet Manufacturer's Guarantee. The manufacturer of the sheets shall submit with the certified analysis a guarantee providing that all metal furnished shall conform to the certified analysis filed, shall bear a suitable identification brand or mark, and shall be replaced without cost to the purchaser when not in conformity with the specified analysis, gage, or spelter coating; and the guarantee shall be so worded as to remain in effect so long as the manufacturer continues to furnish material.

-2.3 Identification. No culverts will be accepted unless the metal is identified by a stamp on each section showing

First. Name of sheet manufacturer
Second. Name of brand and kind of base metal.
Third. Gage number.
Fourth. Weight of spelter coating.
Fifth. Identification symbols showing (heat no. / pot no.)

Provided, however, identification symbols showing heat numbers will not be required for wrought iron. However, identification by pot number will be required.

The identification brands shall be placed on the sheets by the manufacturers of the sheets in such a way that when rolled into culverts such identification shall appear on the outside of each section of each pipe. Pipe having any sections not so stamped shall be rejected. The kind of base metal shall be designated independently of the brand or trade mark so as to clearly identify the base metal furnished with one of the "Kind of Base Metal" enumerated in the table. The designation of the "Kind of Base Metal" may be accomplished by placing on the sheets the initials of the exact name of the base metal given in the table, as follows: PI for pure iron; CBPI for copper bearing pure iron; CI for copper iron; CMI for copper molybdenum iron; CS for copper steel; and GWI for genuine wrought iron.

Corrugations shall not be less than 2-1/4 inches nor more than 2-3/4 inches center to center. The corrugations shall have a depth of not less than 1/2 inch.

-2.4 Perforated Pipe. Perforations shall be approximately 1/4 inch in diameter after galvanizing, punched 1-1/2 inch centers lengthwise in the sheet so as to be in inside ridges of all but the end corrugations of each culvert section. The number of longitudinal rows of perforations shall conform to the following table:

Diameter	Number of Rows of Holes
8	8
10	8
12	10
15	10
18	15
21	15
24	20
30	20

-2.5 Gage Determinations and Tolerances. The gage of the culvert metal shall be determined from the weight of the galvanized sheets. The theoretical weights per square foot, together with permissible tolerances, on the flat galvanized sheets, shall be as indicated in the following.

Galvanized sheet gage number	Weight of galvanized sheet oz. per sq. ft.	Permissible tolerances in weights of sheets, plus or minus in percentage of theoretical weight (1)		
		All of one gage and size in shipment (2)	Single packages	Single sheets
8	112.5	5.0	7.0	10.0
10	92.5	5.0	7.0	10.0
12	72.5	5.0	7.0	10.0
14	52.5	5.0	7.0	10.0
16	42.5	5.0	7.0	10.0

(1) References are to gross weights of bundled material and to net weights of crated and boxed material. If the minimum or maximum only be ordered, double tolerance is to be taken on permissible side.

(2) All of one gage and size in shipment shall apply to lots of not less than 6,000 pounds.

-2.6 Dimensions and Weights. The length of sheets, widths of laps, gages, and computed weights per linear foot of the finished culverts, shall be as specified in the following table. The dimensions given for diameter of pipe are nominal. The average weight per linear foot of a finished culvert, exclusive of end finish, shall not underrun the computed weight specified by more than five percent.

Nominal diameter	Length of sheet before forming	Minimum width of lap	Galvanized sheet gage number	Computed weight per linear foot of finished culvert exclusive of end finish	Connecting bands galvanized sheet gage number (or heavier)
inches	inches	inches		pounds	
8	28½	1½	16	7.3	16
10	35	1½	16	9.0	16
12	41	1½	16	10.5	16
15	50½	1½	16	12.9	16
18	60	1½	16	15.3	16
21	69½	1½	16	17.7	16
24	80	2	14	25.2	16
30	98	2	14	30.9	16
36	117	2	12	51.0	14
42	137	3	12	59.5	14
48	156	3	12	68.0	14
54	1-80 1-98	3	12	77.8	14
60	2-98	3	10	108.9	12

In the cases of the 42 and 48-inch sizes, two sheets may be used by allowing sufficient total sheet lengths to provide for an additional standard lap.

The gage of the sheets shall be increased if required in "Special Provisions" for culverts under high fills.

Rivets shall be of the following diameters for the gages specified:

No. 16 gage material - 5/16"
No. 14 gage material - 5/16"
No. 12 gage material - 3/8"
No. 10 gage material - 3/8"
No. 8 gage material - 3/8"

All rivets shall be driven cold in such a manner that the plates shall be drawn tightly together throughout the entire lap. The center of no rivet shall be closer than twice its diameter from the edge of the metal. All rivets shall have neat, workmanlike, and full hemispherical heads of a form acceptable to the engineer, shall be driven without bending, and shall completely fill the hole. Longitudinal seams shall be riveted with one rivet in the valley of each corrugation. The longitudinal seams of all pipe 42 inches or more in diameter shall be double riveted. Circumferential, shop-riveted seams shall have a maximum rivet spacing of six inches, except that six rivets will be sufficient in 12-inch pipe.

The length of pipe shall be the net length of the finished pipe which shall not include any material used to procure an end finish on the pipe. If the average deficiency in length of any shipment of pipe is greater than one percent, the shipment shall be rejected.

The inlet and outlet of all culverts fabricated of 16 or 14 gage sheets shall be reinforced in a manner approved by the engineer, when specified.

Field joints shall be made with bands of the same base metal as the pipe and shall be not less than 7 inches wide for diameters of 8 to 30 inches, inclusive, 12-inch band for culverts with diameters 36 to 48 inches, inclusive, and 24-inch band for culverts with diameters 54 to 60 inches, inclusive. Such bands shall be so constructed as to lap on an equal portion of each of the culvert sections to be connected, and preferably shall be connected at the ends by galvanized angles having minimum dimensions of 2"x2"x3/16". The 7-inch band shall have at least two galvanized bolts not less than 1/2-inch diameter. The 12-inch band shall have three and the 24-inch band shall have five 1/2-inch bolts. Other equally effective methods of connecting the coupling bands may be used if approved by the engineer.

Culvert pipe on which the spelter coating has been bruised or broken either in the shop or in shipping, or which show defective workmanship, shall be rejected. Among others, the following defects are specified as constituting poor workmanship, and the presence of any or all of them in any individual culvert pipe or in general in any shipment shall constitute sufficient cause for rejection: Uneven laps; elliptical shaping; variation from a straight centerline; ragged or diagonal-sheared edges; loose, unevenly lined or spaced

rivets; poorly formed rivet heads; unfinished ends; illegible brands; lack of rigidity; bruised, scaled, or broken spelter coating; dents or bends in the metal itself.

The contractor shall furnish an itemized statement of the sizes and lengths of culvert pipe in each shipment. Field inspection shall include an examination of the culvert pipe for deficiency in lengths of sheets used, nominal specified diameter, net length of finished culvert pipe, and any evidence of poor workmanship as outlined above. The inspection may include the taking of samples for chemical analysis, and determination of weight of spelter coating. The pipe making up the shipment shall fully meet the requirements of these specifications, and if 25 percent of the pipe in any shipment fails to meet these requirements, the entire shipment may be rejected.

If the engineer so elects, he may have the material inspected and sampled in the rolling mill or in the shop where fabricated. He may require from the mill the chemical analysis of any heat. The inspection, either in the mill or in the shop, shall be under the direction of the engineer. The engineer or his representative shall have free access to the mill or shop for inspection, and every facility shall be extended to him for this purpose. Any material or pipe which has been previously rejected at the mill or shop and included in a later lot, will be considered sufficient cause for the rejection of the entire lot.

Chemical analysis of the base metal of the finished sheet, when required, may be made of the samples taken for weight of spelter coating test. For testing coating of sheets before fabricating, sample strip about three inches wide shall be cut crosswise or diagonally across the sheet, the full width, from one sheet of each lot of the same identification symbol. From this strip and along the newly sheared edge samples 2½ inches square, or of equivalent area, shall be cut from the middle and near each end. For testing coating of fabricated culverts, at least one sample 2½ inches square, or a sample of equivalent area, shall be selected from each 20 culverts of a shipment, provided that not less than three samples, each from a different section, shall represent any one shipment.

-2.7 Analysis of Finished Sheet. When not otherwise provided, chemical analysis, when required, shall be made using A.S.T.M. Standard Method A33-24.

-2.8 Tests for Spelter Coating. The tests for weight of spelter coating shall be made using A.A.S.H.O. Method T-95.

-3.1 Installation. Culverts under the highway shall be laid so that the minimum distance from the finished surface of roadbed to the top of pipe shall be not less than one-half the diameter of the pipe with a minimum of one foot.

The pipe shall be laid in the trench with the separate sections joined firmly together and with outside laps of circumferential joints pointing upstream and with longitudinal laps on the sides. Any metal in joints which is not protected thoroughly by galvanizing shall be coated with a suitable asphaltum paint.

-3.2 The formation of the bed for the pipe and the backfilling, after the placing of the pipe as prescribed below, shall be as provided under "Bedding and Backfill for Culverts."

-3.3 Placing pipe. Proper facilities shall be provided for lowering the pipe when it is to be placed in a trench. The pipe shall be laid carefully and true to lines and grades as given. Any pipe which is not in true alignment or which shows any undue settlement after laying, or is damaged, shall be taken up and relaid without extra compensation.

-4.1 Method of Measurement. The footages to be paid for shall be the actual number of linear feet of the pipe installed in place, completed and accepted. The measurement shall be from end to end of each culvert in place, as terminated by the end finish.

-5.1 Basis of Payment. The footages determined as provided above, shall be paid for at the contract unit prices per linear foot bid for "Corrugated Galvanized Sheet Metal Pipe" of the several sizes, as the case may be, which prices and payments shall constitute full compensation for furnishing, hauling and installing the pipe, and for all materials, labor, equipment, tools and incidentals necessary to complete this item, but shall not constitute payment for concrete or masonry headwalls or for excavation.

253 BITUMINOUS COATED CORRUGATED SHEET METAL PIPE

253-1.1 Description. This item shall consist of furnishing bituminous coated sheet metal pipe, conforming to these specifications and of the sizes and dimensions required on the plans, and installing such pipe at such places as are designated on the plans or by the engineer and in conformity with the lines and grades given.

This item shall include the furnishing and construction of such joints and such connections to existing pipes, catch basins, end walls, etc., as may be required to complete the work as shown on the plans.

-2.1 Materials and Manufacture. Performance Specification. The bituminous coated pipe shall conform to all the requirements of the specifications hereinbefore for Corrugated Galvanized Sheet Metal Pipe, and in addition shall be completely coated inside and out with an asphalt cement, which will meet the performance requirements set forth herein.

The asphalt cement shall be 99.5 percent soluble in Carbon Bisulphide.

Thickness of Coating. The inside of the pipe shall be coated uniformly for three-fourths of the circumference (top of pipe when installed) to a minimum thickness of .03 inch. The thickness shall be measured on the crests of the corrugations. The bottom quarter of the circumference shall be of such thickness as to comply with the Erosion Test hereinafter described.

The asphalt cement shall adhere to the metal tenaciously; shall not chip off in handling; and shall protect the pipe from deterioration, as evidenced by meeting the following tests successfully:

-2.2 Stability Test. The asphalt cement shall not lose its stability when subjected to the highest summer temperature, as indicated by withstanding the following test successfully.

Parallel lines shall be drawn along the valleys of the corrugations of a representative sample of coated pipe and the specimen placed on end in a constant temperature oven, with the parallel lines in a horizontal position. The temperature of the specimen shall be maintained within 2°F. of 150°F. for a period of four hours. At the end of this time no part of any line shall have dropped more than one-fourth inch.

-2.3 Imperviousness Test. The asphalt cement shall be impervious to liquids as indicated by the following test.

A 25 percent solution of sulphuric acid, or a 25 percent solution of sodium hydroxide, or a saturated salt solution (such as sodium chloride) shall be held in the valley of a corrugation for a period of 48 hours, during which time no loosening or separation of the bituminous material from the galvanizing shall have taken place.

-2.4 Erosion Test. A representative sample consisting of a two-foot length of a fully coated pipe (with ends closed by suitable bulkheads) shall be revolved end over end about its transverse axis at a speed of 3.7 revolutions per minute and in such a manner that the erosive charge shall alternately roll along the inner surface of opposite sides of the pipe (inside top and bottom, as when installed in service). At least 75 percent of the sample shall be immersed, as it revolves, in a bath of water maintained at a temperature of 50°-55°F. The top three-quarters of the pipe, shall not show areas of bare metal more than two inches in length on four of the seven central corrugations after five hours of continuous testing (called a test period), and the bottom one-quarter shall not show a similar failure in nine additional periods of testing. A new erosive charge shall be used for each period of test. The erosive charge shall be 50 pounds of grade B building brick, conforming to the requirements of the A.S.T.M. Serial Designation C62-30, broken up into pieces two or three inches in diameter and three gallons of water.

LICENSE AGREEMENT

The holders of patent No. 1,652,703, which includes a claim similar to this specification, agree to grant licenses for the nominal payment of $1.00 per annum to any company which desires to make application therefor, permitting culverts to be manufactured to meet the requirements of this specification.

Copy of license agreement is attached and made a part of this specification.

(Item 253)

A G R E E M E N T

THIS AGREEMENT, made and entered into by and between The American Rolling Mill Company, a corporation of Ohio, with a principal place of business at Middletown, Ohio, Lincesor, and _____ a corporation of _____, with a principal place of business at _____, Licensee:

WHEREAS, the Licensor is the owner of United States Letters Patent No. 1,652,703, issued December 13, 1927, covering CORRUGATED METAL CULVERTS, with an interior flooring and coating, and

WHEREAS, the Licensee is desirous of obtaining a license under said letters patent.

NOW, THEREFORE, in consideration of $1.00, each to the other paid, receipt whereof is hereby acknowledged, and the mutual covenants herein contained, it is agreed as follows:

1. The Licensor hereby grants to the Licensee a nonexclusive, nonassignable license, under the said letters patent No. 1,652,703, to manufacture a particular product set forth in Article 2 hereof, and to use and sell said product.

2. The license herein granted and conveyed shall extend only to the manufacture, use and sale of a product described as follows:

A circumferentially corrugated culvert having the interior thereof at least coated with an adhesive, resilient substance, covering at least a substantial portion of the lower half of the culvert, but so applied along the base of the culvert as to be substantially thicker than as applied to the side walls. It is understood that the product to be manufactured and sold under this license will not have one or more substantially smooth and/or level floors substantially filling the valleys of the corrugations in the bottom of the invert.

3. For and in consideration of the license grant herein contained, Licensee shall pay to the Licensor a royalty of One Dollar per year.

4. The Licensee agrees to keep Licensor informed at all times of the character and specifications of culvert made under this license, and will, at all reasonable business hours, permit Licensor to inspect the culvert on hand, and in the course of manufacture and the apparatus for making the same, wherever said culvert shall be manufactured or stored by or for Licensee.

5. Licensor reserves the right to cancel this contract forthwith if at any time it ascertains that Licensee is manufacturing and/or selling coated corrugated culvert not made in accordance with Article 2 hereof.

6. This license, unless sooner terminated in accordance with the provisions of paragraph 5 hereof, shall extend for the life of United States Letters Patent 1,652,703, excepting that Licensor reserves the right to cancel this contract for nonuse extending for a period of two years.

7. This license shall be personal to Licensee and shall not be assignable, except upon the written consent of Licensor thereto first obtained.

IN WITNESS WHEREOF, the parties hereto have set their hands and seals, this _____day of_____193__.

THE AMERICAN ROLLING MILL CO.

By (S) W. W. Sebald (Seal)
Vice-President.

Attest:

(s) W. D. Vorhis
Secretary.

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-3.1 Installation. The subsection of the same heading under the specifications herein for "Corrugated Galvanized Sheet Metal Pipe" shall apply and govern for the asphalt protected pipe and, in addition, the following requirements shall obtain.

During installation, the asphalt protected pipe shall be handled without damaging the asphalt coating. The pipe shall be placed so that the element of the cylindrical pipe constituting the centerline of the thickened portion of the asphalt protection shall coincide with the flow line of the culvert.

-4.1 Method of Measurement. The footages to be paid for shall be the actual number of linear feet of pipe of the several sizes installed in place, completed and accepted. The measurement shall be from end to end of the whole culvert in place, as terminated by the end finish.

-5.1 Basis of Payment. The footages determined as provided above shall be paid for at the contract unit prices per linear foot bid for "Bituminous Coated Corrugated Sheet Metal Pipe" of the several sizes, as the case may be, which prices and payments shall constitute full compensation for furnishing the asphalt protected pipe, hauling and installing the pipe, and for all materials, labor, equipment, tools and incidentals necessary to complete the item, but shall not constitute payment for concrete or masonry headwalls or for excavation.

254 VITRIFIED CLAY PIPE

254-1.1 Description. This item shall consist of furnishing vitrified clay pipe conforming to these specifications, and of the sizes and dimensions required on the plans and installing such pipe at such places as are designated on the plans, or by the engineer and in conformity with the lines and grades given. This item shall include the furnishing and construction of such joints and such connections to existing pipes, catch basins, endwalls, etc., as may be required to complete the work as shown on the plans.

-2.1 Materials and Manufacture. Vitrified clay pipe shall be first quality, bell and spigot, fully salt glazed, sound vitrified stoneware sewer pipe. It shall be hard burned without warps, cracks, blisters, or other imperfections, and shall have full rated dimensions for thickness, diameter, and length. The pipe shall conform to the requirements of Federal Specification SS-P-361, and in addition when tested as prescribed therein for a three-edge bearing, it shall show a strength of not less than 2,000 D.

Each manufacturer of pipe shall provide a suitable apparatus for testing his product, in accordance with the above requirements. Upon the request of the engineer, and under his supervision, the manufacturer shall perform such test and in such manner as the engineer may deem necessary, in order to establish the quality of the product as required by these specifications. No payment or allowance shall be made to the manufacturer for such equipment, expenses in testing, or for the broken pipe. The manufacturer shall furnish facilities for inspection during the manufacture.

-3.1 Installation. The formation of the bed for the pipe and the backfilling, after the placing of the pipe as prescribed below, shall be as provided under the item "Bedding and Backfill for Pipe Culverts."

-3.2 Placing Pipe. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. The pipe shall be laid carefully, bells upgrade, ends fully and closely jointed, and true to lines and grades as given. Each section shall be attached securely to the adjoining sections by the method contemplated by the type of joint used. All joints, unless otherwise provided, shall be filled with stiff mortar composed of one part portland cement and one and one-half parts sand. These materials shall conform to the appropriate requirements prescribed under Federal Specification SS-S-61. The mortar shall be placed so as to form a durable watertight joint. After any section of pipe is laid and before any succeeding section is laid the lower portion of the bell of the preceding section shall be plastered thoroughly on the inside with the mortar to such depth as to bring the inner surfaces of the abutting pipes flush and even. After the section is laid the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set the mortar on the outside shall be protected from the air and sun with a thoroughly wetted earth or burlap cover. Any pipe which is not in true alignment or which shows any undue settlement after laying, or is damaged, shall be taken up and relaid without extra compensation.

-4.1 Method of Measurement. The footages to be paid for shall be the actual number of linear feet of vitrified clay pipe installed in place completed and accepted, measured along the flow line of the structure.

-5.1 Basis of Payment. The footages determined as provided above shall be paid for at the contract unit price per linear foot bid for "Vitrified Clay Pipe" of the several sizes, as the case may be, which prices and payment shall constitute full compensation for furnishing, hauling, and installing the pipe, and for all materials, labor, equipment, tools, and incidentals necessary to complete this item, but shall not constitute payment for concrete or masonry headwalls or for excavation.