BRIDGE SECTION LIBRARY

SPECIAL BRIDGE SPECIFICATRIONS

APRIL 1934

TEXAS DEPARTMENT OF TRANSPORTATION

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TECHNICAL LIBRARY

SPECIAL BRIDGE SPECIFICATIONS

		Stencil No.	Tab. No.
	Unclassified Structural Excavation	3976	1
	Unclassified & Solid Rock Structural Excav.	4751	2
91	Reinforcing Steel	4396	3
91-A	Rail Reinforcing Steel	5767	4
93-A	Timber for Structures S. Y. P.	6021	5
93-B	Timber for Structures - Douglas Fir	434-23	6
94-A	Timber Preservative & Treatment S.Y.P.	4165	7
94-B	" " " " Douglas Fir	4164	8
94-C	" " " " Wolmanized Lumber	4858	9
101	Timber Structures	4109	10
107	Timber Piling	4279	11
97	Expansion Joint Materials	5291	12
	Concrete Floor Slabs	5482	13
	High Early Strength Concrete	5763	14
108	Precast Concrete Piling	5082	15
	Open Caisson Pier Construction	3969	16
78	Rip-Rap	4322	17
	Removing Old Structures	4661	18
96 T	Waterproofing	6510	19
92	Metal for Structures	6081	20
103	Steel Structures	6062	21
95	Paint and Painting	6374	22
87	Corrugated Galvanized Metal Pipe	5584	23
	Bituminous Paved Invert	5503	24
85	Reinforced Concrete Pipe Culverts	4559	25
	Vitrified Clay Pipe Culverts	6344	26
106	Name Plates & Markers	4162	27
	Gunite	3975	28
	Bituminous Concrete Pavement (Modified Topeka Type)	047[illegible]	29
	Amiesite Pavement	4795	30
	Cold Rolled Rock Asphalt (Durasc)	2802	31
	Amuloc Asphalt Pavement	5557	32

1353

TEXAS STATE HIGHWAY DEPARTMENT

Revised 11-13-33

SPECIAL ITEM. UNCLASSIFIED STRUCTURAL EXCAVATION

Description: Unclassified Structural Excavation shall provide for all excavation for foundations of structures which shall include disposal of all material obtained from such excavation and backfilling to the level of the original ground. It shall also include all necessary bailing, sheeting, drainage, and the construction of cofferdams or cribs, and if found necessary, their subsequent removal. The material shall be disposed of as directed by the Engineer and in such manner as not to obstruct the streams or otherwise impair the efficiency or appearance of the structure or other parts of the work. The excavation shall be done in accordance with the lines and depths indicated on the plans and established by the Engineer, or, as altered by him in matters of depth, elevation or dimensions to secure adequate bearing and foundation. Unless written permission is given by the Engineer to the contrary, no excavation shall be made outside a plane three feet from the footing lines and parallel thereto. Unless otherwise specified, this work shall include the removal of old structures, including abutments, wings, piers and all other materials, obstructions, etc., necessary to proposed construction or as directed by the Engineer.

Construction Methods: When a structure is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation and the final removal of the foundation material to grade shall not be made until just before the masonry is to be placed.

All rock or other hard foundation material shall be freed from all loose material, cleaned and cut to a firm surface either level, stepped or serrated, as directed by the Engineer. All seams shall be cleaned out and filled with concrete mortar or grout. Ample provisions shall be made for doweling foundation to rock or other hard material by use of reinforcing steel bars placed in the rock by drilling and grouting and by the use of keys cut into the rock.

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

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

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

Unless otherwise provided, cofferdams or cribs with all sheeting and bracing shall be removed by the contractor after the completion of the substructure. The removal shall be effected in such a manner as not to disturb or mar the finished masonry. In lieu of the entire removal of the cofferdams or cribs the Engineer may require the contractor to remove any portion of them or to leave them entirely in place.

Foundation Seals: When conditions are encountered which, in the opinion of the Engineer, render it impracticable to otherwise unwater the foundation, he may require the construction of a concrete foundation seal of such dimensions as may be necessary. The seal shall have a depth of not less than four-tenths of the water head and shall be of Class "A" concrete plus 10% cement. The foundation shall then be pumped out and the balance of the masonry placed in the dry. When weighed cribs are employed and the weight utilized to practically overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal.

Where a concrete foundation seal is used for structures, the following provisions shall be made:

(a) Where foundation piling are used they shall dowel into the dry base concrete at least 12 inches above top of seal.

(b) Where no foundation piling are used a reinforced concrete or steel shell, of sufficient size and thickness to withstand the loads upon it, shall be provided around and for the full depth of the seal and which will remain in place in the completed structure.

Pumping: Pumping from the interior of any foundation enclosure shall be done in such manner as to preclude possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete, or for a period of at least 24 hours thereafter, unless it be done from a suitable sump separated from the concrete work by a water-tight wall. Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

Backfilling: After the structure has been completed, all spaces excavated and not occupied by the permanent structure shall be filled with materials satisfactory to the Engineer in layers of not more than 6 inches in depth and compacted satisfactorily to the level of the original surrounding surfaces. Materials which will not compact readily shall not be used for back-filling. The Material shall be free from large or frozen lumps, wood, or other extraneous material.

For foundation through a hard material exposed to erosion, the backfill around piers and in front of abutments and wings may be ordered by the Engineer to be of stone or lean concrete, in which case, unless otherwise provided, such backfill shall be paid for as extra work.

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

Backfill placed around abutments and piers shall be deposited on both sides to approximately the same elevation at the same time. Special care shall be taken to prevent any wedging action against the structure, and the slopes bounding the excavation shall be stepped or serrated to prevent such wedge action. In no case shall surplus material be dumped in the channel of the stream.

Method of Determining Excavation Quantities: The yardage of structural excavation to be paid for will be that actually removed and measured in its original position by the cross-section method, except that no measurement will be made of material removed from outside of a volume bounded by vertical planes, twelve (12) inches outside the footings and parallel thereto. Such measurements will not include additional yardage caused by slips, slides, cave-ins, siltings, or fillings due to the action of the elements or the carelessness of the contractor. Water will not be classed as excavated material.

Where the excavation is made from Caissons or Cofferdams for which direct payment is made either on a cubic yard basis or a lump sum basis attention is called to the fact that the measurement of excavation quantities will be only to the neat lines of outside dimensions of such caissons or cofferdams.

The log of material indicated by borings and shown on the project plans is considered correct by the State Highway Department, however, bidders should made such additional investigation as they consider necessary to determine the foundation conditions. No additional compensation will be allowed the contractor should it develop during construction that the foundation material is of a different character than shown on the plans.

Basis of Payment: Payment for all work prescribed under this item and measured as provided above shall be made at the contract unit price for "Unclassified Structural Excavation", which shall be full compensation for furnishing all materials, all labor, equipment, tools and incidentals necessary to complete the work.

Should it be necessary, in the opinion of the Engineer, to carry the footing elevations to a greater depth than shown on the plans, then the unit contract price for "Unclassified Structural Excavation" or "Solid Rock Structural Excavation", as the case may be, will be increased at the rate of two percent (2%) per foot for each additional foot of depth required, but no increase in price will be allowed for any other items of contract.

Example: Contract unit price = $1.00, Extra depth = 6 ft. Percentage per ft. of extra depth = (2+4+6+8+10+12) ÷ 6 = 7. Quantity of Excavation in extra depth = 100 C. Y. Payment due = 100 x $1.07 = $107.00.

Monthly estimates will be based on the bid unit price for "Unclassified Structural Excavation" or "Solid Rock Structural Excavation" as the case may be and should there be an adjustment necessary in the unit price on account of deeper excavation such increased amounts will be allowed in the final estimate.

TEXAS STATE HIGHWAY DEPARTMENT

Revised 11-13-33

SPECIAL ITEM. UNCLASSIFIED AND SOLID ROCK

STRUCTURAL EXCAVATION

1. Description: Unclassified and Solid Rock Structural Excavation shall provide for all excavation for foundations of structures which shall include disposal of all material obtained from such excavation and backfilling to the level of the original ground. It shall also include all necessary bailing, sheeting, drainage, and the construction of cofferdams or cribs, and if found necessary, their subsequent removal. The material shall be disposed of as directed by the Engineer and in such manner as not to obstruct the streams or otherwise impair the efficiency or appearance of the structure or other parts of the work. The excavation shall be done in accordance with the lines and depths indicated on the plans and established by the Engineer, or, as altered by him in matters of depth, elevation or dimensions to secure adequate bearing and foundation. Unless written permission is given by the Engineer to the contrary, no excavation shall be made outside a plane three feet from the footing lines and parallel thereto. Unless otherwise specified, this work shall include the removal of old structures including abutments, wings, piers and all other materials, obstructions, etc., necessary to proposed construction or as directed by the Engineer.

"Unclassified Structural Excavation" shall include the removal of all materials excavated for foundations for structures other than solid rock.

"Solid Rock Structural Excavation" shall include the removal of solid rock material. "Solid Rock Material" will be such material as cannot be excavated with a clam shell or orange peel bucket, slip, pick and shovel, dredge or sand pump without first being loosened or broken by blasting, sledging or drilling.

2. Construction Methods. When a structure is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation and the final removal of the foundation material to grade shall not be made until just before the masonry is to be placed.

All rock or other hard foundation material shall be freed from all loose material, cleaned and cut to a firm surface either level, stepped or serrated, as directed by the Engineer. All seams shall be cleaned out and filled with concrete mortar or grout. Ample provisions shall be made for doweling foundation to rock or other hard material by use of reinforcing steel bars placed in the rock by drilling and grouting and by the use of keys cut into the rock.

3. Cofferdams or Cribs: The Contractor shall submit upon request, drawings showing his proposed method of cofferdam construction and other details left open to his choice or not fully shown on the Engineer's drawings. The type and clearance of cofferdams insofar as such details affect the character of the finished work, will be

subject to the approval of the Engineer, but other details of design will be left to the Contractor who will be responsible for the successful construction of the work.

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

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

Unless otherwise provided, cofferdams or cribs with all sheeting and bracing shall be removed by the Contractor after the completion of the substructure. The removal shall be effected in such a manner as not to disturb or mar the finished masonry. In lieu of the entire removal of the cofferdams or cribs the Engineer may require the contractor to remove any portion of them or to leave them entirely in place.

4. Foundation Seals: When conditions are encountered which, in the opinion of the Engineer, render it impracticable to otherwise unwater the foundation, he may require the construction of a concrete foundation seal of such dimensions as may be necessary. The seal shall have a depth of not less than four-tenths of the water head and shall be of Class "A" concrete plus 10% cement. The foundation shall then be pumped out and the balance of the masonry placed in the dry. When weighed cribs are employed and the weight utilized to practically overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal.

Where a concrete foundation seal is used for structures, the following provisions shall be made:

(a) Where foundation piling are used they shall dowel into the dry base concrete at least 12 inches above top of seal.

(b) Where no foundation piling are used a reinforced concrete or steel shell, of sufficient size and thickness to withstand the loads upon it, shall be provided around and for the full depth of the seal and which will remain in place in the completed structure.

5. Pumping: Pumping from the interior of any foundation enclosure shall be done in such manner as to preclude possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete, or for a period of at least 24 hours thereafter, unless it be done from a suitable sump separated from the concrete work by a water-tight wall. Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

6. Backfilling: After the structure has been completed, all spaces excavated and not occupied by the permanent structure shall be filled with materials satisfactory to the Engineer in layers of not more than 6 inches in depth and compacted satisfactorily to the level of the original surrounding surfaces. Materials which will not compact readily shall not be used for back-filling. The material shall be free from large or frozen lumps, wood, or other extraneous material.

For foundation through a hard material exposed to erosion, the backfill around piers and in front of abutments and wings may be ordered by the Engineer to be of stone or lean concrete, in which case, unless otherwise provided, such backfill shall be paid for as extra work.

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

Backfill placed around abutments and piers shall be deposited on both sides to approximately the same elevation at the same time. Special care shall be taken to prevent any wedging action against the structure, and the slopes bounding the excavation shall be stepped or serrated to prevent such wedge action. In no case shall surplus material be dumped in the channel of the stream.

7. Method of Determining Excavation Quantities: The yardage of structural excavation to be paid for will be that actually removed and measured in its original position by the cross-section method, except that no measurement will be made of material removed from outside of a volume bounded by vertical planes, twelve (12) inches outside the footings and parallel thereto. Such measurements will not include additional yardage caused by slips, slides, cave-ins, siltings, or fillings due to the action of the elements or the carelessness of the contractor. Water will not be classed as excavated material.

Where the excavation is made from Caissons or Cofferdams for which direct payment is made either on a cubic yard basis or a lump sum basis attention is called to the fact that the measurement of excavation quantities will be only to the neat lines of outside dimensions of such caissons or cofferdams.

The log of material indicated by borings and shown on the project plans is considered correct by the State Highway Department, however, bidders should make such additional investigation as they consider necessary to determine the foundation conditions. No additional compensation will be allowed the contractor should it develop during construction that the foundation material is of a different character than shown on the plans.

8. Basis of Payment: Payment for work prescribed in this item other than solid rock excavation and measured as provided above shall be made at the contract unit price bid per cubic yard for "Unclassified

Structural Excavation", which shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work.

Payment for solid rock excavation prescribed in this item and measured as provided above shall be made at the contract unit price bid per cubic yard for "Solid Rock Structural Excavation", which shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work. The unit price bid for "Solid Rock Structural Excavation" shall apply regardless of whether the material excavated is above or below the water line.

In no case will payment for "Unclassified Structural Excavation" and "Solid Rock Structural Excavation" be made for the same volume removed.

Should it be necessary, in the opinion of the Engineer, to carry the footing elevations to a greater depth than shown on the plans, then the unit contract price for "Unclassified Structural Excavation" or "Solid Rock Structural Excavation", as the case may be, will be increased at the rate of two percent (2%) per foot for each additional foot of depth required, but no increase in price will be allowed for any other items of contract.

Example: Contract unit Price = $1.00, Extra depth = 6 ft. Percentage per ft. of extra depth = (2/4/6/8/10/12) ÷ 6 = 7. Quantity of Excavation in extra depth = 100. C. Y. Payment due = 100X$1.07 = $107.00.

Monthly estimates will be based on the bid unit price for "Unclassified Structural Excavation" or "Solid Rock Structural Excavation" as the case may be and should there be an adjustment necessary in the unit price on account of deeper excavation such increased amounts will be allowed in the final estimate.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 91. REINFORCING STEEL

(Note: Effective Jan. 1, 1931, this item supersedes Item 86 of the Standard Specifications approved Feb. 26, 1926.)

91.1. DESCRIPTION. Reinforcing steel shall consist of furnishing and placing of reinforcing steel of the type, size and quantity designated for use in concrete structures as shown on the plans and in accordance with these specifications.

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

When deformed bars are specified, the form of the bar 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. Twisted bars are not considered as deformed and shall not be used.

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

91.3. BENDING. The reinforcement shall be bent cold to the shapes indicated on the plans. Bending shall preferably be done in the shop before shipment and not in the field. Bends shall be true to the shapes indicated and irregularities in bending shall be cause for rejection.

91.4. STORING. Steel reinforcement shall be stored above the surface of the ground upon platforms, skids or other supports, and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, it shall be free from dirt, scale, dust, paint, oil or other foreign material.

91.5. SPLICES. All reinforcement shall be furnished in the full lengths indicated upon the plans. No splicing of bars, except when shown on the plans, will be permitted without the written approval of the Engineer. Splices which are permitted shall have a length of not less than 40 times the nominal diameter of the reinforcement,

and shall be well distributed or else located at points of low tensile stress. No splices will be permitted at points where the section is not sufficient to provide a minimum distance of two inches between the splice and the nearest adjacent bar or the surface of the concrete. The bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer.

91.6. PLACING. Steel reinforcement shall be placed in the exact position as shown on the plans and held securely in place during the placing of the concrete. Vertical stirrups shall always pass around the main tension members and be securely attached thereto. The reinforcing steel in all concrete masonry walls shall be spaced its proper distance from the face of the forms by means of approved precast mortar or concrete blocks. All horizontal reinforcing steel shall be spaced vertically by means of approved precast mortar or concrete blocks. All reinforcing steel shall be wired together at all intersections or as directed by the Engineer. Before any concrete is placed all mortar shall be cleaned from the reinforcement.

Sheets of metal mesh shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges.

No concrete shall be deposited until the Engineer shall have inspected the placing of the reinforcing metal and given permission to place concrete. All concrete placed in violation of this provision shall be rejected and removed.

91.7. MEASUREMENT. Reinforcing steel in place will be paid for by the pound except where specifically provided elsewhere in these specifications that full compensation for furnishing and placing reinforcing steel shall be condidered as included in the prices paid for other items of work.

The quantity of reinforcing steel furnished and placed shall be based preferably on the scale weights of the steel actually placed in accordance with these specifications, except that no payment will be made for quantities in excess of the theoretical weight plus two per cent. Tie wires and supporting devices will not be included in the quantity for payment. If the scale weight is less than the theoretical weight minus three percent the material shall be rejected. Railroad weights will not be accepted as actual scale weights.

Where actual scale weights are not obtained the quantity for payment will be determined by theoretical weight using the following units:

Size	Minimum Area sq. in.	Weight per lineal foot
1/4" Round	0.049	0.167
3/8" "	0.110	0.376
1/2" "	0.196	0.668
5/8" "	0.307	1.043
3/4" "	0.442	1.502
7/8" "	0.601	2.044
1" "	0.785	2.670
1/2" Square	0.250	0.850
1" "	1.000	3.400
1 1/8" "	1.266	4.303
1 1/4" "	1.563	5.313

91.8. BASIS OF PAYMENT. Reinforcing steel used in concrete structures, measured as provided above, will be paid for at the contract unit price bid per pound of "Reinforcing Steel" which price shall be full compensation for furnishing, bending, fabricating, weighing, and placing the reinforcement, for all clips, metal spacers, ties, wire or other materials used for fastening reinforcement in place, for all tools, labor, equipment and incidentals necessary to complete the work.

Reinforcement for concrete railing and piling shall be paid for as provided in the specifications for those items.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 91-A. RAIL REINFORCING STEEL

91-A. 1. DESCRIPTION. Rail Reinforcement bars may be used where specified on the plans for concrete structures or portions of structures, but such use shall be limited to the reinforcement for structures having individual spans 20 ft. or less and the maximum size bar to be used shall be 3/4 inch round or square.

2. MATERIALS. Rail Steel Reinforcement bars shall comply with the requirements of the "Standard Specifications for Rail Steel Concrete Reinforcement Bars, Serial Designation: A16-14", of the A. S. T. M.

All reinforcement bars for structures shall be deformed. Hot twisted bars will not be admitted.

The bars shall be rolled from standard section Tee rails. Prior to rolling, the Tee rail shall be separated into sections of such size that the bars may be produced by reducing the section in the rolls, No bar shall be produced by piling the metal. Satisfactory evidence that the bars have been rolled from standard section Tee rails as required by these specifications shall be supplied, and failure to supply such evidence shall be considered as sufficient cause for rejection.

Test specimens from the field shall be not less than thirty-six (36) inches in length.

3. BENDING. The reinforcement shall be bent cold to the shapes indicated on the plans. Bending shall preferably be done in the shop before shipment and not in the field. Bends shall be true to the shapes indicated and irregularities in bending shall be cause for rejection.

4. STORING. Steel reinforcement shall be stored above the surface of the ground upon platforms, skids or other supports, and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, it shall be free from dirt, scale, dust, paint, oil or other foreign material.

5. SPLICES. All reinforcement shall be furnished in the full lengths indicated upon the plans. No splicing of bars, except when shown on the plans, will be permitted without the written approval of the Engineer. Splices which are permitted shall have a length of not less than 40 times the nominal diameter of the reinforcement, and shall be well distributed or else located at points of low tensile stress. No splices will be permitted at points where the section is not sufficient to provide a minimum distance of two inches between the splice and the nearest adjacent bar or the surface of the concrete. The bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer.

6. PLACING. Steel reinforcement shall be placed in the exact position as shown on the plans and held securely in place during the placing of the concrete. Vertical stirrups shall always pass around the main tension members and be securely attached thereto. The reinforcing steel in all concrete masonry walls shall be spaced its proper distance from the face of the forms by means of approved precast mortar or concrete blocks. All horizontal reinforcing steel shall be spaced vertically by means of approved precast mortar or concrete blocks. All reinforcing steel shall be wired together at all intersections or as directed by the Engineer. Before any concrete is placed all mortar shall be cleaned from the reinforcement.

No concrete shall be deposited until the Engineer shall have inspected the placing of the reinforcing metal and given permission to place concrete. All concrete placed in violation of this provision shall be rejected and removed.

7. MEASUREMENT. Rail Reinforcing Steel in place will be paid for by the pound except where specifically provided elsewhere in these specifications that full compensation for furnishing and placing rail reinforcing steel shall be considered as included in the prices paid for other items of work.

The quantity of rail reinforcing steel furnished and placed shall be based preferably on the scale weights of the steel actually placed in accordance with these specifications, except that no payment will be made for quantities in excess of the theoretical weight plus two per cent. Tie wires and supporting devices will not be included in the quantity for payment. If the scale weight is less than the theoretical weight minus three percent the material shall be rejected. Railroad weights will not be accepted as actual scale weights.

Where actual scale weights are not obtained the quantity for payment will be determined by theoretical weight using the following units:

Size	Minimum Area Sq. In.	Weight per lineal feet
1/4" Round	0.049	0.167
3/8" "	0.110	0.376
1/2" "	0.196	0.668
5/8" "	0.307	1.043
3/4" "	0.442	1.502
1/2" Square	0.250	0.850

8. BASIS OF PAYMENT. Rail Reinforcing Steel used in concrete structures, measured as provided above, will be paid for at the contract unit price bid per pound of "Rail Reinforcing Steel" which price shall be full compensation for furnishing, bending, fabricating, weighing, and placing the reinforcement, for all clips, metal spacers, wire, ties, or other materials used for fastening reinforcement in place, for all tools, labor, equipment and incidnetals necessary to complete the work.

Rail Reinforcement for concrete railing and piling shall be paid for as provided in the specifications for those items.

STATE HIGHWAY DEPARTMENT OF TEXAS

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ITEM 93-A. TIMBER FOR STRUCTURES - SOUTHERN-YELLOW PINE.

(REV. 3-1-34)

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(Note: Effective June 1, 1933, this item supersedes Item 83.2 to 83.18 incl. of the Standard Specifications approved Feb. 26, 1926.)

93.1. DESCRIPTION: Untreated structural timber or creosoted structural timber shall be used where shown on the plans or directed by the Engineer, and such structures or portions of structures shall be constructed in accordance with the plans and these specifications. This item shall include only such timber as is a part of the completed work. All timber for erection purposes, as falsework, forms, bracing, sheeting, etc., shall be furnished by the Contractor at his own expense.

93.2. MATERIAL: Unless otherwise specified, material shall be Southern Yellow Pine conforming to these specifications which are based on the 1932 Standard Specification for Grades as adopted by the Southern Pine Association.

Unless otherwise provided Southern Yellow Pine timber for structures may be longleaf or shortleaf conforming to the following grades for the items noted.

Stringers, floorbeams, nailing strips, caps, sawn piling, rail posts, truss members, flooring, (except 2"x4" strip flooring) railing, wheel guards and sills shall be Structural Square Edge and Sound Longleaf or Dense Structural Square Edge and Sound Shortleaf conforming to the requirements of Par. 93.8 (SPA 327 & 377), for timbers 6"x6" and larger, and Par. 93.9 (SPA 338 & 389) timbers 2" to 5" thick and 6" to 16" wide.

Bracing, bulkhead plank, bridging, 2"x4" strip flooring, edging strips, cleats and blocks shall be No. 1 Structural Longleaf or Dense No. 1 Structural Shortleaf conforming to the requirements of Par. 93.10 (SPA 328 & ~~390) for~~ 37 sizes 6" or more in thickness; shall be Longleaf Structural Square Edge and Sound or Dense Structural Square Edge and Sound Shortleaf conforming to the requirements of Par. 93.11 (SPA 338 & 389) for sizes 3" to 5" in thickness; and shall be No. 1 Longleaf Dimension or No. 1 Dense Shortleaf Dimension conforming to the requirements of Par. 93.12 (SPA 359 & 409) for sizes 2" thickness.

When specified, Small Timbers (3"x3" to and including 4"x6")may be used for items given above where applicable in size. Small Timbers shall be No. 1 Longleaf or No. 1 Dense Shortleaf conforming to the requirements of Par. 93.13 (SPA 367 & 418.)

Unless otherwise provided one inch thickness material shall be "No. 1 Common Boards and Strips" (SPA 282)

93.3. When untreated timber is specified it shall show not less than the following amounts of heartwood:

Stringers, floorbeams and flooring; 80% of heart on any girth.
Caps, sills and posts, 75% of heart on each of the four sides measured across the side.
Bracings, struts, rails, etc., 80% of heart on both sides measured across the side.

When treated timber is specified there shall be no heartwood requirements and the amount of sapwood shall not be limited.

93.4. SIZE REQUIREMENTS: Rough timber of all structural grades must be full size when green. A maximum of one-quarter inch shall be allowed for each side surfaced.

Rough Dimension timber shall be 2" thickness, 4", 6", 8", 10" and 12" widths. It is provided that rough dimension grades shall be not less than 1/8" thicker than the corresponding finished dry thickness, excepting that 20% of a shipment may not be less than 3/32" than the corresponding standard finished, dry, thickness. Further, pieces 1/2" or more above nominal thickness, as may be produced by uneven sawing, may, at the option of the Engineer, be rejected. Dimension, ordered rough, if thicker than the nominal thickness for dry or green stock, may be dressed to such thickness and when so dressed shall be considered as rough stock.

Standard lengths of Dimension material are from 4' to 24' inclusive, in multiples of 2', except that 9' and 11' shall be standard in 2x4, 2x6, 2x8; 13' in 2x8 and 2x10, and 15' in 2x10 and 2x12.

Dressed sizes of Dimension material are 1 5/8", thickness; 3 5/8"; 5 5/8"; 7½", 9½" and 11½" width.

Standard rough width or thickness for Small Timbers shall not be less than ¼" off of nominal; when ordered rough, if thicker or wider than aforementioned rough thickness or width, may be dressed to such thickness or width, and when so dressed shall be considered as rough stock. In shipments as rough pieces ½" or more above nominal thickness, or 1" above nominal width, for rough stock, as may be produced by uneven sawing, may, at the option of the Engineer, be rejected.

Dressed sizes of Small Timbers when dressed S 1 S 1 E to S 4 S the dressed size shall be 3/8" less than nominal size.

Sizes of Small Timbers are 3"x3" to and including 4"x6" Standard lengths are 10' to 24' inclusive, in multiples of 2'.

93.5. SHAKES AND CHECKS: All structural grades of timbers shall contain only sound wood and be well manufactured, shall be free from end shakes and checks exceeding one-third the width of the end (narrow face) excepting in No. 1 Structural (Longleaf), in which shakes may measure four-ninths the width of end.

In beams and stringers (pieces of unequal faces) the size of a shake shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the piece. In posts (equal faces) the size of a shake shall be measured between lines parallel to each pair of opposite faces, and the greater of these two distances shall be taken as its size.

93.6. DENSITY REQUIREMENT: Structural grades of Southern Yellow Pine shall show on one end or the other an average of at least six annual rings per inch and at least one-third summerwood, all as measured over the third, fourth, and fifth inches of a radial line from the pith. Wide-ringed material excluded by this rule will be acceptable, provided the amount of summerwood as above measured shall be at least one-half.

The contrast in color between summerwood and springwood shall be sharp and the summerwood shall be dark in color, except in pieces having considerable above the minimum requirement for summerwood.

In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over three inches on an approximate radial line beginning at the edge nearest the pith in timbers over three inches in thickness and on the second inch (on the piece) nearest to the pith in timbers three inches or less in thickness.

In dimension material containing the pith but not a five-inch radial line, which is less than two inches by eight inches in section or less than eight inches in width, that does not show over sixteen square inches on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a five-inch radial line, the inspection shall apply to the three inches farthest from the pith.

The radial line chosen shall be representative. In case of disagreement between purchaser and seller the average summerwood and number of rings shall be the average of the two radial lines chosen.

93.7. GENERAL KNOT LIMITATIONS: In all structural timber grades the following knot limitations shall govern:

On narrow faces of beams or stringers the size of a knot shall be taken as its width between lines parallel to the edges of the piece. On wide faces the smallest diameter of a knot shall be taken as its size. The average diameter of a spike knot shall be taken as the average of its average of its length and its maximum width.

The size of knots on narrow or horizontal faces may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

The size of knots on wide or vertical faces may increase proportionately from the size allowed at the edge to that allowed at the center line.

Knots at edges of wide faces shall not exceed in size the knots permitted on the adjacent narrow face, but the size is measured on the least diameter instead of otherwise. Knots at edges of wide faces may increase

proportionately from size allowed in the middle third to twice that size at the end of the piece.

On wide faces of Joist and Plank the size of knot shall be the mean or average diameter. On narrow faces of Joist and Plank the size of a knot shall be taken as its width between lines parallel to the edges of the piece. The average diameter of a spike knot shall be taken as the average of its length and its maximum width.

The size of knots on wide faces may increase proportionately from the size allowed at the edge to that allowed at the center line. Knots on narrow faces and at edges of wide faces located outside the middle third of the length of the piece may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

In square timbers (usually posts) the size of a knot shall be measured on the mean or average diameter.

In square timbers the sum of the diameters of the knots on all sides within any six inches of length shall not exceed twice the maximum size knot allowable; nor shall there be two maximum allowable knots in the same six inches of length of any face.

93.8. STRUCTURAL SQUARE EDGE AND SOUND LONGLEAF OR DENSE STRUCTURAL SQUARE EDGE AND SOUND SHORTLEAF (FOR SIZES 6"x6" AND LARGER) shall conform to density requirement as given in these specifications (Par. 93.6); shall be of sound wood and well manufactured; shall be free from shakes and checks on ends which exceed 1/3 the width of end (narrow face), and diagonal grain with slope greater than 1" in 12"; wane shall not exceed 1/8 width of face and $\frac{1}{4}$ length of piece on one corner, or the equivalent on two or more corners, or not to exceed 10% of the pieces; no limitations as to heart content. May contain sound knots, (which will include encased knots or knots with pith holes not to exceed $\frac{1}{4}$") provided the size of any knot on the center line of the middle third of the length of the piece shall not exceed the measurements hereinafter given, measured on the face in which it appears as prescribed in "General Knot Limitations" and provided that the aggregate diameter of all knots within the center half of the length of any face shall not exceed the width of that face. Knot limitations are:

	Unequal Face Timbers		Square
Size	Narrow Face	Wide Face	Timbers
6"	$1\frac{3}{4}$"	--	$1\frac{3}{4}$"
8"	$2\frac{1}{4}$"	$2\frac{1}{2}$"	$2\frac{1}{2}$"
10"	$2\frac{1}{2}$"	3 "	3 "
12"	$2\frac{3}{4}$"	$3\frac{3}{4}$"	$3\frac{1}{2}$"
14"	$2\frac{3}{4}$"	4 "	4 "
16"	3 "	$4\frac{1}{4}$"	$4\frac{1}{4}$"
18"	--	$4\frac{1}{2}$"	$4\frac{1}{2}$"

93.9. LONGLEAF STRUCTURAL SQUARE EDGE AND SOUND OR DENSE STRUCTURAL SQUARE EDGE AND SOUND SHORTLEAF (2 to 5" thick and 6 to 16" wide) shall conform to density requirement as given in these specifications (Par. 93.6); shall be of sound wood and well manufactured; shakes and checks on end shall not exceed four-ninths of the width of end (narrow face); Wane shall not exceed one-

eighth the width of any face and one-fourth of the length of the piece on one corner; slope of grain shall not be greater than one inch in twelve inches in the center half of the length; no limitations as to heart content; may contain sound knots (which will include encased knots or knots with pith holes not to exceed one-fourth inch), provided that the size of any one knot on the center line shall not exceed the measurements hereinafter given, measured on the face in which it appears as prescribed under "General Knot Limitations", and provided the sum of diameters in the center half of the length of any face shall not exceed one and one-half ($1\frac{1}{2}$) times the width of the face. Knot limitations are as follows:

Width of Face	At edge of Wide Face Middle Third of Length	On Center Line of Wide Face
4"	$\frac{3}{4}$"	$1\frac{1}{4}$"
6"	$1\frac{1}{4}$"	2 "
8"	$1\frac{1}{2}$"	$2\frac{1}{2}$"
10"	2 "	$3\frac{1}{4}$"
12"	$2\frac{1}{4}$"	4 "
14" and 16"	$2\frac{1}{2}$"	$4\frac{1}{2}$"

Knots on narrow faces of boxed heart pieces, middle third of length are limited as follows:

For 2" thickness	5/8 "
3" "	1 "
4" "	$1\frac{1}{4}$ "
5" "	$1\frac{1}{2}$ "

93.10. NO. 1 STRUCTURAL LONGLEAF OR DENSE NO. 1 STRUCTURAL SHORTLEAF (FOR SIZES 6"x6" AND LARGER) shall conform to density requirement as given in these specifications (Par. 93.6); shall contain only sound wood and be well manufactured; shall be free from shakes and checks on ends which exceed 4/9 the width of end (narrow face), and diagonal grain with slope greater than 1" in 10"; wane permitted if it does not exceed $1\frac{1}{2}$" on 2 faces for 1/3 the length of the piece; no limitations as to heart content. May contain sound knots (which will include encased knots or knots with pith holes not to exceed 1/4") provided the size of any knot on the center line of the middle third of the length of the piece shall not exceed the measurements hereinafter given, measured on the face in which it appears as prescribed in "General Knot Limitations" and provided that the aggregate diameter of all knots within the center half of the length of any face shall not exceed the width of that face. This grade will admit of pith knots; unsound knots not to exceed $1\frac{1}{2}$" diameter; and a limited number of pin worm holes well scattered. Knot limitations are:

Unequal Face Timbers

Size	Narrow Face	Wide Face	Square Timbers
6"	$2\frac{1}{4}$"	--	$2\frac{1}{2}$"
8"	$2\frac{3}{4}$"	$3\frac{3}{4}$"	3 "
10"	3 "	4 "	$3\frac{1}{4}$"
12"	$3\frac{1}{4}$"	$4\frac{3}{4}$"	$3\frac{3}{4}$"
14"	$3\frac{1}{2}$"	$5\frac{1}{4}$"	4 "
16"	$3\frac{3}{4}$"	$5\frac{1}{2}$"	$4\frac{1}{2}$"
18"	--	$5\frac{3}{4}$	5 "

93.11. LONGLEAF STRUCTURAL SQUARE EDGE AND SOUND OR DENSE STRUCTURAL SQUARE EDGE AND SOUND SHORTLEAF JOIST AND PLANK (FOR SIZES 3" to 5" THICKNESS) shall conform to density requirement as given in these specifications (Par. 93.6); shall be of sound wood and well manufactured; shakes and checks on end shall not exceed 4/9 the width of end (narrow face); wane shall not exceed 1/8 the width of any face and ½ of the length of the piece on 1 corner; slope of grain shall not be greater than 1" in 12" in the center half of the length; no limitations as to heart nor sap. May contain sound knots (which will include encased knots or knots with pith holes not to exceed ½"), provided that the size of any one knot on the centerline shall not exceed the measurements hereinafter given, measured on the face in which it appears as prescribed in "General Knot Limitations", and provided the sum of diameters of knots in the center half of the length of any face shall not exceed 1½ times the width of the face. Knot limitations are as follows:

Width of Face	At Edge of Wide Face Middle Third of Length	On Center Line of Wide Face
4"	¾"	1¼"
6"	1¼"	2 "
8"	1½"	2½"
10"	2 "	3¼"
12"	2¼"	4 "
14"	2½"	4½"
16"	2½"	4½"

Knots on narrow faces of boxed heart pieces, middle third of length are limited as follows:

For 3" thickness	1"
4" "	1¼"
5" "	1½"

93.12. NO. 1 LONGLEAF DIMENSION OR NO. 1 DENSE SHORTLEAF DIMENSION (FOR SIZE 2" IN THICKNESS). Each piece shall show, at one end or the other, at least 6 annual rings, and at least 1/3 summerwood, measured according to density requirement as given in these specifications (Par. 93.6), or if less than 6 rings per inch there shall be at least ⅓ summerwood; must be suitable for use without waste as substantial structural material, and will admit the following defects or their equivalent; any number of sound, encased, and pith knots, the average diameter of any one knot not to exceed 1½" in 2x4's, and in wider stock not to exceed 1/3 the cross-section of the piece in the rough; pith knots or small defective knots which do not weaken the piece more than the knots aforesaid; surface or through checks; a limited number of medium worm holes, well scattered; loosened or torn grain, or other machine defects which will not cause waste; pitch pockets; pitch; pith; splits in ends that do not exceed in length the width of the piece; shakes that do not go through; firm red heart; stain; wane, ¼ the thickness, ¼ the width, and ¼ the length of the piece. Based on 16 foot lengths the following crooks are permissible:

2 x 4 - - - -	¾"
2 x 6 - - - -	11/16"
2 x 8 - - - -	5/8"
2 x 10 - - -	1/2"
2 x 12 - - -	1/2"

Pieces longer or shorter than 16 feet may have proportionate amounts of crook.

93.13. NO. 1 LONGLEAF OR NO. 1 DENSE SHORTLEAF SMALL TIMBERS (3"x3" TO AND INCLUDING 4"x6") shall be graded in accordance with the requirements of Par. 93.12 except that wane shall not exceed $\frac{1}{4}$ the width of the face in which it appears and 1/3 the length of the piece.

93.14. When treated timber is required it shall be treated with a preservative oil of quality and manner as hereinafter specified for "Preservative and Treatment".

93.15. MEASUREMENT AND PAYMENT: No direct compensation will be made for timber material or preservative treatment. Payment for same shall be included in the contract unit price per thousand feet board measure of timber complete in place as hereinafter provided for "Timber Structures".

6021-7

93.18 SPECIAL PROVISIONS AND DEFINITIONS.

CLOSE GRAIN shall mean an average on either one end or the other of a piece of not less than six nor more than 20 annual rings per inch, measured over 3 inches on a line located as follows:

In boxed heart pieces, the line shall run from the pith to the corner farthest from the pith. When the least dimension is 6" or less, the 3" portion of the line shall begin at a distance of 1" from the pith. When the least dimension is more than 6", the 3" portion of the line shall begin at a distance of 2" from the pith.

In side cut pieces, the line on which the measurement shall be made shall run at a right angle to the annual rings and the center of the 3" portion of the line shall be at the center of the end of the piece.

When the rings are very irregular, it may be necessary to shift the line somewhat around the piece to get a fair average for inspection, but the distance from the pith to the beginning of the 3" line in boxed heart pieces must not be changed.

Pieces averaging from 5 to 6 annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

DENSE MATERIAL shall average on either one end or the other of a piece not less than 6 annual rings per inch and, in addition, one-third or more summerwood (the dark portion of the annual ring), measured over the same portion of a radial line as provided for close grain. The contrast in color between summerwood and springwood shall be distinct.

Coarse grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

In case of disagreement, two radial lines shall be chosen and the summerwood and number of rings shall be taken as the average on these lines.

A SLIGHT VARIATION IN SAWING shall not be more than:

In 3" to 7"	3/16" under	or	3/8" over
" 8" and up	1/4" "	"	1/2" "

A MEDIUM PITCH POCKET is one not over 1/8" in width and not more than 8 inches in length.

The numbers given opposite the following grades refer to paragraph numbers of the Standard Grading and Dressing Rules No. 9 of West Coast Lumbermen's Association July 1st, 1929.

93.19 STRUCTURAL STRINGERS, ETC. (218) This grade must be sound, square edged, well manufactured and close grained; free from spiral or diagonal grain with a slope of more than 1" in a length of 15" in the center three-fourths of the length of the piece. Will admit occasional slight variation in sawing, and any number of the following defects, or their equivalent:

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 93. TIMBER FOR STRUCTURES.

(Note: Effective May 1, 1930, this item supersedes Items 83.2 to 83.18 incl. of the Standard Specifications approved Feb. 26, 1926)

B. DOUGLAS FIR OF THE WEST COAST REGION.

93.14 DESCRIPTION. Untreated structural timber or creosoted structural timber shall be used where shown on the plans or directed by the Engineer, and such structures or portions of structures shall be constructed in accordance with the plans and these specifications. This item shall include only such timber as is a part of the completed work. All timber for erection purposes, as falsework, forms, bracing, sheeting, etc., shall be furnished by the Contractor at his own expenses.

93.15 MATERIAL. Where specified, material shall be Douglas Fir of the West Coast Region conforming with these specifications which are based on the Standard Grading and Dressing Rules of the West Coast Lumbermen's Association No. 9. Certain portions of the Rules are quoted for general information. Whenever the term "Douglas Fir" appears on the plans or in these specifications it shall be construed to mean "Douglas Fir of the West Coast Region."

Unless otherwise provided, Douglas Fir timber for structures shall conform to the following grades for the items noted:

ITEM	GRADE	Paragraph Reference West Coast Lumbermen's Association Grading Rules, No. 9.
Stringers, Butt Blocks.	Structural Stringers, etc.	218
Caps	Structural Post and Timbers	210

93.16 When untreated timber is specified it shall show not less than the following amounts of heartwood:

Stringers and butt blocks; 80% of heart on any girth.
Caps; 75% of heart on each of the four sides measured across the side.

When treated timber is specified the grades as given in the foregoing tabulation shall be used without modification as to heartwood and sapwood requirements.

93.17 SIZE REQUIREMENTS. Timber shall be full sawn or dressed as indicated on the plans. Rough timber shall not be thinner than the nominal dimension less $\frac{1}{4}$ inch, and not narrower than the nominal width less $\frac{1}{4}$ inch for sizes 2 to 7 inches inclusive, and less 3/8 inches for sizes 8 inches and larger.

Stringers, butt blocks and caps shall be, when surfaced S1S, S1E, S2S or S4S, not smaller than the nominal size less $\frac{1}{2}$ inch off each way.

Knots - sound tight, if not in clusters, approximately:

Width of Face	Size of Knot: On Narrow Faces	Size of Knot: On Center Line of Wide Face
5"	1"	---
6"	1¼"	---
8"	1½"	1-3/4"
10"	1-3/4"	2¼"
12"	1-3/4"	2¼"
14" and wider	2" Maximum	3" Maximum

The diameter of a knot on the narrow face shall be measured between lines parallel to the edges of the narrow face. On the wide face the knot shall be measured on the smallest diameter. Knots at the edges of a wide face are limited to the same size as on the adjacent narrow face, but measured on the smallest diameter, and the sizes may increase proportionately to the size allowed at the center line of the wide face.

Pitch pockets--medium
Checks-seasoning
Sap--2" on edges and 3" on faces, measured over its widest point.

93.20 STRUCTURAL POSTS AND TIMBERS (210) This grade must be sound, square edged, well manufactured and close grained; free from spiral or diagonal grain with a slope of more than 1" in a length of 15". Will admit occasional slight variation in sawing, and any number of the following defects or their equivalent:

Knots - sound tight, if not in clusters, approximately:

1¼" on a 6" face
1½" on an 8" face
2" on a 10" face
2½" on a 12" and wider faces

In timbers having faces 24" or wider or lengths 50' and longer the size of knots may be proportionately larger in relation to their effect on the strength of the piece.

Checks--seasoning
Pitch pockets--medium
Sap-¼ thickness, 1/3 width

93.21 GRADING CERTIFICATE. An official grading certificate from the West Coast Lumbermen's Association, The Pacific Lumber Inspection Bureau, or other agency approved by the State Highway Engineer shall accompany each carload of lumber whether treated or untreated, and a duplicate copy of such certificate shall be delivered directly to the State Highway Engineer, Austin, Texas. The cost of such certificates will be furnished without separate charge to the State Highway Department.

93.22 When treated timber is required it shall be treated with a preservative oil of quality and manner as hereinafter specified for "Preservative and Treatment."

93.23 MEASUREMENT AND PAYMENT. No direct compensation will be made for timber material or preservative treatment. Payment for same shall be included in the contract unit price per thousand feet board measure of timber complete in place as hereinafter provided for "Timber Structures".

STATE HIGHWAY DEPARTMENT OF TEXAS

(10-25-32)

ITEM 94. TIMBER PRESERVATIVE AND TREATMENT

(Note: Effective June 1, 1930, this item supersedes Items 83.19 to 83.22 incl. of the Standard Specifications approved Feb. 26, 1926.)

A. SOUTHERN YELLOW PINE

94.1. DESCRIPTION. This item shall consist of the conditioning, seasoning, preparation, preservative and treatment of lumber, timber and piling when treatment is shown on the plans, unless otherwise provided.

94.2. CONDITIONING. Timbers shall be conditioned for treatment in accordance with American Wood Preservers' Association "Standards for the Purchase and Preservation of Treateble Timber."

94.3. SEASONING.

(a) Timbers shall be seasoned by air or steam as agreed upon, until in the judgment of the Engineer any moisture in the wood will not prevent the injection and proper distribution of the specified amount of preservative.

(b) When, in the judgment of the Engineer, steam seasoning is necessary for adequate treatment, timbers may be steamed in the cylinder at not more than 30 lbs. pressure per square inch for not more than 20 hours at not more than 274°F., which pressure and temperature maxima shall not be reached in less than 2 hours. The cylinder shall be provided with vents to relieve it of air and insure proper circulation of steam. After steaming is completed a minimum vacuum of 22 inches shall be maintained for not less than 15 minutes. The cylinder shall be relieved continuously or frequently enough to prevent condensate from accumulating in sufficient quantity to reach the wood. Before the preservative is introduced the cylinder shall be drained of condensate.

94.4. PREPARATION FOR TREATMENT. Any charge of timbers shall be confined to one kind or designated group or kinds of wood of pieces approximately equal in size and moisture and sapwood content, into which approximately equal quantities of preservative can be injected, on which all necessary framing, boring, or chamfering shall have been done, where possible, and so separated as to insure contact of preservative, and steam if used, with all surfaces.

94.5. MANNER OF TREATMENT. The ranges of pressure, temperature and time duration shall be controlled so as to result in maximum penetration by the quantity of preservative injected which shall permeate all of the sapwood, and as much of the heartwood as practicable. The vacuum requirements stipulated are those at sea level, and necessary corrections shall be made for altitude.

94.6. RETENTION OF PRESERVATIVE. No charge shall contain less than 90% nor more than 110% of the quantity of preservative specified; but the average retention of preservative by the material treated for the project shall be at least 100% of the quantity specified. The amount of preservative retained shall be calculated on the basis of preservative at 100°F. from readings of working tank gauges, or scales, or from weights before and after treatment of loaded trams on suitable track scales checked as desired by the Engineer.

94.7. DETERMINATION OF PENETRATION. Penetration shall be determined by sampling timbers in each charge, as may be desired by the Engineer. Any holes which may be bored shall be filled with tight fitting treated plugs.

94.8. PLANT EQUIPMENT. The treating plant shall be equipped with thermometers and gauges necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in condition satisfactory to the Engineer. The apparatus and chemical necessary for making the analysis and tests required by the Engineer shall also be provided by the treating plant and kept in condition for use at all times.

94.9. PRESERVATIVES. The preservative used for the treatment of timber and piling shall be the American Wood Preservers' Association Standard Grade 1 Creosote Oil for ties and structural timber, as follows:

1. The oil shall be a distillate of coal-gas tar or coke-oven tar. Owing to the complexity of the chemical composition and physical properties of coal-tar creosote oil, and to the fact that some of the same compounds and properties which characterize coal-tar creosote are found in certain petroleum derivatives, the determination of the purity of creosote oil is difficult. When there is not certain assurance that the oil is a pure product, the following tests will aid in arriving at an opinion as to its coal-tar origin:

A. Fraction distilling between 210°C. is usually solid or contains some solids when cooled to 25°C.

B. All of the fractions up to 315°C. contain tar acids in varying amounts, usually at least 1%, calculated on the amount of the fraction tested.

C. The specific gravity of the fraction between 235°C and 315°C. is usually not lower than 1.025 and specific gravity of the fraction between 315° and 355° is usually not lower than 1.085 at 38°C. compared with water at 15.5°C. However, some pure coal-tar distillates fall slightly below these limits.

If the oil does not comply with at least one of the foregoing tests, it is undoubtedly not a pure coal-tar creosote.

The oil shall comply with the following requirements:

2. It shall not contain more than 3% of water.

3. It shall not contain more than 0.5% of matter insoluble in benzol.

4. The specific gravity of the oil at 38°C., compared with water at 15.5°C., shall not be less than 1.03.

5. The distillate, based on water-free oil shall be within the following limits:

Up to 210°C., not more than 5%
Up to 235°C., not more than 25%

6. The residue above 355°C., if it exceeds 5% shall have a float test of not more than 50 seconds at 70°C.

7. The oil shall yield not more than 2% of coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Wood Preservers' Association.

94.10. AMOUNT OF PRESERVATIVE TO BE USED: The amount of preservative and process will be as shown on the plans and proposal.

TREATING OPERATIONS.

94.11. FULL CELL PROCESS:

(a) Timber shall be subjected to a vacuum of sufficient intensity and duration to insure that the wood is dry and free from air as practicable, and to permit a retention of the specified number of pounds of preservative per cubic foot of wood.

(b) The preservative shall be introduced between 165° and 200°F., and the cylinder filled without breaking the vacuum. The pressure shall then be raised to and maintained at a minimum of 100 lbs. per square inch, or until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or until the Engineer is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall not be less than 150°F., nor more than 200°F. After the 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.

94.12. EMPTY CELL PROCESS WITH INITIAL AIR. Timber shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of surplus preservative, and to insure a retention and proper distribution of the stipulated number of pounds of preservative per cubic foot of wood. The preservative shall be intorduced between 165°F. and 200°F., the cylinder pressure being maintained constant until the cylinder is filled with preservative. The pressure shall then be raised to and maintained at a minimum of 150 lbs. per square inch or until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by a quick high vacuum, or, until the Engineer is satisfied that the largest volumetric injection that is practicable

has been obtained. The temperature of the preservative during the pressure period shall not be less than 150°F., nor more than 200°F., and shall average at least 180°F. After the pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

94.13. EMPTY CELL PROCESS WITHOUT INITIAL AIR. The preservative between 165°F. and 200°F. shall be introduced to the timber until the cylinder is filled. Pressure shall then be raised to and maintained at a minimum of 100 pounds per square inch or until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by a quick high vacuum, or until the Engineer is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be of not less than 150°F., nor more than 200°F., and shall average at least 180°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 for not less than 30 minutes until the quantity of preservative injected is reduced to the required retention and the wood can be removed from the cylinder free of dripping preservative.

94.14. MEASUREMENT AND PAYMENT. No direct compensation is provided for this item. Payment for all work prescribed herein shall be included in the contract price bid per thousand feet board measure for timber or per linear foot for piling as provided in Item 101 (Timber Bridges).

4165-4

Note: Grade No. 1 Creosote Oil conforming to the requirements of these specifications which has been used may contain as much as 1.5% of matter insoluble in benzol.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 94. TIMBER PRESERVATIVE AND TREATMENT.

(Note: Effective June 1, 1930, this item supersedes Items 83.19 to 83.22 incl. of the Standard Specifications approved Feb. 26, 1926.)

B. DOUGLAS FIR OF THE WEST COAST REGION.

94.15. DESCRIPTION. This item shall consist of the conditioning, seasoning, preparation, preservative and treatment of Douglas Fir Timber of the West Coast Region when treatment is shown on the plan

The following paragraphs from the foregoing specifications for Preservative and Treatment of Southern Yellow Pine apply for Douglas Fir.

Pars. 94.2, 94.4, 94.5, 94.6, 94.7, 94.8, 94.9, 94.10, and 94.14.

In the creosote treatment of Douglas Fir the Manual of Recommended Practice of the American Wood Preserver's Association shall govern and as given herein: "Standards for the Purchase and Preservation of Treatable Timber, (2c)" and the "Standard Specifications for the Preservative Treatment of Douglas Fir Lumber by Pressure Processes, (45a)", or subsequent Amendments to the Manual as may be adopted by the Association.

94.16. SEASONING.

(a) Lumber shall be seasoned, by air or by boiling under vacuum as agreed upon, until in the judgment of the Engineer any moisture in the wood will not prevent the injection and proper distribution and penetration of the specified amount of preservative.

(b) When in the judgment of the Engineer, seasoning by boiling under a vacuum is necessary for adequate treatment, lumber shall be held in creosote under a vacuum at temperatures not less than 180° and not more than 200°F. The seasoning shall be maintained until condensation passing off the lumber is approximately .1 lb. per cubic foot of lumber per hour. A minimum vacuum of 20 in. shall be maintained during seasoning.

94.17. HEATING. Whenever it is desirable to warm dry lumber, it shall be heated in preservative gradually to not more than 190°F., and held at that temperature for not more than 6 hours.

94.18. FULL-CELL PROCESS. During the heating period, in the case of dry lumber, a vacuum shall be created, and, following this, or the seasoning-by-boiling-under-vacuum period, in the case of green lumber, the cylinder shall be filled with preservative without breaking the vacuum. The pressure shall then be raised and maintained within a maximum of 175 lbs. per sq. in. until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or, failing this, until the Engineer is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of preservative during the pressure period shall be not less than 160°F., nor more than 200°F., and shall average at least 180°F. After pressure is completed, the

cylinder shall be emptied speedily of preservative and a vacuum of at least 20 in. promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

94.19. EMPTY-CELL PROCESS WITH INITIAL AIR. (a) Following the heating period, in the case of dry lumber, or the seasoning-by-boiling-under-vacuum period, in the case of green lumber, the cylinder shall be emptied of preservative and the lumber shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of surplus preservative and to insure a retention and proper distribution of the stipulated number of pounds of preservative per cubic foot of lumber.

(b) The preservative shall then be reintroduced, the cylinder pressure being maintained constant until the cylinder is filled with preservative. The pressure shall then be raised and maintained within a maximum of 175 lbs. per sq. in. until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum, or, failing this, until the Engineer is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 160°F., nor more than 200°F., and shall average at least 180°F.

After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of at least 20 in. promptly created and maintained until the lumber can be removed from the cylinder free of dripping preservative. Or, after pressure is completed and before removal of preservative from the cylinder, the preservative surrounding the lumber may be reheated to a maximum of 210°F., the steam to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed, until the steam is turned off the coils in this expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above. Or, after the pressure is completed and before removal of preservative from the cylinder the preservative surrounding the lumber may be reheated to a maximum of 210°F. and a vacuum created during this heating period to further assist in expelling excess preservative from the lumber, the steam to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed, until the steam is turned off the coils in this expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above.

94.20. EMPTY-CELL PROCESS WITHOUT INITIAL AIR. (a) Following the heating period, in the case of dry lumber, or the seasoning-by-boiling-under-vacuum period, in the case of green lumber, the cylinder shall be emptied of preservative and atmospheric pressure established. The preservative shall then be reintroduced to the lumber until the cylinder is filled. Pressure shall then be raised and maintained within a maximum of 175 lbs. per sq. in. until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum or, failing this, until the Engineer is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 160°F., nor more than 200°F., and shall average at least 180°F.

After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of at least 20 in. promptly created and maintained for not less than 30 min. until the quantity of preservative injected is reduced to the required retention and the lumber can be removed from the cylinder free of dripping preservative. Or, after pressure is completed and before removal of preservative from the cylinder, the preservative surrounding the lumber may be reheated to a maximum of 210°F., the steam to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed, until the steam is turned off the coils in this expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above. Or, after the pressure is completed and before the removal of preservative from the cylinder, the preservative surrounding the lumber may be reheated to a maximum of 210°F. and a vacuum created during this heating period to further assist in expelling excess preservative from the lumber, the steam to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed, until the steam is turned off the coils in this expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above.

94.21. The treating plants which are unfamiliar with the treatment of Douglas Fir should keep well within the maximum temperatures permitted in this specification as it has been found that Douglas Fir from some localities and in various degrees of dryness may be damaged when held at these maximum temperatures too long or in combination with high pressures. In some cases the liability to damage increases with the dryness of the lumber.

STATE HIGHWAY DEPARTMENT OF TEXAS

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ITEM 94. TIMBER PRESERVATIVE AND TREATMENT.

C. WOLMANIZED LUMBER

94.22 DESCRIPTION. This item shall consist of the conditioning, seasoning, preparation, preservative and treatment of timber by the pressure treatment of the American Wood Impregnation Corporation's Wolman Salts (Triolith) or equal.

The following paragraphs from the foregoing specifications for Preservative and Treatment of Southern Yellow Pine apply for Wolmanized lumber.

94.2, 94.4, 94.5, 94.6, 94.7 and 94.8.

94.23 SEASONING. All timber should be air seasoned until moisture content is below 20%. Green timber must be given an artificial seasoning in an airtight retort by a bath of live steam at from 10 to 15 pounds pressure for a period of from 4 to 10 hours, followed by a vacuum of at least 22" for one hour, or with alternating periods of vacuum and pressure, as may be found necessary to put the timber into condition for treatment. The cylinder shall be relieved continuously or frequently enough to prevent condensate from accumulating in sufficient quantity to reach the wood.

94.24 PRESERVATIVE. The Triolith mixture shall be composed essentially of the following ingredients:

Sodium Fluride, Dinitro-phenol, and neutralizing chromates.

The preservative, and the manner of treatment shall be such that after the solution has been injected into the timber and allowed time for the water to dry out and the salts to crystallize, the latter will be fixed in the interior structure of the wood.

The treating solution shall have a strength of concentration in water of from 1.8 to 2% of Triolith, analyzing to the American Wood Impregnation Corporation's "Standard Procedure for Determination of Triolith", in 98.2 to 98% of water; but the solution shall be no stronger than necessary to obtain the required retention of preservative specified below, with the largest volumetric absorption practicable.

94.25 AMOUNT OF PRESERVATIVE TO BE USED. The amount of solution injected into the timber and its strength of concentration must be so controlled as to leave not less than 3/10 pounds of dry salt for each cubic foot of timber treated, and this shall permeate all of the sapwood and as much of the heartwood as practicable. No charge shall contain less than 90% nor more than 110% of the quantity of preservative specified.

94.26 TREATMENT. After the above process of seasoning, or in the case of air seasoned timber after a vacuum period at not less than 22" for at least 15 minutes, the preservative solution, maintained at a temperature of between 150 and 180 degrees Fahrenheit, shall be admitted into the treating cylinder, without breaking the vacuum until timber is completely submerged. The preservative solution shall then be pumped into the timber under pressure sufficient to secure the desired absorption or if this cannot be attained then under a pressure of 125 pounds per square inch continuing until the charge is treated to refusal. The solution shall then be quickly drained off, and the timber may be left in the cylinder to drip for about 30 minutes, or a quick final vacuum, at no time greater than the minimum vacuum during submergency, may be created and maintained until the charge can be removed from the cylinder free of dripping preservative. After treatment the timber shall be allowed to dry at least four weeks before using. When it is necessary to cut the timbers after treatment, or when any surface has been badly scarred, the bared place must be given a three coat treatment of concentrated solution of Triolith applied with a brush; and this solution must be hot, 150 to 180 degrees Fahrenheit, while being applied.

94.27 PAINTING. Wolmanized timber, treated as outlined above is intended for use as Bridge railing and after erection must be given two coats of aluminum paint meeting the requirements of the specifications of the Texas State Highway Department.

The surface of the lumber must be thoroughly dry when the paint is applied. The surfaces to be painted shall be the front and top faces of the horizontal railings.

94.28 MEASUREMENT AND PAYMENT. No direct compensation is provided for this item. Payment for all work prescribed herein shall be included in the contract unit price bid per thousand feet board measure for "Treated Timber" as provided in the Item 101 (Timber Bridges).

4858-2

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 101. TIMBER STRUCTURES

(Note: When used for a project and attached to the proposal, this item supersedes Item 83.23 to 83.44 inclusive of the Standard Specifications approved Feb. 26, 1926.)

101.1. DESCRIPTION. Timber structures shall include all culverts, bridges, bulkheads, retaining walls, piers, bents, fenders or any portion thereof which involves the use of timber materials of whatever grade or kind and whether treated or untreated. Such structures or incidentals shall be constructed to the lines, grades and as shown on the plans and in accordance with these specifications unless otherwise provided.

101.2. MATERIALS. All materials used in the construction of timber structures shall conform to the requirements of the pertinent specifications.

101.3. PRESERVATIVE TREATMENT. Lumber and piling for Timber Structures shall be "Treated" or "Untreated" as shown on the plans. "Treated" Lumber and piling shall be impregnated with a preservative of such quantity and process as shown on the plans and as specified elsewhere in these specifications.

CONSTRUCTION METHODS

101.4. STORAGE OF MATERIALS. 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. 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.

101.5. HANDLING. Timber shall be carefully handled without sudden dropping, breaking of outer fibers or bruising. The surface of treated timbers and piling shall not be penetrated with tools. They shall be handled with rope slings. Cant dogs, hooks or pike poles shall not be used.

101.6. WORKMANSHIP. Workmanship shall be first-class throughout. None but competent bridge carpenters shall be employed and all framings shall be true and exact. 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 the removal of the workman causing them. The workmanship on all parts shall conform to the requirements of these specifications.

101.7. PILING BENTS. The piling shall be driven as accurately as possible in the correct location and to the vertical or batter lines indicated on the plans.

In case a piling is driven out of line, it shall be straightened without injury before it is cut off or braced. Where excavation is made around a piling to straighten, the material shall be carefully replaced and tamped. Piling damaged in driving or straightening, or piling driven below grade, shall be removed and replaced at the Contractor's expense. No shimming on tops of piling will be permitted.

Piling for any one bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. Cut-offs shall be accurately made to insure perfect bearing between the cap and piling.

101.8. FRAMED BENTS. Mud sills of untreated timber shall be of durable material as shown on the plans. They shall be firmly and evenly bedded to solid bearing and carefully tamped in place.

Concrete Pedestals. 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 $\frac{3}{4}$ inch diameter and projecting not less than 6 inches above the tops of the pedestals, shall be set in them when they are cast, for anchoring the sills or posts

101.9. SILLS. Sills shall have true and even bearing on piles or pedestals. They shall be drift bolted to piles with bolts of not less than $\frac{3}{4}$ inch diameter and extending into the piles not less than 6 inches. When possible all earth shall be removed from around sills so that there will be free air circulation around them.

101.10. POSTS. Posts shall be fastened to pedestals with dowels of not less than $\frac{3}{4}$ inch diameter extending not less than 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 $\frac{3}{4}$ inch diameter extending not less than 6 inches into posts and sills.

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

101.11. PILING OR POST COVERS. After making cut-offs the tops of piling or posts if untreated material shall be given a thick coat of red lead paint, hot tar, hot asphaltum, or hot coal-tar creosote and covered with a sheet of 3 ply roofing felt or 20 gauge galvanized metal as indicated on the plans. The cover shall measure at least 6 inches more in each dimension than the diameter of the piling or side of the post, and shall be bent down over the piling or post and the edges fastened with large headed galvanized nails or secured by binding with galvanized wire as indicated on the plans.

For treated materials the tops shall be given 3 coats of hot creosote oil. They shall then be covered with a coat of hot tar pitch over which shall be placed a cover as specified for untreated material above and as indicated on the plans.

101.12. CAPS. 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 $\frac{3}{4}$ 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.

101.13. BRACING. Sway bracing shall be placed diagonally on bents to engage the cap and all piling or posts. They shall be secured to cap and piling or posts with bolts of not less than $\frac{3}{4}$ inch diameter. Spikes shall be used in addition to bolts.

Sash bracing and longitudinal bracing, where indicated on the plans, shall be placed and fastened at contact points of piling, posts, caps or stringers as specified for sway bracing.

No undue bending of bracing will be permitted. Where necessary, shims of the same material and width as bracing shall be used.

101.14. 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 of cap at each end. The lapped ends of untreated stringers shall be separated at least $\frac{1}{2}$ inch for the circulation of air and shall be securely fastened by drift-bolting where specified. When stringers are two panels in length the joints shall be staggered.

101.15. BRIDGING. Cross bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails in each end.

Treated bridging need not be framed before treating, but the framed ends shall be given two coats of hot creosote oil before placing.

101.16. FLOORING. Single plank floors for roadways shall have a nominal thickness of not less than 3 inches and a width of not less than $1\frac{1}{2}$ inches. They shall be placed with the heart side down with $\frac{1}{4}$ inch openisngs between them for seasoned material and tight joints for unseasoned material. Sidewalk floors shall have a nominal thickness not less than 2 inches, and a width of not less than 6 inches. Each plank shall be spiked to each stringer or nailing strip with not less than 2 spikes, the length of which shall be at least 3 inches greater than the thickness of the plank. The ends of the planks shall be cut off on a straight line parallel to the center line of roadway. The planks shall be carefully graded as to thickness and so laid that no two adjacent planks shall vary in thickness more than 1/16 inch.

101.17. Where double plank floors are indicated on the plans the top course shall be laid diagonal or parallel to the center line of roadway, as may be specified, and each plank shall be spiked to the lower course at intervals of not more than 2 feet with two spikes which shall extend into the lower course at least 3 inches. Joints shall be staggered at least 3 feet. If the planks are placed parallel to the center line of the roadway, special care shall be exercised to fasten their ends securely and at the ends of the bridge they shall be beveled.

101.18. For laminated floors the strips shall be placed on edge and at right angles to the center line of roadway. The strips shall be full length, random lengths will not be permitted. Each strip shall be spiked to the adjacent strip

at intervals of 2 feet, the spikes being staggered 8 inches in adjacent strips. The spikes shall be of sufficient length to pass through two strips and halfway through the third. In addition, the strips shall be toe-nailed to the stringer with 20d spikes, the nailing of successive strips being staggered so that the spacing of spikes along each stringer shall be not less than 6 inches. For strips 3 inches in thickness spikes driven vertically through the strips and extending into the stringer not less than 3 inches may be substituted for toe-nailing.

101.19. WHEEL GUARDS. Wheel guards, as shown on the plans, shall be constructed on each side of the roadway. They shall be raised from the floor by blocks 3 inches thick by one foot long, spaced about 5 feet apart center to center, and shall be fastened in place by a bolt not less than 5/8 inch diameter passing through the wheel guard, each block and floor plank. When indicated on the plans the bolts shall be hook bolts, hooked to the underside of outside stringers and passing through the floor, spacer blocks and wheel guard. Hook bolts shall be drawn tight against the stringer and threaded end above nut shall be cut off. The hooked end on inside face of stringer shall be at least 3 inches long. Wheel guards shall be laid in sections not less than 12 feet long and preferably shall be aporoximate panel length.

101.20. When a bituminous wearing surface is provided, a header shall be placed on top of the floor and under the wheel guard and spacing blocks. The thickness of the header shall be the same as the edge thickness of the wearing surface.

In addition to bolting, headers, spacer blocks and wheel guards shall be nailed in place. Header butts shall be made under spacer blocks.

Wheel guards shall be spliced at the ends as shown on the plans and the workmanship shall be first class.

101.21. RAILINGS. Railings shall be constructed as shown on the plans. Posts shall be bolted to stringers and caps with not less than $\frac{3}{4}$ inch diameter bolts. Railings shall be bolted to posts with not less than $\frac{1}{2}$-inch diameter bolts where possible and all railings shall be nailed with 16d. galvanized nails. The top rail shall be nailed to side rail at not to exceed 3 feet intervals and to tops of posts with at least two nails. Railings shall be so constructed so that no two rails butt on the same posts.

101.22. HOLES FOR BOLTS, DOWELS, RODS AND LAG SCREWS. Holes for round drift bolts 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 drift bolts 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.

101.23. 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 surface. Mortises shall be true to size for their full depth and tenons shall make snug fit therein. No shimming will be permitted in making joints, nor will open joints be accepted.

Countersinking shall be done wherever smooth faces are required.

All cutting, framing and boring of treated timbers shall be done before treatment in so far as is practicable. In waters infested by marine borers cutting below high water shall be avoided.

101.24. HARDWARE. Machine bolts, drift bolts and dowels may be either wrought iron or medium steel, washers may be cast O-gee or Malleable castings, or may be cut from medium steel or wrought iron plate, as specified.

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

101.26. A washer, of the size and type specified, shall be used under all bolt heads and nuts which would otherwise come in contact with wood. Cast washers shall have a thickness equal to the diameter of the bolt and a diameter of four times the thickness. For plate washers, the size of the square shall be equal to four times, and the thickness equal to one-half the diameter of the bolt.

All bolts shall be effectually checked after the nuts are adjusted.

101.27. PAINTING. For treated timber structures, hot creosote oil shall be poured into the bolt hole before the insertion of the bolt, in such a manner that the entire surface of the holes shall receive a coating of the oil. Heads of piling shall be treated as provided hereinbefore. All cuts in treated piling or timbers and all abrasions after having been carefully trimmed shall be brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch. After completion of structure all bolt heads, threads, nuts, washers and exposed portions of bolts shall be given a thorough coating of hot asphalt.

101.28. Railings for treated structures, in addition to creosote treatment, shall be painted with one coat of aluminum paint. The materials and application to conform to general specifications for paints and application.

101.29. For untreated timber structures the following surfaces shall be thoroughly coated with a thick coat of red lead paint, hot tar, hot asphaltum, or hot coal tar creosote before assembling: Heads of piles, ends, tops, and all contact surfaces of pile caps, floor beams and stringer ends, joints and all contact surfaces of truss members, laterals and braces. The back face of bulkheads and all other timber in contact with earth shall be thoroughly coated with one of the materials specified above, or a carbolineum.

All bolts passing through non-resinous wood shall be painted with two coats of red lead paint at least 85% pure.

101.30. METHOD OF MEASUREMENT. "Treated Timber" and "Untreated Timber" complete in place according to the plans and these specifications shall be

measured separately by the thousand feet board measure. Measurements shall be computed from the dimensions shown on plans, unless changes in such dimensions have been authorized by the Engineer. "Standard" timber sizes and lengths shall be used in computations. This measurement shall include only such timber as is a part of the completed and accepted work, and shall not include timber used for erection purposes, such as falsework, forms, bracing, sheeting, etc. Any piling, concrete, masonry, or any supplementary floor wearing tops, shown on plans will be measured as provided in pertinent specifications.

101.31. BASIS OF PAYMENT. Timber structures complete in place shall be paid for by the quantities as above measured at the contract unit price per thousand feet board measure bid for "Untreated Timber" or "Treated Timber", as the case may be, complete in place according to the plans or as directed by the Engineer, which prices shall be full compensation for all materials, hardware, equipment, tools, labor, painting, preservative treatment, and all incidentals necessary to complete the structure ready for use provided, however, that piling, concrete, masonry, and bituminous wearing surfaces shown on plans shall be paid for as provided in pertinent specifications.

101.32. No partial estimates will be allowed for timber structures, materials or completed work unless the Contractor has insured the timber materials in accordance with existing regulations of the Department.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 107 TIMBER PILING.

(Note: Effective June 1, 1930, this item supersedes Items 103 and 104 of the Standard Specifications approved Feb. 26, 1926)

107.1. DESCRIPTION. Timber Piling shall consist of round or square piling of the kind and dimensions specified, and in conformity with pertinent designated plans. They shall be driven in accordance with these specifications in the location and to the elevation shown on the plans or as directed by the Engineer.

107.2. MATERIAL. Piling may be of any species of durable timber which will satisfactorily stand driving. They shall be cut from live, sound trees, shall be solid and free from defects such as injurious ring shakes, large, unsound or loose knots, decay, knots in clusters, groups of single knots, or other defects which might impair their strength and durability. Sound knots will be permitted provided they are not in clusters and they do not exceed one-third (1/3) of the small diameter or least dimension, and are not over four (4) inches in diameter. Any defect or combination of defects which would be more injurious than the maximum allowable knot shall not be permitted. All knots shall be trimmed close to the body of the pile. Piling shall be cut from above the ground swell and have a uniform taper. A line drawn from the center of the butt to the center of the tip shall not fall outside of the center of the pile at any point more than 1% of the length of the pile. In short bend, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4% of the length of the bend or 2½ inches. The piling shall be peeled soon after cutting. All of the rough bark and at least 80% of the inner bark shall be removed. No strip of inner bark remaining on the stick shall be over 3/4 inch wide or over 8 inches long, and there shall be at least 1 inch of clean wood surface between any two strips. Square piling shall be uniform in cross-section, not less than 10x12 inches for lengths over 30 Ft.

The minimum diameter of round piling at a section four feet from the butt, measured under the bark, and the minimum diameter of the tip, shall be as follows:

Length of Pile	Min. Diam. 4' from Butt	Length of Pile	Min. Diam. of tip
40' and under	--- 12"	30' and under	--- 9"
Over 40'	--- 13"	30' to 50'	--- 8"
		Over 30'	--- 7"

The maximum diameter of the butt shall be 20 inches.

Treated piling shall be impregnated with a preservative of such quantity and process as shown on the plans and as specified elsewhere in these specifications.

107.3. USE OF UNTREATED PILING. Except for trestle work, untreated timber piling shall be used only below permanent ground water level. Untreated timber piling shall not be used in water which is infested by marine borers.

107.4. LONG LENGTHS AND SPLICES. If possible, piling shall be full length. Where the length required is greater than is practical to obtain, they may, upon written approval of the Engineer, be spliced. All splices shall be made in accordance with detail plans, prepared to meet the special conditions encountered and which shall be approved before the piling is driven.

107.5. STORING AND HANDLING. The method of storing and handling piling shall be such as to avoid injury to them. Treated piling shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. They shall be handled with rope slings. Cant dogs, hooks or pike poles shall not be used where such tools will penetrate into the untreated wood.

107.6. PROTECTION OF HEADS. When the nature of the driving is such as to unduly injure them, the heads of timber piling shall be protected by caps of approved design, preferably having a rope or other suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. When the area of the head of the pile is greater than that of the face of the hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the cross section of the pile, and thus avoid, as far as possible, the tendency to split or shatter the pile. Collars or bands to protect the piling against splitting and broomings shall be provided where necessary.

107.7. POINTS AND SHOES. The piling shall be pointed where soil conditions require it. Where necessary, the piling shall be shod with metal shoes of design shown on the plans or as acceptable to the Engineer. The points of the piling shall be carefully shaped to secure an even and uniform bearing on the shoes.

107.8. DRIVING. Piling shall not be driven until after the excavation is complete. Any material forced up between piling shall be removed to correct elevation before masonry for the foundation is placed. Timber piling shall be driven with a gravity hammer, steam hammer, water jets, a combination of water jets and hammer, or in bored pilot holes. The driving of piling with followers shall be avoided if practicable, and, shall be done under written permission of the Engineer only.

Piling shall be driven with a total variation of not more than three inches in the direction parallel to the centerline of roadway, and not more than 6 inches along a line at right angles to centerline of roadway. All piling raised during the process of driving adjacent piling shall be driven down again if required by the Engineer. Broken, split, or misplaced piling shall be withdrawn and properly replaced. Piling driven below the cut-off grade fixed by the Engineer shall be withdrawn and replaced by new and, if necessary, longer piling, at the expense of the Contractor.

107.9. HAMMERS. Gravity hammers for driving timber piling shall weigh not less than 2000 pounds and the fall shall be so regulated as to avoid injury to the pile, and in no case shall exceed 20 feet.

Steam hammers for driving timber piling shall be capable of developing an energy per blow at each full stroke of the piston of not less than 9000 foot pounds for single acting, and not less than 6000 foot pounds for double acting steam hammers. This requirement may be modified for driving in sandy materials when suitable water jets are used.

107.10. LEADS. Pile driver leads shall be constructed in such a manner as to afford freedom of movement to the hammer and they shall be held in position by guys or stiff braces to insure support to the pile driving. Except where piling are driven through water, the leads shall be of sufficient length so that the use of a follower will not be necessary.

107.11. WATER JETS. Water jets may be used, either alone or in combination with a hammer. The volume and pressure of the water at the jet nozzles, and number of jets used, shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 100 pounds per square inch pressure at two 3/4" jet nozzles.

If water jets and a hammer are used for driving, the jet shall be withdrawn and the piles shall be driven by the hammer to secure final penetration and resistance. This procedure may be varied if the desired results are not obtained.

107.12. PILOT HOLES. Where indicated on the plans, pilot holes shall be bored or formed to permit pile penetration into hard statified foundation materials. Where such holes are formed, a casing pipe of sufficient diameter to admit the pile and sufficient length to extend through the upper strata of loose material shall be placed around the boring device. Provision shall be made to hold the casing pipe in place until the pilot hole is completed, and the driving of the pile is started, and to a sufficient depth into the hard material to prevent sand and gravel from dropping into the pilot hole. Piling, after having been driven in pilot holes, and pilot casing removed, shall have additional driving necessary to secure the required bearing value as determined by test or pile formula, and to securely fix the end of pile into the hard material.

107.13. PENETRATION. In general, the penetration for any trestle pile shall be not less than one-third the length of the pile, and preferably should not be less than 20 feet. For foundation work, no piling shall be used to penetrate a very soft upper stratum overlying a hard stratum unless the piling penetrate the hard material a sufficient distance to rigidly fix the ends. Penetration required for foundation piling will be essentially as shown on the plans regardless of the bearing value requirements as determined by test or formula.

Water jets shall be used where necessary to secure penetration as outlined and to prevent "over driving" of the piling such as would cause brooming, breaking or splitting. The jet should be withdrawn just prior to reaching final penetration to permit driving to safe resistance required. Drilling of pilot holes shall be done wherever necessary to secure penetration for piling into hard materials. Drilling pilot holes shall be required only when driving, jetting or a combination of driving and jetting are insufficient to produce the desired penetration results.

107.14. CUT-OFFS. The tops of all piling shall be sawed to a true plane as shown on the plans, and at the elevation fixed by the Engineer. Piling which support timber caps or grillage work shall be sawed to the exact plane of the superimposed structure and shall exactly fit it. Broken, split, or misplaced piling shall be drawn and properly replaced. Piling driven below the cut-off grade fixed by the Engineer shall be withdrawn and replaced by new and, if necessary, longer piling, at the expense of the Contractor.

Foundation piling for framed bents shall be cut off level approximately 3 feet above the surface of the ground and the cap rigidly secured to each pile by drift bolts extending at least 9 inches into the pile.

Trestle piling whether treated or untreated shall be cut off level at the elevation shown on the plans and the caps secured as described above. If the cut-off is 10 feet or more above the ground line, timber piling shall be braced by diagonal cross-bracing composed of 3-inch by 10-inch timbers, secured to the piling by $\frac{3}{4}$-inch diameter through bolts.

107.15. TREATMENT OF CUTS, ETC. After the necessary cutting has been done to receive the cap, the heads of treated trestle piling shall be given three coats of hot creosote oil. They shall then be covered with a coat of hot tar pitch over which shall be placed a sheet of 3 ply roofing felt or 20 gauge galvanized metal as indicated on the plans. The cover shall measure at least 6 inches more in each dimension than the diameter of the piling, and shall be bent down over the piling and the edges fastened with large headed galvanized nails or secured by binding with galvanized wire as indicated on the plans.

The heads of untreated trestle piling shall be thoroughly coated with a thick protective coat of red lead paint, hot tar, hot asphaltum, or hot coal-tar creosote and covered with felt or galvanized metal as provided above.

All places where the surface of treated piling is broken by cutting boring, or otherwise, shall be thoroughly coated with hot creosote oil and then with a coating of hot tar pitch. Hot creosote oil shall be injected into the bolt holes before the insertion of the bolts in such manner that the entire surface of the holes shall receive a coating of the oil.

107.16. EMBEDMENT IN CONCRETE. The tops of foundation piling shall be embedded in the concrete footing at least 1 foot, and where seals of concrete deposited in water are used with piling, the piling shall project at least 1 foot above the top of the seal concrete. They shall be cut off level at such elevation that the tops of the piling will be always wet.

107.17. LOAD TESTS. When required, the size and number of piling shall be determined by actual loading tests. In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, together with suitable apparatus for accurately determining the superimposed weight and the settlement under each increment of load. The safe allowable load shall be considered as 50 per cent of that load which, after 48 hours' application causes a permanent settlement measured at the top of the pile, of not more than one-fourth inch. At least, one pile of each group of one hundred shall be thus tested.

107.18. SAFE LOAD FORMULAS. In the absence of loading tests, the safe bearing values for timber piling shall be determined by the following formulas:

$$P = \frac{2WH}{S + 1.0} \text{ for gravity hammers.}$$

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

$$P = \frac{2H\ (W + AP)}{S + 0.1} \text{ for double-acting steam hammers.}$$

where P = safe bearing power in pounds.
W = weight, in pounds, of striking parts of hammer.
H = height of fall in feet
A = area of piston in square inches
P = steam pressure in pounds per square inch
S = the average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammer.

The above formulas are applicable only when

(a) The hammer has a free fall.
(b) The head of the pile is free from broomed or crushed wood fiber.
(c) The penetration is at a reasonably quick and uniform rate.
(d) There is no sensible bounce after the blow. Twice the height of the bounce shall be deducted from "H" to determine its true value in the formula.

107.19. SAFE LOAD REQUIREMENTS. The bearing powers of timber piling, as determined by the foregoing formulas, shall be considered effective only when they are less than the crushing strengths of the piling. In general, piling shall be required to develop a bearing capacity of not less than 15 tons nor more than 25 tons. However, the character of the soil penetrated, conditions of driving, distribution, sizes and lengths of the piling involved, and the computed load per pile shall be given due consideration in determining the reliability of driven pile.

In case water jets are used in connection with the driving, the bearing power shall be determined by the above formulas from the results of driving after the jets have been withdrawn, or a load test may be applied.

107.20. TEST PILING. The lengths of piling shown on the plans are approximate and shall be used for estimating purposes only. Whenever called for on the plans, test piling shall be driven to determine more accurately the length of piling to be used for the proposed structure. Test piling shall meet the requirements herein specified

for untreated timber piling. The pile shall be of greater length than the lengths assumed in design in order to provide for any variation in soil conditions. The number, lengths, locations for driving, disposal of test piling above the ground line, etc., will be as directed by the Engineer. The number of test piling shown on the plans may be increased or decreased as deemed necessary to secure the desired information.

Test piling shall be driven in any manner herein specified for timber piling.

When test piling are specified, no piling for the proposed structure shall be ordered until test piling results with recommended lengths have been examined and approved by the State Bridge Engineer. In all cases, the order list must be approved by the Bridge Engineer before same is placed.

107.21. BASIS OF PAYMENT. All piling left in the structure, conforming to the specification requirements, and acceptable to the Engineer, will be paid for at the contract unit price bid per lineal foot for "Untreated Timber Piling" or "Treated Timber Piling" as the case may be, complete in place. Such price shall be full compensation for furnishing all piling, preservative and treatment, driving, jetting, pilot holes and shoes when indicated on the plans and no other payment provided, all materials, equipment, tools, labor and incidentals necessary to complete the work.

One half the contract unit price bid per lineal foot for "Untreated Timber Piling" or "Treated Timber Piling" as the case may be, complete in place, will be allowed for cutoffs made after driving, less one foot for each cutoff, provided this cutoff is not necessitated by unnecessary brooming, splitting or other injuries resulting from careless driving.

No payment will be made for falsework piling. No payment will be made for any piling which are not driven in accordance with the specifications, or as ordered by and made acceptable to the Engineer.

Test piling will be paid for at the contract unit price bid for each "Untreated Test Piling", which price shall be full and complete compensation for furnishing, driving and removal of piling, for all materials, equipment, tools, labor and incidentals necessary to complete the work.

INSPECTION NOTES. Where slightly seasoned, partially seasoned or seasoned piling are submitted for inspection the Engineer may require a few inches cut off the ends of piling before or after treatment.

Piling which show excessive checking before or after treatment and prior to driving shall be rejected. Excessive checking shall be interpreted as follows:

Where large check at butt of pile will permit a No. 10 wire to be extended three feet into the body of the pile.

Where checking is of such size that at any point along the pile two checks may occur which will permit a silver dollar to extend half its diameter into the side of the pile.

4279

STATE HIGHWAY DEPARTMENT OF TEXAS

(9-8-33)

ITEM 97. EXPANSION JOINT MATERIALS.

97.1. DESCRIPTION. Expansion Joint Materials shall provide for materials used in joints for structures whether the joint provides for expansion and contraction, deflection or construction. The materials shall be used where indicated on the plans and in accordance with the pertinent specifications.

97.2. PREMOLDED MATERIAL. Premolded material shall be a bituminous premolded joint of the dimensions required on the plans and shall be of asphaltic or tar composition of approved quality. The joint 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. The bitumen by weight in the bituminous joint shall be not less than 72 per cent for joints one inch or less in thickness and not less than 77 per cent for joints more than one inch in thickness. The bitumen by weight in rock asphalt joints shall be not less than 40 per cent. The physical properties of the joint material shall be as follows:

Absorption, not more than - - - - - - - - - - 5%
Distortion, not more than - - - - - - - - - - $1\frac{1}{2}$ inches
Brittleness: The joint shall not crack or shatter when subjected to the test for brittleness.

One section at least 1 foot long and the full width of the joint shall be submitted from each consignment and tested in accordance with the following method:

(a) Absorption. A sample 2 by 6 inches is cut from the joint material in such a manner that all edges are freshly cut and weighed. The specimen is then immersed in water for 24 hours, removed, and the surface water wiped off with a slightly dampened cloth. The specimen is then quickly weighed and the percentage of absorption computed.

(b) Brittleness. A sample 2 by 6 inches is cut from the joint material parallel to the lay of the fiber and maintained at a temperature of from 4° to 6°C. in water for at least two hours prior to testing. It is then clamped between two boards so that expansion joint cantilevers $3\frac{1}{2}$ inches and is held in any suitable support. A cast-iron ball, weighing 0.95 pound and having a diameter of 1.875 inches, is suspended by a cord, which is tied to an eyelet soldered to the ball. For samples having a thickness of nine-sixteenths inch or less, the ball is suspended 1 foot above the center of the projected portion of the specimen. For samples over nine-sixteenths inch in thickness the ball is suspended 2 feet above the specimen. The ball is released by burning the string above the eyelet.

(c) Distortion. A sample 2 by 6 inches, absolutely flat and straight, which has been cut parallel to the lay of the fiber, is clamped between two blocks so that the expansion joint cantilevers $3\frac{1}{2}$ inches. The clamp with the expansion joint is then placed in an oven maintained at 125°F. for two hours. The deflection from the horizontal is then measured.

97.3. POURED JOINTS. Asphalt for use in poured joints shall be homogeneous, free from water, and shall not foam when heated to 200°C. (392°F). It shall conform to the following requirements:

Flash point (open cup), not less than - - - - - 200°C. (392°F)
Softening point (ring and ball method) - - -65 to 110°C. (149° to 230°F.)
Penetration at 0°C (32°F.), 200 g., 60 sec., not less than - - - 10
Penetration at 25°C (77°F.), 100 g., 5 sec., - - - - - - - - - 30 to 50.
Penetration at 46°C (115°F.)., 50 g., 5 sec., not more than - - 110.
Loss on heating at 163°C, (325°F.), 50 g., 5 hrs., not more than 1.0%
Penetration at 25°C. (77°F.), 100 g., 5 sec., of residue after heating at 163°C. (325°F.), as compared with penetration of asphalt before heating, not less than - 60.0%
Ductility at 25°C. (77°F.), not less than - - - - - - - - - - - - - 3.0 cm.
Proportion of bitumen soluble in carbon tetrachloride, not less than - 99.0%
Total bitumen (soluble in carbon disulphide) not less than - - - 99.0%

97.4. MEASUREMENT AND PAYMENT. No direct payment will be made for expansion joint materials. Payment for same shall be included in the contract unit price bid per cubic yard of concrete as provided in these specifications, Item 102.

5291-2

CONCRETE FLOOR SLABS. In addition to the specifications given under Item 85 of the Standard Specifications of the State Highway Department of Texas, the following special provisions shall apply to the mixing, placing and curing of concrete for the floor slabs.

The mixing shall preferably be done by a portable outfit placed alongside the bridge and the concrete hoisted into place by a derrick or other suitable means.

If the mixer plant is to be located on the structure, it shall not be placed on a section of the roadway slab which has been placed less than 21 days. Special care shall be made in placing the concrete farthest away from the mixing plant and placing same towards the mixing plant in such a manner that the freshly placed concrete will not be damaged during the process of setting. In case the Contractor desires to cart or wheel concrete batches over the freshly placed concrete floor slab, same will not be permitted until the slab is at least seven days old and the trackway for carts shall be carried by timber planking so that the loads will be distributed over the slab.

Concrete floors shall be finished as provided in the specifications and shall be immediately covered with suitable sections of 10 oz. cotton canvas with a lap at edges of at least 8 inches. The canvas shall be saturated with water previous to placing. Great care must be taken in placing the canvas so as not to disturb the fresh concrete surface. The canvas shall be sprayed lightly with water at hourly intervals for a minimum time of eight hours and then as soon as practicable a half inch thickness of sand or earth covering substituted. The wet canvas must remain in place until the other cover material is ready for placing. The cover material must be saturated with water eight times per day for a period of 8 days. Ponding may be used instead of the earth or sand cover mentioned above.

The roadway surface shall be struck off with a templet having a crown as shown on the plans. The surface shall be brought to a smooth riding surface preferably by means of longitudinal screeding, which shall be free from rolls or bumps and shall show no deviation more than $\frac{1}{4}$ inch from a 10 ft. straight edge laid on the surface parallel to the center line of the roadway.

Compensation for curing concrete floor slab and other incidentals involved in the construction of the floor slab shall be included in the unit price per cubic yards of concrete for same.

5482

STATE HIGHWAY DEPARTMENT OF TEXAS

SPECIAL ITEM. HIGH EARLY STRENGTH CONCRETE FOR STRUCTURES

1. DESCRIPTION. High Early Strength Concrete shall consist of concrete so proportioned to attain a high early strength as hereinafter provided, with a minimum cement content as specified in Par. 85.1. It shall be used for structures or portions of structures when desired by the Contractor and approved by the Engineer. The standard specification for "Concrete" (Item 85) shall apply for High Early Strength Concrete except as herein provided.

2. MATERIALS. Materials used for high early strength concrete shall be as provided in Item 85. The cement used shall be standard Portland Cement as provided in Item 85 or shall be High Early Strength Portland Cement conforming to the requirements of the American Society for Testing Materials as set out in their "Tentative Standards for High Early Strength Portland Cement" Serial Designation C-74-30-T.

3. DETERMINATION OF STRENGTH. The various materials entering into and composing the concrete shall be such as to satisfy the requirements of the governing specifications. During the progress of the work concrete test cylinders or beams will be made by the Engineer and tested for compressive strength or modulus of rupture for the purpose of checking the field control of the quality of the concrete. Three such specimens shall be made from each run of concrete representing a unit of the finished structure, but in each event such specimens shall be made for every 50 cubic yards of concrete placed or for every 225 lineal feet of piling cast.

The method of making and testing cylinders shall be in accordance with the requirements of the "Tentative Standard Specifications for Highway Materials and Methods of Sampling and Testing" of the American Association of State Highway Officials. The method of making and testing transverse slabs for modulus of rupture shall be in accordance with Bulletin C1 of the State Highway Department.

4. STRENGTH REQUIREMENT. High Early Strength Concrete shall attain a compressive strength or modulus of rupture complying with the following requirements twenty-four (24) hours after placing.

	COMPRESSIVE STRENGTH	MODULUS OF RUPTURE
Class A Concrete	2200 lbs. per sq. in.	500 lbs. per sq. inch
" B "	1700 " " " "	375 " " " "
" D "	2600 " " " "	550 " " " "

The proportions of cement to aggregate for high early strength concrete in which standard Portland Cement is used shall be designed to obtain the strengths shown in the above table. Such designs shall be checked and approved by the Engineer.

5. CURING. Shall be in accordance with the requirements of the Standard Specifications but may be discontinued when the required strength, determined by tests has been secured but in no case shall the period for keeping the concrete surfaces thoroughly wet be less than three days, after which the surfaces shall be covered with sand, earth or other suitable material and kept moist by sprinkling with water at least three times each day three additional days.

6. REMOVAL OF FORMS. The following compressive strengths and modulus of rupture shall be attained before forms are removed or the concrete placed in service.

	COMPRESSIVE STRENGTH	MODULUS OF RUPTURE
Class A Concrete	3500 lbs. per sq. in	700 lbs. per sq. in.
" B "	3000 " " " "	600 " " " "
" D "	4000 " " " "	750 " " " "

The following table shall serve as a general guide for the minimum time required before removal of forms, not counting the days on which the temperature is below 40 degrees unless proper precautions have been taken to maintain the concrete at a satisfactory higher temperature.

Forms, centering and supports under beams, girders and slabs;	
of less than 20 ft. clear span	four (4) days
of over 20 ft. and less than 30 ft.	six (6) days
of over 30 ft. and less than 40 ft.	seven (7) days
Floor slabs	three (3) days
All other parts	three (3) days

After removal of forms and centering concrete may be subjected to only such loading as was provided for in the design of the structure.

7. CONCRETE PILING. The contractor may, at his option, use High Early Strength Cement Concrete "Class D" as herein provided for, in concrete piling.

Such piling shall not be moved and stacked in less than three (3) days after making nor driven in less than seven (7) days, and in no event until a compressive strength of four thousand (4000) pounds per sq. in. and a modulus of rupture of 750 lbs. per sq. in. has been attained, to the satisfaction of the Engineer.

Curing shall be in accordance with the provisions of these specifications given above.

8. GOVERNING SPECIFICATIONS. The special provisions of this specification will govern over Item 85 for concrete when High Early Strength Concrete is used or specified, but the remainder of Item 85 shall remain in full force. No additional compensation will be allowed the contractor when High Early Strength Concrete is used or specified but shall be paid for at the contract unit price bid for the class of concrete in which it is used.

Measurement and Payment for High Early Strength Concrete, complete in place, shall be as provided in the standard specifications for "Concrete Structures", Item 85.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 108. PRECAST CONCRETE PILING.
(August, 1932)

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108.1. DESCRIPTION. Precast concrete piling shall consist of piling precast of portland cement concrete made and reinforced in accordance with these specifications and in conformity with the pertinent designated plans. They shall be driven in accordance with these specifications in the location and to the elevation shown on the plans or as directed by the Engineer.

108.2. MATERIALS. All concrete materials and their preparation and placing shall be in accordance with the requirements of Class D concrete, (All coarse aggregate to pass a 1-inch diameter circular ring.) When the Contractor is ordered to proceed with the work and the data from specified test piling or other sources is available, the Engineer will furnish the Contractor with an approved list of piling lengths for casting.

Reinforcement shall conform to the requirements for reinforcing steel of these specifications, and the weight and dimensions shall be as shown on plans.

108.3. DESIGN. Precast concrete piling may be square, circular, or octagonal in section. If a square section is used, the corners shall be chamfered at least one inch. Piling shall be cast with a driving point as shown on plans and for hard driving shall be shod with a metal shoe as indicated on plans. Piling may be either of uniform section or tapered as desired. Tapered piling shall not, in general, be used for trestle construction except for that portion of the pile which extends below the ground line; nor shall tapered piling be used in any location where the piling are to act as columns. In general, concrete piling shall have a cross-sectional area, measured above the taper, of not less than 140 square inches and, when they are to be used in salt water, they shall have a cross-sectional area of not less than 220 square inches.

Reinforcement for precast concrete piling shall consist of longitudinal bars in combination with lateral reinforcement in the form of hoops or spirals. The longitudinal reinforcement shall be not less than 1 per cent and preferably not less than $1\frac{1}{2}$ per cent of the total cross-section area of the pile. The reinforcement shall be placed at a clear distance from the face of the pile or not less than 2 inches, and, when the piling are for use in salt water or alkali soils, this clear distance shall be not less than 3 inches. The driving point and also the top of the pile shall be protected against impact by means of special spiral winding or bands designed for this purpose. The reinforcing system shall preferably be of the "unit" type, rigidly wired or fastened at all intersections and held to true position in the forms by means of concrete blocks or other suitable device. Where piling exceeds 55 feet in length, additional longitudinal reinforcement shall be added throughout the center one-third of the length. Piling under retaining walls, abutments, etc., shall be designed to withstand the lateral stress induced.

Concrete piling when properly designed, constructed and placed, may be subjected to loads as determined by tests or formula, but not to exceed 300 pounds per square inch of total cross-section at the smallest effective point and generally not to exceed 25 tons per pile with a maximum limit of 35 tons per pile.

Where waterproofing is to be used, special specifications will be given and the work shall be in accordance therewith.

108.4. FORMS. In addition to the requirements for forms as provided in Item 102.5, the following shall govern for concrete piling:

Form lumber for the side forms shall not be less than one and one-quarter ($1\frac{1}{4}$) inches in thickness after being surfaced. Studding and waling shall be so spaced as to prevent the spreading of forms. All forms shall be built mortar tight. Forms shall be so maintained as to eliminate the formation of joints due to shrinkage of the lumber.

Forms re-used shall be oiled and maintained in good condition as to accuracy of shape, rigidity, strength, mortar tightness and smoothness of surface. Any warped or bulged lumber must be properly sized and re-conditioned before re-using. When vertical forms are used, special care shall be exercised to puddle and tamp the concrete around the reinforcing and to avoid the formation of stone pockets. When horizontal forms are used, the piling shall not be cast in tiers.

Forms shall be accessible for tamping and consolidation of the concrete. Under good weather-curing conditions, side forms may be removed at any time not less than twenty-four hours subsequent to placing concrete, but the entire pile shall remain supported for at least seven days, and shall not be subject to any handling stress until the concrete has set for at least fourteen days, and for a longer period in cold weather; the additional time to be determined by the Engineer.

108.5. CASTING. Piling may be cast either in a vertical or horizontal position. Piling cast in horizontal position shall be supported on a level unyielding foundation. When timber sills are used they shall be of such dimentions as will support the weight of the concrete thru-out without settlement. The transverse studding shall be so spaced as to prevent the sagging of flooring.

During the placing of concrete, the forms shall be vibrated by tapping with a hammer or wooden maul. Concrete shall be placed continuously in each pile and shall be carefully spaded, puddled, and tamped, date marked, special care being exercised to avoid horizontal or diagonal cleavage planes, and to see that the reinforcement is properly embedded in the concrete.

108.6. CURING. The piling shall be cured by being kept thoroughly wet for a period of seven days and at the same time protected from the direct rays of the sun. After this 7-day period the piling shall be kept damp and covered for a period of 21 days. The piling shall not be subjected to any handling stress, but kept upon the molding platform for a period of at least 14 days after molding. Under normal weather conditions, and as soon as the piling have cured sufficiently to permit, they may be removed from the forms. Unless otherwise provided no pile shall be driven until it has set for at least thirty days, and in cold

weather for a longer period, as determined by the Engineer. Concrete piling for use in sea water or alkali soils shall be cured for not less than sixty days before being used.

108.7. FINISH. As soon as the forms are removed, concrete piling shall be carefully pointed with 1:2 mortar, filling up all cavities or irregularities.

Trestle piling exposed to view shall be finished above the ground line in accordance with the provisions of Paragraph 102.20 governing the finishing of concrete columns. Foundation piling, that portion of trestle piling which will be below the ground surface, and piling for use in sea water or alkali soils, shall not be finished except by painting as above set forth.

108.8. HANDLING. For precast piling the method of storing and handling shall be such as to eliminate the danger of fracture by impact or undue bending stresses, in curing or transporting the piling from the molds and into the leads. In general, concrete piling shall be lifted by means of a suitable bridle or sling attached to the pile at points not over 20 feet apart. In no case shall the methods of handling be such as as to induce stresses in the concrete of more than 650 pounds compression per square inch or in the reinforcing steel in excess of 12,000 pounds per square inch, allowing 100 per cent of the calculated load for impact and shock effects.

In handling piling for use in sea water or alkali soils, special care shall be exercised to avoid injury to the surface of the pile.

108.9. DRIVING EQUIPMENT. The driving of concrete piling shall be done with steam pile hammer equipment meeting the following requirements.

If a single acting steam hammer is used it shall be capable of striking at least 60 blows per minute of not less than 17,000 ft. lbs. per blow and shall operate on an efficiency of not less than 80 percent of the Manufacturers' rated capacity, or if a double acting steam hammer is used, it shall be capable of striking not less than 110 blows per minute of not less than 12,000 ft. lbs. per blow and shall operate on an efficiency of not less than 80 percent of the Manufacturers' rated capacity.

Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer and they shall be rigidly held in position by stiff braces or guys to insure adequate support to the pile during driving. Except where piling are driven through water, the leads shall be of sufficient length so that a follower will not be necessary.

Gravity hammers, when their use is permitted, shall weigh not less than the weight of the pile and the maximum drop shall not exceed 8 feet.

Requirements for equipment and driving large concrete piling will be covered by special specifications.

108.10. PENETRATION. The piling shall be driven to a depth as shown on the plans, or to a greater depth if same is necessary to secure a bearing power specified on plans, as determined by formula given in Paragraph 108.11 of these specifications.

The following methods are given for securing the desired penetration for concrete piling:

(a) In localities where water is available and the material is suitable for jetting such as sand or gravel or a mixture of both, or a mixture of sand and clay, the Contractor shall provide jetting equipment as an auxiliary to the steam hammer as a means of placing the concrete piling. The equipment shall be as follows:

Sufficient power shall be provided in addition to that used for operating the steam hammer to operate one or more pumps and one or two (depending upon requirements of material) 2½" inside diameter jet pipes provided with a 1" diameter nozzle. The plant shall be such that with two pumps operating at the same time each pump shall be capable of delivering a minimum of 200 lbs. pressure per square inch at the nozzle.

The two jets may be used together or separately, depending upon trial results obtained during the driving. The compensation for furnishing jetting equipment and jetting operations shall be included in the unit price bid per linear foot of concrete piling.

If water jets and a hammer are used for driving, the jets shall be withdrawn and the piling shall be driven by the hammer to secure the final penetration. This procedure may be varied if the desired results are not obtained.

(b) Pilot Holes: For soil material which will not permit of efficient jetting operations and the piling are to penetrate a hard or firm material which cannot be penetrated by ordinary driving, the Contractor shall use a device for making pilot holes so that the piling may be placed to depth required and driven to a specified resistance as follows:

The pilot holes shall unless otherwise provided be of a diameter 2" less than the least side or diameter of the piling and shall be made to such depth necessary to secure the penetration shown on the plans. Where necessary in solid rock or other firm material the pilot holes may be of the same diameter as the piling. Where pilot holes are required in material which consists of loose sand or gravel overlying a hard clay or shale which cannot be sealed off by ordinary "mudding" drilling methods, the following method shall be used.

A casing pipe of sufficient diameter shall be placed around the boring device and of sufficient length to extend down through the upper strata of loose material to the firm material and same must be held in position until the pilot holes are completed and the driving of the concrete piling is started a sufficient depth through the clay material to prevent sand and other loose material from dropping into the pilot hole. Should boring or drilling of pilot holes be necessary in order to place the concrete piling, the cost of forming pilot holes and other incidental work included therewith sahll be included in the unit price bid for the concrete piling in place. Each pile shall be

driven to a resistance specified on plans as computed by the formula given in the specification of Paragraph 108.11.

108.11. BEARING VALUE. When required, the bearing value of piling shall be determined by actual loading tests. In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, together with suitable apparatus for accurately determining the superimposed weight and the settlement of the pile under each increment of load. The safe allowable load shall be considered as 50 per cent of that load which, after 48 hours application, causes a permanent settlement, measured at the top of the pile, of not more than one-fourth inch.

In the absence of the loading tests, the safe bearing values for piling shall be determined by the following formulas:

$$P = \frac{2WH}{S + 1.0} \quad \text{for gravity hammers}$$

$$P = \frac{2WH}{S + 0.1} \quad \text{for single-acting steam hammers}$$

$$P = \frac{2H(W + Ap)}{S + 0.1} \quad \text{for double-acting steam hammers}$$

Where P = safe bearing power in pounds
W = weight, in pounds, of striking parts of hammer
H = height of fall in feet
A = area of piston in square inches
p = steam pressure in pounds per square inch at the hammer
S = the average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammer.

The above formulas are applicable only when

(a) The hammer has a free fall.
(b) The penetration is at a reasonably quick and uniform rate.
(c) There is no sensible bounce after the blow. Twice the height of the bounce shall be deducted from "H" to determine its true value in the formula.

In case water jets are used in connection with the driving the bearing power shall be determined by the above formulas from the results of driving after the jets have been withdrawn, or a load test may be applied.

Jetted piling shall extend to a good solid stratum. Their carrying capacity shall be determined by actual test or, if driven with the aid of a jet and for the last five blows of the gravity hammer or last twenty blows of the steam hammer, driven without any jet, the same formula may be applied as in the case of driven piling.

When required, the Contractor shall drive test piling of a length and at the location designated by the Engineer. These piling shall be of greater length than the length assumed in the design in order to provide for any variation in soil conditions.

108.12. CUT-OFFS, SPLICES OR BUILD-UPS. Extensions, splices, or "build-ups" on concrete piling generally shall be avoided but when necessary they shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel exposed for a length of forty diameters; the final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary form work shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used originally in the pile. Just prior to placing concrete, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement retempered mortar, or either suitable bending material. The forms shall remain in place not less than seven days and shall then be carefully removed and the entire exposed surface of the pile finished as above specified.

108.13. ALLOWABLE VARIATION FOR DRIVING. The precast concrete piling for trestle shall be driven to the vertical or batter line indicated, not to exceed the following allowable variations:

(a) In the direction of the center line of the project the top of the completed piling shall not be more than 4 inches from the position shown on the plans.

(b) In the direction at right angles to the center line of the project, or along the line of the bent, the top of the completed piling shall not be more than 8" from the position shown on the plans.

108.14. MEASUREMENT AND PAYMENT. (a) Precast concrete piling will be paid for at the contract unit price bid per lineal foot, measurement being made on the lineal feet of acceptable piling in place after all cut-offs have been made.

(b) Cut-offs will be paid for at one-half the contract unit price bid per lineal foot where the cut-off is above grade. Where the cut-offs are below grade for the purpose of making build-up no allowance will be made for same.

(c) In the case of "Build-Ups" the Contractor will be paid 1½ times the contract unit price bid per lineal foot for precast concrete piling, measurement of build-ups to be taken after cut-offs are made to secure 40 diameter splice of the main reinforcing steel. No allowance for "Build-ups" shall be made where same are necessary due to improper handling or driving of piling.

The foregoing shall be full compensation for furnishing all materials including reinforcement, tools, labor, equipment, jetting, pilot holes and incidentals necessary to complete the work.

The cost of metal shoes will be paid for at unit bid price or as an extra plus 15 per cent if no bid price is made, but the labor in placing shall be included in the unit bid price for piling. Piling ordered cast and not used will be paid for on the same basis as Cut-offs.

5082-7

TEXAS STATE HIGHWAY DEPARTMENT

OPEN CAISSON PIER CONSTRUCTION

Description: Open caisson construction of bases for piers consisting of reinforced concrete, steel shell, steel shell lined with concrete or timber caissons or cofferdams constructed above the ground or water line and lowered into position by the open dredging method shall be constructed of such materials and as shown on the plans to the dimensions, grades, and in conformity with the general specifications when not in conflict with these provisions. When conditions are encountered during construction which are not shown on the general plans, the Engineer will make such changes as necessary in alignment, elevations or dimensions to obtain safety and stability of construction as anticipated by original designs.

Materials: All materials shall comply with the requirements of the general specifications unless otherwise provided by notations on the plans or supplementary provisions attached.

Construction Methods: The construction of caissons shall be made above the ground or water line. Where necessary, the falsework shall be provided to support the caisson during the construction and lowering period. Such falsework shall be rigidly constructed to support the loads which may come upon it such as wind, water currents, drift, etc., as well as the load of the caisson. Forms for concrete caissons may be of wood or metal of good quality and well braced to insure correct dimensions, alignment, and placing of concrete. Care shall be used to maintain a vertical outside face of caisson.

Concrete for caissons shall be Class "A" mix unless otherwise provided. The concrete shall be allowed to set for a period of forty-eight hours after placing before being lowered or otherwise moved from its position of placing. When so desired by the Contractor, a cement producing high early strength concrete may be used for the concrete in caissons and lowering may begin twelve hours after placing. No additional compensation will be allowed on account of the use of such cement. Concrete shall be placed and tamped in such manner as to prevent "honeycombs" and shall be made as water-tight as practicable. Construction joints should be avoided where possible and when used, care should be taken to obtain water-tight joints.

Reinforcement shall be wired in place to dimensions as shown on the plans. Dowels shall be used at construction joints where not provided on the plans and bill of steel revised accordingly before placing order.

The weight of the caisson is considered ample for lowering under ordinary conditions which may be encountered. In addition to interior dredging the lowering of caissons shall when necessary be facilitated by the following methods:

(1) Addition of weight by increasing thickness of caisson by adding to outside dimensions or by the addition of removable loads to the top of the caisson.

(2) Water or air jets placed around the sides of caissons.

(3) The use of explosives which will be permitted in extreme cases only and in light charges which will in no manner damage the construction. Written permission must be given by the Engineer prior to use of explosives.

The excavation shall be made from the inside of the caisson only. Excavated materials shall be disposed of as provided by the general specifications and as directed by the Engineer. Where the original ground surface adjacent to caissons has been disturbed due to slides, cave-ins, washes, etc., it shall be backfilled to the original surface with material acceptable to the Engineer. The excavation and lowering of caisson shall proceed until the final position, acceptable to the Engineer, is reached. When foundation piling are to be used the excavation should be carried below the bottom of caisson to a depth sufficient to allow for swell of material during driving of piling. After driving of piling, if the foundation material rises to a point more than one foot from bottom of caisson, the Contractor shall be required to remove such material to the level of the bottom of caisson.

Timber or concrete foundation piling shall be driven with an under-water hammer or by the use of a follower where the piling are to be placed below the water line. Water jets shall be used where necessary to obtain penetration or safe load required and to prevent over-driving of piling which would cause them to break, split or broom.

The depth of seal course required shall be 0.4 of the existing water head. The seal may be placed with a tremie or bottom dump bucket in accordance with the provisions of the general specifications. The class of concrete for seal course shall be Class "A" with an addition of ten percent cement. If a tremie is used for placing seal, it should be placed and operated around piling to obtain a near level surface of concrete with as few set-ups as possible. The completed seal shall not be higher or lower than 1/16 the largest inside caisson dimension at point of finished seal as shown on the plans or as altered by the Engineer, or the maximum variation of top of seal shall not be more than 1/8 the maximum inside caisson dimension.

The seal shall be allowed to set for at least 100 hours before unwatering caisson. After unwatering, the top of seal shall be cleaned of all laitance or other loose materil which can be readily loosened with a pick. Piling shall be cut off at such elevations as to provide doweling into base without interference to reinforcing mat as shown on the plans and not necessarily at the same elevation.

The placing of concrete base above seal course shall proceed only after caisson is free from water, seal course cleaned and piling cut off as above specified. The concrete for base course shall be Class "B" unless otherwise provided. Reinforcing dowels, concrete keyway and copper sheet metal protection shall be provided at the top of base as provided on the plans.

Shafts, webwall, struts and copings shall be constructed in accordance with the plans and general specifications. All reinforcing steel except in caissons shall have a minimum concrete cover of 3 inches below the ground or water line. Where shafts, struts or webwall are to be constructed below the water line and are not protected by caissons, temporary cofferdams or water-tight forms shall be provided. All construction joints below the ordinary high water line shall be constructed as shown on the plans. Construction joints above the ordinary high water line shall be provided with ample dowels and concrete keyway, but the copper sheet metal around reinforcing steel may be omitted.

Construction Changes: In order to obtain suitable foundation the Engineer may vary the depth of footings as necessary. Such variations will be necessary only when conditions encountered are not in accordance with data shown on the plans and anticipated for design. For such changes of not more than five feet in depth the depth of seal will be determined as 0.4 the existing water head, the depth of base will remain the same and the lower shaft length will be increased or decreased as necessary maintaining the same batter.

For changes of more than five feet in depth, the design may be revised.

Method of Measurement: The yardage of structural excavation for caissons to be paid for will be that actually removed and measured in its original position by the cross section method to the outside caisson dimensions. Structural excavation for piers other than caissons shall be measured as above except that no measurement will be made of material removed from outside of a volume bounded by vertical planes, twelve (12) inches outside the outside concrete dimensions and parallel thereto. Such measurements will not include additional yardage caused by slips, slides, cave-ins, siltings or fillings due to the action of the elements or the carelessness of the Contractor. Water will not be classed as excavated material.

Concrete of the several classifications, reinforcing steel, structural steel, foundation piling, and timber will be measured as provided in the general specifications.

Basis of Payment: Payment shall be made for the following items of open method pier construction, where such items are shown on the plans, in accordance with the general specifications for the item. Structural Excavation, Treated timber, Untreated timber, Class "A" Concrete plus ten per cent Cement, Class "A" Concrete, Class "B" Concrete, Reinforcing Steel, Structural Steel, untreated timber piling, treated timber piling, precast concrete piling.

Payment for all jetting, weighting, backfilling, blasting and sinking of caissons to be included in the unit price bid per cubic yard of excavation.

Payment for unwatering caissons, furnishing and placing copper metal shoots for construction joints and temporary cofferdams where required to be included in the unit price bid per cubic yard for concrete.

Payment for cleaning top of seal course to be included in the unit price bid per cubic yard of Class "A" Concrete plus ten percent Cement.

No partial payments will be made on items of pier construction until after caissons have been lowered to their correct positions and seal course placed, all to the satisfaction of the Engineer.

Basis of Payment for Changes: Where necessary to carry the footing elevations to a greater depth than shown on the plans, then the unit contract price for structural excavation will be increased at the rate of two percent (2%) per foot for each additional foot of depth required, but no increase in price will be allowed for any other items of contract. Monthly estimates will be based on the bid unit price for structural excavation and should there be an adjustment necessary in the unit price on account of deeper excavation, such increased amounts will be allowed in the final estimate.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 78 - RIP-RAP

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Note: Effective Sept. 1, 1930, this item supersedes Item 107 and 108 of the Standard Specifications approved Feb. 26, 1926.

78.1. DESCRIPTION. Rip-Rap shall provide for a protective covering of stone, precast concrete or concrete in bags placed along the slopes of embankments or around foundations at such places as indicated on the plans or as directed by the Engineer. The work shall be done in accordance with these specifications, and in conformity with the depth of course and other details shown on the pertinent plans.

78.2. MATERIALS. The stone used shall consist of field stone or rough unhewn quarry stone as nearly rectangular in section as is practicable. The stone shall be dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended.

For precast concrete Rip-Rap the material shall conform to requirements provided in these specifications, "Concrete for Structures."

78.3. CONSTRUCTION METHODS. Stone, precast concrete or concrete in bags for embankment protection shall be placed upon a slope not steeper than the natural angle of repose of the filling material and so laid that the weight of the Rip-Rap material is carried by the earth and not by the adjacent stones, blocks or bags.

Mortar, Grouted and Precast Concrete Rip-Rap shall not be placed on embankment slopes until the embankment has been thoroughly compacted.

78.4. DRY RIP-RAP CLASS 1 FOR SLOPE WALLS. Unless otherwise specified, all stones used in this class of rip-rap shall weigh between 50 and 150 pounds each and at least 60 percent of them shall weigh more than 100 pounds each. The stones shall be laid with close joints and shall be placed on end with the upright axes of the stones sloping toward the top of the bank. The courses shall be laid from the bottom of the bank upward, the larger stones being placed in the lower courses. Open joints shall be filled with spalls.

78.5. DRY RIP-RAP CLASS 2 FOR SLOPE WALLS. Stones having one broad flat surface shall be used when possible, this surface being laid on a horizontal earth bed prepared for it and so placed as to overlap the underlying course, the intent being to secure a lapped or "Shingled" surface which will shed a maximum amount of water. Fifty percent of the mass shall be of stones having a volume of two cubic feet or more. These stones shall be placed first and roughly arranged in close contact. The spaces between the larger stones shall then be filled with stone of suitable size so placed as to leave the surface evenly stepped, conforming to the contour required, and capable of shedding water to the maximum degree practically attainable.

78.6. MORTAR RIP-RAP FOR SLOPE WALLS. Stone for this purpose shall, as far as practicable, be selected as to size and shape in order to secure fairly large, flat surfaced stone which will lay up with a true and even surface and a minimum of voids. Fifty per cent of the mass shall be broad flat stones, two cubic feet or more in volume, laid with the flat surface uppermost and parallel to the slope. These stones shall be placed first and roughly arranged in close contact, the largest stones being placed near the base of the slope. The spaces between the larger stones shall be filled with stone of suitable size, leaving the surface smooth, reasonably tight and conforming to the contour required. In general, the stones shall be laid with a degree of care that will insure for plain surfaces a maximum variation from a true plane of not more than 3 inches in 4 feet. Warped and curved surfaces shall have the same general degree of accuracy as specified above for plane surfaces. As each of the larger stones is placed, it shall be surrounded by fresh mortar and adjacent stones shall be shoved into contact. After the larger stones are in place, all of the spaces or openings between them shall be filled with mortar and the smaller stones then placed by shoving them into position, forcing excess mortar to the surface and insuring that each stone is carefully and firmly bedded laterally.

After the work has been completed as above described, all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints shall then be roughly pointed up either with flush joints or with shallow, smooth raked joints.

78.7. GROUTED RIP-RAP FOR SLOPE WALLS. Grout for grouted rip-rap shall consist of one part of Portland Cement and three parts of sand, thoroughly mixed with water to produce a grout having a thick, creamy consistency.

The stone shall be placed in the same manner as specified above for Dry Rip-Rap, Class 1, care being taken to keep earth or sand from filling the spaces between the stones. After the stones are in place, the spaces between them shall be completely filled with grout from bottom to top, and the surface swept with a stiff broom. No rip-rap shall be grouted in freezing weather and in hot dry weather the work shall be protected from the sun and kept moist for at least three days after grouting.

78.8. STONE RIP-RAP FOR FOUNDATION PROTECTION. Stone rip-rap for pier and abutment protection shall be of sizes ranging from derrick stone down and shall be graded from coarse to fine in such manner as to produce a minimum of voids. It shall be deposited where directed; stone deposited contrary to directions will be considered wasted and will not be paid for.

78.9. CONCRETE RIP-RAP IN BAGS. Concrete rip-rap in bags shall consist of Class "C" concrete in cement sacks or suitable burlap bags. The bags shall be about two-thirds filled with concrete, securely wired, and immediately placed in the work. When used for foundation protection the bags of concrete shall be placed in accordance with the provisions governing the placement of stone rip-rap for foundation protection as specified above. When used for slope protection, rip-rap of this material shall be placed in conformance with the above specified provisions governing the placement of Dry Rip-Rap, Class 1.

78.10. PRECAST CONCRETE RIP-RAP. Precast concrete rip-rap shall consist of precast concrete slabs or blocks to the size and shape shown on the plans. The slabs or blocks shall be of Class "A" concrete cast in accordance with the pertinent concrete specifications. They shall be placed on the slopes as indicated on the plans and as provided in these specifications. Where reinforcement is provided the payment for same shall be included in the unit price per cubic yard of concrete.

78.11. METHOD OF MEASUREMENT. "Dry Rip-Rap, Class 1", "Dry Rip-Rap, Class 2", "Mortar Rip-Rap" and "Grouted Rip-Rap", for slopes, "Stone Rip-Rap for Foundations", "Precast Concrete Rip-Rap" and "Concrete Rip-Rap in Bags" shall be measured by the cubic yard of completed work in accordance with the plans or as altered by the Engineer.

78.12. BASIS OF PAYMENT. "Dry Rip-Rap, Class 1", "Dry Rip-Rap, Class 2", "Mortar Rip-Rap", "Grouted Rip-Rap", "Stone Rip-Rap for Foundations", "Precast Concrete Rip-Rap" and "Concrete Rip-Rap in Bags" shall be paid for at the contract unit price per cubic yard which shall be full compensation for furnishing all materials, tools, labor, equipment, preparation of slopes, and incidentals necessary to complete the work.

4322 Revised Feb. 2, 1932.

STATE HIGHWAY DEPARTMENT OF TEXAS
ITEM 82
REMOVING OLD STRUCTURES

82.1. DESCRIPTION. Removing old structures shall provide for the removal and disposal of old structures as shown on the plans, in accordance with these specifications and as directed by the Engineer, unless otherwise provided. It shall also include all excavation and backfilling where necessary in the removal of structures.

82.2. METHODS OF REMOVAL.

Culverts. Pipe culverts shall be removed by excavating all dirt on top and within six inches of the sides, and in such manner that the pipe will not be damaged.

Concrete Structures. Concrete structures or concrete portions of structures shall be removed by blasting and sledging up the concrete into sizes not larger than one cubic foot.

Concrete portions of bridges below the permanent ground line which will not, in any manner, interfere with the proposed construction may be left in place. The removal shall be carried at least two feet below the permanent ground line and neatly squared off. Reinforcement shall be cut off close to the concrete.

Steel Structures. Steel structures or steel portions of structures shall be carefully removed in sections as determined by the Engineer. Trusses shall be carefully match-marked with paint according to diagram furnished by the Engineer prior to dismantling.

All rivets and checked bolts shall be removed where necessary by cutting the heads with a "cold cut" and punching or drilling from the hole, or by such other method which will not injure the members, meeting the approval of the Engineer.

Timber Structures. Timber structures or timber portions of structures shall be removed in such manner as to damage the timber for further use as little as possible. All bolts and nails shall be removed from such lumber as deemed salvageable by the Engineer.

Salvaging. All material such as pipe culverts, structural steel, timber, railings, etc., which is deemed salvageable by the Engineer shall be carefully placed in neat piles along the right-of-way at convenient loading points which will not interfere with traffic or construction. All materials salvaged shall be the property of the State Highway Department.

Materials such as concrete, reinforcement, timber, etc., which is not deemed salvageable by the Engineer, shall be placed in neat piles along the right-of-way so as not to interfere with construction or traffic and as not to obstruct the flow of the stream, unless otherwise provided.

Where temporary structures are necessary for a detour adjacent to the present structure the Contractor will be permitted to use the material in the old structure for the detour structure, but shall dismantle and stack the material as required above as soon as the new structure is opened for traffic.

The Bidders' attention is called to Par. 7.9 regarding responsibility in the use of explosives.

82.3. METHOD OF MEASUREMENT. The work as provided for by this item shall be measured as each individual structure to be removed.

82.4. BASIS OF PAYMENT. The work as prescribed for in this item shall be paid for at the unit price bid each for "Removing Old Structures," which price shall be full compensation for all work, labor, tools, materials and incidentals necessary to complete the work.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 96-T. WATERPROOFING (Jan. 1, 1934)

96.1-T DESCRIPTION: Waterproofing shall provide for a protective covering for concrete surfaces of the type herein specified.

DOUBLE MOP COATING METHOD

96.2-T DOUBLE MOP COATING METHOD: The double mop coating method shall consist of a prime and final coating of waterproofing of materials and application conforming to the following requirements.

96.3-T PRIME COAT: The prime coat shall meet the requirements of either the manufactured Cut-back (A) or the field mixed cut-back (B) as shown below:

(A) MANUFACTURED CUT-BACK

Specific Viscosity (Engler at 50°C) (first 50 cc) ---------- 8 to 15

Distillation Special Method of Asphalt Association for separation of asphalt base from distillate.

Distillate by Volume.

To 175°C ----------not less than ----------15%
To 190°C ----------not less than ----------20%
To 225°C ----------not less than ----------25%
To 360°C ----------not more than ----------45%

Specific Gravity Distillate at 25°C -- not more than -- 77

The residue from the distillation to 360°C shall meet the following requirements:

	Min.	Max.
Penetration at 25° C (100 g. 5 sec.) --------		250
Total Bitumen (Soluble in Carbon disulphide)	995	
Ductility -- cms	50	

(B) FIELD MIXED CUT-BACK

The field mixed cut-back shall be composed of gasoline, kerosene, and asphalt mixed as directed below and in the approximate quantities, by weight, of 1 part gasoline to 1 part kerosene to 3 parts asphalt.

The gasoline shall be commercial white gasoline.
The kerosene shall be commercial kerosene oil.
The asphalt shall meet the requirements of item 96.4-T

When the asphalt has been heated to an easy stirring consistency the vessel in which it is heated shall be removed from the flame and allowed to cool slightly. The kerosene shall then be added and stirred and the mixture be allowed to cool further after which the gasoline shall be added and the whole mixture thoroughly stirred. This should produce a cut-back of approximately the viscosity specified for the above manufactured cut-back.

96.4-T FINAL COAT: The final coat shall consist of a grade of asphalt as specified below, heated to a temperature between 300°F. and 350°F with frequent stirring to avoid burning. The heating kettle shall be equipped with thermometers. Any batch which shows evidence of having been burned or which has been heated above 700°F shall be rejected and not used on the work. Waterproofing asphalt shall meet the following requirements:

		Min.	Max.
1.	Flash point °F	392	
2.	Softening point °F	149	
3.	Penetration at 25°C. (77°F.), 100 g., 5 sec.	10	50
	Penetration at 0° C. (32°F.), 200 g., 1 min.	10	
	Penetration at 26.1°C. (115°F.), 50 g., 5 sec.		110
4.	Ductility at 25° C. (77° F) cms	2	
5.	Loss at 163°C (325°F) 5 hrs. %		1
	Penetration of residue at 25° C (77°F), 100 g. 5 sec. as compared to penetration before heating not less than 60%		
6.	Bitumen (soluble in carbon disulphide) %	99.5	

96.5-T PREPARATION OF CONCRETE SURFACES: The surface to be waterproofed shall be smooth, dry, free from projections or porous places and shall be thoroughly cleaned of dust and loose material. The dryness requirement will be such that no steam is formed when the hot asphalt is applied.

96.6-T APPLICATION: No waterproofing shall be done in wet weather or when the temperature is below 35° F.

The prime coat may be applied by the use of mops as ordinarily used for applying tar roofing. The entire surface to be waterproofed shall be completely covered with the prime coat material.

After the prime coat has been applied and allowed to remain in place from 2 to 3 days, depending on weather conditions, the final coat may be applied by the use of mops. The final coat shall be applied at a temperature of not less than 250° F. On horizontal surfaces not less than 4 gallons of asphalt shall be used for 100 square feet of finished work and on vertical surfaces not less than 5 gallons shall be used. If any imperfections appear in the waterproofing, additional coats shall be applied.

96.7-T MEASUREMENT AND PAYMENT: Payment will be made at the contract unit price bid per square yard for Waterproofing complete in place, which payment shall be full compensation for furnishing all materials, labor, tools, equipment and incidentals necessary to complete the work.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 92. METAL FOR STRUCTURES

92.1. DESCRIPTION. Metal for structures shall provide for the materials such as structural, rivet and eyebar steel, steel forgings, steel castings, gray-iron castings, malleable castings, wrought iron, phosphor bronze, and other metals used in structures except reinforcing steel.

Fabrication, erection, measurement and payment for structural steel and other metals, except reinforcement, shall be as provided in these specifications, Item 103. Paint and painting of metal for structures shall be as provided in these specifications, Item 95. Reinforcing steel shall conform to the requirements of these specifications, Item 91. Metal for Guard Fence shall be as elsewhere provided in these specifications.

92.2. STRUCTURAL, RIVET AND EYEBAR STEEL. All structural, rivet and eyebar steel shall conform to the requirements of the Standard Specifications for Structural Steel for Bridges, Serial Designation A7-24, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the society, and supplemented by the following paragraphs:

Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges, and other defects. It shall have a smooth, uniform finish, and shall be straightened in the mill before shipment.

Material shall be free from loose mill scale, rust pits, or other defects affecting its strength and durability.

When full-size tests of built-up structural members and eyebars are required by the contract, the Contractor shall supply testing machines of the proper type and capacity and shall provide all facilities and labor incidental to the making of tests. In all tests involving the determination of tensile and compressive strengths, the ultimate strength, deformation and other pertinent data shall be recorded.

Test specimens of structural, rivet or eyebar steel shall show a fracture having a silky or fine granular structure throughout, with a bluish gray or dove color, and shall be entirely free from granular, black and brilliant specks.

When tests of full-size bars are required, the following conditions and requirements shall supplement the foregoing general provisions:

The number and size of the bars to be tested shall be designated by the Engineer before the mill order is placed. The number shall not exceed 5 per cent of the whole number of bars ordered, with a minimum of two bars on small orders.

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 the capacity of the testing machine. They shall be selected by the inspector from the finished bars, preferably after annealing. 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 and shall have the second head formed upon them after being cut to the greatest length which can be tested.

Full-size tests of eyebars 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 fracture, of not less than 12 per cent 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 melt shall be tested. The bars represented by the test may be reannealed before the additional bars are tested.

If two of the three test bars fail to give satisfactory results, the bars of that size and melt shall be rejected.

A record of the annealing charges shall be furnished the engineer showing the bars included in each charge and the treatment they received.

92.3. STEEL FORGINGS. Steel forgings from which pins, rollers, trunnions, or other forged parts are to be fabricated, shall conform to the requirements of the Standard Specifications for Carbon-Steel Forgings for Locomotives, Serial Designation A20-21, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the society.

All forgings shall be thoroughly annealed prior to being machined to form finished parts.

92.4. STEEL CASTINGS. Steel castings shall conform to the requirements of the Standard Specifications for Carbon Steel Castings Serial Designation A-27-24, of the American Society for Testing Materials with subsequent amendments and additions thereto adopted by the society, and supplemented by the following:

Unless otherwise specified all castings shall be Class B, Medium Grade.

All steel castings shall be thoroughly annealed unless otherwise provided.

Steel castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended.

Blow holes appearing upon finished castings shall be so located that a straight line laid in any direction will not cut a total length of cavity greater than 1 inch in any 1 foot, nor shall any single blow hole exceed 1 inch in any dimension or have an area greater than $\frac{1}{2}$ square inch. Blow holes shall not have a depth injuriously affecting the strength of the casting. Minor defects which do not impair the strength may, with the approval of the Engineer, be welded by an approved process. The defects shall be removed to solid metal by chipping, drilling or other satisfactory methods and, after welding, the castings shall be annealed, if required by the Engineer. Castings which have been welded without the Engineer's permission shall be rejected.

Large castings, if required by the Engineer, shall be suspended and hammered all over. No cracks, flaws or other defects shall appear after such treatment.

No sharp unfilleted angles or corners will be allowed.

92.5. GRAY-IRON CASTINGS. Iron castings shall conform to the requirements of the Standard Specifications for Gray-Iron Castings, Serial Designation A48-B, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the society.

Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect.

Iron castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

92.6. MALLEABLE CASTINGS. Malleable castings shall conform to the requirements of the Standard Specifications for Malleable Castings, Serial Designation A47-27, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the society.

The castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. The surfaces shall have a workmanlike finish.

Malleable castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

92.7. WROUGHT IRON. Wrought-iron shall conform to the requirements of the Standard Specifications for Refined Wrought-Iron Bars, Serial Designation A41-18, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the society.

92.8. PHOSPHOR BRONZE. Phosphor-bronze shall conform to the requirements of the Standard Specifications for Bronze Bearing Metals for Turn-Tables and Movable Railroad Bridges, Serial Designation B22-21, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the society.

Grade B. metal shall be used.

Bronze castings shall be free from inclusions of foreign material, casting faults, injurious blow holes or other defects rendering them unsuitable for the service intended.

92.9. GALVANIZED SHEET METAL. Galvanized sheet metal for use in structures shall be of the size and dimensions shown on the plans and shall conform to the requirements for metal as given in these specifications for "Corrugated Galvanized Metal Pipe Culverts", Item 87. All galvanizing to be in accordance with Serial Designation A 123-28T, American Society for Testing Materials.

92.10. MEASUREMENT AND PAYMENT. No direct payment will be made for metal for structures unless otherwise provided in plans or by special provisions. Measurement and Payment for Structural Steel, Forgings, Castings, Phosphor Bronze and Wrought Iron will be made at the contract unit price bid per pound, complete in place, as provided in these specifications Item 103. Payment for galvanized sheet metal shall be included in the contract unit price bid for one of the items of timber, concrete, or steel.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 103. STEEL STRUCTURES.

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103.1. DESCRIPTION. Steel structures shall provide for the fabrication, erection, basis of payment and weight determination for structural steel and other metals except reinforcing steel which are used for steel structures or steel portions of structures. The items for materials, paint and design are covered by Item Numbers 92, 95, and 110 respectively.

FABRICATION

103.2. SHOP DRAWINGS. Unless otherwise provided on the plans the Contractor shall prepare and submit detailed shop drawings for each detail of the general plans requiring the use of Structural Steel, Forgings, Wrought Iron, Castings or Bearings. Camber and erection diagrams will be required for each truss span. The drawings shall be prepared on sheets 22"X36" which are the same size as the general plan sheets furnished by the State Highway Department. Each sheet shall have the sheet index data shown in the upper right hand corner of the project plans with sheet numbering for the shop drawings. Each sheet shall also have in the lower right hand corner a proper title giving name of stream, span length, name of Fabricator and name of Contractor.

All shop drawings shall be checked by the Fabricator before being submitted for approval. In general the number of copies of shop drawings required for this Department will be as follows: 3 for State Projects and 6 for Federal Aid Projects. In special cases additional copies may be requested.

The Contractor shall furnish the Engineer with as many copies of mill orders and shipping statements as the Engineer may direct. The weights of the individual members shall be shown on the statements.

103.3. NOTICE OF BEGINNING OF WORK. 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.

103.4. INSPECTION AND TESTING. 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 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 Inspector shall have the authority to reject any material or work which does not meet the requirements of these specifications. In case of dispute the Contractor may appeal to the Engineer, whose decision shall be final.

The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

103.5. MATERIALS AND WORKMANSHIP. All materials shall conform to the requirements set forth in Item 92 of these specifications.

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.

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.

Workmanship and finish shall be equal to the best general practice in modern bridge shops.

103.6. PUNCHED WORK. If general reaming is not required, all main material, forming parts of a member composed of not more than five 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 five 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 per cent 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.

103.7. REAMED WORK. 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 diaframs, 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 of 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. Accuracy of reamed work is given in Par. 103.8. All riveted trusses and skew portals shall have general reaming. See Par. 103.10.

103.8. DRILLED WORK. 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 group of holes, shall not show an offset greater than 1/32 inch between adjacent thicknesses of metal.

103.9. SHOP ASSEMBLING. 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-size punched material, the rivet holes, if necessary, shall be spear-reamed for the admission of the 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 carefully adjusted to correct position and bolted, clamped, or otherwise firmly held in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts, in so far 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.

103.10. REAMING OF FIELD CONNECTIONS. If general reaming is required, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, and holes for field connections drilled or reamed while so assembled. Holes for 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 template without assembling.

If provided in the contract, the field connections in punched work, except those for lateral, longitudinal and sway bracing, shall be reamed to a metal template 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.

103.11. SHOP RIVETS AND RIVETING. Rivets, before driving, shall be of 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.

Rivets for field driving shall be furnished in excess of the nominal number requied to the amount of 10 per cent plus 10 rivets for each diameter and length.

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 by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed. If rivets are driven with a pneumatic hammer, a pneumatic bucker shall be used if practicable.

103.12. BOLTED CONNECTIONS. Bolted connections shall not be 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 2 nuts.

Unfinished bolts in shear shall have not more than 1 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 specified. 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.

Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for pin ends of diameters greater than $1\frac{1}{2}$ inches, they shall be made with six threads to the inch.

103.13. PLANING, FACING AND FIT OF MEMBERS. 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. 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.

Surfaces of bronze bearing plates intended for sliding contact, shall be 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 neatly rounded unless another form is required.

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 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 tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

Finished members shall be true to line and free from twists, bends and open joints.

103.14. EYEBARS. Eyebars 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 eyebars are made, if they are satisfactory to the Engineer. The thickness of the head and neck shall not overrun more then 1/16 inch.

Eyebars 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, eyebars 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.

If tests of full-size eyebars 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 per cent 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 the 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. Then they shall be cut and the second head formed, making a bar of the greatest length that can be tested.

Full-size tests of eyebars 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 per cent 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.

103.15. PINS AND ROLLERS. Pins and Rollers shall be accurately turned 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.

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.

Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

103.16. WELDING. Welding of steel, unless specified on the plans, shall not be done except to remedy minor defects and then only with the approval of the Engineer.

103.17. PAINTING. The paint and application shall conform to the requirements of Item 95 of these Specifications.

103.18. MARKING, WEIGHING AND SHIPPING. All structural members shall be marked in accordance with the erection diagram. The markings shall be over the painted surface and in no case shall shop paint be left off in order to preserve markings on unpainted steel.

Finished work shall be weighed in the presence of the Inspector, if practicable. The Contractor shall supply satisfactory scales and shall do the handling and weighing. (See also Par. 103:31)

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

Anchor bolts, washers, and other anchorage or grillage materials, shall be shipped in time to suit the requirements of the masonry construction.

The loading, transportation, unloading, and storing of structural material shall be conducted so that the metal will be kept clean and free from injury.

ERECTION

103.19. METHODS AND EQUIPMENT. Before starting work, 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 without the sanction of the Engineer.

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. Temporary structures or falsework placed by the State Highway Department, if suitable, may be used by the Contractor.

103.20. RESPONSIBILITY. 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 be responsible for loss of, or damage to, materials; for all damage to persons or property; and for the casualties of every description caused by his operations during the progress of the work.

The stream profile, borings and water elevations shown on the plans are considered the most reliable information available by the State Highway Department at the time the surveys were made and are given for the benefit of the bidder but it shall be the responsibility of the Contractor to assume any extra costs which may result from errors in the data given on the plans and not otherwise provided in the plans and specifications and from changes in profile due to shifting of streams.

During the progress of the work the Contractor shall have a competent foreman or superintendent in personal charge of the work. Instructions given to the foreman or superintendent shall be considered as given to the Contractor. All work shall be done by skilled, competent workmen.

The Contractor shall comply with federal, state and local laws, regulations, and ordinances, and shall obtain at his own expense the necessary permits for his operations.

The work shall be subject at all times to inspection by the Engineer.

103.21. STORING MATERIALS. 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.

103.22. FALSEWORK. The falsework shall be properly designed and substantially constructed 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.

103.23. 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. Unless otherwise directed by the Engineer, they shall be placed on a layer of canvas and red lead applied as follows:

Thoroughly swab the bridge seat bearing area with red lead paint and place upon it three layers of 12 to 14 ounce duck, each layer being thoroughly swabbed on its top surface with red lead paint. Place the superstructure shoes or pedestals in position while the paint is plastic.

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.

103.24. STRAIGHTENING BENT MATERIAL. The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the Engineer, in which case the heating shall not be to a higher temperature than that producing a dark "cherry red" color. After heating, the metal shall be cooled as slowly as possible.

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

103.25. HANDLING AND ASSEMBLING MATERIAL. 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 fully riveted 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.

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

103.26. RIVETING. 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. Cupfaced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be accurately and securely fitted up 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 symetrical, 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.

103.27. PIN AND BOLT CONNECTIONS. Pilot and driving nuts shall be used in driving pins. They will be furnished with the steel work and shall be returned to the contractor on completion of the work. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

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

103.28. MISFITS: Corrections of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets will be considered a legitimate part of the erection. Any error in shop work which prevents the proper assembling and fitting-up of parts by the moderate use of drift pins or a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Inspector, and his approval of the method of correction obtained. The correction shall be made in the presence of the Inspector, who will check the time and material. The Contractor shall render within 30 days an itemized bill for such work of correction for the approval of the Engineer.

103.29. PAINT AND PAINTING. The paint and application shall conform to the requirements of these specifications, Item 95.

103.30. CLEANING UP. Upon completion and before final acceptance, the Contractor 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 his 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.

MEASUREMENT AND PAYMENT

103.31. MEASUREMENT. The payment shall be based on the weight of metal in the fabricated structure, including quantity of field rivets provided in these specifications, Par. 103.11. The weight of erection bolts, field paint, and all boxes, crates or other containers used for packing, together with sills, struts, and rods used for supporting members during transportation shall be excluded. Where changes in sizes or weights of members have been made which were not ordered by the State Bridge Engineer, Measurement will be made on the sizes or weights given on the project plans.

For the purpose of payment, such items as bearing plates, pedestals, drains, etc., shall, unless otherwise provided, be considered as structural steel, even though made of other material.

Weights paid for shall be shop scale weights, unless otherwise provided. If specified in the contract or permitted by the State Bridge Engineer, computed weights as hereinafter provided may be made the basis of measurement.

Finished work shall be weighed in the presence of the Inspector. The Contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various parts.

Before final payment is made the Contractor shall furnish the Engineer four sets of bills showing tabulated scale weights and four sets of bills showing weights computed from shop detail plans.

Computed weights shall be made as follows:

The weight of steel shall be assumed at 0.2833 pounds per cubic inch. The weight of cast iron shall be assumed at 0.26 pounds per cubic inch. The weight of bronze shall be assumed at 0.315 pounds per cubic inch. The weights of rolled shapes and of plates up to and including 36 inches in width shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts, and open holes. The weights of plates wider than 36 inches shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts and open holes. To this shall be added one-half of the allowed percentages of overrun in weight given in the Standard Specification for Structural Steel for Bridges, Serial Designation A7-21, of the American Society for Testing Materials. The weight of castings shall be computed from the dimensions shown on the approved shop drawings, with an addition of 10 per cent for fillets and overrun.

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

Diameter of Rivet	Weight for 100 Heads
1/2"	4.0 lbs.
5/8"	7.5 lbs.
3/4"	12.5 lbs.
7/8"	18.5 lbs.
1"	27.0 lbs.

To the total computed weight of metal may be added an allowance of 0.4 of 1 per cent for shop paint.

If the weight of any member is more than 2 per cent less than the computed weight, it may be cause for rejection. If the total scale weight of any structure exceeds the computed weight by more than 2 per cent, the weight in excess of 2 per cent above the computed weight shall not be paid for.

103.32. BASIS OF PAYMENT. Structural steel shall be paid for at the contract unit price bid per pound for "Structural Steel", which price shall be full compensation for all material, fabrication, shop work, transportation and erection, all equipment, tools, labor and incidentals necessary to complete the work.

Any full-size member tested to destruction shall be paid for at the unit contract price, less its scrap value, if the test proves satisfactory. If the test proves unsatisfactory the members represented by it will be rejected and the expense of conducting tests shall be borne by the Contractor, unless otherwise provided.

Full size eyebars which are tested and meet the requirements of these specifications shall be paid for at the contract unit price bid per pound of structural steel. Bars which fail to meet these requirements, and all bars rejected as a result of tests shall not be paid for.

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL - A.S.T.M. ADOPTED 8-25-13. REV. 1921

PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS

Permissible Excess in Average Weights per Square Foot of Plates for Widths Given. - Expressed in Percentages of Nominal Weights.

Ordered Thickness in Inches	Under 48 in.	48 in. to 60 in. excl.	60 in. to 72 in. excl.	72 in. to 84 in. excl.	84 in. to 96 in. excl.	96 in. to 108 in. excl.	108 in. to 120 in. excl.	120 in. to 132 in. excl.	132 in. or Over	Ordered Thickness in Inches
Under 1/8	9	10	12	14	--	--	--	--	--	Under 1/8
1/8 to 3/16 excl.	8	9	10	12	--	--	--	--	--	1/8 to 3/16 excl
3/16 to 1/4 excl.	7	8	9	10	12	--	--	--	--	3/16 to 1/4 excl.
1/4 to 5/16 excl.	6	7	8	9	10	12	14	16	19	1/4 to 5/16 excl.
5/16 to 3/8 excl.	5	6	7	8	9	10	12	14	17	5/16 to 3/8 excl.
3/8 to 7/16 excl.	4.5	5	6	7	8	9	10	12	15	3/8 to 7/16 excl.
7/16 to 1/2 excl.	4	4.5	5	6	7	8	9	10	13	7/16 to 1/2 excl.
1/2 to 5/8 excl.	3.5	4	4.5	5	6	7	8	9	11	1/2 to 5/8 excl.
5/8 to 3/4 excl.	3	3.5	4	4.5	5	6	7	8	9	5/8 to 3/4 excl.
3/4 to 1 excl.	2.5	3	3.5	4	4.5	5	6	7	8	3/4 to 1 excl.
1 or Over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or Over

6062-13

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STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 95. PAINT AND PAINTING

95.1. DESCRIPTION. Paint and Painting shall provide for the paint materials including Vehicle, Pigment, Paste, Driers and Thinners, mixed paint; for their inspection, sampling, testing and packing; and for application to structures. All paint materials and application shall conform to these specifications and shall be used where specified and of the number of coats given on the plans.

PAINT

95.2. GENERAL. Unless otherwise provided herein, the materials entering into the composition of paints shall conform to the requirements of the Standard Specifications of the Federal Specifications Board issued by the U. S. Bureau of Standards, and in the examination of paints the methods specified therein shall be used. The Bureau of Standards Circulars, to which reference is made herein, may be secured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents per copy.

Paint shall consist of pigments of the required fineness and composition ground to the desired consistency in linseed oil in a suitable grinding machine, to which shall be added additional oil, thinner and drier as required.

Paint shall be furnished for use in ready mixed or paste form, as may be specified.

PIGMENTS

95.3. GENERAL. Dry pigments shall conform to the requirements hereinafter specified. All pigments except the prepared aluminum powder and lampblack shall be thoroughly ground with linseed oil to form a paste before using. No pigment containing coal tar or asphaltic products shall be used.

In addition to lampblack and ochre as hereinafter specified, chrome yellow and chrome green may be used as tinting pigments, subject to the approval of the Engineer.

Chrome yellow shall conform to the requirements of the Tentative Specifications for Chrome Yellow, Serial Designation D211-26T, of the American Society for Testing Materials with subsequent amendments and additions thereto adopted by the Society.

Chrome green shall conform to the requirements of the Tentative Specifications for Pure Chrome Green, Serial Designation D212-26T, of the American Society for Testing Materials with subsequent amendments and additions thereto adopted by the Society.

Inert pigments, when used, shall be silica, magnesium silicate, aluminum silicate, barium sulphate, pure tinting colors, or any mixture thereof. Inerts shall in no case contain organic coloring matter, soap or emulsifying products.

95.4. RED LEAD. The dry pigment shall conform to the requirements of A. S. T. M. Specifications D-49-29 95% grade, as follows:

The dry pigment used in making the paste shall be made by roasting litharge or lead, or compounds of lead which yield litharge by heating. The dry pigment shall consist entirely of exides of lead, free from all adulterants, and shall conform to the following requirements:

True red lead, Pb_3O_4, not less than 95.0%

Total impurities, including moisture, soluble matter, water and matter insoluble in a mixture of nitric acid and hydrogen peroxide, not more than 1.0%

The remainder shall be lead monoxide (PbO).

Coarse particles retained on a No. 325 sieve, not more than 1.0%

95.5. BASIC CARBONATE WHITE LEAD. The pigment shall be the product made from metallic Lead and shall have a composition corresponding approximately to the formula $2PbCO_3 - Pb(OH)_2$. It shall be thoroughly washed after corroding, shall be free from impurities and adulterants, and shall conform to the following requirements:

Coarse particles retained on a No. 325 sieve not more than ... 1.0%

Lead Carbonate ..... 65 to 75%

Total impurities, including a moisture not more than 2.0%

95.6. BASIC SULPHATE WHITE LEAD. The pigment shall be the sublimed product prepared from lead sulfide ores, free from impurities and adulterations, and shall conform to the following requirements:

Coarse particles retained on a No. 325 sieve not more than 1.0%
Lead Oxide ..... 11.0 to 18.0%
Zinc Oxide not more than 9.0%

The remainder shall be lead sulphate.

95.7. PURE ZINC OXIDE. The dry pigments shall consist of pure oxide of zinc which shall contain not less than ninety-eight (98) per cent of zinc oxide, not more than two-tenths (0.2) per cent of sulphur or two (2) per cent of total impurities including moisture. The pigment shall be so ground that 99% will pass a No. 325 (44 micron) sieve.

95.8. SUBLIMED BLUE LEAD. The sublimed blue lead pigment shall consist of sublimed blue lead fume, free from all adulterants and shall meet the following requirements:

Lead sulphate (PbSO)	45-55 per cent
Lead oxide (PbO)	30-40 per cent
Lead sulphide (PbS)	Not over 12 per cent
Lead sulphite ($PbSO_3$)	Not over 5 per cent
Zinc Oxide (ZnO)	Not over 5 per cent
Carbon and undetermined	Not over 5 per cent

This material shall be entirely a sublimed product and shall not be a mechanical mixture either in part or as a whole. 99% of this material shall pass a standard No. 325 sieve. The material shall be tested in accordance with A. S. T. M. serial Designation, D-126-27.

95.9. GRAPHITE. The pigment in both semi-paste and ready mixed paint shall consist of finely ground graphitic carbon and insoluble siliceous material. The graphitic carbon may be derived from either natural or artificial graphite and the insoluble siliceous matter may be either the naturally occurring insoluble impurities of the graphite or added insoluble siliceous matter. The pigment shall show the following analysis:

Graphitic Carbon not less than	50%
Insoluble Siliceous matter not less than	30%
Sum of graphitic carbon and insoluble siliceous matter, not less than	85%
Calcium and magnesium carbonate and sulphates, not more than	5%

The pigment shall be ground so that one hundred (100) per cent will pass two hundred (200) mesh sieve.

95.10. LAMPBLACK. The pigment shall be furnished in the dry form or ground in oil to form a paste, as specified. The dry pigment shall be made by burning oils or tars in such a manner as to form a deposit of carbon or soot. It shall be high grade in every respect, shall be free from oil, greasy matter and from admixture of any other substance. The dry pigment shall conform to the following requirements:

Coarse particles retained on a No. 325 sieve not more than ...	1.0%
Ash, not more than	1.0%
Benzol extract (which must be colorless), not more than	0.5%
Tone when diluted with zinc oxide	clear-blue-gray.

95.11. ALUMINUM. Powdered aluminum shall be made by the best commercial methods from metallic aluminum having a minimum aluminum content of ninety-nine (99) per cent. It shall be powdered in the form of flakes, shall be polished and shall possess the property of "leafing" when suspended in varnish or airplane dope. It shall meet the following requirements:

Acetone extract (2 hrs.) not more than	3.0%
Lead and Zinc not more than	0.0%
Copper not more than	0.2%
Sum of iron, Silicon and copper not more than	1.0%
The remainder shall be aluminum	
Adulterants such as, powdered mica, not more than	0.0%
Passing 140 mesh sieve	100.0%
Passing 325 mesh sieve, not less than	50.0%

PASTE

95.12. GENERAL. Paint paste shall consist of the specified pigment or pigments ground to the required consistency in raw or refined linseed oil. The paste so prepared shall be uniform in consistency and composition and shall not cake or segregate in the containers. When additional vehicle is added, the paint paste shall be such as to readily break up, to form a smooth, uniform liquid of the proper brushing consistency and one which will not run or sag.

95.13. PASTE PROPORTIONS. The pigment shall be ground in oil in the following proportions for 100 pounds of paste.

	Pigment	Linseed Oil
Red Lead	91 - 93	9 - 7
Basic Carbonate White Lead	92	8
Basic Sulphate White Lead	90	10
Zinc Oxide	84	16
Sublimed Blue Lead	88 - 90	12 -10
Graphite	65	35
Lampblack	20	80
French Ochre	70	30

VEHICLE

95.14. GENERAL. The term vehicle shall be used to designate the mixture of pure linseed oil with the necessary amount of drier or thinner to produce an acceptable drying coefficient and a workable consistency. The total amount of thinner shall in no case exceed 10% of the total vehicle, nor shall the vehicle contain in excess of 1% of water.

To each gallon of paint prepared as hereinafter specified, may be added such amounts of thinner and drier as necessary to secure workability and a good drying coefficient, but in no case shall the amounts so added be such as to cause a separation of pigment and vehicle, nor shall they

exceed the following:

Maximum amount of drier per gallon of paint - - - - - 1/3 pint.
" " " thinner " " " " - - - - - 1/3 "

When the paint is for use on work exposed to water action the amount of drier used shall not exceed 1/6 pint per gallon.

95.15. RAW LINSEED OIL. Linseed oil shall be the pure oil pressed from flax-seed and shall conform to the following requirements of the A. S. T. M. Standard Specifications for Raw Linseed Oil D-234-28 with subsequent amendments and additions thereto.

	Maximum	Minimum
Specific Gravity 15.5° C./15.5° C	0.936	0.931
Acid Number	4.0	.....
Saponification Number	195.0	189.0
Unsaponifiable Matter, per cent	1.50	.....
Iodine Number (Wijs)		177.0
Loss on heating at 105-110° C., per cent ..	0.2	
Color	Not darker than a freshly prepared solution of 1.0 g. potassium bichromate in 100 cc. pure sulfuric acid (sp. gr. 1.84.)	
Foots, per cent:		
Heated Oil	1.0	.....
Chilled Oil	4.0	.....

95.16. BOILED LINSEED OIL. Boiled linseed oil shall be pure linseed oil that has been treated by heating and incorporating compounds of lead, and at the option of the manufacturer suitable compounds of other drying metals, so as to produce a product that will dry rapidly. It shall be clear, free from sediment, and shall conform to the following requirements of the A. S. T. M. Standard Specifications D 260-28T with subsequent amendments and additions thereto.

	Maximum	Minimum
Time, of drying on glass, hours	18.0	.....
Specific Gravity 15.5° C./15.5° C	0.945	0.931
Acid Number	7.5	.....
Saponification Number	195.0	189.0
Unsaponifiable Matter, per cent	1.50	.....
Iodine Number (Wijs)		170.0
Loss on Heating at 105 to 110°C., per cent	0.2	.....
Ash, per cent.	0.50	.....
Lead, per cent		0.05

95.17. LONG OIL SPAR VARNISH. Long oil spar varnish as a vehicle for aluminum paint shall meet the following requirements:

Exterior varnish material for use with aluminum bronze powder may either be a bodied linseed oil or a specially prepared spar mixing

varnish fulfilling the following requirements:

Non volatile oils and gums not less than 50%
Ratio of oil to gum not less than . . . . . 3 to 1
Shall pass a sixty (60) per cent Kauri reduction test.
Shall set to touch . . . . . 2 to 6 hours.
Shall be dry hard and tough in not more than 24 hours.

The varnish shall be of such consistency that when thoroughly mixed with aluminum bronze powder in the proportion of two (2) pounds per gallon of vehicle, the paint shall show satisfactory spreading qualities and shall not run or sag where applied to a verticle surface.

95.18. DRIER. These specifications cover both straight oil drier (material free from resins or "gums") and Japan drier (material containing varnish "gums"). The drier shall be composed of lead, manganese, or cobalt, or a mixture of any of these elements combined with a suitable fatty oil, with or without resins or "gums", and mineral spirits or turpentine, or a mixture of these solvents.

The drier shall conform to the following requirements:

(a) Appearance:- Free from sediment and suspended matter.
(b) Flash point (Tag closed tester):- Not less than 86°F.
(c) Elasticity:- The drier when flowed on metal and baked for 2 hours at 212°F., shall have an elastic film.
(d) Drying:- It shall mix with pure raw linseed oil in the proportion of 1 volume of drier to 19 volumes of oil without curdling, and the resulting mixture when flowed on glass shall dry in not more than 18 hours.
(e) Color:- When mixed with pure raw linseed oil in the proportion of 1 volume of drier to 8 volumes of oil, the resulting mixture shall be no darker than a solution of 6 g. of potassium dichromate in 100 cc. of pure sulphuric acid (sp. gr. 1.84).

95.19. TURPENTINE. Turpentine shall be spirits of turpentine made from gum (oleoresin) from a living tree, commonly known as "gum spirits" or "turpentine", or steam-distilled wood turpentine, which is distilled with steam from the oleoresin within the wood. The gum spirits of turpentine, or steam-distilled wood turpentine, shall conform to the following requirements:

(a) Appearance:- Clear and free from suspended matter.
(b) Water:- None.
(c) Color:- "Standard" or better.
(d) Odor:- Mild, aromatic, and characteristic of gum spirits of turpentine. If required, it shall conform to the odor of a sample furnished by the Department.
(e) Specific gravity at 59.9° /59.9°F. . . . . 0.860 to 0.875
(f) Refractive index at 68°F . . . . . 1.465 to 1.478

(g) Residue after polymerization with 38 N. H_2SO_4:-
Volume, not more than 2.0%
Refractive index at 68° F., not less than 1.5
Consistency . . . . . .Viscous.
Color . . . . . Straw or darker.
(h) Initial boiling point at 760 mm. pressure . . 302° to 320° F.
(i) Distilling below 338° F. at 760 mm. pressure, not less than 90.0%

95.20. MINERAL SPIRITS. Mineral spirits shall be petroleum distillates and shall conform to the following requirements:

(a) Appearance:- Clear and free from suspended matter.
(b) Water:- None.
(c) Color:- Not darker than No. 21 Saybolt chromometer.
(d) Flash Point (Tag closed tester):- Not lower than 86° F.
(e) Corrosion:- Shall not corrode clean metallic copper in 30 min. at the boiling point of the spirits.
(f) Distillation:- Below 236° F., not more than 5%. Below 446° F. not less than 97%.
(g) Acidity of Residue:- Neutral.

MIXED PAINTS

95.21. GENERAL. The resulting paints when mixed in the proportions given herein when brushed on a smooth vertical surface shall dry hard and elastic without running, streaking, or sagging.

Where white lead is specified herein either basic carbonate or basic sulphate meeting the requirements of these specifications may be used.

95.22. RED LEAD SHOP COAT FOR STRUCTURAL STEEL.

	Pigment - Red Lead			Paste - Red Lead		
	Gals.	Percent	Weight (Lbs.)	Gals.	Percent	Wt. (Lbs.)
Red Lead Pigment	.385	76.40	28.	--	--	--
Red Lead Paste	--	--	--	2.232	83.09	100.
Raw Linseed Oil	1.000	21.14	7.75	2.352	15.14	18.23
Turpentine	.0625	1.23	0.45	.147	.88	1.06
Drier	.0625	1.23	0.45	.147	.88	1.06
Totals	1.51	100.00	36.65	4.878	100.00	120.35
Weight per Gal.			24.2			24.67

95.23. RED LEAD FIRST FIELD COAT (LIGHT BROWN) FOR STRUCTURAL STEEL.

	Pigment - Red Lead			Paste- Red Lead		
	Gals.	Percent	Weight	Gals.	Percent	Weight
Red Lead Pigment	0.405	75.98	28, Lb.			
Red Lead Paste				2.232	82.58	100. Lb.
Raw Linseed Oil	1.000	21.04	7.75	2.352	15.05	18.23
Turpentine	0.0625	1.22	.45	0.147	.875	1.06
Drier	0.0625	1.22	.45	0.147	.875	1.06
Lampblack		.54	.20	0.082	.62	0.75
Totals	1.53	100.00	36.85	4.96	100.00	121.10
Weight per Gal.		24.15 Lb.			24.42 Lb.	

95.24. WHITE LEAD PAINT, TINTED GRAY, FOR FIRST FIELD COAT, STRUCTURAL STEEL

	Formula			Allowable Percentages	
	Gal.	Percent	Weight (lb.)	Max.	Min.
White Lead in Oil Paste		75.23	100.	77.	73.
French Ochre		.75	1.	--	--
Pure Raw Linseed Oil	4.	23.32	31.	25.	21.
Drier (1 Pt.)	.125	.68	.90	--	--
Lampblack in Oil ($\frac{1}{2}$ oz.)		.02	.031	--	--
Totals		100.00	132.931	--	--
Weight per Gal.		Not less than 17 lbs.			

95.25. LITHOPONE PAINT - MATERIALS AND COMPOSITION

(a) The paint shall be composed of 60 percent by weight of pigment and 40 percent of liquid vehicle. The pigment shall not settle out or cake to such extent that it will not readily break up.

The pigment shall be composed of 40 per cent lead free zinc oxide, 40 per cent light proof lithopone, and 20 per cent inerts.

The liquid vehicle shall be composed of 90 per cent pure raw linseed oil, and 10 per cent gum spirits turpentine and oil drier.

(b) Zinc Oxide:- The dry pigment, "Zinc White" or Zinc Oxide shall conform to the requirements of paragraph 95.7.

(c) Lithopone:- The lithopone pigment shall be made by suitable treatment of a mixture of precipitated zinc sulfide and precipitated barium sulfate. It shall be light fast, i.e. it shall be a bright white and shall not darken when exposed to sunlight. The tinting strength (or hiding power) shall be high.

The dry pigment shall meet the following requirements:

	Maximum	Minimum
Coarse particles and skins (total residue retained on a standard No. 325 screen), per cent	1.0	----
Zinc Sulfide, per cent	30.0	26.0
Zinc Oxide, per cent	1.0	----
Material soluble in water, per cent	0.8	----
Barium Sulfate	74.0	67.2

(d) Raw Linseed Oil:- The raw linseed oil used in the liquid vehicle shall conform to the requirements of paragraph 95.15.

(e) Drier for Lithopone Paint:- Drier shall be composed of turpentine, lead and manganese oxides cooked in linseed oil. The proportion of lead shall be not less than three (3) times that of manganese. It shall contain no resin or varnish gums, and not more than seventy (70) per cent shall volatilize at 450 degrees F. When flowed on metal and allowed to dry, it shall produce an elastic film. The flash point shall not be lower than ninety-five (95) degrees F., when tested in an open cup tester. When a mixture of ten (10) per cent of drier with ninety (90) per cent pure raw linseed oil is flowed on a glass slab, which is then held nearly vertical, and is kept at a temperature of seventy (70) degrees F., with free access of air, the coating shall dry throughout, neither sticky nor brittle, in not over ten (10) hours.

(f) Turpentine For Lithopone Paint:- The Turpentine used shall be that commonly known as Gum Spirits. This is the product distilled from the oleoresin exuding from living pine trees and shall comply with the Detail Requirements of the U. S. Government Master Specification No. 7b, Department of Commerce Circular of The Bureau of Standards No. 86. Steam-Distilled Wood turpentine shall not be used.

95.26 BATTLESHIP GRAY EQUIPMENT PAINT

(a) The Paint shall be composed of 19% by weight of pigment and 81% of liquid vehicle.

The pigment shall be composed of pure Titanium Dioxide and white lead carbonate in the ratio of 76 to 16 and shall contain sufficient Battleship Gray Tinting Color to match a sample which will be furnished by the Department.
Note:- This will usually require about 8%

The liquid vehicle shall be composed of 90% Phenolic Varnish and 10% pure gum spirits of turpentine and oil drier.

(b) White Lead Carbonate:- The white lead carbonate shall conform to paragraph 95.5.

(c) Phenolic Varnish:- The varnish portion of the vehicle shall be free from resin and contain not less than 52% of non-volatile material.

The non-volatile material shall be Bakelite Synthetic Resins or Bakelite Synthetic Resin combined with other phenolic resins suitably dispersed by heat in linseed oil or china wood oil. The volatile portion to be turpentine or a mixture of turpentine and mineral spirits.

(d) The paint shall dry rapidly to touch and shall be hard and tough in twelve hours. A metal panel coated with this material and allowed to dry thoroughly shall show no discoloration or dulling after seventy two hours immersion in cold water.

(e) Raw Linseed Oil:- The linseed oil used in the vehicle shall conform to the requirements of paragraph 95.15.

(f) Drier for Battleship Gray Paint:- Drier shall conform to the requirements of paragraph 95.25 (e).

(g) Turpentine for Battleship Gray Paint:- The turpentine used shall conform to paragraph 95.25 (f).

95.27 ALUMINUM PAINT FOR FIELD COATS STRUCTURAL STEEL. The paint shall be mixed in the proportion of two (2) pounds of aluminum bronze powder per gallon of vehicle of Long Oil Spar Varnish. This makes a paint containing twenty-one (21) per cent pigment and seventy-nine (79) per cent vehicle. The weighed amount of powder shall be placed in a suitable mixing container and the measured volume of vehicle then poured over it. The powder shall be incorporated in the paint by vigorous stirring with a paddle. The powder will readily disperse in the vehicle. Before removing any paint from the mixing container, the paint shall be thoroughly stirred to insure a uniform mixture and the paint shall be suitably stirred during use. The paint shall be mixed on the job and only enough for one day's use shall be mixed at once.

Where two field coats of aluminum paint are specified, the first coat shall be tinted with lamp black paste or prussian blue paste in the quantity of 1/5 lb. or more to each gallon of paint. The exact quantity used shall be sufficient to give a contrast in color which can be readily distinguished. Where three field coats of aluminum paint are specified the second coat shall be tinted.

95.28 SUBLIMED BLUE LEAD PAINT FOR FIELD COATS - STRUCTURAL STEEL.

	Pigment	Paste
Sublimed Blue Lead Pigment	90 lb.	--
Sublimed Blue Lead Paste	--	100 lb.
Raw or Boiled Linseed Oil	4 gal.	2-2/3 gal.
Turpentine	1½ gals.	1½ gals.
Drier	2 pts.	2 pts.

The ready mixed paint when prepared by either of the above methods shall contain 66 to 74% pigment and shall weigh not less than 17½ pounds per gallon.

95.29 GRAPHITE PAINT FOR SECOND FIELD COAT - STRUCTURAL STEEL.

	Percentage	
	Maximum	Minimum
Graphite Pigment	35	27
Raw Linseed Oil	70	65
Turpentine and Volatile Matter	6	3
Drier	6	5

95.30 WHITE LEAD PAINT FOR TIMBER. The priming coat for new timber or for old timber on which the paint is in good condition (Designated "A") and the priming coat for old seasoned timber on which there is no paint and for timber on which the old paint is scaled or chalky so that the timber is practically bare (Designated "B") shall be mixed as follows:

	"A"	"B"
White lead in oil (90% pigment)	80 lbs.	80 lbs.
Zinc oxide in oil (84% pigment	20 lbs.	20 lbs.
Raw linseed oil	4 gals.	7 gals.
Turpentine	2 gals.	-
Drier	1 pt.	1 pint.
Weight per gallon	_____	_____

The second coat (and following coats, where specified) for all timber paint, except guard fence and creosoted timber, shall be mixed as follows:

White lead in oil (90% pigment)	80 lbs.
Zinc oxide in oil (84% pigment)	20 lbs.
Raw linseed oil	5 gals.
Drier	1 pt.
Weight per gallon	_____

Where specified the prime coat may be used conforming to the requirements for "second coat."

95.31 WHITE LEAD PAINT FOR GUARD FENCE. The prime coat shall conform to the requirements for prime coats for timber as provided in paragraph 95.30.

The second coat for painting timber guard fence shall be mixed as herein specified.

The composition of the pigment, based on the dry weights of the ingredients, shall be as follows:

White lead	65% to 70%
Zinc Oxide	20% to 25%
Inert material	10% to 15%

The composition of the vehicle shall be as follows:

Raw linseed oil	90%
Japan drier	5%
Turpentine	5%

The paint shall be mixed using 60 to 65% pigment and 40 to 35% vehicle, and weighing not less than_____pounds per gallon.

95.32 ALUMINUM PAINT FOR CREOSOTED TIMBER. Aluminum paint for timber shall consist of a pigment meeting the requirements of paragraph 95.11 and a vehicle meeting the requirements of paragraph 95.17. The paint for immediate use shall be mixed in the proportion of $2\frac{1}{4}$ pounds of aluminum powder to 1 gallon of long oil spar varnish and during use shall be kept thoroughly stirred.

95.33 CONTAINERS AND MARKING. All paints shall be shipped in strong, substantial containers, plainly marked with the weight, color and volume, in gallons, of the paint content; a true statement of the percentage composition of the pigment, the proportions of pigment to vehicle, the name and address of the manufacturer, and the stencil of the authorized inspecting agency. Any package or container not so marked will not be accepted for use under these specifications.

95.34 CERTIFIED ANALYSIS. When, in the opinion of the Department, it is not feasible to have the ingredients analized and/or the mixing witnessed by the authorized inspecting agency, a certified analysis will be acceptable in lieu thereof. (Written permission to waive inspection must be obtained.) The manufacturer of each brand of paint submitted for acceptance under these specifications shall file with the Commission a certificate of analysis setting forth the trade name or brand of paint to be furnished together with a facsimile copy thereof and a typical analysis showing the percentage of each of the chemical elements in the pigment vehicle. The manufacturer shall provide that all paint furnished under these specifications shall conform to the certified analysis as filed and to the statement of the various percentages of the ingredients on the receptacle or container. The certified analysis shall be sworn to by a person having legal authority to bind the company by his acts.

95.35 SAMPLING AND TESTING. Before work is commenced on the manufacture of these paints, the manufacturer shall permit the authorized inspecting agency to secure representative samples of all pigments and vehicles to be used in such paints. The manufacturer shall furnish to said authorized inspecting agency such pertinent data as is necessary in order to identify the project, requisition, or destination of the paint together with the specification paragraph number or numbers applicable and shall give said agency reasonable notice prior to beginning of any mixing or packaging. The non appearance of said inspecting agency's representative will not be considered as sufficient cause for proceeding with the work without proper inspection.

Paints which on analysis show more than a 3 per cent variation in the proportion of any pigments or vehicle from that called for will be rejected.

In testing paint used under these specifications the tests shall conform to the following:

1. Percent of Water in Paint Vehicle. Determination of water with amyl reagent.

2. Raw Linseed Oil. Methods of testing prescribed in A. S. T. M. Standard Specification for Raw Linseed Oil D234-28.

3. Boiled Linseed Oil. Methods of testing prescribed in A. S. T. M. Standard Specification for Boiled Linseed Oil D260-28T.

4. Determination of Volatile Oils in Vehicle, Bureau of Standards Misc. Pub. No. 15, p. 40.

5. Long Oil Spar Varnish. Methods in Bureau of Standards, Spec. Symbol TT-V-121 (Mar. 31, 1931)

6. Drier, Methods in Bureau of Standards, Spec. Symbol TT-D-651 (Mar. 31, 1931)

7. Red Lead. A. S. T. M. Standard Methods Routine Analysis Dry Lead D49-29.

8. White Lead. A. S. T. M. Standard Methods Routine Analysis of White Pigments D81-24.

9. Sublimed Blue Lead. Shall be made in accordance with method of

analysis of paint materials, sub-committee V111 A.S.T.M., Vol. 22, part 1, and subsequent revisions thereto adopted by the society.

10. Zinc Oxide. A.S.T.M. Standard Method of Routine Analysis of White Pigments D79-24.

11. Graphite Pigment. Methods of tests prescribed in Bulletin 1216 (U. S. Department of Agr.)

The references made above to the A. S. T. M., Bureau of Standards and the U. S. Department of Agriculture shall be interpreted to mean the latest subsequent revisions thereto.

The No. 325 (44 micron) sieve referred to in this specification is a woven rectangular mesh, wire sieve having not less than 322 nor more than 327 meshes per lineal inch in either direction. The nominal size of opening shall be .0017 inches square and the size of wire shall be .0014 inches diameter.

No sieve is to be used in the determination of the fineness of the pigments for these paints which on examination under a 150 magnification lens in a microscope shows any irregularity of wire spacings in the mesh or shows any noticeable amount of wear on the sides of the wires.

95.36 INSPECTION. The Contractor for these paints shall allow the State Inspector free access to all parts of his shops while work on these paints is being carried out; also the Contractor shall give the Inspector every reasonable facility to enable him to insure that these paints are being made in accordance with this specification.

PAINTING

95.37 DESCRIPTION. The painting of structures shall include, unless otherwise provided in the contract, the proper preparation of the surfaces, the application, protecting and drying of the paint coatings, the protection of pedestrian, vehicular, or other traffic upon or underneath the bridge structure, the protection of all parts of the structure (superstructure and substructure) against disfigurement by spatters, splashes and smirches of paint or of paint materials, and the supplying of all tools, tackle, scaffolding, labor, workmanship, paint and materials necessary for the entire work.

95.38 WEATHER CONDITIONS. Paint shall not be applied when the air temperature is below 40 degrees Fahrenheit (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 in open yards or upon erected structure shall not be done when the metal has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

95.39 NUMBER OF COATS AND COLOR. All new structural steel work shall, unless otherwise especially provided upon the plans or in the special provisions, be painted three coats of paint. The first coat is to be applied immediately after the shop fabrication is complete except that the inside of top chords for trusses and laced members or inaccessible parts shall be painted before assembling. The second and third coats are to be applied after all erection is complete, except that immediately following the field riveting of the members, the heads of field rivets, and all abrasions of the shop coat due to handling at the shop, shipment, erection, etc., and all field erection marks shall be thoroughly covered with one coat of shop paint and permitted to become thoroughly dry before the first field coat is applied.

Unless otherwise provided upon the plans or in the special provisions, all timber including guard rails, shall be given two coats of paint.

The color of each succeeding coat shall be sufficiently different from that previously applied to readily permit the discovery of an incomplete application of the paint coat. The colors of the coats shall be determined by the Engineer.

95.40. SHOP CLEANING. All surfaces of metal to be painted shall be thoroughly cleaned from rust, loose mill scale, dirt, or grease, and all other foreign substances. The removal of rust, scale, and dirt shall generally be done by the use of sand blast, metal brushes, scrapers, chisels, hammers, or other effective means. Oil and grease may be removed by the use of gasoline or benzine. Bristle or wood fibre brushes shall be used for removing loose dust.

95.41. FIELD CLEANING. When the erection work is complete including all riveting, straightening of bent metal, etc., all adhering rust, scale, dirt, grease, or other foreign matter shall be removed as specified under shop cleaning.

95.42. APPLICATION. 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 four inches in width.

The paint when applied shall be so manipulated under the brush as to produce a uniform, even coating in close contact with the metal or with previously applied paint, and shall be worked into all corners and crevices.

On surfaces which are inaccessible to paint brushes, the paint shall be applied with sheepskin daubers specially constructed for the purpose.

Paint shall be thoroughly stirred, preferably by means of mechanical mixers, before being removed from the containers, and to keep the pigments in suspension shall be kept stirred while being applied.

If it is necessary in cool weather to thin the paint in order that it shall spread more freely, this shall be done only by heating in hot water or on steam radiators.

95.43. SHOP PAINTING. When all fabrication work is complete and has been tentatively accepted as such, all surfaces not painted before assembling shall be cleaned as provided in Par. 95.40 and painted one coat of Red Lead shop paint conforming to the requirements of these specifications. Shipping

pieces shall not be loaded for shipment until thoroughly dry. No painting shall be done after loading material on cars.

Erection marks for the field identification of members shall be painted upon previously painted surfaces.

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

The composition used for coating machine finished surfaces shall be mixed in the following proportions:

4 lbs. pure tallow.
2 lbs. pure whitelead.
1 qt pure linseed oil.

95.44 FIELD PAINTING. As soon as the field cleaning is done to the satisfaction of the Engineer, the heads of field rivets and bolts and any other surfaces from which the shop coat of paint has become worn off or has become otherwise defective, shall be covered with one coat of the same paint as used in the shop.

When the paint applied for "touching up" rivet heads and abraded surfaces has become thoroughly dry; the first field coat may be applied. In no case shall a coat be applied until the previous coat has dried throughout the full thickness of the paint film.

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

95.45. MAINTENANCE PAINTING. Unless otherwise provided, maintenance painting shall consist of the removal of the rust, scale, dead paint, dirt, grease or other foreign matter from the metal parts or portions of existing structures and the application of paint thereon in conformity with the general requirements of these specifications.

All metal surfaces not in close contact with other metal surfaces or with wooden floor or truss members, concrete, stone masonry, etc., shall be considered as exposed to deterioration by rusting and shall be

thoroughly cleaned and painted the number of coats indicated in and made a part of the contract.

Unless otherwise provided, metal after being cleaned to the satisfaction of the Engineer, shall be painted with at least two coats of paint.

The requirements and methods of procedure for maintenance, cleaning, and painting shall be the same as specified for shop and field painting.

Whenever roadway or sidewalk planking is laid too closely in contact with the metal to permit free access for proper cleaning and painting, the planks shall either be removed or shall be cut to provide at least a one-inch clearance for that purpose. The removal or the cutting of planks shall be done as directed by the Engineer. All planks removed shall be satisfactorily replaced and if broken or otherwise injured to an extent rendering them unfit for use, they shall be renewed at the expense of the Contractor.

95.46. REMOVAL OF IMPROPER PAINT. All surfaces coated with impure or unauthorized paint or paint applied on surfaces which show insufficient or improper cleaning shall be thoroughly cleaned and repainted to the satisfaction of the Engineer, at the expense of the Contractor. The acceptance of the fabricated steel and painting by the inspector shall not be a bar to subsequent rejection, if found defective. See Par. 5.8 of these specifications. Cleaning and repainting or other necessary corrections will not be considered to constitute basis of claim for extension of contract time.

95.47. BASIS OF PAYMENT. Unless specifically stated otherwise the cost of all paint materials and the application of the same shall be included in the contract unit price bid per pound of structural steel or per M. F. B. M. of Timber, as the case may be, as provided in the pertinent specifications.

Maintenance painting when not performed by State Maintenance forces shall be contracted for on a lump sum basis.

STATE HIGHWAY DEPARTMENT OF TEXAS

ITEM 87. CORRUGATED GALVANIZED METAL PIPE.
(Rev. August 1st, 1933)

(Note: This item supersedes Item 92 of the specifications approved Feb. 26, 1926, by the Chief Engineer of the U. S. Bureau of Public Roads for use of the State Highway Department of Texas.)

87.1. DESCRIPTION. Corrugated Galvanized Metal Pipe shall consist of furnishing and placing corrugated galvanized metal pipe conforming to these specifications. The pipe shall be furnished of the sizes and dimensions required and shall be installed at such places as shown on the plans or as designated by the Engineer in accordance with these specifications, and in conformity with the lines and grades given.

87.2. BASE METAL. Corrugated metal pipe culverts shall be fabricated from corrugated galvanized sheets, the base metal of which shall be made by the open hearth process. The base metal shall conform to some one of the following chemical requirements:

Table I

Elements	Chemical composition by ladle analysis (Position of base metals does not indicate preference)					Tolerance by check analysis of finished sheets
	Pure iron	Copper Br.P.I.	Copper Iron	Copper Moly Ir.	Copper Steel	
Carbon						
Manganese						
Phosphorus, Max. %	.015	.015	.015	.015		
Sulphur, Max. %	.040	.040	.040	.040	.050	.010
Silicon						
Copper, Min. %		.20	.20	.40	.20	.02
Molybdenum, Min. %				.05		
Sum of first 5 elements Max. %		.10	.25	.25	.70	.04
Sum of first 6 elements Max. %	.10					.04

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

87.4. SPELTER COATING. Weight of Spelter Coating. 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 2 ounces per square foot of double exposed surface. If the average spelter coating, as determined from the required samples, is less than 2 ounces of spelter per square foot, or if any one

specimen is less than 1.80 ounces of spelter per sq. ft. 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.

87.5. MILL AND FACTORY INSPECTION. 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 made 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.

87.6. SAMPLING. 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 3 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 $2\frac{1}{4}$ inches square or equivalent area shall be cut from the middle and near each end. For testing coating of fabricated culverts at least one sample $2\frac{1}{4}$ inches square or 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.

87.7. ANALYSIS OF FINISHED SHEET. When not otherwise provided, chemical analysis, when required, shall be made in accordance with the methods of the American Society for Testing Materials, Serial Designation A 33-24. No lot of metal shall be rejected for composition of base metal until after a check has been made in any case in which the analysis of the base metal is in dispute, the question may be referred to an umpire chemist mutually satisfactory to both parties, whose decision shall be considered final. The cost of laboratory check tests shall be paid by the State for all culverts accepted under these specifications, and for all culverts rejected the costs of tests shall be borne by the Contractor.

87.8. TESTS FOR SPELTER COATING. The tests for weight of spelter coating shall be made as described in "Tentative Standard Specifications for Highway Materials and Methods of Sampling and Testing", T-65, adopted by the American Association of State Highway Officials, with subsequent revision.

87.9. ACCEPTED BRANDS OF METAL. 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.

87.10. SHEET MANUFACTURER'S CERTIFIED ANALYSIS. The manufacturer of each brand shall file with the Engineer a certificate setting forth the name or brand of metal to be furnished and 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.

87.11. 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, gauge, or spelter coating; and the guarantee shall be so worded as to remain in effect so long as the manufacturer continues to furnish material.

87.12. 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. Gauge number
Fourth. Weight of spelter coating
Fifth. Identification symbols, (1) heat number
(2) pot number

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 promptly 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 "Kinds of Base Metal" enumerated in Table 1. 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 Table 1, as follows:

PI for pure iron; CBPI for copper bearing pure iron; CI for copper iron; CMI for copper molybdenum iron; and CS for copper steel.

87.13. CORRUGATIONS. Corrugations shall not be less than $2\frac{1}{4}$ inches nor more than 2-3/4 inches center to center. The corrugations shall have a depth of not less than 1/2 inch.

87.14. PERFORATED PIPE. Perforations shall be approximately 1/4 inch in diameter after galvanizing, punched $1\frac{1}{2}$ 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	No. of rows of holes
8	8
10	8
12	10
15	10
18	15
21	15
24	20
30	20

87.15. GAUGE DETERMINATION AND TOLERANCE. The gauge of culvert sheets shall be determined by weight only. The gauge weight tolerances, which are the same as indicated in Table III of A.S.T.M. Spec. A93-27, shall be as indicated below.

Gauge range	Permissible Tolerances in Weights of Sheets, Plus or Minus, in Percentage of Theoretical Weight (1)			Gauge range
Weight of sheets, oz. per sq. ft. Not less than	All of one gauge and size in shipment (2)	Single packages	Single Sheets	Galvanized sheet, gauge No. Not lighter than
42.5	5.0	7.0	10.0	16

(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 gauge and size in shipment shall apply to lots of not less than 6,000 lb.

FABRICATION

87.16. SHAPE. Culverts 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. (Part circle culverts, with or without flat bottom, or full circle culverts of the nestable knock-down type, may be specified for special requirements).

87.17. DIMENSIONS AND WEIGHTS. The length of sheets, widths of laps, gauges, and computed weights per lineal 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 lineal foot of a finished culvert, exclusive of end finish, shall not underrun the computed weight specified by more than five per cent.

Nominal diameter, inches	Length of sheet before forming, inches	Minimum width of lap, inches	Galvanized: sheet Minimum gauge number	Computed weight per linear foot of finished culvert exclusive of end finish, pounds	Connecting bands galvanized sheet, gauge No. (or heavier)
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
x - - -	- - -	- - -	- - -	- - -	- - -
54	1-80 1-98	3	12	77.8	14
60	2-98	3	10	108.9	12
66	1-98 1-117	3	10	120.6	12
72	2-117	3	10	130.4	12
78	1-117 1-137	3	8	172.8	12
84	2-137	3	8	185.2	12

* Two sheets may be used by allowing sufficient total sheet lengths to provide for an additional standard lap.

x Sizes below dotted line are to be used only in special cases.

All culverts 48" diameter under fills of 25 ft. or more, and all culverts of 54" diameter or larger under any heights of fill are to be strutted as provided in Par. 87.25.

87.18. RIVETS AND RIVETING. Rivets shall be of the following diameters for the gauges specified:

No. 16 gauge material - 5/16"
No. 14 " " - 5/16"
No. 12 " " - 3/8"
No. 10 " " - 3/8"
No. 8 " " - 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 or 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 full 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 6 inches, except that six rivets will be sufficient in 12 inch pipe.

87.19. NET LENGTH OF CULVERT PIPE. The length of culvert specified shall be the net length of the finished culvert which does 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 1 per cent, the shipment shall be rejected.

87.20. LENGTHS OF SECTIONS. All pipe shall be furnished in the lengths ordered, except that pipe for culverts twenty-six feet or more in length may be furnished in sections not less than twelve feet in length. For shipments involving less than carload lots, these requirements may be modified to allow shipping lengths to conform to most economical railway tariff regulations.

87.21. END FINISH. The inlet and outlet of all culverts fabricated of 16 or 14 gauge sheets shall be reinforced in a manner approved by the Engineer, when specified.

87.22. COUPLING BANDS. Field joints shall be made with bands of the same base metal as the culverts and shall be not less than 7" wide for diameters of 8" to 30" inclusive; 12" bands for culverts with diameters 36" to 48" inclusive and 24" bands for culverts with diameters 54" to 84" inclusive except where field riveting is specified. Such bands shall be so constructed as to lap on an equal portion of each of the culvert sections to be connected, but shall be connected at the ends by galvanized angles having lengths equal to full width of band, having minimum dimensions of 2" by 2" by 3/16" spread to a 98° angle. The 7" bands should have at least two galvanized bolts not less than 1/2" by 4½". The 12" bands should have three, and the 24" band have five, 1/2" by 4½" bolts. Other equally effective methods of connecting coupling bands may be used if approved by the Engineer.

87.23. WORKMANSHIP. It is the essence of these specifications that in addition to compliance with the details of construction the completed pipe shall show careful, finished workmanship in all particulars. Culvert pipe on which the spelter coating has been bruised or broken either in the shop or in shipping, or which shows defective workmanship, shall be rejected. This requirement applies not only to the individual pipe, but to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual culvert pipe or in general in any shipment shall constitute sufficient cause for rejection.

1. Uneven laps.
2. Elliptical shaping.
3. Variation from a straight center line.
4. Ragged or diagonal sheared edges.
5. Loose, unevenly lined or spaced rivets.
6. Poorly formed rivet heads.
7. Unfinished ends.
8. Illegible brand.
9. Lack of rigidity.

10. Bruised, scaled, or broken spelter coating.
11. Dents or bends in the metal itself.

87.24. FIELD INSPECTION AND ACCEPTANCE. The field inspection shall be made by the Engineer who shall be furnished by the seller with an itemized statement of the sizes and lengths of culvert pipe in each shipment. This inspection shall include an examination of the culvert pipe for deficiencies in 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 or spelter coating. The inspection shall be made promptly upon the arrival of the material, and the State Highway Department shall be responsible for any demurrage which accrues on account of the neglect to make proper inspection after receiving 48 hours notice of the arrival of shipment. The pipe making up the shipment shall fully meet the requirements of these specifications, and if 25 per cent of the pipe in any shipment fails to meet these requirements, the entire shipment may be rejected.

87.25. INSTALLATION. The pipe shall be so placed that the outside laps of circumferential joints point upstream and with the longitudinal laps on the sides. When it is necessary or advisable to use band couplers, the different sections of pipe shall be securely fastened together before placing the pipe in the trench. In general, the minimum cover, measured from the crown of finished roadway surface to shell of pipe, shall be as follows:

Dia. of Pipe, Inches	Min. Cover, Inches
Up to 48	18 Including Paving Slabs
54 to 60	24 " " "
66 to 72	30 " " "
78 to 84	36 " " "

Where culverts are required to be strutted the vertical diameter should be increased by forcing the pipe out of round five (5) per cent of the nominal diameter. Timbers necessary for retaining the culvert in this position shall include soft material for compression caps and shall be furnished and placed by the Contractor without additional compensation. Pipes shall be strutted in accordance with the details shown on the plans.

87.26. ASPHALT DIPPED PIPE. Where specified on the plans, corrugated galzanized metal culvert pipe shall, after fabrication at the plant before shipment, be submerged in a bath of suitable asphalt pipe coating, approved by the Engineer, maintained at a temperature of from 400 to 500° Fahrenheit, and the pipe shall be kept in such bath until attaining the same temperature. It shall then be thoroughly drained in an inclined position until cool. The quality and character of the asphaltic coating and the method of application shall be such that the coating on the pipe shall be tough and pliable and shall adhere firmly to the spelter. Abrasions and spots where coating is removed in handling during shipment and installation shall be retouched with same grade of asphalt as original coating properly heated.

87.27. MEASUREMENT AND PAYMENT. Payment will be made at the contract unit prices bid per lineal foot for the several sizes of "Corrugated Galvanized Metal Pipe" or "Asphalt Dipped Corrugated Galvanized Metal Pipe" as the case may be, measured complete in place, which price shall be full compensation for furnishing, hauling and installing the pipe and band couplers, for preparing sub-foundations and backfilling, and for all material, equipment, tools, labor, and incidentals, but shall not be payment for excavation nor for concrete or masonry headwalls.

5584-8 (3/24/33)

STATE HIGHWAY DEPARTMENT OF TEXAS

(Mar. 24, 1933)

SPECIAL ITEM. BITUMINOUS PAVED INVERT CORRUGATED GALVANIZED

METAL PIPE (PATENTED)

1. DESCRIPTION. Bituminous Paved Invert Corrugated Galvanized Metal Pipe sections shall be furnished and installed in accordance to the sizes and dimensions at the locations indicated on the plans and in conformity with the lines and grades given. The pipe may be used only as an alternate to other types of non-patented materials.

2. MATERIALS. Bituminous paved invert corrugated galvanized metal pipe shall conform to the requirements of Item 87, Corrugated Galvanized Metal Pipe, for materials, manufacture, galvanizing, fabrication, testing and inspection and shall be coated for at least the lower half with a bituminous material, of such characteristics and analysis as to meet the requirements as herein specified; this material to be applied in such manner that one or more smooth pavements shall be formed in the lowest portion of the invert. Each pavement shall be of such width that the thickness above the crest of the corrugation, measured at the middle of the pavement shall be at least one-eighth (1/8) of an inch. The bituminous coating shall adhere to the metal tenaciously and shall not chip off in handling, shall not lose its stability when subjected to the highest summer temperature and shall be impervious to moisture.

3. TESTS. The tenacity of adherence of the coating shall be indicated by the successful withstanding of a steel ball 2¾ inches in diameter, weighing 1.67 pounds dropped from a height of 7½ feet through a vertical tube of 2½ inch inside diameter, upon the outside crest of a coated corrugation of a full round, riveted section of culvert pipe. This shall be conducted with the specimen at a temperature of 50°F. Failure of the coating on the inside of the culvert pipe, as indicated by the spalling from the metal or the formation of cracks longer than one-half (1/2) inch from the point of impact, shall be considered sufficient cause for rejection.

The loss of stability when subjected to high summer temperature is indicated by its withstanding the following test.

Parallel lines shall be drawn along the crest of the corrugations and the specimen placed on end in a constant temperature oven with the line of the corrugations horizontal. 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-quarter (1/4) inch.

The imperviousness to moisture shall be determined by the following test:
A 25% solution of sulphuric acid, or a 25% solution of sodium hydroxide, or a saturated salt solution (sodium chloride) shall be placed in a valley of a coated corrugation for a period of forty-eight (48) hours, during which time no loosening or separation of the coating from the galvanizing shall have taken place.

4. CONSTRUCTION METHODS. Methods of Construction shall be in accordance with Par. 87.25 of the specifications for "Corrugated Galvanized Metal Pipe."

5. MEASUREMENT AND PAYMENT. Payment will be made at the contract unit price bid per lineal foot for the several sizes of "Bituminous Paved Invert Corrugated Metal Pipe", measured complete in place, which price shall be full compensation for furnishing, hauling and installing the pipe and band couplers, for preparing sub-foundations and backfilling, and for all material, equipment, tools, labor, and incidentals but shall not be payment for excavation nor for concrete or masonry headwalls.

STATE HIGHWAY DEPARTMENT OF TEXAS

Revised 11/13/33

ITEM 85. REINFORCED CONCRETE PIPE CULVERTS.

(Note: Effective February 1, 1931, this item supersedes Item 90 of the specifications approved Feb. 26, 1926.)

85.1. DESCRIPTION. Reinforced Concrete Pipe Culverts shall provide for the furnishing and placing of extra strength or standard concrete pipe manufactured and placed as provided in these specifications: of the sizes and to the lines and grades as shown on the plans, or as altered by the Engineer.

85.2. MATERIALS. The materials used in the construction of the pipe shall comply with the following requirements:

Portland Cement shall meet the requirements of the current Standard Specifications and Tests for Portland Cement of the American Society for Testing Materials as provided in the pertinent specifications of this Department.

Reinforcement may consist of wire which meets the requirements of the current Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement of the American Society for Testing Materials, or of bars which meet the requirements of the current Standard Specifications for Billet - Steel Concrete Reinforcement Bars of the American Society for Testing Materials.

Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains and free from unjurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances. Fine aggregate shall be well graded and shall pass a $\frac{1}{4}$ inch screen.

Coarse aggregate shall consist of crushed stone, gravel, or other approved inert materials with similar characteristics, or combinations thereof, having clean, hard, strong, durable, uncoated particles, free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter.

The water used in mixing mortar or concrete shall be free from oil, acids, alkalies, and vegetable matter and shall be reasonably clear. Under no circumstances shall sea water be used.

85.3. COMPOSITION. The concrete shall be a mixture composed of not less than one (1) part Portland Cement, two (2) parts fine aggregate and not more than four (4) parts coarse aggregate, with water mixed in such proportions as will produce a homogeneous concrete mixture of such quality that the concrete will meet the test and design requirements herein specified. A one (1) to two (2) mortar is required, but the coarse aggregate may be decreased in order to get the desired workability.

85.4. PIPE. Concrete pipe shall be cast in sections, the lengths of which shall be as herein specified or shown on plans. When no particular length is specified, the pipes shall be manufactured in standard lengths of not less than three (3) feet, nor more than six (6) feet.

The sections of the pipe shall be smooth and straight with a true circular cross section and the ends of the pipe shall be perpendicular to the longitudinal axis. The pipe shall not be patched after being removed from the forms and shall be free from fractures or cracks passing through the shell, except that an end crack that does not exceed the depth of the joint, or a fracture that at its deepest point does not exceed the depth of the joint nor extend more than ten per cent (10%) around the circumference shall not be considered cause for rejection unless these defects occur in more than five per cent (5%) of the pipe inspected. It shall be free from surface roughness and defects which indicate imperfect mixing and molding and shall produce a clear metallic ring when stood on end and tapped with a light hammer. The diameter or nominal size shall refer to inside diameter, which shall be uniform in all directions. Variations of the internal diameter shall not exceed one and one-half ($1\frac{1}{2}$) per cent nor shall the shell thickness be less than that specified by more than five (5%) per cent at any point.

The joints shall be of the lock type, bell and spigot, tongue and groove, or other type approved by the Engineer, and shall be self centering when laid so that the pipe will make a continuous conduit with a smooth and uniform interior surface.

The pipe shall not absorb moisture in excess of eight per cent (8%) of its dry weight.

When a single line of reinforcement is used, it shall be placed in the center of the pipe shell. When two lines of reinforcement are used, one shall be placed near the inner and one near the outer surface of the pipe. When a single line of elliptical reinforcement is used

in circular pipe it shall be placed near the inner surface at the "top" and "bottom" of the pipe and near the outer surface at the sides. Each line of circumferential reinforcement shall be assembled into a cage which shall have sufficient longitudinal bars or members, extending through the barrel of the pipe to afford rigidity and maintain the reinforcement in exact shape and correct position within the form. The reinforcement shall be lapped not less than forty (40) diameters or, if welded, the joints shall develop the full strength of the reinforcement. The spacing center to center of adjacent rings of circumferential reinforcement in a cage shall not exceed four inches (4") up to and including pipe thirty-six inches (36") in diameter. The bell shall have a circumferential reinforcement equal in unit area to that of a single line within the barrel of the pipe. Variation in the position of the reinforcement cages shall not exceed one-fourth ($\frac{1}{4}$) inch from the position provided in the design, nor shall the cover on the reinforcement be less than three-fourths ($\frac{3}{4}$) inch at any point.

85.5. STRENGTH. Concrete pipe shall be manufactured in such manner, with such workmanship, and of a composition of materials of such quality that samples taken from the manufactured pipe shall show a load supporting capacity per lineal foot of pipe, when initial cracking occurs not less than that given in the following table. Samples shall be selected and tested as prescribed in the "U. S. Department of Agriculture Bulletin No. 1216."

Size of Pipe	Extra Strength Reinforced Concrete Culvert Pipe			
	3 Edge Bearing		Sand Bearing	
	Cracking Load	Ultimate Load	Cracking Load	Ultimate Load
12"	3,200	4,000	4,800	6,000
15"	3,600	5,000	5,400	7,500
18"	4,000	6,000	6,000	9,000
24"	4,400	8,000	6,600	12,000
30"	5,000	10,000	7,500	15,000
36"	6,000	12,000	9,000	18,000

Size of Pipe	Standard Reinforced Concrete Culvert Pipe			
	3 Edge Bearing		Sand Bearing	
	Cracking Load	Ultimate Load	Cracking Load	Ultimate Load
12"	1,600	2,000	2,400	3,000
15"	1,800	2,500	2,700	3,750
18"	2,000	3,000	3,000	4,500
24"	2,200	4,000	3,300	6,000
30"	2,500	5,000	3,750	7,500
36"	3,000	6,000	4,500	9,000

Extra Strength Reinforced Concrete Culvert Pipe

For

Uniform Load of 4,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 2,750 Pounds Per Square Inch
(f_c = 1,030 lbs.)

FOR HAND MADE PIPE

Internal Diameter of Pipe in Inches	Minimum Thickness of shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches		Minimum Area of Circular Reinforcement Square Inches per Lineal Foot of Pipe: Cold Drawn Steel Wire f_s = 27,500# sq.in.		Billet Steel Hard and Intermediate Grades f_s = 20,000 lbs. sq.in.	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe & Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe & Cir. Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe & Circular Reinforcement in Elliptical Pipe
12	2-1/2	1-1/4	1-1/2	1 Line .11	1 Line .09	1 Line .15	1 Line .13
15	2-3/4	1-3/8	1-3/4	1 " .15	1 " .12	1 " .21	1 " .17
18	3-1/8	1-5/8	2-1/8	1 " .18	1 " .14	1 " .26	1 " .20
24	3-7/8	2	2-7/8	1 " .26	1 " .19	1 " .37	1 " .27
30	4-5/8	2-1/4	3-5/8	1 " .36	1 " .23	1 " .51	1 " .33
30	4-5/8	3-5/8	3-5/8	2 "ea .23	1 " .23	2 " ea. .33	1 " .33
36	5-3/8	4-3/8	4-3/8	2 " " .28	1 " .28	2 " " .40	1 " .40

When loaded to the cracking load, as shown in the above table, there shall be no crack in the barrel of pipe with a surface width of one-hundredth inch (0.01") or more for a length of one foot (1') or more.

EXTRA STRENGTH REINFORCED CONCRETE CULVERT PIPE

For

Uniform Load of 4,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 4,750 Pounds Per Square Inch

(f_c = 1,780 lbs.)

FOR MACHINE MADE PIPE

Internal Diameter of Pipe in Inches	Minimum Thickness of Shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches: Circular Reinforcement in Circular Pipe	Min. Dist. Center Reinforcement to Compressive Surface in Inches: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Minimum Area of Circular Reinforcement Square Inches Per Lineal Foot of Pipe: Cold Drawn Steel Wire f_s = 27,500 lbs. sq.in.: Circular Reinforcement in Circular Pipe	Cold Drawn Steel Wire: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Billet Steel Hard and Intermediate Grades f_s = 20,000 Lbs. sq. in.: Circular Reinforcement in Circular Pipe	Billet Steel: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
12	2	1		1 Line .14		1 Line .19	
15	2-1/4	1-1/8	1-1/4	1 " .19	1 " .17	1 " .26	1 " .24
18	2-1/2	1-1/4	1-1/2	1 " .24	1 " .21	1 " .34	1 " .29
24	3	1-1/2	2	1 " .35	1 " .27	1 " .50	" .39
30	3-1/2	1-3/4	2-1/2	1 " .47	1 " .34	1 " .66	" .48
30	3-1/2	2-1/2	2-1/2	2 "ea. .34	1 "ea. .34	1 "ea. .48	" .48
36	4	3	3	2 " " .41	1 " " .41	.57	" .57

Standard Reinforced Concrete Culvert Pipe

For

Uniform Load of 2,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 4,000 Pounds Per Square Inch
(f_c = 1,500 lbs.)

FOR MACHINE MADE PIPE

Internal Diameter of Pipe in Inches	Minimum Thickness of shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches		Minimum Area of Circular Reinforcement Square Inches per Lineal Foot of Pipe			
				Cold Drawn Steel Wire f_s = 27,500# sq. in.		Billet Steel Hard and intermediate Grades f_s = 20,000 lbs. sq. in.	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe & Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe & Cir. Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe & Circular Reinforcement in Elliptical Pipe
12	1-3/4	7/8	-	1 Line .08		1 Line .11	
15	2	1	-	1 " .11		1 " .15	
18	2-1/4	1 1/8	1 1/4	1 " .14	1 Line .12	1 " .19	1 Line .17
24	2-5/8	1 1/4	1 5/8	1 " .21	1 " .17	1 " .30	1 " .23
30	3	1 1/2	2	1 " .29	1 " .21	1 " .38	1 " .29
30	3	2	2	2 "ea. .21	1 " .21	2 "ea. .29	1 " .29
36	3 3/8	2 3/8	2 3/8	2 " " .26	1 " .26	2 " " .36	1 " .36

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STANDARD REINFORCED CONCRETE CULVERT PIPE

For

Uniform Load of 2,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 2,750 Pounds Per Square Inch

(f_c = 1,030 lbs.)

FOR HAND MADE PIPE

Internal Diameter of Pipe in Inches	Minimum Thickness of Shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches: Circular Reinforcement in Circular Pipe	Min. Dist. Center Reinforcement to Compressive Surface in Inches: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Minimum Area of Circular Reinforcement Square Inches per Lineal Foot of Pipe: Cold Drawn Steel Wire f_s = 27,500 lbs. sq. in.: Circular Reinforcement in Circular Pipe	Cold Drawn Steel Wire: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Billet Steel Hard and Intermediate Grades f_s = 20,000 lbs. sq. in.: Circular Reinforcement in Circular Pipe	Billet Steel: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
12	2	1		1 Line .07		1 Line .09	
15	2 1/4	1 1/8	1 1/4	1 " .09	1 Line .08	1 " .13	1 Line .12
18	2 1/2	1 1/4	1 1/2	1 " .12	1 " .10	1 " .17	1 " .14
24	3	1 1/2	2	1 " .17	1 " .13	1 " .25	1 " .19
30	3 1/2	1 3/4	2 1/2	1 " .23	1 " .17	1 " .32	1 " .23
30	3 1/2	2 1/2	2 1/2	2 "ea. .17	1 " .17	2 "ea. .23	1 " .23
36	4	3	3	2 " " .20	1 " .20	2 " " .28	1 " .28

85.6. MARKING. Each section of pipe shall be clearly marked with the following data:

(a) Date of manufacture.

(b) The class of pipe shall be indicated by an "X" for extra strength pipe.

(c) The name or trade-mark of the manufacturer.

85.7. TESTS. The manufacturer shall provide at the place of manufacture satisfactory testing equipment and facilities to enable the Engineer to carry out the test herein provided for.

The Engineer shall be entitled to test a number of pipe equal to two percent (2%) of the number ordered but not to exceed five (5) pieces of any one size. Pipe for testing shall be selected at random by the Engineer from the stock of pipe available for the work. In case of a failure of not more than one specimen out of each five selected from each size as above, the Contractor shall be entitled to a retest on two (2) like specimens for each specimen that failed. The pipe shall be acceptable only when all of these retest specimens meet the test requirements. No further retest shall be permitted. The pipe shall be tested only after it has been allowed to age not less than fourteen (14) days.

Pipe shall be considered ready for shipment at such age as they meet the test requirements or when tests of the test specimens indicate that the concrete has attained the specified strength.

Test specimens of the concrete consisting of six inch by twelve inch (6"x12") cylinders molded and cast in accordance with the practice of the State Highway Department shall, when tested at the age of twenty-eight (28) days, develop an average compressive strength of not less than three thousand (3000) pounds per square inch.

In addition to the above specified tests the pipe will be subject to inspection at all times prior to placing. The pipe will be subject to rejection through failure to comply with the above or any of the following conditions:

(1) Where the permissible variations are exceeded.

(2) Fractures or cracks passing through the body or bell.

(3) Failure to give a clear ringing sound when tapped with a light hammer.

(4) Exposure or misplacement of the reinforcement.

(5) Incomplete or improper mixing of concrete.

(6) Porous spots on either inside or outside of pipe.

(7) Unauthorized patching.

85.8. INSTALLATION. The trench shall be excavated to fit the curve of the body of the pipes and holes for bells shall be dug if necessary. The pipes shall be laid carefully to line and grade in the trench. Joints shall be properly grouted and connections between sections of pipe shall be at least as strong as the body of the pipe. No pipe shall be laid which is cracked, checked, spalled or damaged, but all such sections of pipe must be permanently removed from the work. Nothing but fine material, free from large stones, shall be placed around and about the pipe, and all material placed around the pipe shall be thoroughly tamped in place with a thin iron tamping bar.

85.9. HEADWALLS. The ends of pipe culverts shall be protected by concrete headwalls as shown on the plans.

85.10. MEASUREMENT AND PAYMENT. Reinforced concrete pipe for culverts shall be paid for at the contract unit price bid per lineal foot of the several sizes of "Extra Strength Reinforced Concrete Pipe" or "Standard Reinforced Concrete Pipe" as the case may be, measured complete in place, which price shall be full compensation for furnishing, hauling and installing the pipe, for preparation of bed and for all material, equipment, tools, labor and incidentals necessary to complete the work. The excavation and backfill of the trench will be measured and paid for as provided in the pertinent specifications for "Structural Excavation". Concrete headwalls shall be paid for as elsewhere provided.

STATE HIGHWAY DEPARTMENT OF TEXAS

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Revised 11-13-33

SPECIAL ITEM. VITRIFIED CLAY PIPE CULVERTS.

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DESCRIPTION. Vitrified Clay Pipe Culverts shall provide for the furnishing and placing of double strength or triple strength vitrified clay pipe meeting the requirements of these specifications and of the sizes and to the lines and grades shown on the plans, or as altered by the Engineer.

MATERIALS. Vitrified clay pipe shall be of the bell, or hub and spigot type and shall be self-centering when laid so that the pipe will make a continuous conduit with a smooth and uniform interior surface. It shall be made in sections the lengths of which shall be as shown in the plans or as herein specified. When no particular length of section is specified the pipe shall be manufactured in standard lengths of not less than two (2) feet nor more than six (6) feet.

The pipe shall be of the first quality, straight, sound and thoroughly and perfectly burned and without warps, cracks or other imperfections. It shall be round and true to form and the ends of the pipe shall be perpendicular to the longitudinal axis. It shall be fully and smoothly salt-glazed over the entire inner and outer surfaces, except that the inside of the hub or bell and the outside of the spigot may be unglazed for two-thirds (2/3) of the depth of the hub. On all other portions of the pipe the glazing shall completely cover and form an integral part of the body of the pipe. The inside of hub and outside of the spigot shall be scored in three (3) parallel lines extending completely around the circumferences. The pipe shall be manufactured at a suitable temperature to secure a tough, vitreous material which, when broken, shall show a dense solid body without detrimental cracks or laminations. It shall be of such toughness that it may be cut with a chisel and hammer, and shall give a true metallic ring when struck with a light hammer. The nominal size specified shall refer to the inside diameter. Variations of the inside diameter shall not exceed two (2%) percent, nor shall the shell thickness be less than specified by more than five (5%) percent at any point.

The maximum average absorption by the Standard Boiling Test shall not exceed eight (8%) percent of the dry weight of the pipe classification. T pipe will be classified and paid for as "Vitrified Clay Pipe" (Double Stren and "Vitrified Clay Pipe" (Triple Strength).

STRENGTH. Vitrified clay pipe shall be manufactured in such manner and workmanship and of materials of such quality that samples taken from the manufactured pipe shall show a load supporting capacity in pounds per lineal foot of pipe, when initial cracking occurs, not less than that given in the following table. Samples shall be selected and tested as prescribed in the "U. S. Department of Agriculture Bulletin No. 1216."

Size of Pipe	Double Strength Vitrified Clay Culvert Pipe		Triple Strength Vitrified Clay Culvert Pipe	
	3 Edge Bearing	Sand Bearing	3 Edge Bearing	Sand Bearing
8"	1200	1800	1800	2700
10"	1200	1800	1800	2700
12"	1200	1800	1800	2700
15"	1500	2250	2250	3375
18"	1800	2700	2700	4050
21"	2100	3150	3150	4725
24"	2400	3600	3600	5400
27"	2700	4050	4050	6075
30"	3000	4500	4500	6750
33"	3300	4950	4950	7425
36"	3600	5400	5400	8100

DIMENSIONS. The minimum requirements for vitrified clay culvert pipe shall comply with the following.

Size of Pipe Inches	Double Strength Vitrified Clay Culvert Pipe			Triple Strength Vitrified Clay Culvert Pipe		
	Minimum Thickness of Shell in Inches	Minimum Depth of Hub in Inches	Minimum Diameter Length in Feet	Minimum Thickness of Shell in Inches	Minimum Depth of Hub in Inches	Minimum Diameter Length in Feet
8	11/16	2 1/2	2	7/8	2 1/2	2
10	7/8	2 1/2	2	1 1/16	2 1/2	2
12	1	2 1/2	2	1 1/4	2 1/2	2
15	1 1/4	2 1/2	2	1 9/16	2 1/2	2
18	1 1/2	3	2	1 7/8	3	2
21	1 3/4	3	2	2 3/16	3	2
24	2	3	2	2 1/2	3	2
27	2 1/4	3 1/2	2 1/2	2 13/16	3 1/2	2 1/2
30	2 1/2	3 1/2	2 1/2	3 1/8	3 1/2	2 1/2
33	2 3/4	4	2 1/2	3 7/16	4	2 1/2
36	3	4	2 1/2	3 3/4	4	2 1/2

TESTS. The manufacturer shall provide at the place of manufacture satisfactory testing equipment and facilities to enable the Engineer to carry out the tests herein provided for.

The Engineer shall be entitled to test a number of pipe equal to two (2%) percent of the number ordered but not to exceed five (5) pieces of any one size. Pipe for testing shall be selected at random by the Engineer from the stock of pipe available for the work. In case of a failure of more than one specimen out of each five selected from each size as above, the Contractor shall be entitled to a retest on two (2) like specimens for each specimen that failed. The pipe shall be acceptable only when all of these retest specimens meet the test requirements. No further retest shall be permitted.

In addition to the above tests the pipe will be subject to inspection at all times prior to placing. The pipe will be subject to rejection through failure to comply with the above or any of the following conditions:

(1) Variation in any dimensions exceeding the permissible variations given.

(2) Fractures or cracks passing through the body or hub, except that a single crack at either end of the pipe not exceeding two (2) inches in length or a single fracture in the socket not exceeding three (3) inches in width or two (2) inches in length will not be deemed cause for rejection unless these defects exist in more than five (5) percent of the entire shipment or delivery.

(3) Blisters where the glazing is broken, or which exceed three (3) inches in diameter, or which project more than one eighth (1/8) inch above the surface.

(4) Laminations which indicate extended voids in the pipe material.

(5) Fire cracks or hair cracks sufficient to impair the strength, durability, or serviceability of the pipe.

(6) Glaze which does not fully cover and protect all parts of the shell and ends, other than those excepted above, or which is not of the first quality.

(7) Failure to give a clear ringing sound when tapped with a light hammer.

(8) Insecure attachment or fitting of branches or spurs.

INSTALLATION. The trench shall be excavated to fit the curve of the body of the pipes and holes for hubs or bells shall be dug if necessary. The pipes shall be laid carefully to line and grade in the trench with the bell end upstream. Joints shall be properly grouted and connections between sections of pipe shall be at least as strong as the body of the pipe. No pipe shall be laid which does not meet the requirements herein before stated but all rejected pipe must be permanently removed from the work. Nothing but fine material, free from large stones, shall be placed around and about the pipe, and all material placed around the pipe shall be thoroughly tamped in place with a thin iron tamping bar. In general, the minimum cover, measured from the crown of finished roadway surface to shell of pipe shall not be less than one (1) foot or one-half the nominal diameter of the pipe.

HEADWALLS. The ends of pipe culverts shall be protected by concrete headwalls when and as shown on the plans.

MEASUREMENT AND PAYMENT. Vitrified clay pipe for culverts shall be paid for at the contract unit price bid per lineal foot of the several sizes of "Vitrified Clay Pipe (Double Strength)" and "Vitrified Clay Pipe (Triple Strength)" as the case may be measured complete in place, which price shall be full compensation for furnishing, hauling and installing the pipe, for preparation of bed and for all material, equipment, tools, labor and incidentals necessary to complete the work. The excavation and backfill of the trench will be measured and paid for as provided in pertinent specifications for "Structural Excavation". Concrete headwalls shall be paid for as elsewhere provided.

ITEM 106. NAME PLATES AND MARKERS.

Revised 11/13/33

106.1. DESCRIPTION. Name Plates and Markers shall provide for furnishing and placing name plates on bridges, and markers at the beginning and end of projects, in accordance with the pertinent plans, specifications and as directed by the Engineer.

106.2. MATERIALS. Name Plates and Markers shall be bronze castings:- 85% copper; 5% tin, 5% lead and 5% zinc. Raised edges, letters and stencil blocks shall be polished. The size of the plates or markers shall be as given on the plans and the minimum thickness shall be one-quarter inch. They shall be provided with permanent fastenings to the concrete or steel.

106.3. NAME PLATES. One or more name plates shall be provided for each bridge. They shall be placed on the right side of the roadway as approached on end posts of end steel spans or on end railing posts of end concrete spans, unless otherwise provided. They shall be placed on steel spans when there are no concrete spans on the ends of the project.

Name Plates shall contain the words "State Highway Commission"; the names of the members of the State Highway Commission, State Highway Engineer, Bridge Engineer, Division Engineer, Resident Engineer; County, stream; year of construction and General Contractor. The letters and edges shall be raised at least 1/8" for name plates and 1/16" for markers. All lettering shall be block or plain gothic, cut square and not tapered. The size of the lettering shall be as shown on the plans and in general will not exceed one inch in height.

106.4. MARKERS. Markers shall be placed at the beginning and end of the project, paralleling the centerline in case of Federal Aid projects. Arrows shall be stenciled on center block to show direction. The markers will be furnished free to the Contractor. The data for all stencil work necessary shall accompany the application of the Resident Engineer for Markers.

When the end of the project is on fill section place marker at top of slope. If fill exceeds 4'-0" place marker on right-of-way line or as the Engineer may direct.

When the end of the project is on a level or cut section place marker 1'-0" from the back side of ditch as shown on the plans.

When the end of the project is the end of a concrete bridge place marker in rail post (left side as approached) at end of bridge.

Where necessary, concrete posts shall be constructed for placing markers. The posts shall be precast of 1:1 1/3:3 concrete. It shall be 6"x8"x4'-6" set 2'-0" in the ground. Around the post shall be placed a base of 1:2:4 of 1'-0"x1'-0"x2'-0". The post shall be reinforced with 4-$\frac{1}{2}$" round bars longitudinally and shall have 2-$\frac{1}{2}$" round bars transverse, one near the bottom and one near the ground line which shall dowel into the base concrete. The posts shall be chamfered $\frac{1}{2}$" on all square corners. The marker shall be placed on the 8" face of the post and flush with the post.

106.5. MEASUREMENT AND PAYMENT. Payment for "Name Plates" shall be made at the contract unit price for each plate which shall include furnishing, placing, all materials, tools, labor and incidentals necessary to complete the work.

If the direct payment above is not provided on proposal, payment for name plates shall be included in the unit price bid per pound of structural steel when located on steel or shall be included in the contract unit price per linear foot of concrete railing when located on concrete railing. Such payments shall be full compensation for furnishing, placing, all materials, tools, labor and incidentals necessary to complete the work.

No direct payment will be made for markers. The cost of placing markers, furnishing materials for and placing concrete posts where necessary shall be included in one of the pay items of the contract. This method of payment for markers will apply unless otherwise provided.

SPECIAL SPECIFICATION FOR "GUNITE ENCASEMENT OF STEEL "I" BEAMS"

GENERAL SPECIFICATIONS FOR "GUNITE".

1. "Gunite" as used herein is the name given to a mixture of sand and cement of the proportions specified for different types of work, thoroughly mixed in a dry state, and placed under pneumatic pressure with a machine manufactured under the Trade Name and Trade Mark "Cement Gun".

2. Cement shall be any brand of Standard Portland Cement which shall conform to the Standard Specifications; Paragraph 85.19. Each bag of cement shall be deemed to be one cubic foot.

3. Sand shall be clean, sharp and free from clay, loam or silt. It shall be well graded and have sufficient fine material partially to fill the voids between the coarser particles.

4. The term "dry" as applied to the sand to be used shall not mean that all moisture must be removed but rather that it shall contain a normal content of not less than 3 per cent of moisture.

5. Before placing the mixture in the hopper of the "Cement-Gun" all material and lumps over 3/8 inch in size shall be removed by screening.

6. No less pneumatic pressure than 30 pounds per square inch at the "Cement-Gun" shall be used in placing the mixed material. Where the lengths of hose exceed 100 feet the pressure at the "Gun" shall be increased so as to produce a minimum nozzle velocity equivalent to 30 pounds air pressure at the "Gun" with 100 feet of hose. Air must be maintained at a steady pressure.

7. The water used in hydrating the material at the nozzle shall be clean and free from all substances that would interfere with the setting qualities or strength of the cement. It shall be maintained at a uniform pressure of 60 pounds per square inch or at a pressure greater than 15 pounds above the pressure of the air as used.

8. The contractor shall do the work only with experienced men. No man operating the nozzle of the "Cement-Gun" will be deemed experienced unless he has done considerable work in other countracts where the work was of a similar type to that specified, or has otherwise proved his qualifications to the satisfaction of the Engineer by other equally important work.

9. In shooting all surfaces the nozzle shall be held at such distance and position that the stream of flowing material shall impinge as nearly as possible at right angles to the surface being covered. Any deposit of loose sand shall be removed prior to placing any original or succeeding layers of "Gunite" and should any sand deposit be covered with "Gunite" it shall be cut out and replaced.

10. The "Gunite" shall be kept dampened by sprinkling for at least four days after placing. No "Gunite" shall be placed during freezing weather unless under directions and precautions directed by the Engineer and in no case shall it be placed against any surface in which any frost is present.

11. In case of "Gunite" construction where steel members are to be encased by or to support "Gunite" they shall be delivered and erected unpainted.

12. "Gunite" shall be mixed in the proportions of one part cement and three parts of sand.

13. The metal reinforcing mesh shall be either electric welded fabric all No. 12 wires spaced 2 inches in each direction, or No. 10 wires placed 3 inches in each direction, or it may be expanded metal of no less than $1\frac{1}{2}$ inch opening and of equivalent cross sectional area as the welded fabric. Holes not less than 1/2 inch in diameter, for attaching the "Gunite" reinforcement, shall be punched, during fabrication, in webs of members as near as possible to top and bottom flanges. In placing the mesh or rods, no less than 1/4 inch in diameter shall first be fastened to the steel through holes punched in the webs or stiffeners and subsequently the mesh shall be securely tied outside of these rods with wires spaced at about 12 inch intervals. The mesh shall conform, in so far as possible, to a spacing 1/2 inch out from the face of the steel members. Wherever adjacent sheets meet they shall lap at least 4 inches and the sheets shall be securely and properly fastened together.

14. The steel members to be covered with "Gunite" shall be cleaned thoroughly of all paint, rust, scale, grease or other material before the "Gunite" is applied.

15. The "Gunite" encasement for all steel Beams shall follow generally the outline of the member. The corners shall be squared and the surface of the "Gunite" shall be finished as directed.

16. For all exposed members, "shooting strips" shall be employed to insure square corners and proper thicknesses of the "Gunite". The finish of the web portion of the "Gunite" shall, when exposed to view, be treated with a "Brush coat" of clean water applied with a whitewash brush, or a "flash coat" finish.

17. Method of Measurement: This item shall be measured by the square foot complete in place. Measurement of all areas shall be deemed to be the actual area of the "Gunite" encasement of the members to be covered measured along the center line of the "Gunite" section.

18. Basis of Payment: The unit price bid per square foot for "Gunite" shall be full compensation for furnishing, hauling and placing all materials including Gunite reinforcing, for preparation of all material, royalties and for all labor, equipment, tools and incidentals necessary to complete the work.

STATE HIGHWAY DEPARTMENT OF TEXAS

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SPECIAL ITEM

BITUMINOUS CONCRETE PAVEMENT (MODIFIED TOPEKA TYPE)

1. DESCRIPTION: Bituminous Concrete Pavement of the modified Topeka Type shall consist of a wearing course composed of a compacted mixture of mineral aggregate and bituminous material and shall be constructed on the completed and approved base course, or, in the case of a bridge, on the prepared floor slab, in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross section shown on the plans.

2. MATERIALS. The mineral aggregate shall be composed of a coarse aggregate of crushed stone, a fine aggregate, and mineral filler. Samples of the coarse aggregate, fine aggregate, and mineral filler shall be submitted in accordance with prescribed methods. Approval both of the material and of the source of supply must be obtained from the Engineer prior to delivery of material.

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

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

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

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

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

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

The bituminous material shall be OA-55 Oil Asphalt. The material shall be homogeneous, free from water, shall not foam when heated to 175 degrees C. (347° F.),

and shall meet the following requirements:

	Min.	Max.
1. Penetration at 25°/25°C. 100 gms. 5 sec.	50	60
2. Penetration at 0°/0° C. 200 gms. 60 sec.	22	
3. Ductility at 25°/25° C. cms.	50	
4. Flash Point °C.	232	
5. Melting Point °C.	45	60
6. Loss at 163° C., 5 hrs. %		1.0
7. Penetration of Residue 25°/25°C.	30	
8. Solubility in CS_2	99.5	
9. Bitumen Soluble in CCL_4 %	99.5	

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

Passing ½ inch screen and retained on ¼ inch screen ---	5-10%
Passing ¼ inch screen and retained on 10 mesh sieve ---	15-22%
Total retained on 10 mesh sieve ----------	25-32%
Passing 10-mesh sieve, retained on 40-mesh sieve ------	7-22%
Passing 40-mesh sieve, retained on 80 mesh sieve ------	14-34%
Passing 80-mesh sieve, retained on 200 mesh sieve -----	11-25%
Passing 200-mesh sieve ----------	7-12%
Bitumen soluble in carbon disulphide ----------	7½-11%

The percentage of bitumen in the finished course shall not vary more than one-half per cent from the proportion established by the Engineer. All materials, and sources of materials shall be satisfactory to the Engineer and whenever required by him, samples of the hot mixture may be taken several times daily, to be acceptable, must invariably conform to all requirements.

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

3. CONSTRUCTION METHODS: When the bituminous concrete pavement is to be laid on a concrete base course, or in case of a bridge, on the concrete slab floor, the surface of the slab shall be finished moderately rough with the coarse aggregate well embedded, but not covered with a coating mortar and with the entire surface free from all depressions or other irregularities.

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

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

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

4. MIXING: The prepared aggregates, the mineral filler and the bituminous material shall be proportioned by weighing, and mixed as directed in the order mentioned, and in adequate and suitable apparatus, so that the resulting mixture shall be thoroughly homogeneous and shall meet all the requirements herein specified. When discharged the mixture shall have a temperature of between 250 and 350 degrees F.

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

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

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

The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacements occuring as a result of reversing the direction of the roller or by any other cause, shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall continue with out interruption until all roller marks disappear and the surface shows no further compressibility. After the pavement has had its initial compression limestone dust or Portland Cement as directed by the Engineer shall be swept thinly over all the entire surface. A sufficient number of rollers must be employed to obtain the maximum compression, and in no case shall less than 96 per cent of the calculated density be obtained. Places which the roller cannot effectively reach shall be compressed with hot iron tampers.

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

8. NON SKID SURFACE COURSE: The granular type surface mixture shall consist of a uniform mixture of coarse aggregate, fine aggregate, mineral filler and bituminous materials to be proportioned by weight, to produce a mixture comming within the following limits. The exact proportion of each constituent producing the total mixture shall be as directed by the Engineer. When tested by means of laboratory sieves the granular type surface mixture shall meet the following requirements:

Passing ½ inch screen, and retained on ¼ inch screen --	0-40%
Passing ¼ inch screen, and retained on 10-mesh sieve --	25-75%
Total retained on 10 mesh sieve ----------	65-75%
Passing 10 mesh sieve and retained on 40 mesh sieve ---	3-10%
Passing 40 mesh sieve and retained on 80 mesh sieve ---	6-12%
Passing 80 mesh sieve and retained on 200 mesh sieve --	4-10%
Passing 200 mesh sieve ----------	3-6 %
Bitumem soluble in carbon disulphide ----------	5-7 %

The granular type surface mixture shall be dumped and then spread with a finishing machine over the modified Topeka surface following its initial rolling. The granular mixture shall be applied at the rate of 30 to 40 pounds per square yard and the rolling continued until the final compaction is reached.

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

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

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

METHOD OF MEASUREMENT: The yardage to be paid for shall be the number of square yards of wearing course in place, completed and accepted.

BASIS OF PAYMENT: Payment will be made by the yardage measured as provided above at the contract unit price bid per square yard of "Bituminous Concrete Pavement" (modified Topeka Type) which price shall be full compensation for quarrying, furnishing all materials, for all heating, mixing, hauling, placing, rolling and finishing, and all labor, tools, equipment and incidentals necessary to complete the work.

6473-5

AMIESITE PAVEMENT

1. Description. This item shall consist of a wearing course composed of a compacted mixture (laid cold) of mineral aggregate and bituminous material having a total depth after compaction as shown on plans (not less than two inches), and a surface covering, and shall be constructed on the prepared base course in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the plans.

2. Materials.

2.1. Bottom Course. On the prepared base course as elsewhere specified, there shall be constructed a bottom course $1\frac{1}{2}$ inches thick after compression, which shall consist of a uniform mixture of mineral aggregate, mineral filler, asphaltic cement, lime and liquifier proportioned as hereinafter specified. The constituents of the base course shall meet the following requirements:

Mineral Aggregate. The mineral aggregate for the bottom course shall consist of clean, tough, durable crushed rock of approved quality, passing screens having circular openings not greater than $1\frac{1}{4}$ inches in diameter and being retained on a $\frac{1}{4}$ inch screen. It shall have a percentage of wear not more than 6 and shall be well graded from the largest to $\frac{1}{4}$ inch size.

Mineral Filler. The mineral filler shall consist of clean crushed rock screenings or sand of approved quality and approved limestone dust if necessary, all of which shall pass the $\frac{1}{4}$ inch screen. Of this material 20 to 35% shall be retained on the 10 mesh sieve.

Asphaltic Cement. Asphaltic cement shall meet the requirements given below for O A-5 or N A-5.

O A-5 Oil Asphalt shall be homogeneous, free from water, and shall not foam when heated to 175°C (347°F).

It shall meet the following requirements:

1. Specific gravity 25°/25°C (77°/77°F) not less than 1.01.

2. Flash Point. Not less than 175°C. (347°F.).

3. Melting Point . . . . . 40°C (104°F) to 60°C (140°F).

4. Penetration at 25°C (77°F) 100 G., 5 Sec. 60 to 70.

5. Loss at 163°C (325°F) 5 hours - not more than 1.0%.

   a. Penetration of resudue at 25°C (77°F) not less than 40.

6. Total bitumen (soluble in carbon disulphide) not less than 99.5%

   b. Organic matter insoluble - not more than 0.2%.

Note: Material for any one contract shall not vary more than 0.020 in specific gravity.

N A-5. Fluxed Bermudez asphalt shall be homogeneous, free from water, and shall not foam when heated to 175°C (347°F).

It shall meet the following requirements:

1. Specific gravity 25°/25°C (77°/77°F) ... 1.050 to 1.070.

2. Flash Point ..... not less than 175°C (347°F).

3. Melting Point .....45°C (113°F) to 55°C (131°F)

4. Penetration at 25°/25°C (77°F) 100 G., 5 Sec. 60 to 70.

5. Loss at 163°C (325°F) 5 hours - not more than 3.0%.

   a. Penetration of residue at 25°C (77°F)

   100 G., 5 Sec. - not less than 30.

6. Total bitumen (soluble in carbon disulphide) not less than 94.5%.

   b. Inorganic matter insoluble - not more than 2.0% to 3.5%.

Tests of the physical and chemical properties of the asphalt shall be made in accordance with the methods prescribed in United States Department of Agriculture Bulletin 1216.

Lime. The lime shall be commercial hydrated lime meeting the requirements of the American Society of Testing Materials.

Liquifier. The liquifier shall be naptha varying between 45 and 58 degrees Baume to meet the requirements of construction conditions.

When tested by laboratory methods, the paving mixture for bottom course shall meet the following requirements. The exact proportion and character of each constituent producing the total mixture within these limits, shall be as directed by the Engineer.

Mineral Aggregate	65 - 80 per cent
Mineral Filler	15 - 30 per cent
Asphaltic Cement	4.0 - 6.0 per cent
Lime	0.5 - 1.0 per cent
Liquifier	0.6 - 0.8 per cent

2.2. Top Course. Upon the bottom course there shall be constructed a top course which shall be ½ inch thick after compression, and which shall consist of a uniform mixture of mineral aggregate, mineral filler, lime and liquifier proportioned as hereinafter specified. The constituents of this course shall meet the following requirements:

Mineral Aggregate. The mineral aggregate shall be the same as for the bottom course except that all of the material shall pass a 5/8 inch screen.

Mineral Filler. The mineral filler shall be of the same quality as for the bottom course. All shall pass a 1/4 inch screen. Of this material not less than 15% nor more than 25% shall pass the 80 mesh screen and be retained on a 200 mesh screen and not less than 8% nor more than 12% shall pass a 200 mesh screen.

Lime. The lime shall be the same as for the bottom course.

Liquifier. The liquifier shall be the same as for the bottom course.

The paving mixture when tested by laboratory methods shall meet the following requirements. The exact proportion and character of each constituent producing the total mixture within these limits shall be as directed by the Engineer.

	Min	Max.
Mineral Aggregate	55%	75%
Filler	20%	40%
Asphaltic Cement	5%	7%
Lime	0.5%	1.0%
Liquifier	0.6%	0.8%

2.3. Surface Covering Material. This material shall consist of clean, dry sand or limestone or Portland Cement placed in such quantity so as to cover the entire surface with a thin uniform course.

3. Construction Methods.

3.1. The percentage of bitumen in the finished course shall not vary more than ½ per cent from the proportion established by the Engineer. All materials and sources of materials shall be satisfactory to the Engineer and whenever required by him samples of the mixture may be taken several times daily and the mixture to be acceptable must invariably conform to all requirements.

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

3.3. Inspection. Approval of sources of material supply:

Sources of supply for the asphaltic cement, fine and coarse aggregate shall be approved by the Engineer before the delivery of materials is started; and samples shall be submitted in accordance with the requirements of the Engineer as prescribed in the U. S. Department of Agriculture Bulletin No. 1216.

3.4. Plant Inspection: Materials and the preparation of mixtures shall be subject to inspection at the refineries and plant as may be directed.

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

3.6. Mixing: The prepared aggregate and the mineral filler and the asphalt cement shall be proportioned by weighing, for each batch, and mixed as directed by the Engineer in the order mentioned in adequate and suitable apparatus, approved by the Engineer, so that the resulting mixture shall be thoroughly homogeneous and shall meet all the requirements herein specified. The mixer used shall have revolving blades and shall be of the batch type.

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

3.8. The mineral aggregate must be perfectly dry when coated and have a temperature of not less than 60°F nor more than 175°F. The bitumen, when applied to the aggregate, must have a temperature of not less than 250°F nor more than 350°F, and must be free from unmelted lumps.

In preparing the paving mixture for both the top and bottom courses, the stone and sand shall first be placed in the mixing chamber after which some liquifier shall be added, if needed, and as soon as the aggregate is coated therewith the asphaltic cement shall be added. More liquifier shall then be added and the mixing continued until the aggregate is completely coated with the asphaltic cement. The hydrated lime shall then be added, and more liquifier, if necessary, to secure the proper distribution of the asphaltic cement. The mixing shall continue until all particles of the aggregate are completely and uniformly coated with the asphaltic cement.

3.9. The mineral filler should be so cast into the mixing chamber that it is evenly distributed over the surface of the aggregate and not dumped in one end of the mixing chamber. The asphaltic cement should also be added slowly in a thin sheet the full width of the mixing chamber. If the filler and asphaltic cement are not added in this manner, the time required to produce a uniform paving mixture will be two or more minutes per batch, otherwise from one to one and one-half minutes will be sufficient.

3.10. The paving mixture, when properly prepared, must be uniform in composition, free from lumps or balls containing an excessive quantity of bitumen, from materials containing less bitumen than that required and not shown evidence of the improper application of the liquifier.

3.11. The bituminous concrete mixture prepared as specified, shall be hauled to the work in tight vehicles previously cleaned of all foreign materials. The dispatching of the vehicles shall be arranged so that all material delivered may be placed and shall have received initial rolling in daylight.

3.12. Placing Bottom Course. Prior to the arrival of the bottom course mixture on the work the base course shall have been cleaned of all loose and foreign materials. The bottom course mixture shall be laid only on a base course which is dry and only when the weather conditions are suitable. Contact surfaces of curbings and gutters, and all joints shall be painted with a thin, uniform coating of asphaltic cement before the surface mixture is spread. Upon arrival on the work the bottom course mixture shall be deposited outside of the area on which it is to be spread, the entire load distributed into place, and spread by suitable means in a uniform layer of not less than one and one-half inches in depth after compression. The mixed material shall be kept clean at all times and dirt or foreign materials shall not be allowed to mix with under or on the mixed material while being unloaded from cars, spread or rolled.

3.13. The time and manner of rolling shall be governed by the condition of the paving mixture. If the paving mixture contains enough liquifier to be soft and plastic it shall not be rolled until the bitumen has hardened sufficiently to give the pavement the necessary stability when properly consolidated by rolling.

When properly cured the paving mixture shall be rolled with a power roller weighing not less than 10 tons, or with a roller having compression of not less than 200 pounds per inch of rear wheel width. The initial rolling shall be continued until the desired bond between the ingredient of the aggregate is secured and porous or low spots disclosed. Depressions made by rolling shall be filled with additional material and rerolled so that the surface of this bottom course will be of a uniform character and have the required grade and crown.

3.14. After being spread and rolled as above specified, the bottom course must be protected from all travel and kept perfectly clean until the top course has been applied. If any part of this course shows a lack of bond, becomes loose or broken up or covered with mud, it must be replaced with proper material laid in accordance with the requirements given herein. If the bottom course becomes wet before it can be covered, it must be allowed to dry before the surface pavement is laid.

3.15. Placing Top Course. After this bottom course is properly rolled the top course shall be spread and rolled in a uniform layer to a depth of not less than one-half of an inch after compression, so as to cover the underlying bottom course. Adjacent to flush curbings, gutters, liners and structures the surface course shall be spread uniformly high so that when completed it will be slightly above the edge of the curbing, gutter, etc. Adjacent to curbing, gutter and railway track liners, and all other locations inaccessible to the roller, the compression shall be effected with iron tampers weighing not less than 25 pounds and having a bearing area not exceeding 48 square inches.

3.16. Final Compression. After the top course has been spread evenly, rolling shall begin at the sides and work to the center of the roadway. The total compressed depth of the finished mixed material surface shall not be less than two inches.

The motion of the roller shall at all times be slow enough to avoid displacement of the mixture and any displacements occurring as a result of reversing the direction of the roller or by any other means, shall at once be corrected by the use of rakes and of fresh mixtures where required. Rolling shall proceed at a rate not in excess of 150 square yards per hour per roller. Rolling shall continue without interruption until all roller marks disappear and the surface shows no further compressibility.

The roller should not pass off the paving mixture during rolling and the wheels of the same must be kept clean and oiled at all times. No water shall be applied to the wheels of the roller. Ashes, coal, dirty water or grease must not be allowed to drop from the roller onto the pavement. After the pavement has had its initial compression limestone surface covering material as directed by the Engineer, shall be swept thinly over the entire surface. A sufficient number of rollers must be employed to obtain the maximum compression, and in no case shall less than 96% of the calculated density be obtained.

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

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

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

3.18. Protection of Pavement. If at the time of laying surface course mixture permanent side supports such as curbs, edgings, headers or gutters have not been constructed, planks of suitable thickness shall be laid along side of the pavement and rigidly supported so as to prevent the mixture from squeezing out under the roller. These planks shall remain in place until final compaction has been obtained. During the construction of shoulders the surface of the pavement shall be kept clean and free from foreign material.

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

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

1793

S.A.P. No._____
F.A.P. No._____
Job No._____
_____County.

COLD ROLLED ROCK ASPHALT

(DURACO)

1. DESCRIPTION:

This item shall consist of a surface course composed of a mixture of asphalt and natural limestone rock asphalt, coarse mineral aggregate, liquifier and water, which shall be laid cold upon a prepared surface brought to the proper cross-section and compacted by means of rolling.

The specifications for the materials shall conform to the requirements given below:

2. MATERIALS:

(a) Asphaltic Oil shall be an asphalt base oil fulfilling the following requirements:

Specific gravity @ 25°C, not less than.....95
Percent of asphalt @ 100 Penetration, not less than.....50

(b) Mineral Aggregate - Coarse: This shall consist of a clean, tough, durable crushed rock having a percent of wear of not more than 6.
The size of this aggregate shall be as follows:

Retained on the ¼" screen, not more than.....5%
Passing ¼ and retained on 10.....50 - 75
Passing 10 and retained on 40 .....10 - 25

(c) Mineral Aggregate - Rock Asphalt. This shall consist of a carefully selected, well graded as to size, LIMESTONE ROCK ASPHALT containing naturally from 9 - 15% of native bitumen and from 85% - 91% of carbonate of lime and the size of this aggregate shall be as follows:

Retained on ½" screen 5%
Passing ½" retained on ¼".....11 - 25%
" ¼" " " #10..... 7 - 25%
" #10 " " #40.....11 - 36%
" #40 " " #80.....10 - 25%
" #200 ..... 5 - 11%

(d) Liquifier: Naptha and meeting the following requirements:

Baume Equivalent @ 25 C.....40 - 50
Flash point not less than 125°F

3. PREPARATION & MIXING OF MATERIALS:

In preparing this material ready for use, the LIMESTONE ROCK ASPHALT shall be run through a pulverizer having gratings with 3/8" openings and mixed with coarse aggregate, asphaltic flux oil, liquifier and water in accurate proportions. The proportion of each shall be as follows:

Coarse aggregate..... 20% - 30%
Rock Asphalt " ..... 65 - 75
Liquifier ..... .2 - .5
Asphaltic Oil .....1.75 - 3
Water permitted ..... .1 - .3

4. The percentage of bitumen in the finished course shall not vary more than 1.0 percent from the proportion established by the Engineer. All materials shall be satisfactory to the Engineer and whenever required by him samples of the mixture may be taken several times daily and the mixture to be acceptable must invariably conform to all requirements.

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

6. INSPECTION: Approval of sources of Material supply:
Sources of supply for the asphaltic oil, fine and coarse aggregate shall be approved by the Engineer before the delivery of materials is started, and samples shall be submitted in accordance with the requirements of the Engineer as prescribed in the U. S. Department of Agriculture Bulletin No. 1216.

7. PLANT INSPECTION:
Materials and the preparation of mixtures shall be subject to inspection at the refineries and plant as may be directed.

8. The Asphalt flux shall be separately heated in kettles so designed as to admit of even heating of the entire mass with an efficient and postive control of the heat at all times. It shall be heated as directed by the Engineer to a temperature between 140°F and 180°F.

9. MIXING:
The prepared aggregates and the asphalt flux shall be proportioned by weighing for each batch, and mixed as directed by the Engineer in the order mentioned in adequate and suitable apparatus approved by the Engineer, so that the resulting mixture shall be thoroughly homogeneous and shall meet all the requirements herein specified. The mixer used shall have revolving blades and shall be of the batch type

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

11. The mineral aggregate must have a temperature of not less than 50 degrees F. The asphaltic flux, when applied to the aggregate, must have a temperature of not less than 140 degrees F. nor more than 180 degrees F.
In preparing the DURACO paving mixture for surface course, the crushed stone and crushed rock asphalt shall first be placed in the mixing chamber after which the liquifier shall be added, and as soon as the aggregate is coated therewith the asphaltic oil shall be added, and the mixing continued until the aggregate is completely coated with asphalt.
It is contemplated that the paving mixture will be prepared at some central point and shipped ready for use to the work and unloaded either in stock pile or in trucks and placed in the work within at least three weeks from the time of shipment. If material is stored in a stock pile it must be placed under cover or shed.

12. METHOD OF LAYING:
The sub-planking of bridge floor to be covered shall be swept clean and painted with an asphaltic base oil or a cut back asphalt paint (50% roofing asphalt - 50% gasoline). This paint shall be put on at the rate of one-tenth gallon per sq. yd. The asphaltic oil or paint shall be broomed in with a wire broom or ordinary fibre push broom.

The DURACO mixture shall be spread to a thickness of $1\frac{1}{2}$ inches taking care to break up any lumps which may be present. Where a patch is made the mixture shall be feathered out on all edges by first combing the edges with the rake teeth and then smoothing with the back of the rake. Particular care should be taken to see that all the paint is covered up with mixture and no paint left adjacent to the work so that the roller can pick it up. In laying, an allowance of approximately 50% shall be made for compression, that is, if the thickness is to be an average 1", the mixture should be raked to a thickness loose of $1\frac{1}{2}$ inches. After same is rolled as indicated below then in the same manner the second course is placed and rolled to the cross-section shown on plans, so that the total average thickness is 2 inches.

The DURACO wearing surface shall then thoroughly be rolled with a power driven roller, having a compression of not less than 200 lbs. per lineal inch according to thickness of pavement. Where possible, the surface shall be diagonally rolled and all places inaccessible to the roller shall be compressed by means of hand tamps. All low and uneven places shall be built up with additional mixture and re-rolled. Bond between one day's work and the next shall be accomplished by roughing up the end of the pavement laid the previous day and depositing fresh material upon it, feathering out the new mixture where it joins the old pavement.

13. TRAFFIC:

No traffic shall be allowed on that part of work under construction but the completed pavement shall be thrown open to traffic within 24 hours.

14. INSPECTION:

All work and materials in connection with the construction of the pavement shall be subject to the inspection and approval of the Engineer.

15. PAYMENT:

The completed pavement shall be paid for at the unit bid price per sq. yd. which shall include the use of all necessary equipment, tools, material and labor.

2802(Revised)

TEXAS STATE HIGHWAY DEPARTMENT

AMULCO ASPHALT PAVEMENT

1. DESCRIPTION. This item shall consist of a pavement composed of coarse and fine mineral aggregates, premixed with asphaltic emulsion and shall be constructed on the completed and approved foundation as specified, or in the case of a bridge upon the prepared floor of same. The pavement shall be laid as black base course, wearing course, or seal coat as called for on the plans, all in accordance with these specifications and in conformity with the lines, grades, compacted thickness and typical cross-section shown on the plans.

2. MATERIALS. The Mineral Aggregate shall be composed of a Coarse Aggregate of crushed stone, and a fine aggregate of stone screenings or natural sand. Samples of the coarse aggregate and fine aggregate shall be submitted in accordance with prescribed methods.

3. The Coarse Aggregate shall consist of clean, tough, durable angular particles of crushed rock, (excluding shcist, shale or slate) of uniform quality throughout, shall be free from an excess of thin or elongated pieces and free from soft or disintegrated stone, dirt, organic or other injurious matter occuring either free or as a coating on the stone. All stone shall meet the requirements of the soundness test. All stone shall have a percent of wear of not more than 8, and when tested by laboratory methods, shall fulfill the grading requirements of the course for which it is to be used and shall be construed to mean all the material retained on a 1/4" screen.

4. The Fine Aggregate shall consist of sand, or a combination of one or more sands and stone screenings. The sand shall be composed of sound, durable hard particles, reasonably free from a coating of clay or loam. The screenings shall be of the same or similar material as specified for Coarse Aggregate. The Fine Aggregate shall be of such grading that it will pass a 1/4" screen and fall within the following limits.

Passing 1/4" Screen.....	95% to 100%
Passing 20-Mesh Sieve.....	50% to 80%
Passing 50-Mesh Sieve.....	5% to 30%
Passing 100 Mesh Sieve.....	0% to 5%

5. The Asphalt Emulsion shall be homogenous in character and the stability shall be such that it will uniformly coat wet and dry mineral particles without showing any appreciable separation of the asphalt content, while it is being manipulated and/or incorporated into mixtures.

It shall be miscible in all ordinary proportions with any potable water with alkalinity not exceeding two hundred and fifty (250) parts per million.

The amount of saponifiable substances shall not exceed 1.5 percent when determined in accordance with Test Method 37-E, as described on Page 753 of the Third Edition of "Asphalt and Allied Substances", by Abraham.

When distilled in accordance with the method described in A.S.T.M. Tentative Standard, Serial Designation D-244-28-T, the percentage of oil distillate and total distillate in the emulsion shall be as follows:

Total Distillate.....40 to 45% inclusive
Oil Distillate ..... 0 to 2%

Asphaltic Residue obtained by distillation shall meet the following requirements:

Specific Gravity 25/25°C - Not less than...1.00
Penetration at 25°C - 100 grm. 6 Seconds...70 to 110
Ductility at 25°C - Not Less than.....60 CM
Solubility in CS2 - Not Less than.....99.0%

VOLATILIZER. Volatilizer shall consist of a volatile liquid with an initial boiling point not less than 90°F., and with an end point not more than 410°F.

6. CONSTRUCTION METHODS. The wearing Course shall be composed of fine and coarse aggregate, volatilizer and cold emulsified asphalt, and shall have an average thickness of not less than 1-1/2" after compaction. The composition of the finished mixture, after complete evaporation of the liquefying agent and volatilizer, shall fall within the limits as follows:

Asphalt Cement..... 4.0% to 6.0%
Fine Aggregate.....10.0% to 30.0%
Coarse Aggregate.....64.0% to 86.0%

The Coarse Aggregate content shall be graded so as to fall within the limits as follows:

Passing 1" Screen.....95.0% to 100.0%
Passing 1/2" Screen.....30.0% to 65%
Passing 1/4" Screen..... 0.0% to 5.0%

7. The Seal Coat shall be composed of Fine Aggregate, or fine and coarse aggregate, volatilizer and cold emulsified asphalt, and shall have an average thickness of not less than 1/2" after compaction. The composition of the finished mixture after complete evaporation of the Liquefying agent and volatilizer, shall fall within the limits as follows:

Asphaltic Cement.....5.0% to 8.0%
Fine Aggregate.....62.0% to 92.0%
Coarse Aggregate..... 0.0% to 33.0%

The Coarse Aggregate shall be graded so as to fall within the limits as follows:

Passing 1/2"Screen.....100%
Passing 1/4" Screen..... 40% to 95.0%

8. PROPORTIONING MATERIALS AND MIXING. All materials shall be accurately proportioned by weight, or by volume based on weight, in batches of a size which will not exceed the capacity of the mixing device, which shall be of a pug-mill, or concrete type of mixer.

The mineral aggregate graded and proportioned as hereinbefore specified shall first be placed in the mixer, then volatilizer introduced to the extent of from two-tenths (2/10) percent to six-tenths (6/10) percent by weight of the total mix and the proper amount of emulsified asphalt added and mixed until all mineral particles are thoroughly coated and the resultant mixture thoroughly homogeneous. Excessive mixing will not be permitted.

9. LAYING AND ROLLING. The Asphalt Mixtures, prepared as hereinbefore specified, shall be conveyed from the plant to the work in suitable vehicles and shall be successively deposited upon the foundation or previous course. If spread by hand the material shall not be deposited upon the place it is to occupy but sufficiently in advance of the course, so that in placing, all the material shall be turned by means of shovels or forks, and uniformly leveled by means of rakes or other suitable appliances, to the required depth and contour. Care shall be taken to prevent segregation. The mixture shall then be allowed to harden until it reaches a semi-plastic condition. The hardening time required will be dependent upon depth of layer, temperature and atmospheric conditions, and will be of such duration as deemed necessary by the Engineer.

When the mixture has hardened sufficiently to be in a semi-plastic condition, it shall receive an initial rolling which shall be sufficient to smooth the surface and thoroughly key the stone. After complete aeration, which should be from twelve (12) to twenty-four (24) hours after laying, it shall be finally rolled with a three-wheeled, self-propelled roller giving a compression of not less than 200 pounds per inch of roller width, until the furface is firm and unyielding.

When the pavement is composed of two or more courses of the mixture hereinbefore specified, each mixture shall be laid as hereinabove required. Each course shall be so laid that the upper surface of the course shall be parallel to the established grade and contour of the

finished pavement and be below the established grade and contour by an amount which will approximate the aggregate depth of all the succeeding courses. After receiving final compaction, each course shall show an average depth equal to the specified depth.

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

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

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

11. METHOD OF MEASUREMENT. The yardage to be paid for shall be the number of square yards of pavement in place, completed and accepted.

12. BASIS OF PAYMENT. This item shall be paid for by the yardage measured as provided above as the price bid per square yard for "Amulco Asphalt Pavement" which price shall be full compensation for quarrying, furnishing all materials, for mixing, hauling, placing, rolling and finishing and for all labor, tools, equipment and incidentals necessary to complete the work.