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STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION

MARCH, 1950

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ITEM S-100

CLEARING AND GRUBBING

S-100.1. DESCRIPTION. "Clearing and Grubbing" will consist of the removal and disposal of trees, stumps, brush, roots, vegetation, logs, rubbish, and other objectionable matter.

S-100.2. CONSTRUCTION METHODS. The entire right-of-way shall be cleared of all trees, stumps, brush, logs, and rubbish, except such trees and brush as may be designated by the Engineer for preservation. Trees and brush designated to be left in place shall be carefully trimmed as directed and shall be protected from scarring, barking, or other injuries during construction operations.

Areas required for embankment construction; for roadway, channel and structural excavation; and for borrow sites and material sources shall be cleared and grubbed. On areas required for roadway, channel, or structural excavation, all stumps, roots, etc., (except for designated trees and brush) shall be removed to a depth of at least one foot below the finished surface of the required cross-section. On areas required for embankment construction, all stumps, roots, etc., (except for designated trees and brush) shall be removed to a depth of at least one foot below the existing ground surface. On areas required for borrow sites and material sources, stumps, roots, etc., (except for designated trees and brush) shall be removed to the complete extent necessary to prevent such objectionable matter becoming mixed with the material to be used in construction.

All cleared and grubbed material shall be disposed of in a manner satisfactory to the Engineer. Unless otherwise provided, all merchantable timber removed as above required shall become the property of the Contractor.

S-100.3. MEASUREMENT. "Clearing and Grubbing" will be measured by the "Acre".

Measurement for payment will be made only on areas indicated and classified on plans as "Clearing and Grubbing", except that required work on additional areas (such as additional right-of-way, additional borrow and material sources, additional cut and embankment areas, etc.,) not originally proposed by plans but found necessary during construction, and which comes within the purview of "Clearing and Grubbing" as established on plans for the contract shall be measured accordingly.

Areas other than those set forth above will not be measured for payment.

S-100.4. PAYMENT. All work performed and measured as provided under "Measurement" will be paid for at the unit price bid for "Clearing and Grubbing," which price shall be full compensation for furnishing all labor, equipment, tools, supplies, and incidentals necessary to complete the work.

All work performed in clearing and grubbing areas not so designated on plans, except "additional areas" as defined under "Measurement," will not be paid for directly but shall be considered as subsidiary work pertaining to the various contract items.

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ITEM S-101

ROADWAY EXCAVATION

S-101.1. DESCRIPTION. "Roadway Excavation" will consist of required excavation within the limits of the roadway (except excavation otherwise classified, such as excavation for drainage structures, outlet ditches, channels, etc.,); the removal and proper utilization or disposal of all excavated materials; and the constructing, shaping, and finishing of all earthwork on the entire length of roadway and approaches to same in conformity with the required lines, grades, and typical cross-sections and in accordance with specification requirements herein outlined.

S-101.2. CLASSIFICATION. All authorized roadway excavation will either be unclassified or classified as indicated on the plans.

(1) "Unclassified Road Excavation".
If no classification is indicated on the plans "Unclassified Road Excavation" shall include all materials encountered regardless of their nature or the manner in which they are removed.

If classification is made, one of the following methods shall be employed:

(2) "Rock Road Excavation", "Special Road Excavation", and "Common Road Excavation".

(a) "Rock Road Excavation" will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than one-fourth (1/4) cubic yard each in volume.

(b) "Special Road Excavation" will include all boulders and loose stones of less than one-fourth (1/4) cubic yard in volume and all materials in masses (such as caliche, iron ore, conglomerate, slate, shale,etc.,) which cannot be removed efficiently with the usual earth-moving equipment, but which it is possible to move with pick or bar without blasting, even though the Contractor may elect to employ blasting.

(c) "Common Road Excavation" will include all other materials excavated

(3) "Rock Road Excavation" and "Common and Special Road Excavation".

(a) "Rock Road Excavation" will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than one-fourth (1/4) cubic yard each in volume.

(b) "Common and Special Road Excavation" will include all other materials encountered.

When, in the Contractor's opinion, materials encountered are other than as shown on the plans, the Engineer shall be notified prior to removal of any such material in order to permit classification and measurement.

Objections on the part of the Contractor to the Engineer's classification of roadway excavation shall be filed in writing with the Engineer within 15 calendar days of receipt of the partial estimate which includes the particular classification objected to. Failure on the part of the Contractor to file such objections as outlined above will be construed as his concurrence with the classifications made.

S-101.3. CONSTRUCTION METHODS: All Roadway Excavation and corresponding embankment construction shall be performed as specified herein and in the Item "Embankment", and the completed roadway shall conform to the established alignment, grades, and cross-sections.

All suitable excavated materials shall be utilized, insofar as practicable, in constructing the required roadway sections. Unsuitable roadway excavation and required roadway excavation in excess of that needed for construction of the required roadway sections shall be known as "waste". Where indicated on plans or directed, suitable waste shall be used to uniformly widen embankments, flatten slopes, etc.; otherwise, waste shall be removed and disposed of at designated points in such manner as to present a neat appearance and not to obstruct proper drainage or cause injury to highway improvements or to abutting property. Unless otherwise provided, waste deposits shall be manipulated as required by the Item "Embankment", except that the loose depth of each layer shall not exceed two (2) feet.

"Waste" will not be permitted unless specifically indicated on plans or required by written order of the Engineer.

Payment will not be allowed for excavation of any material which is used for purposes other than those designated except as provided in the governing specifications under Item 4, "Scope of Work".

During construction the roadbed and ditches shall be maintained in such condition as to insure proper drainage at all times, and ditches and channels shall be so constructed and maintained as to avoid damage to the roadway section.

Unless otherwise indicated on plans, excavation in solid rock shall extend six inches below the required subgrade elevation for the entire roadbed width, and shall be backfilled with suitable selected materials as indicated on plans or as instructed. All slopes except in solid rock or other materials, which in the judgment of the Engineer require variation, shall be accurately trimmed, and care shall be taken that no material is loosened below the required slopes. All breakage and slides shall be removed and disposed of as directed.

S-101.4. SELECTION OF MATERIALS. Where shown on plans, selected materials shall be utilized to improve the roadbed, in which case the work shall be performed in such manner and sequence that suitable materials may be selected, removed separately, and deposited in the roadway within limits and at elevations required.

S-101.5. MEASUREMENT. All accepted roadway excavation will be measured in its original position and the volume computed in cubic yards by the method of average end areas. Measurements will include all authorized excavation below grades and slides or over-breakage which, in the Engineer's opinion, are not attributed to the Contractor's carelessness, except that all over-breakage in solid rock shall not exceed, in any half station, ten (10) per cent of the actual quantity required for the same half station. Unauthorized work will not be paid for.

S-101.6. PAYMENT. All work performed as required herein and in the Item "Embankment" and measured as provided under "Measurement", will be paid for at the unit price bid for "Unclassified Road Excavation"; or as "Rock Road Excavation", "Special Road Excavation" and "Common Road Excavation"; or as "Rock Road Excavation" and "Common and Special Road Excavation"; as the case may be, which prices shall each be full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

All work required for utilizing or disposing of waste (except hauling) will not be paid for directly but shall be considered as subsidiary work pertaining to the various contract items, and such costs shall be included in the unit prices bid for these items.

All hauling of materials (including authorized waste) will be measured and paid for in accordance with the provisions governing the item of "Overhaul".

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ITEM S-102

BORROW

S-102.1. DESCRIPTION. Borrow will consist of required excavation, removal, and proper utilization of materials obtained from designated sources.

Borrow will be resorted to only when shown on plans or directed by the Engineer and then only from designated sources.

S-102.2. CLASSIFICATION. All authorized borrow will either be unclassified or classified as indicated on the plans.

(1) Unclassified Borrow.

If no classification is indicated on the plans "Unclassified Borrow" shall include all materials encountered regardless of their nature or the manner in which they are removed.

If classification is made by the Engineer one of the following methods shall be employed:

(2) "Rock Borrow", "Special Borrow" and "Common Borrow".

(a) "Rock Borrow" will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than one-fourth (1/4) cubic yard each in volume.

(b) "Special Borrow" will include all boulders and loose stones of less than one-fourth (1/4) cubic yard in volume and all materials in masses (such as caliche, iron ore, conglomerate, slate, shale, etc.,) which cannot be removed efficiently with the usual earthmoving equipment but which it is possible to move with pick or bar without blasting, even though the Contractor may elect to employ blasting.

(c) "Common Borrow" will include all other materials excavated.

(3) "Rock Borrow" and "Common and Special Borrow".

(a) "Rock Borrow" will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than one-fourth (1/4) cubic yard each in volume.

(b) "Common and Special Borrow" will include all other materials encountered.

When, in the Contractor's opinion, materials encountered are other than as shown on the plans, the Engineer shall be notified prior to removal of any such materials in order to permit classification and measurement.

Objections on the part of the Contractor to the Engineer's classification of borrow shall be filed in writing with the Engineer within 15 calendar days of receipt of the partial estimate which includes the particular classification objected to. Failure on the part of the Contractor to file such objections as outlined above will be construed as his concurrence with the classifications made.

S-102.3. CONSTRUCTION METHODS. All suitable materials removed from the excavation shall be used, insofar as practicable, in the formation of embankments as required by the Item "Embankment," or shall otherwise be utilized as indicated on plans or as directed, and the completed work shall conform to the established alignment, grades, and cross section. During construction, the borrow sources shall be kept drained, insofar as practicable, and the work shall be prosecuted in a neat and workmanlike manner.

Payment will not be allowed for excavation of any material which is used for purposes other than those designated, except as provided in the governing specifications under Item 4, "Scope of Work".

Site of the borrow operation shall be left in a suitable and sightly condition, such as to provide proper drainage where practical and to permit accurate measurement. Where indicated on plans, the sides and/or ends of borrow pits shall be sloped to the dimensions indicated by the plans.

The Engineer shall be notified sufficiently in advance of opening any designated borrow source to permit necessary staking and measurement.

S-102.4. SELECTION OF MATERIALS. Where shown on plans, selected materials shall be utilized to improve the roadbed, in which case the work shall be performed in such manner and sequence that suitable materials may be selected, removed separately, and deposited in the roadway within limits and at elevations required.

S-102.5. MEASUREMENT. Borrow will be measured in its original position and the volume computed in cubic yards by the method of average end areas. Unauthorized work will not be paid for.

S-102.6. PAYMENT. All work performed as required herein and in the Item "Embankment" and measured as provided under "Measurement", will be paid for at the unit price bid for "Unclassified Borrow"; or as "Rock Borrow", "Special Borrow" and "Common Borrow"; or as "Rock Borrow" and "Common and Special Borrow"; as the case may be, which prices shall each be full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Payment will not be allowed the Contractor for any materials excavated prior to staking out and cross-sectioning the borrow sources by the Engineer.

All hauling of materials will be measured and paid for in accordance with the provisions governing the Item of "Overhaul".

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ITEM S-103

CHANNEL EXCAVATION

S-103.1. DESCRIPTION. Channel excavation will consist of required excavation for all channels, both on and outside the limits of the highway; the removal and proper utilization or disposal of all excavated materials; and constructing, shaping, and finishing of all earthwork involved in conformity with the required lines, grades, and typical cross-sections and in accordance with specification requirements herein outlined.

S-103.2. CLASSIFICATION. All authorized channel excavation will either be unclassified or classified as indicated on the plans.

(1) Unclassified Channel Excavation.

If no classification is indicated on the plans, "Unclassified Channel Excavation" shall include all materials encountered regardless of their nature or the manner in which they are removed.

If classification is made by the Engineer one of the following methods shall be employed:

(2) "Rock Channel Excavation", "Special Channel Excavation" and "Common Channel Excavation".

(a) "Rock Channel Excavation" will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than one-fourth (1/4) cubic yard each in volume.

(b) "Special Channel Excavation" will include all boulders and loose stones of less than one-fourth (1/4) cubic yard in volume and all materials in masses (such as caliche, iron ore, conglomerate, slate, shale, etc.,) which cannot be removed efficiently with the usual earth-moving equipment but which it is possible to move with pick or bar without blasting, even though the Contractor may elect to employ blasting.

(c) "Common Channel Excavation" will include all other materials excavated.

(3) "Rock Channel Excavation" and "Common and Special Channel Excavation".

(a) "Rock Channel Excavation" will include all masses which cannot be removed without blasting and all detached rock or boulders measuring more than one-fourth (1/4) cubic yard each in volume.

(b) "Common and Special Channel Excavation" will include all other materials encountered.

When, in the Contractor's opinion, materials encountered are other than as shown on the plans, the Engineer shall be notified prior to removal of any such material in order to permit classification and measurement.

Objections on the part of the Contractor to the Engineer's classification of channel excavation shall be filed in writing with the Engineer within 15 calendar days of receipt of the partial estimate which includes the particular classification objected to. Failure on the part of the Contractor to file such objections as outlined above will be construed as his concurrence with the classifications made.

S-103.3. CONSTRUCTION METHODS. All suitable materials removed from the excavation shall be used, insofar as practicable, in the formation of embankments as required by the Item "Embankment", or shall be otherwise utilized or satisfactorily disposed of as indicated on plans, or as directed, and the completed work shall conform to the established alignment, grades, and

cross-sections. During construction, the channel shall be kept drained, insofar as practicable, and the work shall be prosecuted in a neat workmanlike manner.

Payment will not be allowed for excavation of any material which is used for purposes other than those designated, except as provided in the governing specifications under Item 4, "Scope of Work."

S-103.4. SELECTION OF MATERIALS. Where shown on plans, selected materials shall be utilized to improve the roadbed, in which case the work shall be performed in such manner and sequence that suitable materials may be selected, removed separately, and deposited in the roadway within limits and at elevations required.

S-103.5. MEASUREMENT. All accepted channel excavation will be measured in its original position and the volume computed in cubic yards by the method of average end areas. Unauthorized work will not be paid for.

S-103.6. PAYMENT. All work performed as required herein and in the Item "Embankment" and measured as provided under "Measurement" will be paid for at the unit price bid for "Unclassified Channel Excavation"; or as "Rock Channel Excavation", "Special Channel Excavation" and "Common Channel Excavation"; or as "Rock Channel Excavation" and "Common and Special Channel Excavation"; as the case may be, which prices shall each be full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

All hauling of materials will be measured and paid for in accordance with the provisions governing the item of "Overhaul".

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ITEM S-104

STRUCTURAL EXCAVATION

S-104.1. DESCRIPTION. These specifications shall govern the excavation for the placing of structures; for the disposal of all material obtained from such excavation; and for the backfilling around completed structures to the level of the original ground. The work to be done shall include all necessary pumping or bailing, sheeting, drainage, and the construction and removal of any required cofferdams. Unless otherwise provided, the work included hereunder shall provide for the removal of old structures or portions thereof (such as abutments, wingwalls, piers,) trees, and all other obstructions necessary to the proposed construction.

Where excavation is not classified, all excavation will be grouped under the item "Unclassified Structural Excavation" and this item shall include the removal of all materials encountered regardless of their nature or the manner in which they are removed.

Where excavation is classified it shall be classed as "Common Structural Excavation" or "Rock Structural Excavation" in accordance with the following criteria:

"Common Structural Excavation" shall include the removal of all materials other than rock.

"Rock Structural Excavation" shall include the removal of such firm and compact materials as cannot be excavated with a clam shell or orange peel bucket, slip, pick and shovel or dredge without first being loosened or broken by blasting, sledging, or drilling.

S-104.2. CONSTRUCTION METHODS. Excavation shall be done in accordance with the lines and depths indicated on the plans or as established by the Engineer. Unless written permission to the contrary is given by the Engineer, no excavation shall be made outside a vertical plane three feet from the footing lines and parallel thereto. When caissons are provided, no excavation will be permitted outside the outer faces of the caissons.

In order that the Engineer may judge the adequacy of a proposed foundation, the Contractor, if requested, shall make soundings to determine the character of the subgrade materials. The maximum depth of such soundings will not be required to exceed 5 feet below the proposed footing grade. It is the intent of this provision that soundings shall be made at the time the excavation in each foundation is approximately complete.

The final elevation to which a foundation is to be constructed shall be as shown on the plans or as raised or lowered by written order of the Engineer when such alterations are judged proper to satisfactorily comply with the design requirements for the structure. Should it be found necessary, in the judgement of the Engineer, to increase or decrease the depth of footings from that shown on the plans, the necessary alterations in the details of the structure shall be accomplished in a manner as directed by the Engineer. The Department shall have the right to substitute revised details resulting from consideration of the changes in the design conditions.

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 performed until just before the footing 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 at the time the footing is placed. The quantity of concrete required for filling seams shall be measured and included for payment in the quantities for the unit of the structure for which the excavation is made.

Excavated material required to be used for backfill may be deposited by the Contractor in storage piles at points convenient for rehandling of the material during the backfilling operations. The location of storage piles shall, however, be subject to the approval of the Engineer, who may require that the survey center line of the structure and the transverse or hub line of any unit of the structure be kept free of any obstruction. In all cases, the provisions of Item 5.7 of the specifications shall be complied with by the Contractor in locating storage piles for excavated materials.

Excavated material required to be wasted shall be disposed of as directed by the Engineer, and the disposal shall be in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure or other parts of the work.

For all single and multiple box culverts, pipe culverts, pipe-arch culverts and storm sewers of all types, where the soil encountered at established footing grade is a quicksand, muck or similar unstable material, the following procedure shall be used unless other methods are called for on the plans or in the special provisions: All unstable soil shall be removed to a depth 2 feet below bottom of culvert or sewer for culverts or sewers 2 feet or more in height and to a depth equal to the height of culvert or sewer for culverts or sewers less than 2 feet in height. Such excavation shall be carried at least one foot beyond the horizontal limits of the structure on all sides. All unstable soil so removed shall be replaced with suitable stable material, placed in uniform layers of suitable depth for compaction as directed by the Engineer, and each layer shall be wetted, if necessary, and compacted by rolling or tamping as required to provide a stable foundation for the structure. Soil which is considered to be of sufficient stability to sustain properly the adjacent sections of the roadway embankment will be considered a suitable foundation material for the culvert or sewer.

S-104.3. COFFERDAMS AND CAISSONS. The term cofferdam, whenever used in this specification, designates any temporary or removable structure which is constructed to hold the surrounding earth, water, or both, out of the excavation, whether such structure is formed of earth, timber, steel, concrete, or a combination of these. It thus includes earthen dikes, timber cribs, any type of sheet piling, removable steel shells and the like and all necessary bracing; and it shall be understood also to include the use of pumping wells or well points for the same purpose. The cost of cofferdams is always to be included as a part of the bid price for excavation.

The term caisson, wherever used in this specification, designates a permanent part of the substructure so constructed as to sink gradually into place as material is excavated within the area protected by its sidewalls. Such caisson may be of either the open-well or pneumatic type, and quantities for same will always be included as bid items separate from excavation.

In addition to interior dredging, the lowering of caissons may be facilitated by the following methods:

(1) Addition of weight by increasing the thickness of caissons, where such increase is permitted by the type of design and is requested by the Contractor prior to beginning the work. Increased quantities due to this change shall be at the Contractor's expense.

(2) Addition of removable loads to the caisson.

(3) The use of water or air jets placed around the caisson.

(4) The use of light charges of explosives placed in a manner that will preclude likelihood of damage to the construction. Written permission shall be secured from the Engineer prior to the use of explosives, and the work shall be under the direction of an expert in the use of same.

(5) Steel shell caissons may be driven with a drop or steam hammer if the Contractor will, at his own expense, provide a suitable driving ring. The driving ring shall be of sufficient strength, and the manner of driving shall be regulated to preclude damage to the caisson.

When no provision for caissons is shown on the plans, it shall be the intent of this specification to require that a suitable cofferdam be provided for all excavations where such cofferdam may be necessary in order to control water conditions or to preclude sliding and caving of the walls of the excavation. Where no ground or surface water is encountered, the cofferdam need be sufficient only to protect the workmen and to avoid cave-ins or slides extending beyond the excavation limits set forth in Section S-104.2.

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 plans. The type, strength and clearance of cofferdams, insofar as such details affect the character of the finished work and the safety of laborers and inspectors working therein, will be subject to the approval of the Engineer, but other details of design will be left to the choice of the Contractor, who will be responsible for the successful completion of the work. Approval of the drawings by the Engineer will not relieve the Contractor of such responsibility in any manner. The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction and removal of any required forms and the inspection of their exteriors and to permit pumping outside of the forms.

In general, sheet piling cofferdams shall extend well below the bottom of the footings and shall be well braced and as water-tight as practicable.

When foundation piling are to be driven inside a caisson or cofferdam and when it is judged impractical to unwater the caisson or cofferdam before placing a concrete seal, the excavation may be extended below the footing grade to a depth sufficient to allow for swell of the material during pile driving operations. After the piling have been driven, all foundation material that has risen to a level more than one foot above the footing grade shall be removed. It is the intention of this provision to establish a construction tolerance to be applied when a foundation is being constructed under water. Where it is possible to unwater the caisson or cofferdam before a seal is placed, it is considered practicable to remove the foundation material to exact footing grades after foundation piling are driven. Backfilling in a foundation to compensate for excavation which has been extended below grade will not be permitted. Such areas below grade shall be filled with concrete at the time the seals or base courses are placed, and the concrete quantities involved shall be at the Contractor's expense. The Engineer shall deduct from the pay quantities for concrete in seals when the thickness of the seal is reduced due to the swellage of foundation above the footing grade.

Caissons or cofferdams which tilt or move laterally during the process of sinking shall be righted or enlarged, as necessary, at the sole expense of the Contractor.

Unless otherwise provided, cofferdams 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 structure. In lieu of the entire removal of the cofferdams, the Engineer may require the Contractor to remove any portion of them or to leave them entirely in place.

S-104.4. PUMPING OR BAILING. Pumping or bailing from the interior of any foundation enclosure shall be done in such manner as to preclude possibility of the movement of water through or alongside any concrete being placed. No pumping or bailing will be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a water-tight wall. Pumping or bailing to unwater a sealed cofferdam or caisson shall not be started until the seal has set at least 36 hours.

S-104.5. BACKFILLING:

a. General. As soon as practicable, all spaces excavated under this specification and not occupied by the permanent structure shall be backfilled. Backfill material shall be free from large or frozen lumps, wood, or other extraneous material.

That portion of backfill which will not support any portion of completed roadbed or embankment shall be placed in layers not more than ten inches in depth (loose measurement) and shall be compacted to a density comparable with the adjacent, undisturbed material.

If the excavation has been made through a hard material resistant 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, and unless otherwise provided, such backfill shall be paid for as extra work.

That portion of the backfill which will support any portion of the roadbed or embankment shall be placed in uniform layers not to exceed 6" depth (loose measurement) and each layer compacted to the density specified herein. Each layer of backfill material, if dry, shall be wetted uniformly to the moisture content required to obtain the specified density, and shall be compacted to the required density by means of mechanical tamps or rammers except that the use of rolling equipment of the type generally used in compacting embankments will be permitted on those portions which are accessible to such equipment. All portions of embankment which lie so closely adjacent to any portion of any structure as to prevent compaction by the use of the blading and roll-

ing equipment used in compacting adjoining sections of embankment shall be placed and compacted in the same manner as specified above for backfill material. These provisions shall be construed to require the mechanical compaction, by means of either rolling equipment or mechanical tamps or rammers, of all backfill and embankment adjoining the barrels and wing walls of culverts and adjoining all sides of bridge abutments and retaining walls, regardless of whether or not such embankment or backfill is above or below the original surface of the ground and regardless of whether the excavation at structure site was performed as Structural Excavation, Road Excavation or Channel Excavation. Unless otherwise provided by the plans or special provisions, hand tamping will not be accepted as an alternate for mechanical compaction. As a general rule material used in filling or backfilling the portions described in this paragraph shall be an earth free of any appreciable amount of gravel or stone particles more than 4" in greatest dimension and of such gradation as to permit thorough compaction. When in the opinion of the Engineer, such material is not readily available, the use of rock or gravel mixed with earth will be permitted in which case no particles larger than 12" in greatest dimension and 6" in least dimension may be used and the percentage of fines shall be sufficient to fill all voids and insure a uniform and thoroughly compacted mass of proper density.

All portions of fill and backfill described in preceding paragraph shall be compacted to the same density requirements as specified for the adjoining sections of embankment in accordance with the governing specifications therefor. Where no embankment is involved on the project and no specifications therefor are included in the contract, the following requirements shall apply:

> For each layer of fill or backfill which will support any portion of the Roadbed or embankment, the compaction shall be such that the apparent dry density of the minus 1/4 inch material in each layer shall be not less than 90 per cent of the maximum dry density as determined by tests on samples of the material by the "Proctor Compaction Test" (AASHO Method T-99-38). The apparent dry density of the minus 1/4 inch material in the compacted layer shall be calculated as the dry weight of the portion passing the 1/4 inch screen divided by the volume occupied by this minus 1/4 inch material. The Engineer will make tests as necessary to establish that the specified density is being obtained.

No backfill shall be placed against any abutment or retaining wall until such structure has been in place at least 7 days.

Backfill placed around abutments and piers shall be deposited on both sides to approximately the same elevation at the same time.

Care shall be taken to prevent any wedging action of backfill against the structure, and the slopes bounding the excavation shall be stepped or serrated to prevent such wedge action.

No backfilling shall be done except in the presence of the Engineer or his authorized representative.

b. Pipe Culverts and Sewers. The following requirements shall apply to the backfilling of pipe culverts and sewers in addition to the pertinent portions of the general requirements given in the preceding section.

After the bedding has been prepared and the pipes installed as required by the pertinent specifications, selected materials from excavation or borrow shall be placed along both sides of the pipe equally, in uniform layers not exceeding 6 inches in depth (loose measurement), wetted if required, and thoroughly compacted so that on each side of the pipe there shall be a berm of thoroughly compacted material at least as wide as the external diameter of the pipe, except insofar as undisturbed material obtrudes into this area. The method and degree of compaction shall be the same as specified in Section S-104.5.a. for portions of backfill within the limits of embankment or roadbed.

Filling and/or backfilling shall be continued in this manner to the elevation of the top of the pipe. Special care shall be taken to secure thorough compaction of the material placed under the haunches of the pipe. All fill or backfill below the top of pipe shall be compacted mechanically in the manner and to the density prescribed above, regardless of whether or not such material is placed within the limits of the embankment or roadbed. In the case of pipe placed in trenches, that portion of the backfill above the top of the pipe which supports embankment or the roadbed, shall receive mechanical compaction as specified in Section S-104.5.a., and the portion which will not support any portion of embankment or roadbed shall be placed in layers not more than ten

inches in depth (loose measurement) and shall be compacted by whatever means the Contractor chooses to a density comparable with the adjacent, undisturbed material. In the case of embankments, the remainder of the fill above the top of pipe shall be placed in accordance with the provisions for placing roadway embankment as prescribed in the pertinent specifications included in the contract. No construction traffic will be permitted to cross any pipe culvert or sewer until the specified minimum depth of fill above the pipe has been placed and consolidated in accordance with these provisions. Where pipe culverts or storm sewers extend 10 feet or more beyond the toe of slope of the embankment and the depth of cover provided by backfill to the original ground level is less than the minimum required by the specifications for the type of pipe involved, additional material shall be placed and compacted, as herein specified for backfill outside the limits of the roadbed, until this minimum cover has been provided. Also, whenever excavation is made for installing pipe culverts or sewers across private property or beyond the limits of the embankment, the top soil removed in excavating the trench shall be kept separate and replaced, as nearly as feasible, in its original position, and the entire area involved in the construction operations shall be restored to a presentable condition.

S-104.6. DETERMINATION OF EXCAVATION QUANTITIES. The yardage of structural excavation to be paid for will be that actually removed as measured in its original position by the cross-section method, except as follows:

(a) For all structures, except the barrels of pipe culverts and sewers, no material outside of vertical planes one foot beyond the edges of the footings and parallel thereto will be included.

(b) For the barrels of pipe culverts and sewers of 36" or less nominal or equivalent diameter no material outside of vertical planes one foot beyond the horizontal projection of the outside surfaces of the pipe and parallel thereto will be included. For the barrels of pipe culverts and sewers more than 36" in nominal or equivalent diameter no material outside of vertical planes located 1/3 of the nominal pipe diameter beyond the horizontal projection of the outside surfaces of the pipe and parallel thereto will be included. (These limits apply only to the barrels. The limits described in paragraph (a) apply to the headwalls, wings, inlets, manholes, etc. of pipe culverts and sewers).

(c) If a caisson, as herein defined, is shown on the plans, only material to the outside face of such caisson will be included.

(d) If a cofferdam, as herein defined, is used, the limitations of (a) above shall apply just as if no cofferdams were used.

(e) Where excavation in addition to that allowed for the footings is required for other portions of the structure, such as for the cap, cross strut, or tie beam of a pier or bent or for the superstructure, measurements for such additional excavation will be limited laterally by vertical planes one foot beyond the face of the member and parallel thereto and will be limited vertically to a depth of one foot below the bottom of such member.

(f) Except as allowed by the above conditions, no account will be taken of any excavation necessary for placing forms or falsework.

(g) On all structures, except side-road culverts, where the contract plans call for road excavation at the structure site such road excavation shall be assumed to have been completed before starting the structural excavation, and the measurement of structural excavation will include only material below or outside the limits of the completed road section. On side road and private entrance culverts, the same procedure will be followed except that the road excavation shall not be assumed to have been carried to a plane below the level of the completed main road at crown line and the measurement of structural excavation will include material below the elevation of the crown line or below natural ground whichever is lower. The method of measurement for payment will be in accordance with this procedure regardless of the actual construction methods followed.

(h) On all structures of bridge classification as defined in Section 1.24 of the Standard Specifications where the contract plans call for channel excavation at the structure site such channel excavation shall be assumed to have been completed before starting the structural excavation, and the measurement of structural excavation will include only material below or outside the limits of the completed channel section. This will not apply to structures of culvert classification as defined in Section 1.25; on such structures, all excavation below natural ground and within the specified limits will be measured as structural excavation regardless of whether or not plans call for channels at the structure site. The method of measurement for payment will be in accordance with this procedure regardless of the actual construction methods followed.

(i) In all cases where excavation diagrams are shown on the plans or in the special provisions, such diagrams shall take precedence over these provisions.

(j) Measurement will not include materials removed below footing grades to compensate for anticipated swellage due to pile driving, and it will not include material required to be removed due to swellage beyond the specified limits during pile driving operations.

(k) 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.

S-104.7. PAYMENT. Payment for all work prescribed under this Item and measured as provided above will be made at the unit price bid per cubic yard for "Unclassified Structural Excavation", "Common Structural Excavation", or "Rock Structural Excavation", as the case may be, which price shall be full compensation for all excavation and backfill including compaction; all soundings; sinking all caissons; constructing all cofferdams; all unwatering; and for furnishing all materials, labor, equipment, tools, sheeting, bracing, cofferdams, pumps, drill, explosives, and incidentals necessary to complete the work, except for specific allowances which follow, and except for materials used in caissons when shown on plans with provisions for separate payment therefor.

To avoid the grouping of excavation of widely different character into a single bid item, the proposal may show "Structural Excavation" subdivided into items relating to individual structures, to parts of structures, or to groups of structures, as for example, "Unclassified Structural Excavation-Retaining Walls", "Unclassified Structural Excavation - Bridges," and "Unclassified Structural Excavation - Culverts". When the terms "bridges" and "culverts" are used to designate such subdivisions, the separation shall be made in accordance with the definitions of bridges and culverts as set forth in Sections 1.24 and 1.25 of the Standard Specifications.

Payment for removal and replacement of unstable material below the footing grades of culverts and sewers, as provided for in Section S-104.2, will be made at a unit price equal to 200% of the unit price bid per cubic yard for "Unclassified Structural Excavation" or "Common Structural Excavation" as the case may be, which price shall be full compensation for removing the unstable material, furnishing, hauling, placing and compacting the suitable material required to replace the unstable material, and for all labor, equipment, tools and incidentals necessary to complete the work.

Should it be necessary, in the opinion of the Engineer, to lower the structure footings to an elevation below the grade shown on the plans, payment for the "Unclassified Structural Excavation", "Common Structural Excavation" or "Rock Structural Excavation", as the case may be, required below plan grade down to and including an elevation 5 feet below plan grade for any individual footing will be made at a unit price equal to 115 per cent of the contract unit bid price; and payment for the excavation from an elevation over 5 feet below plan grade down to and including an elevation 10 feet below plan grade will be made at a unit price equal to 125 per cent of the contract unit bid price for "Unclassified Structural Excavation", "Common Structural Excavation", or "Rock Structural Excavation", as the case may be. No increase in unit price will be allowed for any other bid items of the contract, and no additional extra compensation will be allowed for any required cofferdam adjustments made necessary by such lowering of footings. These provisions shall not apply to the lowering of sewers and culverts except when the flow line grade is lowered one foot or more below the grade shown on plans.

In cases where the extra depth required for any footing or footings exceeds 10 feet, a supplementary agreement shall be made covering the quantities removed from depths in excess of 10 feet below plan grade.

Since this item provides for an adjustment in unit price for additional excavation quantities, the 20 per cent limitation referred to in Item 4.3 will not apply to overruns due to extra depth of 10 feet or less.

Payment will be made for any cofferdam material required to be left in place but only to the extent that its salvage value exceeds the cost of removing it from the ground and from the site.

No direct payment will be made for filling or backfilling around structures. Payment for the backfilling and compacting of those areas which were removed as Structural Excavation shall be

included in the unit prices bid for the various classes of Structural Excavation. Filling or back-filling of areas above the natural ground level or above the limits of road excavation or channel excavation sections shall be considered as "Embankment", and payment therefor shall be included in the unit prices bid for the various classes of Road Excavation, Channel Excavation, or Borrow as the case may be.

Where no channel excavation is provided for at culvert sites and where it is necessary to excavate within the limits of the right-of-way but beyond the limits of structural excavation as herein described in order that the culvert may function properly, such excavation will be considered as road ditch excavation and will be measured and paid for under the governing specifications for Road Excavation.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-106

EMBANKMENT

S-106.1. DESCRIPTION. This item shall govern the placement and compaction of all materials obtained from roadway, borrow, channel and structural excavation for utilization in the construction of roadway embankments, levees, and dykes.

S-106.2. CONSTRUCTION METHODS.

(1) General. Prior to placing any embankment, all "Clearing and Grubbing" operations shall have been completed on the excavation sources and areas over which the embankment is to be placed. Stump holes or other small excavations in the limits of the embankment shall be backfilled with suitable material and thoroughly tamped by approved methods before commencing embankment construction. The surface of the ground, including plowed, loosened ground, or surface roughened by small washes or otherwise, shall be restored to approximately its original slope by blading or other methods and where indicated on plans or required by the Engineer the ground surface thus prepared shall be compacted by sprinkling and rolling.

Where indicated on plans or directed by the Engineer, the surface of hillsides to receive embankment shall be loosened, by scarifying or plowing to a depth of not less than 4 inches, or cut into steps before embankment materials are placed. The embankment shall then be placed in layers, as hereinafter specified, beginning at the low side in part width layers and increasing the widths as the embankment is raised. The material which has been loosened shall be recompacted simultaneously with the embankment material placed at the same elevation.

Where embankments are to be placed adjacent to or over existing roadbeds, the roadbed slopes shall be plowed or scarified to a depth of not less than 4" and the embankment built up in successive layers, as hereinafter specified, to the level of the old roadbed before its height is increased. Then, if directed, the top of the old roadbed shall be scarified and recompacted with the next layer of the new embankment. The total depth of the scarified and added material shall not exceed the permissible depth of layer.

Trees, stumps, roots, vegetation, or other unsuitable materials shall not be placed in embankment.

Except as otherwise required by the plans, all embankment shall be constructed in layers approximately parallel to the finished grade of the roadbed and unless otherwise specified each layer shall be so constructed as to provide a uniform slope of 1/4 inch per foot from the center line of the roadbed to the outside, except that on superelevated curves each layer shall be constructed to conform to the superelevation required by the governing standard.

Embankments shall be constructed to the grade established by the Engineer and completed embankments shall correspond to the general shape of the typical sections shown on the plans and each section of the embankment shall correspond to the detailed section or slopes established by the Engineer. After completion of the roadway, it shall be continuously maintained to its finished section and grade until the project is accepted.

(2) Earth Embankments. Earth embankments shall be defined as those composed principally of material other than rock, and shall be constructed of accepted material from designated sources.

Except as otherwise specified, earth embankments shall be constructed in successive layers, for the full width of the cross section and in such lengths as are suited to the sprinkling and compaction methods utilized. Prior to compaction the layers shall not exceed 6 inches in depth where pneumatic tire rolling is to be used and shall not exceed 8 inches in depth for rolling with other types of rollers. Layers of embankment may be formed by utilizing equipment which will spread the material as it is dumped, or they may be formed by being spread by blading or other acceptable methods from piles or windrows dumped from excavating or hauling equipment in such amounts that material is evenly distributed.

Minor quantities of rock encountered in constructing earth embankment shall be incorporated in the specified embankment layers, or may be placed in accordance with the requirements for the construction of rock embankments in the deeper fills within the limits of haul shown on the plans, provided such placement of rock is not immediately adjacent to structures. Also, rock may be placed in the portions of embankments outside the limits of the completed roadbed width where the size of the rock prohibits their incorporation in the normal embankment layers.

Each layer of embankment shall be uniform as to material, density and moisture content before beginning compaction. Where layers of unlike materials abut each other, each layer shall be featheredged for at least 100 feet or the material shall be so mixed as to prevent abrupt changes in the soil. No material placed in the embankment by dumping in a pile or windrow shall be incorporated in a layer in that position, but all such piles or windrows shall be moved by blading or similar methods. Clods or lumps of material shall be broken and the embankment material mixed by blading, harrowing, or similar methods to the end that a uniform material of uniform density is secured in each layer. Water required for sprinkling to bring the material to the moisture content necessary for maximum compaction shall be evenly applied and it shall be the responsibility of the contractor to secure a uniform moisture content throughout the layer by such methods as may be necessary. In order to facilitate uniform wetting of the embankment material the contractor may apply water at the material source if the sequence and methods used are such as not to cause an undue waste of water. Such procedure shall be subject to the approval of the Engineer.

All earth cuts, full width or part width cuts in side hill, which are not required to be excavated below subgrade elevation for base and backfilled, shall be scarified to a uniform depth of at least 6" below grade, and the material shall be mixed and reshaped by blading and then sprinkled and rolled in accordance with the requirements outlined above for earth embankments and to the same density as that required for the adjacent embankments.

Compaction of earth embankments shall be obtained by the method hereinafter described as "Ordinary Compaction", or the method hereinafter described as the "Controlled Density Method". "Ordinary Compaction" will be required if no other method is shown on the plans.

When the "Ordinary Compaction" is required, the following provisions shall govern: Each layer shall be compacted until there is no evidence of further compaction, in accordance with provisions governing the item or items of "Rolling". Prior to and in conjunction with the rolling operation, each layer shall be brought to the moisture content ordered by the Engineer, and shall be kept leveled with suitable equipment to insure uniform compaction over the entire layer.

When the "Controlled Density Method" of compaction is required by the plans, each layer shall be compacted to the required density in accordance with provisions governing the item or items of "Rolling". Prior to and in conjunction with the rolling operation, each layer shall be brought to the moisture content necessary to obtain the required density and shall be kept leveled with suitable equipment to insure uniform compaction over the entire layer.

For each layer of earth embankment and select material, it is the intention of this specification to provide an apparent dry density of the minus 1/4 inch material of not less than the per cent shown on the plans of the maximum dry density of samples of the material as determined by the "Proctor Compaction Test" (THD 84). The apparent dry density of the minus 1/4 inch material in the compacted layer shall be calculated as the dry weight of the portion passing the 1/4 inch screen divided by the volume occupied by this minus 1/4 inch material. The apparent dry density of the minus 1/4 inch material in the compacted layer will be determined not later than the day following the completion of compacting operations.

After each section of earth embankment or select material is completed, tests as necessary will be made by the Engineer. If the material fails to meet the density specified, the compaction methods shall be altered on subsequent work as necessary to obtain the specified density.

(3) Rock Embankments. Rock embankments shall be defined as those composed principally of rock, and shall be constructed of accepted material from designated sources.

Except as otherwise specified, rock embankments normally shall be constructed in successive layers for the full width of the cross section and of 18 inches or less in depth. When, in the

opinion of the Engineer, the rock sizes necessitate a greater depth of layer and the height of fill will permit, the layer depth may be increased as necessary, but in no case shall the depth of layer exceed 2 1/2 feet. Each layer shall be constructed by starting at one end and dumping the rock on top of the layer being constructed then pushing the material ahead with an approved "Bulldozer" in such manner that the larger rock will be placed on the ground or preceding embankment layer and the interstices between the larger stones will be filled with small stones and spalls by this operation and from the placing of succeeding loads of material.

The maximum dimension of any rock used in embankment shall be less than the depth of the embankment layer, and in no case shall any rock over 2 feet in its greatest dimension be placed in the embankment. All oversized rock which is otherwise suitable for construction shall be broken to the required dimension and utilized in embankment construction where proposed by plans, except that when preferred by the Contractor and acceptable to the Engineer, such rock may be placed at other points where the embankment layer is of greater depth, thus requiring less breakage. Compensation for additional haul involved in such alternate manipulations will not be allowed. Wasting of excavated rock other than that proposed by plans or ordered by the Engineer, may be resorted to only upon written permission of the Engineer, which permission will be granted only upon agreement between the contractor and the Engineer as to the point of disposal within the right-of-way or upon the presenting by the contractor of written permission to place the material on property outside of the right-of-way. Where excavated rock is to be wasted under the procedure cited above, the contractor shall, at his entire expense, replace the rock so wasted with other suitable materials.

Unless otherwise provided, the upper or final layer of the embankment shall contain no stones larger than 4 inches in their greatest dimension, and, insofar as such is available by selection from the excavation, shall be composed of material so graded that the maximum density and uniformity of the surface layer may be secured. Exposed oversized material shall be reduced by sledging or other methods.

Each embankment layer shall be rolled as directed, and where the embankment materials require, shall be sprinkled when and to the extent directed.

(4) At Culverts and Bridges. Embankments adjacent to Culverts and Bridges which cannot be compacted by use of the blading and rolling equipment used in compacting the adjoining sections of embankment shall be compacted in the manner prescribed under the Item "Structural Excavation".

Embankments placed around spill-through type abutments shall be constructed in 6 inches loose layers of uniform suitable material placed in such manner as to maintain approximately the same elevation on each side of the abutment, and all materials shall be mixed, wetted, and compacted as specified above.

As a general rule embankment material placed adjacent to any portion of any structure and in the first two layers above the top of any culvert or similar structure shall be an earth free of any appreciable amount of gravel or stone particles more than 4 inches in greatest dimension and of such gradation as to permit thorough compaction. When in the opinion of the Engineer, such material is not readily available, the use of rock or gravel mixed with earth will be permitted in which case no particles larger than 12 inches in greatest dimension and 6 inches in least dimension may be used and the percentage of fines shall be sufficient to fill all voids and insure a uniform and thoroughly compacted mass of proper density.

S-106.3. SELECTION OF MATERIALS. In addition to the requirements in the excavation items of the specifications covering the general selection and utilization of materials to improve the roadbed, embankments shall be constructed in proper sequence to receive the select material layers shown on plans, with such modifications as may be directed by the Engineer. The layer of embankment immediately preceding the upper layer of select material shall be constructed to the proper section and grade within a tolerance of not more than one-tenth foot from the established section and grade when properly compacted and finished to receive the select material layer.

S-106.4. PAYMENT. Except as specified below, the work prescribed by this item will not be paid for directly but shall be considered as subsidiary work pertaining to the several types and classes of excavation involved.

Authorized excavation of "steps" will be measured and paid for in accordance with the provisions governing the item of "Roadway Excavation" or such work may be measured and paid for as "Blading", when so indicated on the plans.

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

When specific provisions are made in the plans for direct payment for blading embankment, all blading performed as required will be measured and paid for in accordance with the provisions governing the Item of "Blading". Measurement for payment will be made only after the material has been spread into the specified layers.

When provisions are not made in the plans for separate payment for blading embankments, such blading as necessary to satisfactorily complete the embankment, in accordance with the requirements herein specified, will not be paid for directly but shall be considered as subsidiary work pertaining to the various items of embankment construction.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-108

ROAD GRADER WORK

S-108.1. DESCRIPTION. This item shall consist of the construction of a roadway in conformity with the typical cross sections shown on the plans when the topography is such that it will not be necessary to control the finished grade line for purposes other than to obtain a uniform riding surface and to provide the desirable earth cover over culverts. The limits of "Road Grader Work" shall be shown on the plans, and no section of "Road Grader Work" shall consist of less than five (5) consecutive 100 foot stations.

The work shall be done in accordance with the specification requirements herein outlined. The work performed under this item shall not include work specified for payment under other specification items pertaining to the project.

S-108.2. CONSTRUCTION METHODS. All undesirable materials shall first be removed from within the limits of the section to be graded and disposed of as directed by the Engineer. The roadway shall then be graded and shaped to the typical section shown on the plans and to a finished profile uniform and consistent with the topography and as indicated by the plans.

When required by the plans, "Road Grader Work" may be supplemented by "Scraper Work" and/or "Bulldozer Work" in accordance with the requirements of the governing specifications for "Scraper Work" and "Bulldozer Work."

During the shaping or manipulation of the roadbed, in the event insufficient moisture is present in the existing earth material, water shall be applied at the rate indicated on the plans or as directed by the Engineer in order that a reasonable degree of compaction will be obtained in the roadbed prior to the placing of the base materials.

When the existing natural ground or the roadbed of an existing road is not in a uniformly compacted state, the existing ground or roadbed as the case may be shall be scarified for the full width of the new roadbed for a minimum depth of 6" and then sprinkled and rolled to the extent directed by the Engineer, in conjunction with the new material placed on the roadbed and slopes, in order that the resultant subgrade will be uniformly compacted.

All equipment shall be operated by capable and efficient operators at the locations established by the Engineer to the extent, in the manner, and in the sequence of work as directed by the Engineer, all within the limits of "Road Grader Work" as shown on the plans.

S-108.3. MEASUREMENT. "Road Grader Work" will be measured by the 100 foot station. "Scraper Work" and "Bulldozer Work," if required, will be measured in accordance with the governing provisions of the Items "Scraper Work" and "Bulldozer Work" respectively.

S-108.4. PAYMENT. The work performed as prescribed for this item and measured as provided under "Measurement" will be paid for at the contract unit price bid for "Road Grader Work" which price shall be full compensation for all labor, tools, equipment, and incidentals necessary to complete the work, except "Scraper Work," "Bulldozer Work," "Sprinkling," and "Rolling."

All "Scraper Work", and "Bulldozer Work", will be paid for at the contract unit price bid for those items respectively.

All Sprinkling and Rolling performed as required will be measured and paid for in accordance with the governing provisions of the items "Sprinkling" and "Rolling" respectively.

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Construction Specification
March, 1950

ITEM S-109

STRIPPING

S-109.1. DESCRIPTION. Stripping will consist of the excavation, removal, and satisfactory disposal of unsuitable materials encountered within the limits of designated material sources.

S-109.2. CONSTRUCTION METHODS. The Engineer shall be notified sufficiently in advance of opening any designated material source to permit necessary staking and measurement. Overburden and other unsatisfactory material shall be excavated, removed, and placed in designated spoil banks or shall otherwise be disposed of as directed, in such manner as not to create an unsightly or objectionable condition and to permit accurate measurement of the quantity of material stripped. Measurement will be made as soon as practicable after the satisfactory completion of the stripping operations.

S-109.3. MEASUREMENT. Unless otherwise specified, stripping will be measured in spoil banks and the volume computed in cubic yards by the method of average end areas, except that in unusual cases where such measurement is impracticable, a comparable method acceptable to the Engineer and Contractor may be used.

S-109.4. PAYMENT. Stripping performed and measured as provided under "Measurement" will be paid for at the unit price bid for "Stripping" which price shall be full compensation for all labor, tools, equipment, and incidentals necessary to complete the work.

All hauling of materials will be measured and paid for in accordance with the provisions governing the Item of "Overhaul".

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ITEM S-110

OVERHAUL

S-110.1. DESCRIPTION. Overhaul will consist of performing all operations necessary for moving previously excavated embankment materials or waste over six hundred (600) feet from designated sources to the required points of disposal.

The "Haul Length" will be the distance between the centers of mass of the material in its original and final positions, measured along the shortest practical haul route.

S-110.2. MEASUREMENT AND COMPUTATION. Measurement of all materials except "Stripping" for computing "Overhaul" will be made in the original position by the method of average end areas. Measurement of stripping for computing "Overhaul" will be in accordance with the specification governing the Item of "Stripping."

"Overhaul" will be computed by multiplying the number of cubic yards of material hauled by the "Haul Length" minus six hundred (600) feet, converted to quarter miles and/or fractions thereof.

The unit of measurement for "Overhaul" will be the "Yard Quarter".

Hauling materials six hundred (600) feet or less shall be considered as "Free Haul" for which no direct compensation will be made.

S-110.3. PAYMENT. All work performed and measured as provided under "Measurement" will be paid for at the unit price bid for "Overhaul", which price shall be full compensation for all labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-111

SALVAGING AND PLACING TOPSOIL

S-111.1. DESCRIPTION. This item shall consist of salvaging topsoil, stockpiling the salvaged topsoil along the right-of-way line or at locations designated on plans, and then spreading on areas or finished cut slopes as herein specified and in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-111.2. CONSTRUCTION METHODS. After the clearing and grubbing has been completed, and before any grading work has begun, the existing topsoil shall be moved from the area to be occupied by the roadway in cut sections as indicated on plans to a windrow along the right-of-way line, or to locations designated on the plans.

Trash, wood, brush, stumps and other objectionable materials encountered shall be removed and disposed of as directed by the Engineer prior to beginning of work required by this item.

After the roadway has been completed to required alignment, grades and cross-section, and prior to the spreading of the salvaged topsoil, the surfaces of the cuts shall be scarified by plowing furrows six (6) inches deep along horizontal slope lines at two (2) foot vertical intervals. The spreading of the salvaged topsoil on the cut slopes shall be undertaken as soon as the grading has been completed, or at such time as directed by the Engineer.

After preparation of the slope surfaces, the previously salvaged topsoil shall be spread on the areas or slopes as directed by the Engineer so as to form a cover or mulch of topsoil approximately four inches in thickness compacted. After the topsoil has been placed, and shaped, it shall be sprinkled and/or rolled if directed by the Engineer.

S-111.3. MEASUREMENT. Salvaging topsoil will be measured by the 100 foot station. Measurement for payment will be made only on sections indicated on plans or as directed by the Engineer.

S-111.4. PAYMENT. All work performed as ordered and measured, as provided under "Measurement", will be paid for at the unit price bid for "Salvaging and Placing Topsoil", which price shall be full compensation for excavating, loading, hauling and furnishing all labor, equipment, tools, supplies and incidentals necessary to complete the work, except Sprinkling and Rolling.

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the items of "Sprinkling" and "Rolling", respectively.

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ITEM S-112

BLADING

S-112.1. DESCRIPTION. This item shall consist of blading those portions of the roadway so designated on plans, or as ordered by the Engineer.

Work performed under this item shall not include blading or other work specified for payment under other specification items.

S-112.2. EQUIPMENT. All equipment shall be approved by the Engineer prior to use. Equipment used for blading may be a blade grader, or a power maintainer may be used when the work is of such a nature that such equipment will efficiently produce the desired result. All equipment shall be tight and in good operating condition and shall meet the following requirements:

(1) The "Blade Grader" shall weigh not less than three tons and shall have not less than a ten (10) foot blade, and shall be drawn by suitable power equipment of adequate tractive effort.

(2) The maintainer shall have dual or four-wheel drive, shall be equipped with pneumatic tires; shall have a blade of not less than twelve (12) feet in length, and a wheel base of not less than sixteen (16) feet.

(3) Unless the blade grader and maintainer are equipped with a satisfactory scarifier attachment, a scarifier of approved type shall be provided.

S-112.3. CONSTRUCTION METHODS. The work shall be performed on the designated portions of the roadway by the use of the equipment specified, which shall be operated by competent operators. All areas shall be completed to the section, line and grade shown on the plans, or established by the Engineer.

When necessary to loosen materials prior to blading, or at other points when so directed, the scarifier attachment or separate scarifier shall be used. When a separate scarifier is used, it shall be drawn by suitable power equipment of adequate tractive effort. Around and adjacent to structures, trees, and other obstructions where it is impractical to do the required work with a blade, such work shall be done by hand methods or other approved means.

The dragging, pushing, or scraping of materials along or across completed pavements will not be permitted.

S-112.4. MEASUREMENT. Work as prescribed by this item will be measured by the actual number of hours of blading or scarifying performed as ordered by the Engineer.

S-112.5. PAYMENT. The work performed as prescribed by this item, and measured as provided under "Measurement", will be paid for at the unit price bid for "Blading", which price shall be full compensation for furnishing and operating all equipment, for all labor, fuel, materials, tools, and incidentals necessary to complete the work.

All work in connection with this item required to be done by hand labor methods adjacent to structures, trees and other obstructions will not be paid for directly, but shall be considered as subsidiary work to the Item of "Blading".

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ITEM S-113

SCRAPER WORK

S-113.1. DESCRIPTION. This item shall consist of required excavation within the limits of the roadway as shown on plans or as directed by the Engineer; the removal and proper utilization or disposal of excavated materials; and the constructing, shaping, and finishing of earthwork, except as hereinafter specified, on the designated sections of the roadway and approaches to same, in conformity with the required lines, grades, and typical cross-sections and in accordance with specification requirements herein outlined.

S-113.2. EQUIPMENT. Unless otherwise indicated by plans, the equipment shall consist of a scraper of not less than eight cubic yards capacity (as rated loaded flush by the manufacturer) drawn by suitable power equipment of adequate tractive effort. All such equipment shall be tight and in good operating condition.

S-113.3. CONSTRUCTION METHODS. Scraper Work shall be performed only on those portions of the road as shown on plans or designated by the Engineer.

The work shall be performed on the above sections by the use of the equipment specified, which shall be operated by competent and efficient operators.

All material placed under this item shall be constructed in successive layers, for the full width of the cross-section where practicable, and in such lengths as are suited to the sprinkling and compaction methods utilized, and shall otherwise conform to the requirements of the governing specifications for "Embankment."

Where plans designate "Scraper Work" and "Blading" or "Road Grader Work" within the same limits, the Scraper Work shall be roughed in as directed by the Engineer and finished in accordance with specifications for the pertinent supplementing item.

S-113.4. MEASUREMENT. Work as prescribed by this item will be measured by the actual number of hours of scraper work performed as ordered by the Engineer.

S-113.5. PAYMENT. The work performed as prescribed by this item, and measured as provided under "Measurement" will be paid for at the unit price bid for "Scraper Work" which price shall be full compensation for furnishing and operating all equipment, for all hauling, labor, fuel, materials, tools, and incidentals necessary to complete the work, except that any "Blading" or "Road Grader Work" required to be performed on sections constructed under this item will be measured and paid for in accordance with specifications for those respective items.

All Sprinkling and Rolling performed as required will be measured and paid for in accordance with the governing provisions of the Items "Sprinkling" and "Rolling" respectively.

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ITEM S-114

BULLDOZER WORK

S-114.1. DESCRIPTION. This item shall consist of required excavation with the limits of the roadway as shown on plans or as directed by the Engineer; the removal and proper utilization or disposal of excavated materials; and the constructing, shaping, and finishing of earthwork, except as hereinafter specified, on the designated sections of the roadway and approaches to same, in conformity with the required lines, grades, and typical cross-sections and in accordance with specification requirements herein outlined.

S-114.2. EQUIPMENT. The equipment shall consist of a tractor with bulldozer attachment. The tractor shall be the crawler type with not less than 55 drawbar horsepower. The bulldozer attachment shall have not less than 8 foot width blade. All equipment shall be tight and in good operating condition.

S-114.3. CONSTRUCTION METHODS. Bulldozer Work shall be performed only on those portions of the road as shown on plans or designated by the Engineer.

The work shall be performed on the above sections by the use of the equipment specified, which shall be operated by competent and efficient operators.

All material placed under this item shall be constructed in successive layers, for the full width of the cross-section where practicable, and in such lengths as are suited to the sprinkling and compaction methods utilized, and shall otherwise conform to the requirements of the governing specifications for "Embankment ".

Where plans designate "Bulldozer Work" and "Blading" or "Road Grader Work" within the same limits, the bulldozer work shall be roughed in as directed by the Engineer and finished in accordance with specifications for the pertinent supplementing item.

S-114.4. MEASUREMENT. Work as prescribed by this item will be measured by the actual number of hours of bulldozer work performed as ordered by the Engineer.

S-114.5. PAYMENT. The work performed as prescribed by this item, and measured as provided under "Measurement" will be paid for at the unit price bid for "Bulldozer Work" which price shall be full compensation for furnishing and operating all equipment, for all hauling, labor, fuel, materials, tools, and incidentals necessary to complete the work, except that any "Blading" or "Road Grader Work" required to be performed on sections constructed under this item will be measured and paid for in accordance with specifications for those respective items.

All Sprinkling and Rolling performed as required will be measured and paid for in accordance with the governing provisions of the Items "Sprinkling" and "Rolling" respectively.

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ITEM S-115

MACHINE GRADING

S-115.1. DESCRIPTION. This item shall consist of the construction of a roadway in conformity with the line, continuous grade, and typical cross-sections shown on the plans. The limits of "Machine Grading" shall be shown on the plans and no sections of "Machine Grading" shall consist of less than five (5) consecutive 100 foot stations.

S-115.2. CONSTRUCTION METHODS. Machine Grading shall include all necessary scarifying, plowing, moving, and shaping of the earth to bring the roadbed, slopes and ditches to the grade line established on the plans and conforming to the typical cross-section shown on the plans.

All undesirable material shall first be removed from within the section to be graded and disposed of as directed by the Engineer.

All material placed within the limits of the roadbed, under this item, shall be constructed in successive layers, for the full width of the roadbed and in such lengths as are suited to the sprinkling and compaction methods utilized. Prior to compaction each layer shall not exceed 8 inches in depth unless otherwise directed by the Engineer. Around and adjacent to structures, trees and other obstructions where it is impractical to do the required work with the equipment specified, such work shall be done by hand labor methods or other approved means.

S-115.3. MEASUREMENT. "Machine Grading" will be measured by the 100 foot station.

S-115.4. PAYMENT. The work performed as prescribed by this item and measured as provided under "Measurement" will be paid for at the contract unit price bid for "Machine Grading", which price shall be full compensation for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work except "Sprinkling" and "Rolling".

All work in connection with this item required to be done by hand labor methods or other approved means adjacent to structures, trees and other obstructions will not be paid for directly but it shall be considered as subsidiary work to the Item of "Machine Grading".

All Sprinkling and Rolling performed as required will be measured and paid for in accordance with the governing provisions of the Items "Sprinkling" and "Rolling" respectively.

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ITEM S-202

SPRINKLING

S-202.1. DESCRIPTION. This item shall consist of the authorized application of water on those portions of the roadway as shown on plans or as directed and as herein specified.

S-202.2. CONSTRUCTION METHODS. This work will be done only when ordered by the Engineer. The Contractor shall furnish and operate approved sprinklers equipped with positive and rapidly working cut-off valves and approved spray bars which will insure the distribution of water in a uniform and controllable rate of application. The Contractor shall apply the water in the required quantity where shown on plans or as directed by the Engineer.

S-202.3. MEASUREMENT. Sprinkling performed as provided above will be measured by the 1000-gallons as delivered on the roadway.

S-202.4. PAYMENT. The water furnished and the work performed as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid per 1000-gallons for "Sprinkling", which price shall be full compensation for all costs in connection with furnishing the water; for all costs in connection with furnishing and operating approved sprinklers and all necessary measuring devices; and for applying the water as directed, including all hauling, equipment, tools, materials, labor, and incidentals necessary to complete the work.

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ITEM S-203

ROLLING
(Flat Wheel)

S-203.1. DESCRIPTION. This item shall consist of the compaction of embankment, flexible base, or surface treatments, by the operation of approved power rollers as herein specified and as directed by the Engineer.

S-203.2. EQUIPMENT.

(1) Embankments and Flexible Bases.
Power rollers shall be of the three-wheel, self-propelled type, weighing not less than ten (10) tons and shall provide a compression on the rear wheels of not less than three hundred and twenty-five (325) pounds per linear inch of tire width. All wheels shall be flat, the rear wheels shall have a diameter of not less than forty-eight (48) inches, and each shall have a tire width of not less than twenty (20) inches.

(2) Surface Treatments.
Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

Power rollers shall be the three-wheel or tandem, self-propelled type, weighing not less than three (3) tons nor more than ten (10) tons. If three-wheel type, the roller shall provide a compression on the rear wheels of not less than one hundred and fifty (150) pounds per linear inch of the tire width. If tandem type, the roller shall provide an effective compression of not less than one hundred fifty (150) pounds per linear inch of tire width. All wheels shall be flat.

S-203.3. CONSTRUCTION METHODS. This work shall be done only when ordered by the Engineer. The embankment layer or the base course shall be sprinkled if directed, and rolling with a power roller shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half ($\frac{1}{2}$) of the width of the rear wheel of the power roller. On super-elevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the roller shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer. The rollers, unless otherwise directed, shall be operated at a speed between two (2) and three (3) miles per hour.

For embankment or flexible base material requiring rolling, at least one (1) power roller shall be provided for each one hundred (100) cubic yards or fraction thereof of material placed per hour. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller cannot perform the required compaction satisfactorily, additional rollers shall be provided and operated as directed by the Engineer.

S-203.4. MEASUREMENT. Rolling, performed as provided above, will be measured by the actual hours the power roller works as ordered by the Engineer.

S-203.5. PAYMENT. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid per hour for "Rolling", which price shall be full compensation for furnishing and operating all equipment; and for all labor, fuel, tools, and incidentals necessary to satisfactorily perform the work except sprinkling.

All Sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Sprinkling".

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ITEM S-203A

ROLLING
(Tamping)

S-203A.1. DESCRIPTION. This item shall consist of the compaction of embankment or of flexible base by the operation of approved tamping rollers as herein specified and as directed by the Engineer.

S-203A.2. EQUIPMENT. Tamping rollers shall consist of two metal rollers, drums, or shells of forty (40) inches minimum diameter; each not less than forty-two (42) inches in length and unit-mounted in a rigid frame in such manner that each roller may oscillate independently of the other; and each roller, drum, or shell shall be surmounted by metal studs with tamping feet projecting not less than seven (7) inches from the surface and spaced not less than six (6) inches nor more than ten (10) inches measured diagonally center to center; and the cross-sectional area of each tamping foot, measured perpendicularly to the axis of the stud, shall be not less than five (5) nor more than eight (8) square inches. The roller shall be supplemented with cleaning teeth to provide self cleaning. The roller shall be so designed that by ballast loading, the load on each tamping foot may be varied uniformly from 125 to not less than 175 pounds per square inch of cross-sectional area. The load per tamping foot will be determined by dividing the total weight of the roller by the number of tamping feet in one row parallel to or approximately parallel to the axis of the roller. The compression to be provided at any time shall be as directed by the Engineer. The tamping roller shall be drawn by suitable power equipment of adequate tractive effort. Power equipment for use on embankment construction shall, in all cases, be a crawler type tractor. Two tamping rollers, consisting of four cylinders, conforming to the above prescribed requirements, drawn by approved power equipment, shall be considered a roller unit.

Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-203A.3. CONSTRUCTION METHODS. This work shall be done only when ordered by the Engineer. The embankment layer or the base course shall be sprinkled if directed, and rolling with a tamping roller unit shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half (1/2) of the width of the tamping roller unit. On super elevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the unit shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer. The tamping roller unit, unless otherwise directed, shall be operated at a speed between two (2) and three (3) miles per hour.

For material requiring rolling, at least one (1) tamping roller unit shall be provided for each two hundred (200) cubic yards or fraction thereof of material placed per hour. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily, additional roller units shall be provided and operated as directed by the Engineer.

S-203A.4. MEASUREMENT. Rolling performed as provided above will be measured by the actual hours the tamping roller unit works as ordered by the Engineer.

S-203A.5. PAYMENT. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid per hour for "Rolling", which price shall be full compensation for furnishing and operating all equipment; and for all labor, fuel, tools, and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Sprinkling".

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ITEM S-203B

ROLLING
(Pneumatic Tire)

S-203B.1. DESCRIPTION. This item shall consist of the compaction of embankment, flexible base, surface treatments, or pavements by the operation of approved pneumatic tire rollers as herein specified and as directed by the Engineer.

S-203B.2. EQUIPMENT. Pneumatic tire roller shall consist of not less than nine pneumatic tired wheels, running on axles in such manner that the rear group of tires will not follow in the tracks of the forward group, and mounted in a rigid frame and provided with a loading platform or body suitable for ballast loading. The wheel base of the roller (the distance between the front and rear axles) shall be not less than five feet nor more than ten feet. The front axle shall be attached to the frame in such manner that the roller may be turned within a minimum circle. The pneumatic tire roller under working conditions shall have an effective rolling width of approximately sixty (60") inches and shall be so designed that by ballast loading, the load may be varied uniformly from at least 100 pounds to 325 pounds per inch of width of tire tread. The pressure of the tires and the compression to be provided at any time shall be as directed by the Engineer. The roller under working conditions shall provide a uniform compression under all wheels. The total combined width of effective tire tread shall be not less than eighty-five (85%) per cent of the effective rolling width. The pneumatic tire roller shall be drawn by either a suitable crawler type tractor, a pneumatic tired tractor, or a truck of adequate tractive effort, or may be of the self-propelled type, and the roller, when drawn or propelled by either type of equipment, shall be considered a pneumatic tire roller unit. Power equipment for rolling on asphalt surfacing work shall in all cases be equipped with pneumatic tires.

Rollers shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-203B.3. CONSTRUCTION METHODS. This work shall be done only when ordered by the Engineer. The embankment layer or the base course shall be sprinkled if directed. Rolling with a pneumatic tire roller shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half (1/2) of the width of the pneumatic tire roller. On super-elevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the roller shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer.

The rollers shall be operated at speeds directed by the Engineer which shall be between 4 and 12 miles per hour for asphalt surfacing work and between 2 and 6 miles per hour for all other work.

For embankment and flexible base material requiring rolling, at least one (1) pneumatic tire roller shall be provided for each one hundred (100) cubic yards or fraction thereof of material placed per hour. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller cannot perform the required compaction satisfactorily, additional rollers shall be provided and operated as directed by the Engineer.

S-203B.4. MEASUREMENT. Rolling performed as provided above will be measured by the actual hours the pneumatic tire roller unit works as ordered by the Engineer.

S-203B.5. PAYMENT. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid per hour for "Rolling", which price shall be full compensation for furnishing and operating all equipment; and for all labor, fuel, tools, and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Sprinkling".

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ITEM S-203C

ROLLING
(Heavy Tamping)

S-203C.1. DESCRIPTION. This item shall consist of the compaction of embankment by the operation of approved tamping rollers as herein specified.

S-203C.2. COMPACTION EQUIPMENT. Heavy Tamping Roller Unit. Heavy tamping rollers shall consist of two or three metal drums, rolls, or shells of sixty (60) inches minimum diameter. If the two drum type is furnished, each drum shall be not less than sixty (60) inches in length. If the three drum type is furnished, the roller shall consist of two forward drums and one rear drum, the drums to be so arranged that the rear drum will compact the space between the two forward rolls, and rollers of this type shall have an overall rolling width of not less than ten feet.

The drums shall be unit-mounted in a rigid frame in such manner that each drum may oscillate independently of the other.

Each drum shall be surmounted by metal studs with tamping feet projecting not less than seven (7) inches from the surface and shall be so spaced as to result in one tamping foot for each sixty-five hundredths (0.65) to seven tenths (0.7) square foot of drum area. The area of each tamping foot shall be approximately seven (7) square inches, but shall be not less than six (6) nor more than eight (8) square inches. All rollers shall be provided with cleaning teeth so designed and attached as to prevent the accumulation of material between the tamping feet.

The roller shall be so designed that by ballast loading, the load on each tamping foot may be varied up to at least five hundred and fifty (550) pounds per square inch of cross-section area. The load per tamping foot will be determined by dividing the total weight of the roller by the number of tamping feet in one row parallel to or approximately parallel to the axis of the roller. The compression to be provided at any time shall be as directed by the Engineer.

One tamping roller, consisting of two (2) drums or three (3) drums, conforming to the above requirements and drawn by an approved type tractor of adequate tractive effort, shall be considered a heavy tamping roller unit.

The roller unit shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-203C.3. CONSTRUCTION METHODS. This work shall be done only when ordered by the Engineer. The embankment layer shall be sprinkled if directed, and rolling with a tamping roller unit shall start longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half (1/2) of the width of the tamping roller. On superelevated curves, rolling shall begin at the low sides and progress toward the high sides. Alternate trips of the unit shall be slightly different in length, and rolling shall continue until ordered discontinued by the Engineer. The tamping roller unit, unless otherwise directed, shall be operated at a speed between two (2) and three (3) miles per hour.

For material requiring rolling, at least one (1) tamping roller unit shall be provided for each three hundred (300) cubic yards or fraction thereof of material placed per hour. The quantity of material placed per hour shall be determined by averaging the total quantity of material placed within any one working day. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily, additional roller units shall be provided and operated as directed by the Engineer.

S-203C.4. MEASUREMENT. Rolling performed as provided above will be measured by the actual hours the tamping roller unit works as ordered by the Engineer.

S-203C.5. PAYMENT. The equipment furnished and operated as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid per hour for "Rolling (Heavy Tamping)", which price shall be full compensation for furnishing and operating all equipment; and for all labor, fuel, tools, and incidentals necessary to satisfactorily perform the work except sprinkling.

All sprinkling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Sprinkling".

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ITEM S-204

RESHAPING BASE COURSE

S-204.1. DESCRIPTION. This item shall consist of reshaping and refinishing the surface of the existing base as herein specified and in conformity with the typical sections shown on plans and to the lines and grades established by the Engineer.

S-204.2. CONSTRUCTION METHODS. The surface of the existing base shall first be thoroughly cleaned of all dirt and other objectionable material by blading, supplemented by brooming or other approved methods. All holes, ruts, or depressions in the surface shall be repaired by scarifying where required, reshaping, sprinkling, and rolling as directed until a uniform compaction is secured. The rolling shall be performed as directed. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one quarter (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally, shall be loosened, reshaped, and recompacted by sprinkling and rolling.

S-204.3. MEASUREMENT. Reshaping base course performed as provided above will be measured by the one hundred (100) foot station of reshaping base course, as shown on the plans.

S-204.4. PAYMENT. The work performed as prescribed by this item and measured as provided under "Measurement" will be paid for at the contract unit price bid for "Reshaping Base Course", which price shall be full compensation for furnishing and operating all equipment necessary to satisfactorily perform the work and for furnishing all labor, fuel, tools, and incidentals required except sprinkling and rolling.

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

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ITEM S-205

RECONDITIONING FLEXIBLE BASE
(Calcareous)

S-205.1. DESCRIPTION. This item shall consist of repairing an existing base by adding new material, reshaping, recompacting, and refinishing as herein specified and in conformity with the typical sections shown on plans and to the lines and grades established by the Engineer.

S-205.2. MATERIAL. The material shall be obtained from approved sources. It shall consist of argillaceous limestone, calcareous or calcareous clay particles, with or without stone, conglomerate, gravel, sand or other granular materials. The material shall be approved by the Engineer at the source. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". All the acceptable material shall be screened, and the oversize shall be crushed and returned to the screened material in such manner that a uniform product will be produced. The processed material, when properly slaked and tested by standard laboratory methods, shall meet the following requirements.

Passing 2 inch screen	100%
Retained on 40 mesh sieve	50 to 85%

The material passing the 40 mesh sieve shall be known as Soil Binder and shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The linear shrinkage shall not exceed	8.5%

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

S-205.3. MATERIAL SOURCES. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or designated by the Engineer. These pits, as utilized, shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material, and unless otherwise directed, the material shall be secured (by blasting if necessary) in successive vertical cuts extending through all of the exposed strata.

S-205.4. CONSTRUCTION METHODS. The surface of the existing base, including any bituminous mat, shall first be cleaned of all dirt or other objectionable material by blading, brooming, or other approved methods, then scarified for its full width and to such uniform depth as to permit the elimination of all depressions and irregularities. Acceptable material shall be delivered in approved vehicles of uniform capacity and placed as shown on plans or as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged, and shaped to conform to the typical sections shown on plans. All areas or "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, and if additional binder is considered necessary or desirable after the material is spread and shaped, approved binder shall be furnished and applied. This additional binder shall be carefully and evenly incorporated with the material in place by scarifying, brooming, or by other approved methods and shall be measured and paid for as provided for the normal material. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the reconditioned base is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, the reconditioned base shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over its entire width. During the period traffic is being directed over the base, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, or such other equipment as is required, and these operations shall continue until the course is sufficiently compacted.

All traffic allowed on the reconditioned base shall comply with State laws governing traffic on highways.

S-205.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile shall be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-205.6. PAYMENT. The work performed and the material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Reconditioning Flexible Base", which price shall be full compensation for scarifying the existing base; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, screening and crushing; for loading all materials; for hauling the first one-quarter mile and delivering on the road; for spreading, blading, dragging, shaping, and finishing; and for all manipulations, labor, tools, and incidentals necessary to complete the work except salvaging any existing bituminous surface, hauling beyond the first quarter mile, stripping, sprinkling, and rolling.

Hauling material for reconditioning flexible base into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

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ITEM S-205A

RECONDITIONING FLEXIBLE BASE
(Gravel)

S-205A.1. DESCRIPTION. This item shall consist of repairing an existing base by adding new material, reshaping, recompacting and refinishing as herein specified and in conformity with the typical sections shown on plans and to the lines and grades established by the Engineer.

S-205A.2. MATERIAL. The material shall be obtained from approved sources; shall consist of durable particles of stone or gravel mixed with acceptable binder; and shall be free from thin or elongated pieces, lumps of clay, soil, loam, or vegetable matter. The material shall be approved by the Engineer at the source. When properly slaked and tested, it shall all pass a one and one-half (1 1/2) inch screen and shall be graded down to dust with not less than forty-five (45) per cent retained on the one-fourth (1/4) inch screen.

Material passing the one-fourth (1/4) inch screen shall be known as Binder; that portion of the binder material passing the forty (40) mesh sieve shall be known as Soil Binder and shall meet the following requirements:

The liquid limit shall not exceed	35
The plasticity index shall not exceed	12
The linear shrinkage shall not exceed	7%

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

S-205A.3. MATERIAL SOURCES. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or designated by the Engineer. The overburden and such other material as is considered unacceptable by the Engineer, removed and disposed of as directed, will be classified and paid for as "Stripping". The pit or pits shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata.

S-205A.4. CONSTRUCTION METHODS. The surface of the existing base, including any bituminous mat, shall first be cleaned of all dirt or other objectionable material by blading, brooming, or other approved methods, then scarified for its full width and to such uniform depth as to permit the elimination of all depressions and irregularities. Acceptable material shall be delivered in approved vehicles of uniform capacity and placed as shown on plans or as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged, and shaped to conform to the typical sections shown on plans. All areas or "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, and if additional binder is considered necessary or desirable after the material is spread and shaped, approved binder shall be furnished and applied. This additional binder shall be carefully and evenly incorporated with the material in place by scarifying, brooming, or by other approved methods and shall be measured and paid for as provided for the normal material. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally, shall be corrected by loosening, adding, or removing material, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the reconditioned base is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by

the Engineer, the reconditioned base shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over its entire width. During the period traffic is being directed over the base, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, or such other equipment as is required, and these operations shall continue until the course is sufficiently compacted.

All traffic allowed on the reconditioned base shall comply with State laws governing traffic on highways.

S-205A.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-205A.6. PAYMENT. The work performed and the material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Reconditioning Flexible Base", which price shall be full compensation for scarifying the existing base; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, screening and crushing; for loading all materials; for hauling the first one-quarter mile and delivering on the road; for spreading, blading, dragging, shaping and finishing; and for all manipulations, labor, tools, and incidentals necessary to complete the work except salvaging any existing bituminous surface, hauling beyond the first quarter mile, stripping, sprinkling, and rolling.

Hauling material for reconditioning flexible base into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

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ITEM S-206

SCARIFYING EXISTING PAVEMENT

S-206.1. DESCRIPTION. This item consists of scarifying existing asphalt surfacing and flexible base course material to the lines and grades as shown on the plans or established by the Engineer.

S-206.2. CONSTRUCTION METHODS. The existing asphalt surfacing and flexible base course material at points shown on the plans or designated by the Engineer shall be scarified to the depth and width shown by the lines and grades on the plans or established by the Engineer. The existing material to be removed shall be scarified until it is broken into particles small enough to be easily removed. After scarifying, the material will be classified as "Common Road Excavation".

S-206.3. MEASUREMENT. This item will be measured by the one hundred foot station, regardless of the width of the old base and pavement.

S-206.4. PAYMENT. The work performed as prescribed for this item, measured as provided under "Measurement" will be paid for at the unit price bid per one hundred foot station for "Scarifying Existing Pavement", which price shall be full compensation for furnishing all labor, tools, equipment, supplies, and incidentals necessary to satisfactorily complete the work.

Excavating, hauling, and disposing of the scarified material will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Overhaul".

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ITEM S-207

SALVAGING AND REPLACING FLEXIBLE BASE

S-207.1. DESCRIPTION. This item shall consist of removing the existing flexible base material where shown on plans, such temporary storage as is necessary, and the replacement of this material on the prepared roadbed as herein specified and in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-207.2. CONSTRUCTION METHODS.

(1) Salvaging Existing Base.

The existing base, including any bituminous mat not shown on plans to be salvaged, shall first be cleaned of all dirt or other objectionable material by blading, brooming, or other approved methods, then scarified for its full width and to such depth as will permit the removal of the old base course material without disturbance of the underlying subgrade. The material thus salvaged shall be placed in stockpiles or windrows until sufficient subgrade has been prepared to receive the salvaged material; then, if the Contractor so elects, the remaining old base material as salvaged may be placed directly upon the prepared subgrade as directed by the Engineer, thus eliminating the necessity of stockpiling. It shall be the responsibility of the Contractor that all the available material shall be salvaged and replaced and shall be kept reasonably free of soil from the subgrade or roadbed during the salvaging and replacing operations. When material is windrowed or stockpiled, it shall be so placed as not to interfere with traffic, proper drainage, or the general progress of the work.

(2) Preparation of Subgrade. When the salvaged materials to be replaced directly upon the subgrade, the roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water, reshaped, and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the salvaged base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of one-half (1/2) inch in cross-section and in length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(3) Replacement of Salvaged Material. The material shall then be deposited on the subgrade or other base course, sprinkled if directed, and bladed, dragged, and shaped to conform to typical sections shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with satisfactory salvaged material as directed by the Engineer. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-quarter (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and recompacting, sprinkling, and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

S-207.3. MEASUREMENT. Work, as prescribed for this item, will be measured by the cubic yard of material in vehicles as delivered on the road, or when provided by the plans measurement will be made by the one hundred foot (100') station of base in its original position.

S-207.4. PAYMENT. The work performed as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Salvaging and Replacing Flexible Base", which price shall be full compensation for shaping and fine grading the roadbed; for scarifying, removing, windrowing or stockpiling; for all hauling, for replacing the salvaged material on the prepared subgrade; for spreading, blading, dragging, shaping, and finishing; and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work except rolling, sprinkling, and the excavation required by this item in the preparation of the subgrade and shoulders.

Unless otherwise indicated on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the items of "Roadway Excavation" and "Borrow" respectively with the provision that yardage will be measured and paid for once only, regardless of the manipulation involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

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ITEM S-210

ROADBED TREATMENT

S-210.1. DESCRIPTION. This item shall consist of treating designated sections of the roadbed by the addition of suitable material and shall be constructed as herein specified in conformity with the typical sections shown on the plans and to the lines and grades as established by the Engineer.

S-210.2. MATERIAL. The material shall be obtained from approved sources, and shall be approved by the Engineer, and meet the following requirements for the type or types specified on the plans:

Type "A". This material shall consist of selected clay or calcareous clay, with or without stones, conglomerate, or sand of a proper quality to secure a well bonded course.

Type "B". This material shall consist of sand or other suitable granular material, free from lumps of earth, vegetation, or other objectionable matter.

S-210.3. MATERIAL SOURCES. Should the Contractor elect to obtain the specified material from local pits, the material may be secured from the sources shown on plans.

Material pits shall be stripped, if required, and any material considered unacceptable by the Engineer shall be removed from the pits.

Pits, as utilized, shall be opened up in such manner as to immediately expose the vertical faces of all the various strata of acceptable material and, unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

S-210.4. CONSTRUCTION METHODS. This work will be performed, as directed, in proper sequence with that of preparing subgrade, or other items specified in the contract.

The material shall be delivered in approved vehicles of uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. The material shall be spread to proper section by the use of blades, drags, or other suitable equipment.

If the material is not well mixed or contains clods it shall be thoroughly mixed, after spreading, and all clods broken by raking, blading, discing, harrowing, scarifying, or other approved methods. Upon completion of this work, the course shall be reshaped to conform to the typical sections shown on plans.

The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereon, or the work is accepted. During this maintenance, additional material shall be added, if ordered by the Engineer, as necessary for the maintenance of a satisfactory surface.

S-210.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road.

S-210.6. PAYMENT. The work performed and material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Roadbed Treatment", of the type shown on plans, which price shall be full compensation for all stripping required; for furnishing, loosening, excavating, and loading the material; for all hauling and delivering on the road; for spreading, mixing, breaking clods, and finishing; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

Where additional compaction is desired all sprinkling and rolling as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

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ITEM S211

FLEXIBLE BASE
(Caliche)

S-211.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of caliche and stone materials; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-211.2. MATERIAL. The material shall be obtained from approved sources. It shall consist of argillaceous limestone, calcareous or calcareous clay particles, with or without stone, conglomerate, gravel, sand or other granular materials. The material shall be approved by the Engineer at the source. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". All the acceptable material shall be screened, and the oversize shall be crushed and returned to the screened material in such manner that a uniform product will be produced. The processed material, when properly slaked and tested by standard laboratory methods, shall meet the following requirements.

Passing 2 inch screen	100%
Retained on 40 mesh sieve	50 to 85%

Material passing the 1/4 inch screen shall be known as "Binder", that portion of the binder material passing the 40 mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The linear shrinkage shall not exceed	8.5%

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

S-211.3. MATERIAL SOURCES. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or designated by the Engineer. These pits, as utilized, shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured (by blasting if necessary) in successive vertical cuts extending through all of the exposed strata.

The Contractor shall provide at the processing plant site, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and his assistants. This building shall be not less than 8' x 20' and 8' high, floored, and roofed weather-tight, containing not less than two windows and two doors and a substantial work bench three (3) feet wide and six (6) feet long. This building shall be so located that the details of the processing plant are in full view and plainly visible from at least one window of same.

S-211.4. CONSTRUCTION METHODS. Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished true to line

and grade as established and in conformity with the typical section shown on plans. Any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first twenty-four (24) hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged, and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregate coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming, or by other approved methods. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitduinally shall be corrected by loosening, adding, or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course. During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required and these operations shall continue until the base course is sufficiently compacted and bound to permit the application of the next course.

Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-211.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile shall be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-211.6. PAYMENT. The work performed and material furnished (including additional binder if required) as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flexible Base", which price shall be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, screening and crushing; for loading all materials; for hauling the first one-quarter mile and delivering on the road; for spreading, blading, dragging, shaping, and finishing; and for all manipulation, labor, tools, and incidentals necessary to complete the work except stripping, hauling beyond the first quarter mile, sprinkling, rolling, and the excavation required by this item in the preparation of the subgrade and shoulders.

Hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Scraper Work", "Road Grader Work", "Machine Grading" or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

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ITEM S-212

FLEXIBLE BASE
(Shell with Sand Admixture)

S-212.1. DESCRIPTION. This item shall consist of a foundation course for surface course or other base courses, shall be composed of shell and binder, and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-212.2. MATERIALS. The materials shall consist of durable particles of shell, with or without its natural binding material, and sand admixture obtained from sources designated on the plans or approved by the Engineer.

(1) Sand Admixture. Sand Admixture shall consist of fine sand or fine sand and clay, and shall be free from roots, grass or other foreign materials.

(2) Shell. The shell shall consist of an unwashed, partially washed or washed shell with or without natural binder. The shell, when mixed with the proper proportion of sand admixture, shall produce a base course material which, when properly slaked and tested by standard laboratory methods, shall meet the following requirements:

	Per cent by weight
Passing 1-1/2" screen	90% to 100%
Retained on 40-mesh sieve	45% to 85%

The material passing 40-mesh sieve shall be known as soil binder and shall meet the following requirements:

The Liquid Limit shall not exceed	35
The Plasticity Index shall be not less than	4
Nor more than	12
The Linear Shrinkage shall not exceed	7%

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

Samples to test compliance with these requirements will be taken after mixing and compacting is complete.

For the information of the Contractor, and in order to determine the proper amount of sand admixture to be incorporated with the shell, the Engineer will sample each barge of shell as it is delivered. The Contractor will not be required to hold each barge of shell until testing is completed, but the Contractor shall be responsible for furnishing materials, shell and sand admixture, which will, when properly mixed, produce a satisfactory material as heretofore specified. Each barge of shell shall be uniform throughout. No shell shall be stock-piled without the written permission of the Engineer.

Permission for stock-piling shell will be given only under conditions which will give a uniform product on the road, and the Engineer may require, if necessary, that each barge be kept separate in the stock-pile. Written permission to stock-pile materials will not relieve the Contractor of the responsibility for furnishing a uniform product on the road. Materials improperly stock-piled will be rejected.

The Contractor shall provide at his entire expense, at site selected by the Engineer, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and his assistants. This building shall be not less than eight (8)

feet by twenty (20) and eight (8) feet high, floored, and roofed, weather-tight, containing not less than two windows and two doors and a substantial work bench three (3) feet wide and six (6) feet long.

S-212.3. CONSTRUCTION METHODS. (1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and, if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established, and be in conformity with the typical section shown on plans and any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed. Any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section, and corrections made if necessary.

All materials shall be delivered in approved vehicles of a uniform capacity. The required amount of shell shall be uniformly spread across the section and allowed to dry sufficiently to insure proper slaking and mixing of the binder material. Immediately upon completion of the drying period, as determined by the Engineer, the specified amount of sand admixture shall be spread uniformly across the shell. The material shall then be sprinkled as required and thoroughly mixed by blading and harrowing, or other approved methods.

If approved by the Engineer in writing, a central mixing plant, or a road mixing machine or a combination of machines, which will produce a uniform material meeting all of the requirements of this specification may be used in place of the road mixing described hereinbefore.

After mixing, all material shall be windrowed, and then spread over the section in layers not to exceed two (2) inches in loose depth. If necessary to prevent segregation, the material shall be wet in the windrow prior to spreading. After each lift is spread, it shall be sprinkled and rolled to secure maximum compaction as directed by the Engineer. Succeeding layers shall then be placed similarly until the course is completed. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading; and the surface, upon completion, shall be smooth and in conformity with the typical sections shown on plans, and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing materials; reshaping and recompacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The Contractor shall provide sufficient equipment and conduct his operations in such a manner that the minimum of time consistent with satisfactory results will elapse between the time the shell is placed on the subgrade and the opening of the base course for traffic compaction. Failure to proceed with the placing of sand admixture or mixing and placing operations will be grounds for the suspension of placing of shell. Under no conditions will the Contractor be allowed to place an excessive amount of shell without proceeding with the mixing and placing operations.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract, and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course.

During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required, and these operations shall continue until the base course is sufficiently compacted and bound to permit the application of the next course.

(3) Succeeding Courses. Construction methods shall be the same as those prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-212.4. MEASUREMENT. Work and accepted material as prescribed for this item shall be measured by the cubic yard of material in vehicles as delivered on the road.

S-212.5. PAYMENT. The work performed and material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Flexible Base" and "Sand Admixture".

The unit price bid for "Flexible Base" shall be full compensation for shaping and fine grading the roadbed, for securing and furnishing all materials, including all royalty and freight involved, for all processing required; for loading, all hauling, delivery, placing, mixing and spreading on the road; for blading, shaping, dragging, and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except sprinkling and rolling.

The unit price bid for "Sand Admixture" shall be full compensation for securing and furnishing all materials, including all royalty and freight involved, for all clearing and grubbing, for removing all grass roots, trash, and other objectionable matter from the material source, for excavating, for loading, all hauling, delivering, placing, spreading and mixing on the road, for blading, shaping, dragging and finishing, and for all manipulations, labor, tools and incidentals necessary to complete the work.

All sprinkling and rolling performed as required will be paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively. Unless otherwise provided by the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation", and "Borrow", respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved.

When shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of shoulders and slopes, and for finishing roadway shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work", "Machine Grading", or "Scraper Work". Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for the Items "Blading", "Road Grader Work", "Machine Grading", or "Scraper Work".

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ITEM S-213

FLEXIBLE BASE
(Bank-run Gravel)

S-213.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of bank-run gravel; and shall be constructed as herein specified in one or more courses in conformity with the typical section shown on plans and to the lines and grades as established by the Engineer.

S-213.2. MATERIALS. The materials shall be obtained from approved sources; shall consist of durable particles of gravel mixed with approved binding material; and shall be free from thin or elongated pieces, lumps of clay, soil, loam, or vegetable matter. The material may be bank-run or the binder may be added and incorporated by approved methods as herein specified. The material shall be approved by the Engineer at the source. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". Materials containing gravel or conglomerate over two (2) inches in their largest dimension shall be broken up and uniformly mixed with the remainder of the material.

The material, when properly slaked and tested by standard laboratory methods, shall meet the following requirements:

Retained on 2" screen	0%
Retained on 1/2" screen	20 to 60%
Retained on 1/4" screen	40 to 75%
Retained on 40 mesh sieve	60 to 85%

The material passing the 1/4-inch screen shall be known as "Binder", and that portion of the binder material passing the 40-mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	35
The plasticity index shall not exceed	12
The linear shrinkage shall not exceed	7%

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

S-213.3. MATERIAL SOURCES. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or designated by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

The Contractor shall provide at the processing plant site, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and his assistants. This building shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored, and roofed weather-tight, containing not less than two windows and two doors and a substantial work bench three (3) feet wide and six (6) feet long. This building shall be so located that the details of the processing plant are in full view and plainly visible from at least one window of same.

S-213.4. CONSTRUCTION METHODS.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water, reshaped, and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in con-

formity with the typical section shown on plans, and any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100-foot station. Material deposited upon the subgrade shall be spread and shaped the same day. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first twenty-four (24) hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged, and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming, or by other approved methods. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course. During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required, and these operations shall continue until the base course is sufficiently compacted and bonded to permit the application of the next course.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-213.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-213.6. PAYMENT. The work performed and material furnished (including additional binder if required) as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flexible Base", which price will be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, breaking oversize material; for loading all materials, hauling the first one-quarter mile, and delivering on the road; for spreading, blading, shaping, dragging and finishing; and for all manipulations, labor, tools, and incidentals necessary to complete the work except stripping, hauling beyond the first quarter mile, sprinkling, rolling, and the excavation required by this item in the preparation of the subgrade and shoulders.

Hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work", "Machine Grading", or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

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ITEM S-213A

FLEXIBLE BASE
(Processed Gravel)

S-213A.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of screened and processed gravel; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-213A.2. MATERIALS. The materials shall be obtained from approved sources and shall consist of durable particles of gravel mixed with approved binding material. The material may be bank-run or the binder may be added and incorporated by approved methods as herein specified. The material shall be approved by the Engineer at the source. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". All the acceptable material shall be screened, and the oversize shall be crushed and returned to the screened material in such manner that a uniform product will be produced. The processed material, when properly slaked and tested by standard laboratory methods shall meet the following requirements:

Retained on 2" screen	0%
Retained on 1/2" screen	20 to 60%
Retained on 1/4" screen	40 to 75%
Retained on 40 mesh sieve	60 to 85%

The material passing the one-fourth (1/4) inch screen shall be known as "Binder", and that portion of the binder material passing the 40-mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	35
The plasticity index shall not exceed	12
The linear shrinkage shall not exceed	7

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

S-213A.3. MATERIAL SOURCES. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or designated by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

The Contractor shall provide at the processing plant site, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and his assistants. This building shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored, and roofed weather-tight, containing not less than two windows and two doors and a substantial work bench three (3) feet wide and six (6) feet long. This building shall be so located that the details of the processing plant are in full view and plainly visible from at least one window of same.

S-213A.4. CONSTRUCTION METHODS. Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable con-

dition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

First Course. Immediately before placing the base material, the subgrade shall be checked to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each one hundred (100) foot station. Material deposited upon the subgrade shall be spread and shaped the same day. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first twenty-four (24) hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged, and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming, or by other approved methods. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course.

During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required, and these operations shall continue until the base course is sufficiently compacted and bound to permit the application of the next course.

Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-213A.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-213A.6. PAYMENT. The work performed and material furnished (including additional binder if required) as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flexible Base", which price will be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, screening and crushing; for loading all materials; hauling

the first one-quarter mile and delivering on the road; for spreading, blading, shaping, dragging and finishing; and for all manipulations, labor, tools, and incidentals necessary to complete the work except stripping, sprinkling, rolling, and the excavation required by this item in the preparation of the subgrade and shoulders.

Hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans, all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work", "Machine Grading", or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work", "Machine Grading", or "Scraper Work".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping."

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ITEM S-214

FLEXIBLE BASE
(Iron Ore)

S-214.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of iron ore material; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-214.2. MATERIALS. The materials shall be obtained from designated sources and shall consist of hematite, hydrated hematite or limonite ore, occurring with or without sand, as found at or near the surface, which, when loaded from the material pit, shall not contain an excess of free clay. Material shall be approved by the Engineer at the source. Material containing gravel or hard pieces of ore over two and one-half (2 1/2) inches in their largest dimension shall be broken up and uniformly mixed with the remainder of the material.

S-214.3. MATERIAL SOURCES. It shall be the charge of the Contractor to remove grass, weeds, rubbish or other objectionable materials; to break up by sledging or other approved methods, material over two and one-half (2 1/2) inches in its largest dimensions; and to thoroughly mix the base course material in the pit before loading same, in order that a uniform material may be delivered on the road. This mixing process may be done by blading the material into windrows or by other approved methods. Upon completion of hauling from a pit, the pit site shall be smoothed by blading so as to present a neat appearance. All fences, gates, and other improvements belonging to the owner of the pit site shall be restored to as good a condition of repairs as existed when the pit was opened by the Contractor.

S-214.4. CONSTRUCTION METHODS. Preparation of Subgrade: The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

First Course: The material shall be delivered to the subgrade in approved vehicles of uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each one hundred (100) foot station. Material deposited upon the subgrade shall be spread and shaped within twenty-four (24) hours. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first twenty-four (24) hour period, it shall be scarified and spread as early as possible as directed by the Engineer.

After the material has been spread and shaped, the shoulders shall be bladed and shaped to permit the proper manipulation of the base course material. When necessary, provisions such as ditches through the material on the shoulders shall be provided to effect satisfactory drainage of the base course.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course. During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required, and these operations shall continue until the base course is sufficiently compacted and bound to permit the application

The material shall be scarified, thoroughly wetted, mixed, manipulated, and bladed so as to secure a uniformly wetted material and pulled in over the subgrade in courses and set under the action of traffic and blading. It shall be the responsibility of the Contractor to direct and distribute construction traffic and/or highway traffic uniformly over the courses during this construction process. The work of mixing, blading, rolling, shaping, and subsequent maintenance shall be performed by the continuous use of a sufficient number of satisfactory power units and blade graders with satisfactory scarifier attachments. The above described operations shall continue until, in the opinion of the Engineer, the base course is sufficiently compacted and set to permit the application of the succeeding course or courses.

Succeeding Courses: Construction methods shall be the same as prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-214.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-214.6. PAYMENT. The work performed and material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flexible Base", which price shall be full compensation for shaping and fine grading the roadbed; for removing grass, weeds, rubbish, and other objectionable matter from the surface of the material sources; for furnishing all materials; for all royalty (unless otherwise provided) and freight involved; for loosening, blasting, excavating, mixing, and loading all materials; for breaking oversize material; for hauling the first one-quarter mile and delivering on the road; for spreading, blading, shaping, and finishing; and for all manipulations, labor, tools, and incidentals necessary to complete the work except as specified below.

Hauling material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans all excavation required by this item in the preparation of the subgrade and procurement of additional material for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the items of "Roadway Excavation" and "Borrow". However, where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the item of "Blading", "Scraper Work", "Road Grader Work" or "Machine Grading". Payment under the item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Scraper Work", "Road Grader Work", or "Machine Grading".

All sprinkling and rolling performed as required by this item will be measured and paid for in accordance with the provisions governing the items of "Sprinkling" and "Rolling" respectively.

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ITEM S-215

FLEXIBLE BASE
(Crushed Stone)

S-215.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of crusher-run broken stone; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-215.2. MATERIALS. The material shall be obtained from approved sources, shall be crushed, and shall consist of durable particles of stone mixed with approved binding materials. The material shall be approved by the Engineer at the source. Only such material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". The processed material when properly slaked and tested by standard laboratory methods shall meet the following requirements:

Retained on 2-inch screen	0%
Retained on 1/4-inch screen	45 - 75%
Retained on 40-mesh sieve	60 - 85%

Material passing the one-fourth (1/4) inch screen shall be known as "Binder"; that portion of the binder material passing the 40-mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The linear shrinkage shall not exceed	8.5%

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

S-215.3. MATERIAL SOURCES. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or designated by the Engineer. These pits as utilized shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata.

The Contractor shall provide at the processing plant site, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and his assistants. This building shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored, and roofed weather-tight, containing not less than two windows and two doors and a substantial work bench three (3) feet wide and six (6) feet long. This building shall be so located that the details of the processing plant are in full view and plainly visible from at least one window of same.

S-215.4. CONSTRUCTION METHODS.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and compacting by sprinkling

and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each one hundred (100) foot station. Material deposited upon the subgrade shall be spread and shaped the same day. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first twenty-four (24) hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged, and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming, or by other approved methods. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course. During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required, and these operations shall continue until the base course is sufficiently compacted and bound to permit the application of the next course.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-215.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-215.6. PAYMENT. The work performed and material furnished (including additional binder if required) as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flexible Base", which price shall be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, crushing, and screening; for loading all materials; for hauling the first one-quarter mile and delivering on the road; for spreading, blading, shaping, dragging, and finishing; for all manipulation, labor, tools, and incidentals necessary to complete the work

except stripping, sprinkling, rolling, and the excavation required by this item in the preparation of the subgrade and shoulders.

Hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise noted on the plans all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling" respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

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ITEM S-215A

FLEXIBLE BASE
(Cleaned Crushed Stone)

S-215A.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of crusher-run broken stone; and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-215A.2. MATERIALS. The materials shall be obtained from approved sources, shall be crushed, and shall consist of durable particles of stone mixed with approved binding material. The material shall be approved by the Engineer at the source, and any material removed from the pits as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". Prior to crushing, the material shall be screened or partially screened or otherwise manipulated in a manner satisfactory to the Engineer, in order that all soil, clay, and other objectionable material will be removed. The processed material when properly slaked and tested by standard laboratory methods shall meet the following requirements:

Retained on 2 inch screen	0%
Retained on 1/4 inch screen	45 - 75%
Retained on 40 mesh sieve	60 - 85%

Material passing the 1/4 inch screen shall be known as "Binder"; that portion of the binder material passing the 40-mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The linear shrinkage shall not exceed	8.5%

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

S-215A.3. MATERIAL SOURCES. Should the Contractor elect to produce the specified material from local pits, the material shall be secured from the sources shown on plans or designated by the Engineer. These pits, as utilized, shall be opened up in such manner as to immediately expose the vertical faces of all of the various strata of acceptable material, and unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata.

The Contractor shall provide at the processing plant site, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and his assistants. This building shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored, and roofed weather-tight, containing not less than two windows and two doors and a substantial work bench three (3) feet wide and six (6) feet long. This building shall be so located that the details of the processing plant are in full view and plainly visible from at least one window of same.

S-215A.4. CONSTRUCTION METHODS.

(1) Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water, reshaped, and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in

conformity with the typical section shown on plans, and any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding or removing material reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes or otherwise disposed of as directed, and any additional material required for the completion of the shoulders and slopes shall be secured from sources indicated on plans or designated by the Engineer.

(2) First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each one hundred (100) foot station. Material deposited upon the subgrade shall be spread and shaped the same day. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first twenty-four (24) hour period, the material shall be scarified and spread as directed by the Engineer. The material shall then be sprinkled, if directed, and shall be bladed, dragged, and shaped to conform to typical sections as shown on plans. All areas, and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming, or by other approved methods. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course. During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required, and these operations shall continue until the base course is sufficiently compacted and bound to permit the application of the next course.

(3) Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-215A.5. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile will be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

S-215A.6. PAYMENT. The work performed and material furnished (including additional binder if required) as prescribed by this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flexible Base", which price shall be full compensation for shaping and fine grading the roadbed; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, crushing, and screening; for loading all materials; for hauling the first one-quarter mile and delivering on the road; for spreading, blading, shaping,

dragging, and finishing; and for all manipulations, labor, tools, and incidentals necessary to complete the work except stripping, hauling beyond the first quarter mile, sprinkling, rolling, and the excavation required by this item in the preparation of the subgrade and shoulders.

Hauling base course material into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Unless otherwise indicated on plans all excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow" respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved. Where shown on plans, the excavation required in the preparation and shaping of the subgrade, for the completion of the shoulders and slopes and for finishing roadway, shall be performed, measured and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work", "Machine Grading", or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work".

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

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ITEM S-216

FLEXIBLE BASE
(Selected Material From Excavation)

S-216.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for other base courses; shall be composed of materials obtained from roadway cuts and shall be constructed as herein specified in one or more courses in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-216.2. MATERIAL. Material shall consist of selected portions of excavation meeting the requirements set out below for "Flexible Base" and shall be obtained from selected and reserved portions of "Roadway Excavation" and "Channel Excavation" as shown on plans or as designated by the Engineer. The excavation of such sources for selected material shall be performed in such manner and sequence that suitable material may be selected, removed separately, and utilized in flexible base construction. Such material as is secured from these designated sources and utilized in the flexible base shall be processed and manipulated as herein stiuplated and shall be measured and paid for as hereinafter provided.

The material shall be of the type designated on the plans and shall meet the following requirements:

(1) Flexible Base (Caliche). The material shall consist of argillaceous limestone, calcareous or calcareous clay particles, with or without stone, conglomerate, gravel, sand or other granular materials. The material shall be approved by the Engineer at the source. All the acceptable material shall be screened, and the oversize shall be crushed and returned to the screened material in such manner that a uniform product will be produced. The processed material, when properly slaked and tested by standard laboratory methods, shall meet the following requirements:

Passing 2 inch screen	100%
Retained on 40 mesh sieve	50 - 85%

The material passing the 40 mesh sieve shall be known as Soil Binder and shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The linear shrinkage shall not exceed	8.5%

(2) Flexible Base (Crushed Stone). The materials shall be crushed, and shall consist of durable particles of stone mixed with approved binding material. The material shall be approved by the Engineer at the source. The processed material when properly slaked and tested by standard laboratory methods shall meet the following requirements:

Retained on 2 inch screen	0%
Retained on 1/4 inch screen	45 - 75%
Retained on 40 mesh sieve	60 - 85%

Material passing the one-fourth (1/4) inch screen shall be known as "Binder"; that portion of the binder material passing the 40-mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The linear shrinkage shall not exceed	8.5%

(3) Flexible Base (Cleaned Crushed Stone). The materials shall be crushed, and shall consist of durable particles of stone mixed with approved binding material. The material shall be approved by the Engineer at the source. Prior to crushing, the material shall be screened or partially screened or otherwise manipulated in a manner satisfactory to the Engineer, in order that all soil, clay, and other objectionable material will be removed. The processed material when properly slaked and tested by standard laboratory methods shall meet the following requirements:

Retained on 2 inch screen	0%
Retained on 1/4 inch screen	45 - 75%
Retained on 40 mesh sieve	60 - 85%

Material passing the 1/4 inch screen shall be known as "Binder"; that portion of the binder material passing the 40-mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The linear shrinkage shall not exceed	8.5%

(Note: For all types, the linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

The Contractor shall provide at the processing plant site, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and his assistants. This building shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored, and roofed, weather-tight, containing not less than two windows and two doors, and a substantial work bench three (3) feet wide and six (6) feet long. This building shall be so located that the details of the processing plant are in full view and plainly visible from at least one window of same.

S-216.3. CONSTRUCTION METHODS. Preparation of Subgrade. The roadbed shall be excavated and shaped in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be thoroughly wetted with water and reshaped and rolled to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be finished to line and grade as established and in conformity with the typical section shown on plans, and any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work.

First Course. Immediately before placing the base material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of specified material shall be delivered in each 100 foot station. Material deposited upon the subgrade shall be spread and shaped the same day. In the event inclement weather or other unforeseen circumstances render impractical the spreading of the material during the first twenty-four (24) hour period, the material shall be scarified and spread as directed by the Engineer. The material shall be sprinkled, if directed, and shall then be bladed, dragged, and shaped to conform to typical sections as shown on plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder material shall be carefully and evenly incorporated with the material in place by scarifying, harrowing, brooming, or by other approved methods. The course shall then be sprinkled as required and rolled as directed until a uniform compaction is secured. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections

shown on plans and to the established lines and grades. In that area on which pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross section and in a length of sixteen (16) feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and recompacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

The utilization of traffic to compact and bind the base course or courses is an essential part of the contract and is of prime importance to the satisfactory completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the traffic uniformly over the entire width of the course. During the period traffic is being directed over the course, the surface shall be satisfactorily maintained by the use of a sufficient number of approved blades, drags, and such other equipment as is required, and these operations shall continue until the base course is sufficiently compacted and bonded to permit the application of the next course.

Succeeding Courses. Construction methods shall be the same as prescribed for the first course.

All traffic allowed on the completed base shall comply with State laws governing traffic on highways.

S-216.4. MEASUREMENT. Work as prescribed for this item, except for the excavation involved, will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile shall be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road, irrespective of the locations the Contractor may choose for his crushing plant.

S-216.5. PAYMENT. The work performed as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit prices bid for "Flexible Base (Caliche)", "Flexible Base (Crushed Stone)", "Flexible Base (Cleaned Crushed Stone)", as the case may be, which price shall each be full compensation for shaping and fine grading the roadbed; all handling of material at the crusher; all crushing, screening, loading, hauling the first quarter mile; delivering on road, blading, scarifying, finishing, and dragging; all manipulations, labor, equipment, tools, and incidentals necessary to complete the work except as follows:

Hauling material into each quarter mile beyond the first quarter mile will be paid for at the contract unit price bid for "Additional Quarter Mile Haul".

> Note: All excavation required by this item in the removal of flexible base material will be measured and paid for in accordance with the provisions governing the Item of "Roadway Excavation" and "Channel Excavation" with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved.

Unless otherwise provided by plans, all excavation required by this item in the preparation of the subgrade and for completion of the shoulders and slopes, and for finishing the roadway will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage will be measured and paid for once, only, regardless of the manipulations involved.

Where shown on plans, excavation required on the cross sections designated on plans, in the preparation and shaping of the subgrade, for completion of the shoulders and slopes, and for finishing the roadway, will be performed, measured, and paid for in accordance with the provisions governing the Items of "Blading", "Road Grader Work", "Machine Grading", or "Scraper Work", respectively. Payment under the Item "Roadway Excavation" will not be allowed within the limits designated for the Items "Blading", "Road Grader Work", "Machine Grading" or "Scraper Work".

All sprinkling and rolling, performed as required, will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

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ITEM S-218

FOUNDATION COURSE

S-218.1. DESCRIPTION. This item shall consist of a foundation course for surface course or for additional foundation courses; and shall be composed of material or mixture of materials constructed in conformity with the typical sections shown on plans and to the lines and grades as established by the Engineer.

S-218.2. MATERIAL. The material shall be obtained from approved sources, and shall be approved by the Engineer at the source. Only such material removed from pits or quarries or designated sources within roadway limits or channels reserved for use under this item as directed and considered unacceptable by the Engineer shall be classified and paid for as "Stripping". The material shall be free of vegetation or other objectionable matter and when tested by standard laboratory methods, the material and/or mixtures of materials, shall meet the requirements specified by the plans and shall be unprocessed or processed as may be necessary to comply with the requirements set out in the plans.

S-218.3. MATERIAL SOURCES. The specified material shall be produced from sources shown on plans or designated by the Engineer. Where pits or quarries or roadway or channel sources are utilized, they shall be opened and operated in a manner to provide proper mixture of acceptable material and/or segregation of materials considered unacceptable by the Engineer.

Vegetation and stripping from pits or quarries shall be disposed of as directed by the Engineer and the site shall be left in a satisfactory and sightly condition.

When material is obtained from sources reserved from roadway cuts or channels, only that material actually used in the work under this item shall be measured and paid for as provided herein, and the remainder of the material in the source shall be measured and paid for as "Roadway Excavation" or "Channel Excavation" in accordance with the provisions of those items, and all provisions thereof, including completion to established alignment, grades, and cross sections shall apply.

S-218.4. CONSTRUCTION METHODS. Prior to the inauguration of this work the roadbed shall have been graded and/or shaped, compacted and finished to conform to the typical sections shown on the plans and to the lines and grades established by the Engineer. Unstable material or material not intended to remain in the roadbed for use in this work shall have been removed and all operations incident thereto shall have been performed and, if so specified, paid for under other items of work.

Preparation of Subgrade. The roadbed shall be shaped to conform to the subgrade section indicated on plans. It shall be firm and to the line and grade established by the Engineer and free of holes, ruts, and depressions.

Placing and manipulation of material. The material shall be delivered in approved vehicles, and it shall be the charge of the Contractor that the required amount of material for each operation is delivered and uniformly distributed in each one hundred (100) foot station. Material shall be uniformly and thoroughly mixed on the subgrade or preceding course by blading, harrowing, discing or other approved methods before compaction. Where plans indicate an admixture of materials to be performed on the subgrade, the heavier course shall be uniformly and thoroughly mixed and spread prior to delivery of other material which shall then be spread and the combined material uniformly and thoroughly mixed by operations above specified. Where plans indicate an admixture using material existing on the roadway, the existing material shall be scarified to the depth indicated on plans, pulverized by use of blades, scarifiers, harrows, discs or other implements, uniformly and thoroughly mixed, and placed in a layer prior to the delivery of the material to be added. The added material shall be uniformly distributed and the two materials shall then be uniformly and thoroughly mixed by operations above specified.

Prior to compaction the mixed material shall be windrowed. It shall then be bladed to position for compaction by sprinkling and rolling in thin, successive layers and approved suitable equipment shall be kept in operation to maintain the section and grade. Compaction shall be carried to the extent directed by the Engineer. Irregularities which may develop shall be corrected imme-

diately by scarifying the areas affected, adding and incorporating suitable material as required, recompacting and reshaping. The completed course shall be smooth and free of segregation, ruts or depressions.

The Contractor shall at all times provide proper and sufficient equipment and conduct his operations in a satisfactory and workmanlike manner. Failure to manipulate materials promptly and perform the various operations required in a continuous and coordinated manner will be grounds for suspension of any part of the work.

The utilization of traffic to compact and bind the course or courses is an essential part of the contract and of prime importance to the completion of the work. As directed by the Engineer, each course shall be opened to traffic, and the Contractor shall direct and distribute the construction and/or highway traffic uniformly over the entire width of the course. During the period traffic is being directed over the course, the surface shall be satisfactorily maintained with approved suitable equipment and the operation shall continue until the course is sufficiently compacted and bound to permit the application of the succeeding course.

Succeeding courses shall follow the design indicated by plans and construction shall in all manner conform to pertinent methods above outlined.

S-218.5. MEASUREMENT. Work and acceptable material as prescribed for this item shall be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each one-quarter mile beyond the first one-quarter mile shall be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

Where indicated on plans and a unit price is provided in the proposal, work and acceptable material may be measured by the ton of 2,000 pounds dry weight actually used in the work, in lieu of measurement by the cubic yard. The dry weight shall be determined by deducting the weight of moisture in the material at the time of weighing from the gross weight of the material. Scales suitable for the purpose of weighing the material shall be provided by the Contractor. Such scales shall be capable of and maintained within accuracy of one per cent (1%) by the Contractor.

S-218.6. PAYMENT. The work performed and material furnished as prescribed by this item, when measured by the cubic yard, as provided under "Measurement" will be paid for at the unit price bid for "Foundation Course", which price shall be full compensation for shaping and fine grading the roadbed; for scarifying and pulverizing existing base material when indicated on the plans; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, crushing, screening, sledging, hand picking or other suitable methods of reducing objectionable or oversize material; for hauling the first one-quarter mile and delivering on the road; for all mixing involved; for spreading, blading, shaping, dragging, and finishing; for maintaining; and for all manipulation, labor, tools, and incidentals necessary to complete the work except hauling beyond the first one-quarter mile, stripping, sprinkling and rolling.

Hauling materials into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

The work performed and material furnished as prescribed by this item, when measured by the ton, as provided under "Measurement" will be paid for at the unit price bid for "Foundation Course", which price shall be full compensation for shaping and fine grading the roadbed; for scarifying and pulverizing existing base material when indicated on the plans; for furnishing all materials; for all royalty and freight involved; for loosening or blasting, excavating, crushing, screening, sledging, hand picking or other suitable methods of reducing objectionable or oversize material; all hauling involved and delivery on the road; for all mixing involved; for spreading, blading, shaping, dragging, and finishing; for maintaining; and for all manipulation, labor, tools, and incidentals necessary to complete the work except stripping, sprinkling and rolling.

All sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively.

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

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ITEM S-221

SOIL ASPHALT BASE (ROAD MIX)

S-221.1. DESCRIPTION. This item shall consist of a foundation for surface course or for other base courses; shall be composed of a compacted mixture of mineral aggregate and asphaltic material and shall be constructed as herein specified and in conformity with the typical cross-sections shown on the plans and to the lines and grades established by the Engineer.

The mineral aggregate and asphaltic material shall not be mixed when the air temperature is below 60° F. and is falling, but they may be mixed when the air temperature is above 50° F. and is rising, the temperature being taken in the shade and away from artificial heat, and with the further provision that the asphaltic mixture shall be mixed or placed only when weather conditions, in the opinion of the Engineer, are suitable.

S-221.2. MATERIALS.

(1) Mineral Aggregate. Mineral aggregate shall consist of approved soil, free from vegetation or other objectionable matter and may be either the material encountered in the existing roadbed; the material secured from approved sources shown on the plans or designated by the Engineer; or of a combination of existing material and additional soil from approved sources, all as shown on plans.

Where plans require the use of mineral aggregate from approved sources, the pits utilized shall be cleaned of all grass, roots, vegetation, or other objectionable matter; and overburden and any other material considered unacceptable by the Engineer shall be removed from the pits and disposed of as directed. The pits shall be opened in such manner as to expose all the various strata of acceptable material, and, unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

It is the intention of this specification to utilize material existing on the roadbed where they are of such quality as to produce the results desired. Where satisfactory materials do not exist, material secured from approved sources shall be admixed with the existing soil or shall be furnished in sufficient quantity to construct the entire base course, all as shown on plans. The Engineer may vary the proportions of the different types of mineral aggregate to produce the most satisfactory material within the soil constant limits specified.

When the processed mineral aggregate is properly slaked and tested by standard laboratory methods, that portion of the material passing the 40-mesh sieve shall meet the requirements indicated on plans.

(2) Asphaltic Material. The asphaltic material shall be of the type and grade shown on plans, and shall conform to requirements for the grade specified, as described in the Item "Asphalts, Oils and Emulsions".

S-221.3. EQUIPMENT.

(1) General. Equipment necessary for the proper construction of the work shall be on the project, in first class working condition, and shall have been approved by the Engineer, both as to type and condition, before construction operations will be permitted to begin. The Contractor shall at all times provide sufficient equipment to enable continuous prosecution of the work and its completion in the required number of working days. If in the opinion of the Engineer additional pieces of equipment of the type specified below are required for the mixing, aerating, compaction and finishing of the asphaltic mixture or to achieve a rate of progress which will insure completion of the work in the required number of working days, the Contractor shall, upon written request of the Engineer, immediately secure and place in operation the required equipment.

(2) Equipment. The following equipment, as required by the Contractor's method of operation, shall be provided by the Contractor and operated by experienced and capable workmen.

(a) Distributor. Asphalt distributors shall be of the self-propelled pressure type, equipped with pneumatic tires of ample size so as not to produce ruts in the subgrade or completed base, and shall be so designed and operated as to distribute the asphaltic material evenly and smoothly in the quantities specified. Distributors shall be equipped with the necessary facilities for determining the temperature and measuring the rate of application of the asphaltic material.

(b) Maintainers. Maintainers shall be self-propelled; shall have dual or 4 wheel drive; shall be equipped with pneumatic tires; shall have a blade of not less than 12 feet in length, and a wheel base length of not less than 16 feet; and shall be tight and in good operating condition. The Contractor shall furnish sufficient Maintainers for continuous prosecution of work in a satisfactory manner and its completion in the required number of working days.

(c) Harrows. Harrows shall be of the offset disc-harrow type with 22 inch discs and not less than 10 feet in width.

(d) Pulverizer. Pulverizer-mixers shall be of an approved type and be not less than 6 feet in width.

(e) Water Sprinklers. Water sprinklers shall be equipped with positive and rapidly working cutoff valves, approved spray bars, and shall be designed, equipped, and operated so as to distribute the water uniformly in the quantity specified.

(f) Compaction Equipment. Suitable and sufficient compacting equipment shall be provided to complete compaction of the subgrade and the soil asphalt base in coordination with the other operations. Compaction equipment shall be of such types as are necessary to obtain the density and stability of soil asphalt base herein specified. Final compaction of subgrade and base shall be obtained by the use of pneumatic tired rollers meeting the requirements of the governing specifications and any special provisions for the Item "Rolling".

(g) Tractors. Tractors of suitable type and of sufficient tractive power shall be furnished as required to draw any of the above equipment at an operating speed of not less than 3 miles per hour.

(3) Mixing Plants. The use of a traveling plant for the mixing of soils and/or the mixing of the asphaltic material with the mineral aggregate will be permitted providing the Contractor makes a written request for the use of this type equipment and such request is approved in writing by the Engineer. The Contractor's request shall describe in full the equipment desired to be used, stating the make, type, size, and capacity of such equipment and citing its successful use on similar work. Such an approval of change in type of equipment shall in no way modify the results required by this specification.

(4) Field Laboratory. The Contractor shall provide at his entire expense a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and inspecting force. It shall be not less than 8 by 20 feet and 8 feet high, floored and roofed weather-tight, containing not less than 2 windows and 2 doors and a work bench 3 feet wide by 8 feet long. In addition the building shall contain a substantial work bench 3 feet by 4 feet with supports extending through the floor and firmly fixed in the ground, clear of the building floor, and a small platform not less than 12 inches square substantially mounted on a post of not less than 6 inch by 6 inch lumber extending through the floor and firmly fixed in the ground.

S-221.4. HEATING ASPHALTIC MATERIALS. Equipment used for the storage, heating, or handling of asphalt shall be kept clean and in good operating condition at all times. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all heating operations. Cut-back asphalt shall not be heated to a temperature in excess of 190°F. and road oil or cracked fuel oil shall not be heated to a temperature in excess of 250°F.

The temperature of the asphaltic material at the time of application will be selected by the Engineer, and the Contractor shall apply the asphalt at a temperature within 15°F. of the temperature

selected. If cut-back asphalt is specified, it shall be applied at a temperature of not more than 175°F. If road oil or cracked fuel oil is specified, it shall be applied at a temperature of not more than 225°F.

S-221.5. CONSTRUCTION METHODS. The roadbed shall be excavated and shaped as shown on the plans, and as required herein and in other pertinent specification items.

Where required by the plans or directed by the Engineer, additional mineral aggregate shall be delivered on the road in the quantity ordered by the Engineer to provide a mineral aggregate of the characteristics desired for the construction of the base. Such mineral aggregate shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station. The material shall be spread uniformly over the width of the roadbed.

The roadbed, composed either of material entirely from designated sources, a mixture of material from designated sources and the existing roadbed soil, or entirely of the existing roadbed soil, shall be loosened for the entire width and to a depth sufficient to produce a compacted base of the depth required by the plans. The material so loosened shall be thoroughly mixed to provide a uniform material and shall be pulverized to the extent that 80 per cent of the soil, by dry weight exclusive of gravel or stone, shall pass a 1/4" screen. If the Contractor desires, sprinkling the mineral aggregate to assist in pulverizing will be permissible.

After completion of the mixing and pulverizing of the mineral aggregate, sufficient material shall be removed to provide for the construction of the required section of base, and the subgrade shall be shaped to conform to the typical sections shown on plans and to the line and grade established by the Engineer. The subgrade shall be sprinkled and compacted to the extent necessary to provide a uniform, firmly compacted and stable surface at the time of the beginning of construction of the soil asphalt base. The stability of the subgrade shall be such as to support construction equipment without rutting.

Where shown on plans or directed by the Engineer, asphaltic material shall be applied on the prepared subgrade before beginning mixing operations. The soil asphalt base shall consist of a uniform mixture of mineral aggregate, asphaltic material, and water and shall be constructed on the approved subgrade by blading the mineral aggregate on to the subgrade, sprinkling as required, and applying the asphaltic material in approximately uniform applications at the rate directed by the Engineer, and in no case at a rate of more than 1 gallon per square yard in each application. The traveling plant method of mixing the mineral aggregate, water and asphaltic material may be employed upon approval of the Engineer as stated above. The amount of asphaltic material in the mixture shall be such as to provide a weight of residual asphalt from 3 1/2 to 7% of the dry weight of the mineral aggregate. The exact percentage of residual asphalt to be obtained in the mixture, within the limits specified, and the amount of asphaltic material shall be as directed by the Engineer.

Each course of soil asphalt base may be mixed as a whole, or the course may be constructed by mixing part width, or by mixing and compacting separate layers, in which case the upper layer of the course of soil asphalt base shall be not less than approximately 3 inches in depth. The mineral aggregate at the time of mixing with the asphaltic material shall contain sufficient and uniformly distributed moisture to allow proper dispersion of the asphalt. The moisture shall in no case be sufficiently great to prevent proper dispersion of the asphaltic material, and if necessary the mineral aggregate shall be dried before the asphaltic material is applied.

The mineral aggregate may be sprinkled with water to assist in the proper dispersion of asphaltic material if the Contractor so desires.

Immediately after each application of the asphaltic material, the mineral aggregate, water and asphaltic material shall be mixed by the use of the disc-harrow specified. Immediately following the application of all asphaltic material required for the soil asphalt base or that layer of the base, the entire amount of material shall be further mixed by the use of the disc-harrow and the pulverizer specified until thorough dispersion of the asphaltic material has been obtained and a homogeneous mixture results. Care shall be exercised to prevent incorporation of any material

from the subgrade or shoulders in the soil asphalt mixture. The operations of mixing, aerating the mixture to reduce the amount of volatiles in the asphaltic material, spreading or placing in windrows, shall be continuous, with such deviations from this procedure as are authorized by the Engineer.

On the completion of mixing of the entire quantity of material required to produce the completed base or the layers of base as specified above, the mixed material shall be spread to the required section, shaped, compacted and finished in conformity with the typical sections shown on the plans and the line and grade established by the Engineer. The shaping and compacting operations shall be continued until the course is uniformly compacted to the extent that it will support loaded trucks and other construction equipment without appreciable displacement. Compaction shall be accomplished by blading and rolling the material at the proper moisture content to the end that a uniform mass without laminations or cleavage planes in the completed layer is obtained having an apparent dry density of the minus 1/4" material of not less than 95 per cent of the maximum dry density of such material. The apparent dry density of the minus 1/4" material in the compacted base shall be calculated as the dry weight of the portion passing the 1/4" screen (including the asphalt residue) divided by the volume occupied by this minus 1/4" material. The maximum dry density of the minus 1/4" material in the asphaltic mixture shall be determined by the Proctor Compaction Test using 50 blows per layer at 110°F., and based on the weight of dry aggregate plus asphalt residue. The apparent dry density of the minus 1/4" material in the compacted base shall be determined not later than the day following the completion of compacting operations.

Shaping and compaction of the soil asphalt base or of a layer of the soil asphalt base shall be continuous and the compaction and finishing of the base shall be completed within the daylight hours of that day on which such work is begun unless unforeseen conditions prevent such completion. Along curbs and at other places not accessible to the rollers, or in such positions that will not allow thorough compaction with the usual equipment, the mixture shall be compacted to the required density by use of lightly oiled hand tamps. Construction joints, formed at the end of each days work or due to unavoidable interruptions of operations, shall be placed in such manner that a satisfactory riding surface shall be secured.

The completed course of soil asphalt base shall be allowed to dry as thoroughly as possible and to the satisfaction of the Engineer. During the drying period, traffic shall be allowed to use the completed course. The course shall be sprinkled, bladed and rolled as directed and maintained true to the required sections and to the established lines and grades until a subsequent base or surface course is placed. In no case shall the drying period for each course be less than 10 days. Any portion of the base course which, after compaction, fails to meet the requirements for apparent dry density and stability, as specified above, shall be scarified and recompacted at the Contractor's entire expense.

The Contractor shall be required to maintain at his own expense the entire roadway within the limits of his contract in good condition satisfactory to the Engineer from the time he first starts work until all work shall have been completed. Maintenance shall include immediate repairs of any defects that may occur before or after the soil asphalt base has been compacted and finished, which work shall be done by the Contractor at his own expense and repeated as often as may be necessary to keep the roadway continuously intact. Repairs are to be made in a manner to insure restoration of a uniform surface and durability of the part repaired. Any low areas will be remedied by replacing the material for the full depth of treatment rather than adding a thin layer of soil asphalt base to the completed work. Shoulders and slopes damaged by the Contractor during base construction shall be restored, bladed, and shaped to the typical section shown on plans.

S-221.6. MEASUREMENT. Additional mineral aggregate as required shall be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile shall be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

Soil asphalt base shall be measured by the square yard of surface area of completed and accepted work based on the width of the soil asphalt base as shown on the plans, or as established by the Engineer at intersections or for other special conditions.

Asphaltic material of the type and grade shown on the plans shall be measured in gallons at the applied temperature at the point of application on the roadbed.

S-221.7. PAYMENT. Work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Soil Asphalt Base" and "Additional Mineral Aggregate" which prices shall each be full compensation for cleaning the roadbed for the surface of the prevsiouly completed base course; for furnishing all materials; for all royalty and freight involved; for loosening, excavating, loading, hauling the first one quarter mile and delivering additional mineral aggregate on the road; for loosening, mixing and pulverizing of the mineral aggregates; for shaping, sprinkling, and compacting the subgrade; for all processing, mixing, drying, incorporation of asphaltic material, aerating and drying, spreading, sprinkling, shaping, compacting and finishing; for maintaining under traffic; and for all manipulations, labor, equipment, fuels, tools, and incidentals necessary to complete the work except as hereinafter provided.

All stripping performed as required will be measured and paid for in accordance with provisions governing the Item of "Stripping".

Hauling mineral aggregate into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

Asphaltic material measured as provided under "Measurement" will be paid for at the unit price bid for "Asphaltic Material" which price shall be full compensation for furnishing the material, for all freight involved, for all unloading, storing, heating, hauling, and applying on the road, and for all labor, equipment, fuels, tools, and incidentals necessary to complete the work.

All earthwork involved in preparation of subgrade, other than that incidental to the specified fine grading, and manipulation necessary to reshape and compact the existing section and to compact the material added, will be measured and paid for in accordance with the provisions governing the pertinent roadway items. No direct payment will be made for blading, wetting or rolling, this being considered as subsidiary work pertaining to the construction of the stabilized base.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-222

SOIL CEMENT BASE (PORTLAND CEMENT)

S-222.1. DESCRIPTION. This item shall consist of a foundation for surface course or for other base courses; shall be composed of a compacted mixture of mineral aggregate, Portland Cement and water and shall be constructed as herein specified and in conformity with the typical cross-sections shown on the plans and to the lines and grades established by the Engineer.

Soil Cement Base shall not be mixed or placed when the air temperature is below 40°F. and is falling, but may be mixed or placed when the air temperature is above 35°F. and is rising, the temperature begin taken in the shade and away from artificial heat, and with the further provision that soil cement base shall be mixed or placed only when weather conditions, in the opinion of the Engineer, are suitable.

S-222.2. MATERIALS.

(1) Mineral Aggregate. Mineral aggregate shall consist of approved soil free from vegetation or other objectionable matter and may be either the material encountered in the existing roadbed, material secured from approved sources shown on the plans or designated by the Engineer, or a combination of existing soils and additional soil from approved sources, all as shown on the plans.

Where plans require the use of mineral aggregate from approved sources, the pits utilized shall be cleaned of all grass, roots, vegetation, or other objectionable matter. Overburden and any other material considered unacceptable by the Engineer shall be removed from the pits and disposed of as directed. The pits shall be opened in such manner as to expose all the various strata of acceptable material, and, unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniformly mixed material will be secured.

It is the intention of this specification to utilize material existing on the roadbed where they are of such quality as to produce the results desired. Where satisfactory materials do not exist, material secured from approved sources shall be admixed with the existing soil or shall be furnished in sufficient quantity to construct the entire base course, all as shown on plans. The Engineer may vary the proportions of the different types of mineral aggregates to produce the most satisfactory material within the soil constant limits specified.

When the processed mineral aggregate is properly slaked and tested by standard laboratory methods, that portion of the material passing the 40-mesh sieve shall meet the requirements indicated on plans.

(2) Cement. The cement shall be of a standard brand of Portland Cement which shall conform to the requirements and tests of the latest "Standard Specification and Tests for Portland Cement", Serial Designation: C150, Type 1, of the American Society for Testing Materials.

One sack, containing 1 cubic foot of cement, shall be considered as weighing 94 pounds net. One barrel of cement shall be considered as weighing 376 pounds, net, and containing 4 cubic feet.

Contractors, at their option, may use bulk cement, provided the apparatus for handling, weighing and spreading the cement is approved by the Engineer in writing.

(3) Water. The water used in the construction of this soil cement base course shall be reasonably free from salt, oil, acid, alkali, organic matter or other deleterious substance and shall be subject to the approval of the Engineer. If, in the opinion of the Engineer the water is of questionable quality, it shall be tested in accordance with A.A.S.H.O. Method T-26.

S-222.3. EQUIPMENT.

(1) General. Equipment necessary for the proper construction of the work shall be on the project, in first class working condition, and shall have been approved by the Engineer, both as to type and condition, before construction operations will be permitted to begin. The Contractor shall at all times provide sufficient equipment to enable continuous prosecution of the work and its completion in the required number of working days.

The equipment provided by the Contractor shall be operated by experienced and capable workmen and shall be that necessary to provide a soil cement base meeting the requirements herein specified.

(2) Field Laboratory. The Contractor shall provide at his entire expense a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the exclusive use of the Engineer and inspecting force. It shall be not less than 8 feet by 20 feet and 8 feet high, floored and roofed weather-tight, containing not less than 2 windows and 2 doors and a work bench 3 feet wide by 8 feet long. In addition the building shall contain a substantial work bench 3 feet by 4 feet with supports extending through the floor and firmly fixed in the ground, clear of the building floor, and a small platform not less than 12 inches square substantially mounted on a post of not less than 6 inch by 6 inch lumber extending through the floor and firmly fixed in the ground.

S-222.4. CONSTRUCTION METHODS.

(1) General. The roadbed shall be excavated and shaped as shown on the plans, and as required herein and in other pertinent specification items.

Where required by the plans or directed by the Engineer, additional mineral aggregate shall be delivered on the road in the quantity ordered by the Engineer to provide a mineral aggregate of the characteristics desired for the construction of the base. Such mineral aggregate shall be delivered in approved vehicles of a uniform capacity, and it shall be the charge of the Contractor that the required amount of material shall be delivered in each 100 foot station.

(2) Preparation of Roadbed.

(a) Preparation of Existing Roadway Soils. When all of the mineral aggregate consists of existing roadway materials, all acceptable existing materials shall be bladed and uniformly spread on the roadbed. Any surplus or unacceptable material shall be disposed of on the adjacent roadway section as directed by the Engineer.

The roadbed and acceptable materials spread thereon shall then be graded and shaped to conform to the lines and grades established by the Engineer and the typical sections as shown on the plans, in accordance with governing specifications pertaining to construction involved.

The roadbed shall be loosened for the entire width of base and to a depth sufficient to produce a compacted base of the depth required by the plans. The material so loosened shall be thoroughly mixed to provide a uniform material and shall be pulverized to the extent that 80 per cent of the soil by dry weight exclusive of gravel or stone shall pass a 1/4 inch screen. If the Contractor desires, the mineral aggregate may be sprinkled to assist in pulverizing it.

The material so loosened and mixed shall be bladed into windrows on the subgrade or on the shoulders as may be directed by the Engineer. The subgrade thus formed shall then be accurately cut to established grade and section and sprinkled and rolled to the extent necessary to provide a uniform, firmly compacted and stable surface immediately prior to construction of the soil cement base.

(b) Preparation of Existing Roadway Soils Supplemented by Mineral Aggregate From Approved Sources. When the mineral aggregate is to consist of both existing roadbed materials and materials from approved sources, the material from designated sources shall be hauled in and delivered on the road in the quantity ordered by the Engineer. The material thus delivered shall be spread uniformly over the width of the roadbed, or incorporated with the existing roadway

material and spread accordingly, as required.

The procedure outlined under (2) (a), "Preparation of Roadbed", paragraphs 2, 3, and 4, shall then be followed.

(c) Preparation of Roadway, Using Only Mineral Aggregate from Approved Sources. When all the mineral aggregate is to be entirely from approved sources, the subgrade shall be excavated, shaped, compacted and prepared to conform to the typical sections as shown on the plans, and to the lines and grades established by the Engineer, in accordance with governing specifications pertaining to the construction involved.

No mineral aggregate shall be placed on the prepared subgrade without prior approval by the Engineer of both the mineral aggregate and the prepared subgrade.

After approval of the previously prepared subgrade, the mineral aggregate shall be delivered on the road in the quantity ordered by the Engineer and placed in windrows, then spread uniformly to provide a base of compacted depth required by plans. The mineral aggregate shall be thoroughly mixed to provide a uniform material and pulverized to the extent that 80 per cent of the soil by dry weight exclusive of gravel or stone shall pass a 1/4 inch screen.

(3) Preparation and Stabilization of Soil Cement Base.

(a) General. The soil cement base shall consist of a uniform mixture of mineral aggregate, Portland Cement, and water and shall be constructed on the approved subgrade by spreading the mineral aggregate uniformly onto the subgrade and applying the Portland Cement within the limits prescribed by the plans or as ordered by the Engineer.

(b) Limitations. Cement shall be applied only to such an area that all the operations can be continuous and completed during the same working day.

No cement shall be applied when the percentage of moisture in the subgrade, immediately beneath the soil material to be processed, exceeds the optimum moisture content specified by the Engineer for the particular type of subgrade soil by more than 2.

When any of the operations after mixing is interrupted continuously for more than 30 minutes for any reason, or when the uncompacted soil-cement is wetted by rain so that the average moisture content exceeds the specified optimum by more than 2, the entire section shall be reconstructed in accordance with this specification at the Contractor's own expense.

(c) Mixing and Processing. When the mineral aggregate has been spread onto the subgrade and the Portland Cement applied thereon at the rate directed by the Engineer, the mineral aggregate and cement shall be thoroughly mixed.

The required amount of water necessary to provide the optimum moisture shall be added uniformly, and thoroughly mixed with the soil and cement. The completed soil-cement mixture shall be spread evenly over the processed width of the subgrade and placed in a loose condition ready for immediate compaction by the rollers. Irrespective of the methods selected in mixing the materials, the completed soil-cement mixture shall be homogeneous and uniform in appearance. When application of water and mixing is completed, the percentage of moisture in the mixture, on a basis of dry weight, shall not be below the specified optimum moisture content of the soil-cement mixture or exceed the specified optimum by more than 2. This specified optimum moisture shall be that prevailing in moist soil-cement at the time of compaction and shall be determined in the field by a moisture-density test, THD-84, on representative samples of soil-cement mixture obtained from the roadway at the conclusion of moist mixing.

The completed soil-cement mixture shall be compacted immediately behind the mixing operations. Compaction shall begin at the bottom and shall continue until the entire depth of soil-cement mixture is uniformly compacted to the density specified by the Engineer. This specified density shall be that prevailing in the moist soil-cement at the time of compaction and shall be determined in the field by a moisture-density test, THD-84, on representative samples of soil-cement mixture obtained from the roadway at the conclusion of moist mixing. The density of the soil-cement roadway will be determined by the Engineer after each day's construction. Any portion which has a density 5 pounds or more below that specified by the Engineer shall be removed and replaced to meet this specification at the entire expense of the Contractor. Rollers of the type, size, shape,

and weight best suited to give the required densities in the soil-cement mixture being compacted shall be used. A granular soil containing little or no minus No. 200 sieve material which does not compact to required densities with sheepsfoot rollers may be compacted with pneumatic tire rollers or other equipment approved by the Engineer. Compaction shall begin within 30 minutes after the last increment of water has been added and uniformly incorporated. The rate of rolling operations shall be sufficient to compact uniformly, for the full depth and processed width, all mixed and processed material within 2 hours. The moisture content in the top mulch left behind the rollers shall be maintained at optimum moisture at all times until and including the final rolling.

During the operations of laying, compacting, and shaping base, "tamping" rollers or similar equipment, shall not turn or operate on adjacent completed, compacted or shaped base.

After the mixture is compacted, the surface shall be moistened,if necessary, and shaped to the required lines, grades, and cross section, and if necessary shall be lightly scarified with either a spike toothed harrow, nail drag, or finger weeders to loosen any imprints left by the compacting or shaping equipment. The surface shall then be thoroughly rolled with approved pneumatic-tire rollers to the extent necessary to provide a dense, uniform surface free of surface compaction planes.

At all places inaccessible to rollers and/or finishing and shaping equipment (such as immediately adjacent to completed base, approach slabs to bridges, etc.) the mixture shall be thoroughly compacted by hand tamping and shaped and finished by hand methods.

For construction joints formed at the end of each day's work, or due to an unavoidable interruption of operations a transverse header shall be placed in such manner that the end of the base can be satisfactorily compacted and shaped. On resuming operations, the header shall be removed and if the exposed edge of the base is not approximately vertical, or is not satisfactory for a riding surface at the joint, the edge of the base shall be cut back to leave a vertical face or as is necessary to secure a satisfactory riding surface.

S-222.5. CURING: PROTECTION AND COVER.

(a) After the soil cement base course has been finished as specified herein, the surface shall be protected against rapid drying by either of the following curing methods until the asphalt surface treatment is placed:

Maintain in a thorough and continuously moist condition by sprinkling.

Apply a two-inch layer of earth on completed base and maintain in a moist condition.

Apply an asphalt membrane to the base course, immediately after same is completed. The quantity and type of asphalt approved for use by the Engineer shall be sufficient to completely cover and seal the total surface of the base and fill all voids. If the Contractor elects to use this method, it shall be his responsibility to protect the asphalt membrane from being picked up by traffic by either sanding or dusting the surface of same. The asphalt membrane may remain in place when the proposed asphalt surface treatment is placed.

(b) The asphalt surface treatment may be applied on the finished base as soon after completion as operations will permit.

S-222.6. TRAFFIC.

The Contractor will not be permitted to drive heavy equipment over completed portions, except pneumatic-tired equipment required for constructing adjoining sections. Turning areas on completed portions of the base shall be protected by a layer of stable earth of not less than 2 inches of compacted depth.

The completed sections of the road shall not be opened to traffic until the soil cement base has cured for a minimum of seven days and the base has been covered by either the asphalt membrane, a layer of moist earth, or the proposed asphalt surface treatment.

S-222.7. MAINTENANCE.

The Contractor shall be required to maintain at his own expense the entire roadway within the limits of his contract in good condition satisfactory to the Engineer from the time he first starts work until all work shall have been completed. Maintenance shall include immediate repairs of any defects that may occur before or after the cement is applied, which work shall be done by the Contractor at his own expense and repeated as often as may be necessary to keep the roadway continuously intact. Repairs are to be made in a manner to insure restoration of a uniform surface and durability of the part repaired. Any low areas will be remedied by replacing the material for the full depth of treatment rather than adding a thin layer of soil-cement in the completed work. Shoulders and slopes damaged by the Contractor during base construction shall be restored, bladed and shaped to the typical section shown on plans.

S-222.8. MEASUREMENT. Additional mineral aggregate as required will be measured by the cubic yard of material in vehicles as delivered on the road. Measurement for hauling material into each quarter mile beyond the first quarter mile shall be based on the shortest practical haul route between the center of mass of the designated material source or sources and the point of delivery on the road.

Soil cement base will be measured by the square yard of surface area of completed and accepted work based on the width of the soil cement base as shown on the plans, or as established by the Engineer.

Cement specified by the Engineer for incorporation in the base course shall be measured by the barrel of 376 pounds of cement.

S-222.9. PAYMENT. Work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" shall be paid for at the unit prices bid for "Soil Cement Base","Mineral Aggregate", and Portland Cement" which prices shall be full compensation for cleaning the roadbed or the surface of the previously completed base course; for furnishing all materials; for all royalty and freight involved; for loosening, excavating, loading, hauling the first one quarter mile and delivering additional mineral aggregate on the road; for loosening, mixing and pulverizing of the mineral aggregates; for shaping, sprinkling, and compacting the subgrade; for all processing, mixing, drying, incorporation of Portland Cement and water, spreading, sprinkling, shaping, compacting, finishing and curing the soil cement base; for all maintaining the completed base; and foraall manipulations, labor, equipment, fuels, tools, and incidentals necessary to complete the work except as hereinafter provided.

Hauling mineral aggregate into each quarter mile beyond the first quarter mile will be paid for at the unit price bid for "Additional Quarter Mile Haul".

All stripping performed as required will be measured and paid for in accordance with the provisions governing the Item of "Stripping".

Texas Highway Department
Construction Specification
March, 1950

ITEM S-300

PRIME COAT
(Asphaltic Material Only)

S-300.1. DESCRIPTION. This item shall consist of an application of asphaltic material on the completed base course in accordance with these specifications.

Prime Coat shall not be applied when the air temperature is below 50°F. and falling, and it may be applied when the air temperature is above 40°F. and is rising, the temperature being taken in the shade and away from artificial heat. Asphaltic Material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

S-300.2. MATERIALS. The asphaltic material used for the prime coat shall be of the type and grade shown on plans and when tested by approved laboratory methods shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

S-300.3. CONSTRUCTION METHODS. When, in the opinion of the Engineer, the base is thoroughly dry and is satisfactory to receive the prime coat, the surface shall be cleaned by sweeping or other approved methods. The asphaltic material shall be applied to the cleaned base at the approximate rate indicated on plans between the limits of 0.2 to 0.35 gallons per square yard of surface area. The application shall be made with an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads.

All storage tanks, piping, retorts, booster tanks, and distributors used in storing or handling asphaltic material shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material applied appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material shall be applied at a temperature between the minimums and maximums recommended in the Item "Asphalts, Oils and Emulsions".

The Engineer shall select the temperature of application and the Contractor shall apply the asphaltic material at a temperature within 15°F. of the temperature selected.

WARNING TO CONTRACTORS. Attention is called to the fact that asphaltic materials are very inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic material or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

The Contractor shall be responsible for the maintenance of the surface until the work is accepted by the Engineer.

No traffic, hauling, or placement of any subsequent courses shall be permitted over the freshly applied prime coat until authorized by the Engineer.

S-300.4. MEASUREMENT. The Asphaltic Material for prime coat will be measured in gallons at applied temperature at point of delivery on the road.

S-300.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Asphaltic Material", of the type and grade specified, which price shall be full compensation for cleaning the base; for furnishing, freight involved, heating, hauling, and distributing the asphaltic material as specified; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-300A

PRIME COAT
(Asphaltic Material and Sand)

S-300A.1. DESCRIPTION. This item shall consist of an application of asphaltic material on the completed base covered with sweepings from the base and native sand, and constructed in accordance with these specifications.

Prime Coat shall not be applied when the air temperature is below 50°F. and falling, and it may be applied when the air temperature is above 40°F. and is rising, the temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

S-300A.2. MATERIALS. The asphaltic material used for the prime coat shall be of the type and grade shown on plans and when tested by approved laboratory methods shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

Base course sweepings shall be those sweepings obtained from cleaning the base.

Native sand shall be local material obtained from approved sources and subject to the approval of the Engineer.

S-300A.3. CONSTRUCTION METHODS. Native sand, as specified above, shall be hauled in vehicles of uniform capacity and dumped on shoulders at spacings given by the Engineer. When, in the opinion of the Engineer, the base is thoroughly dry and is satisfactory to receive the prime coat, the surface shall be cleaned by sweeping or other approved methods. Asphaltic material shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

The surface shall then be covered with base sweepings and native sand as directed by the Engineer. The surface shall then be dragged with an approved type of drag broom so as to evenly and smoothly distribute the cover material. This brooming or dragging shall continue until, in the opinion of the Engineer, the course has properly cured under traffic.

No traffic, hauling, or placing of subsequent courses shall be permitted over the freshly applied prime coat until authorized by the Engineer.

All storage tanks, piping, retorts, booster tanks, and distributors used in storing or handling asphalt shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

Asphaltic materials shall be applied at a temperature between the minimums and maximums, recommended in the Item "Asphalts, Oils and Emulsions".

The Engineer shall select the temperature of application and the Contractor shall apply the asphaltic material at a temperature within 15°F. of the temperature selected.

WARNING TO CONTRACTORS: Attention is called to the fact that asphaltic materials are very inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic materials or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

S-300A.4. MEASUREMENT. The Asphaltic Material for prime coat will be measured in gallons at the applied temperature at the point of application on the road.

Native Sand will be measured by the cubic yard in vehicles as applied on the road.

S-300A.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphaltic Material", of the type and grade specified, and for "Native Sand", which prices shall each be full compensation for cleaning the base; for furnishing, freight involved, preparing, hauling, and placing all materials (including application of base sweepings); spreading, dragging, brooming, finishing, and maintaining under traffic until accepted; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-303

SEAL COAT

S-303.1. DESCRIPTION. This item shall consist of a surface treatment composed of a single application of asphalt covered with aggregate for the sealing of existing pavements in accordance with these specifications.

Seal Coats shall not be applied when the air temperature is below 50°F. and is falling, and may be applied when the air temperature is above 40°F. and is rising, the temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

S-303.2. MATERIALS.

(1) Asphaltic Material. The asphaltic material used shall be of the type and grade shown on the plans and when tested by approved laboratory methods shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

(2) Aggregate. The aggregate used shall be of the type and grade shown on the plans and shall meet the requirements of the Item "Aggregate for Surface Treatment".

(3) Aggregate (Stockpiled). When plans include the Item "Aggregate (Stockpiled)" aggregate of the type and grade specified for the surface treatment shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled if required and prepared as specified in Article 3.

S-303.3. CONSTRUCTION METHODS. The area to be treated shall be cleaned of dirt, dust, or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer, the surface shall be lightly sprinkled just prior to the application of asphaltic material. Asphaltic material shall be applied on the cleaned surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material shall be applied for the full width of the seal coat in one application unless the width exceeds twenty-four (24) feet. Asphaltic material shall not be applied until immediate covering with aggregate is assured.

Aggregate shall be immediately and uniformly applied and spread by mechanical spreading devices of approved design at the approximate rates indicated on the plans and as directed by the Engineer. After the work has been completed as specified above, there should be a slight excess of aggregate on the surface.

The entire surface shall be broomed, bladed, or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment shall meet the governing specifications for the Item of "Rolling".

The Contractor shall be responsible for the maintenance of the surface and the distribution of the excess aggregate until the work is accepted by the Engineer. All holes or failures in the seal

coat surface shall be repaired by use of additional asphalt and aggregate and all fat or bleeding surfaces shall be covered with approved cover material in such manner that the asphaltic material will not adhere to or be picked up on the wheels of vehicles.

Temporary stockpiling of aggregates on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of the temporary stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks, and distributors used in storing or handling asphaltic material shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphalt with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

Asphaltic materials shall be applied at a temperature between the minimums and maximums recommended in the Item "Asphalts, Oils and Emulsions".

The Engineer shall select the temperature of application for the type of asphaltic material to be used and the Contractor shall apply the asphalt at a temperature within 15°F. of the temperature selected. All oil asphalt which has been heated above 400°F. will be rejected.

WARNING TO CONTRACTORS: Attention is called to the fact that asphaltic materials are very inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic material or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

S-303.4. MEASUREMENT. Asphaltic material will be measured in gallons at the applied temperature at the point of application on the road.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

S-303.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate" and "Aggregate (Stockpiled)", if required, of the type and grade specified, which prices shall each be full compensation for cleaning and sprinkling the base; for furnishing, freight involved, preparing, hauling, and placing all materials; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work, except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Rolling".

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ITEM S-304

ONE COURSE SURFACE TREATMENT

S-304.1. DESCRIPTION. This item shall consist of a wearing surface composed of a single application of asphaltic material covered with aggregate, constructed on the prepared base course or surface in accordance with these specifications.

One Course Surface Treatment shall not be applied when the air temperature is below 50°F. and is falling, and it may be applied when the air temperature is above 40°F. and is rising, the temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

S-304.2. MATERIALS.

(1) Asphaltic Materials. The asphaltic materials used shall be of the type and grade shown on the plans, and, when tested by approved laboratory methods, shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

(2) Aggregate. The aggregate used shall be of the type and grade shown on the plans and shall meet the requirements of the Item "Aggregate for Surface Treatments".

(3) Aggregate (Stockpiled). When plans include the Item "Aggregate (Stockpiled)", aggregate of the type and grade specified for the surface treatment shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled if required and prepared as specified in Article 3.

S-304.3. CONSTRUCTION METHODS. The area to be treated shall be cleaned of dirt, dust, or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer the surface shall be lightly sprinkled just prior to the application of the asphaltic material.

Asphaltic material shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material shall be applied for the full width of the surface treatment in one application, unless the width exceeds twenty-four (24) feet. No traffic or hauling will be permitted over the freshly applied asphaltic material. Asphaltic material shall not be applied until immediate covering is assured.

Aggregate shall be immediately and uniformly applied and spread by mechanical spreading devices of approved design, at the approximate rates indicated on the plans and as directed by the Engineer. After the work has been completed as specified above, there should be a slight excess of aggregate on the surface.

The Contractor shall be responsible for the maintenance of the surface and the distribution of the excess aggregate until the work is accepted by the Engineer.

The entire surface shall be broomed, bladed, or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment shall meet the governing specifications for the Item of "Rolling".

Temporary stockpiling of the aggregates on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks, and distributors used in storing or handling asphaltic materials shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic materials with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

Asphaltic materials shall be applied at a temperature between the minimums and maximums recommended in the Item "Asphalts, Oils and Emulsions".

The Engineer shall select the temperature of application for the type of asphaltic material to be used and the Contractor shall apply the asphaltic material at a temperature within 15°F. of the temperature selected.

WARNING TO CONTRACTORS. Attention is called to the fact that asphaltic materials are very inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic material or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

S-304.4. MEASUREMENT. Asphaltic material will be measured in gallons at the applied temperature at the point of application on the road.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

S-304.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate" and "Aggregate (Stockpiled)", if required, of the type and grade specified, which prices shall each be full compensation for cleaning and sprinkling the base; for furnishing, freight involved, preparing, hauling, and placing all materials; and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work, except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Rolling".

Texas Highway Department
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March, 1950

ITEM S-305

TWO COURSE SURFACE TREATMENT

S-305.1. DESCRIPTION. This item shall consist of a wearing surface composed of two applications of asphaltic material, each covered with aggregate, constructed on the prepared base course or surface in accordance with these specifications.

Two Course Surface Treatment shall not be applied when the air temperature is below 50°F. and is falling, but it may be applied when the air temperature is above 40°F. and is rising. Air temperature shall be taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

S-305.2. MATERIALS.

(1) Asphaltic Material. The asphaltic material used shall be of the type and grade shown on the plans, and when tested by approved laboratory methods, shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

(2) Aggregate. The aggregates used shall be of the type and grade shown on the plans for each course and shall meet the requirements of the Item "Aggregate for Surface Treatments".

(3) Aggregate (Stockpiled). When plans include the Item "Aggregate (Stockpiled)", aggregate of the grade and type specified for the second course of the surface treatment shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled, if required, and prepared as specified in Article 3.

S-305.3. CONSTRUCTION METHODS. The area to be treated shall be cleaned of dirt, dust, or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer, the surface shall be lightly sprinkled just prior to the first application of asphaltic material.

Asphaltic material of the type and grade shown on the plans for the first course shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material for each course shall be applied for the full width of the surface treatment in one application, unless the width exceeds twenty-four (24) feet. No traffic or hauling will be permitted over the freshly applied asphaltic material. Asphaltic material shall not be applied until immediate covering is assured.

Aggregate, of the type and grade shown on the plans for the first course, shall be immediately and uniformly applied and spread by mechanical spreading devices, of approved design, at the approximate rates indicated on the plans and as directed by the Engineer. After the first course has been completed as specified above, there should be a slight excess of aggregate on the surface. The Contractor shall be responsible for the maintenance of the surface of the first course and the distribution of the excess aggregate until the second course is applied.

The entire surface shall then be broomed, bladed, or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment

used shall meet the governing specifications for the Item of "Rolling".

The second course shall consist of asphaltic material and aggregate of the type and grade indicated on the plans for the second course. The asphaltic material and aggregate for this second course shall be applied and covered in the manner specified for the first application. The surface shall then be broomed, bladed, or raked as required by the Engineer and thoroughly rolled as specified for the first course. Asphaltic materials and aggregates for both courses shall be applied at the approximate rates indicated on the plans and as directed by the Engineer.

The Contractor shall be responsible for the maintenance of the surface and the distribution of the excess aggregate until the work is accepted by the Engineer.

Temporary stockpiling of aggregates on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks, and distributors used in storing or handling asphaltic material shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

Asphaltic material shall be applied at a temperature between the minimums and maximums recommended in the Item "Asphalts, Oils and Emulsions".

The Engineer shall select the temperature of application for the type of asphaltic material to be used and the Contractor shall apply the asphaltic material at a temperature within 15°F. of the temperature selected.

WARNING TO CONTRACTORS. Attention is called to the fact that asphaltic materials are very inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic materials or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

S-305.4. MEASUREMENT. Asphaltic material will be measured in gallons at the applied temperature at the point of application on the road.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

S-305.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate" and "Aggregate (Stockpiled)", if required, of the type and grade specified, which prices shall each be full compensation for cleaning and sprinkling the base; for furnishing, freight involved, preparing, hauling, and placing all materials; and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work, except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Rolling".

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March, 1950

ITEM S-306

THREE COURSE SURFACE TREATMENT

S-306.1. DESCRIPTION. This item shall consist of a wearing surface composed of three applications of asphaltic material, each covered with aggregate, constructed on the prepared base course or surface in accordance with these specifications.

Three Course Surface Treatment shall not be applied when the air temperature is below 50°F. and is falling, but it may be applied when the air temperature is above 40°F. and is rising. Air temperature shall be taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

S-306.2. MATERIALS.

(1) Asphaltic Materials. The asphaltic material used shall be of the type and grade shown on the plans and when tested by approved laboratory methods shall meet the requirements of the Item "Asphalt, Oils and Emulsions".

(2) Aggregate. The aggregates used shall be of the type and grade shown on the plans for each course and shall meet the requirements of the Item "Aggregate for Surface Treatments".

(3) Aggregate (Stockpiled). When plans include the Item "Aggregate (Stockpiled)," aggregate of the type and grade specified for the third course of the surface treatment shall be stockpiled within the limits of the project at sites designated by the Engineer. Stockpile sites shall be leveled if required and prepared as specified in Article 3.

S-306.3. CONSTRUCTION METHODS. The area to be treated shall be cleaned of dirt, dust, or other deleterious matter by sweeping or other approved methods. If it is found necessary by the Engineer, the surface shall be lightly sprinkled just prior to the first application of asphaltic material.

Asphaltic material of the type and grade shown on the plans for the first course shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distributor, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the Engineer shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material appear to be in error, the distributor shall be calibrated in a manner satisfactory to the Engineer before proceeding with the work.

Asphaltic material for each course shall be applied for the full width of the surface treatment in one application, unless the width exceeds twenty-four (24) feet. No traffic or hauling will be permitted over the freshly applied asphaltic material. No asphaltic material shall be applied until immediate covering is assured.

Aggregate, of the type and grade shown on the plans for the first course, shall be immediately and uniformly applied and spread by mechanical spreading devices of approved design at the approximate rates indicated on the plans and as directed by the Engineer. After the first source has been completed as specified above, there should be a slight excess of aggregate on the surface.

The entire first course shall then be broomed, bladed, or raked as required by the Engineer and shall be thoroughly rolled with the type or types of rollers specified on the plans. Rolling equipment used shall meet the governing specifications for the Item of "Rolling".

The Contractor shall be responsible for the maintenance of the first course and the distribution of the excess aggregate until the second course is applied.

The second course shall consist of asphaltic material and aggregate of the type and grade indicated on the plans for the second course. The asphaltic material for this second course shall be applied and covered with aggregate in the manner specified for the first application. The surface shall then be broomed, bladed, or raked as required by the Engineer and thoroughly rolled as specified for the first course. Asphaltic material and aggregates for the second course shall be applied at the approximate rate indicated on the plans and as directed by the Engineer.

The Contractor shall be responsible for the maintenance of the surface of the second course and the distribution of the excess aggregate until the third course is applied.

The third course shall consist of asphaltic material and aggregate of the type and grade indicated on the plans for the third course. The asphaltic material for this third course shall be applied and covered with aggregate in the manner specified for the first application. The surface shall then be broomed, bladed, or raked as required by the Engineer and thoroughly rolled as specified for the first course. Asphaltic material and aggregates for the third course shall be applied at the approximate rate indicated on the plans and as directed by the Engineer.

The Contractor shall be responsible for the maintenance of the surface and the distribution of the excess aggregate until the work is accepted by the Engineer.

Temporary stockpiling of aggregates on the roadway will be permitted provided the stockpiles are spaced not less than 1,000 feet apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The Contractor shall be responsible for the proper preparation of the temporary stockpile areas before aggregates are placed thereon, including leveling and cleaning of debris necessary for protection of the aggregate to prevent any contamination thereof.

All storage tanks, piping, retorts, booster tanks, and distributors used in storing or handling asphaltic material shall be kept clean and in good operating condition at all times, and they shall be operated in such manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

Asphaltic materials shall be applied at a temperature between the minimums and maximums recommended in the Item "Asphalts, Oils and Emulsions".

The Engineer shall select the temperature of application for the type of asphaltic material to be used and the Contractor shall apply the asphaltic material at a temperature within 15°F. of the temperature selected.

WARNING TO CONTRACTORS. Attention is called to the fact that the asphaltic materials are very inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic material or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

S-306.4. MEASUREMENT. Asphaltic material will be measured in gallons at the applied temperature at the point of application on the road.

Aggregate will be measured by the cubic yard in vehicles as applied on the road.

Aggregate (Stockpiled), if required to be furnished, will be measured by the cubic yard of material in vehicles at the point of stockpiling.

Rolling of the type specified on plans, performed as required by the Engineer, will be measured by the actual hours such rolling equipment works.

S-306.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt", "Aggregate", and "Aggregate (Stockpiled)", if required, of the type and grade specified,

which prices shall be full compensation for cleaning and sprinkling the base; for furnishing, freight involved, preparing, hauling, and placing all materials; and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work, except rolling.

All rolling performed as required will be measured and paid for in accordance with the provisions governing the Item of "Rolling".

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Construction Specification
March, 1950

ITEM S-309

CUT-BACK ASPHALTIC CONCRETE PAVEMENT
(Class F Bituminous Pavements)

S-309.1. DESCRIPTION. This item shall consist of a binder course, a leveling-up course, a surface course, or any combination of these courses as shown on the plans, each of which is to be composed of a compacted mixture of mineral aggregate and asphaltic material and shall be constructed on the previously completed and approved subgrade, sub-base course, base course, or, in the case of a bridge, on the prepared floor slab, all in accordance with these specifications and in conformity with the lines, grades, quantities, and typical cross-sections shown on the plans.

S-309.2. MATERIALS.

(1) Mineral Aggregate. The mineral aggregate shall be composed of a coarse aggregate and a fine aggregate. Samples of coarse aggregate and fine aggregate shall be submitted in accordance with the methods prescribed in Item 6, and approval of both the material and of the source of supply must be obtained from the Engineer prior to delivery.

(a) Coarse Aggregate. The coarse aggregate shall be that part of the aggregate retained on a No. 10 mesh sieve; shall consist of clean, tough, durable fragments of crushed stone, crushed gravel, or gravel, as hereafter specified, of uniform quality throughout; and shall be free from dirt, organic or other injurious matter occuring either free or as a coating on the aggregate. The rock or gravel from which the aggregate is made shall have an abrasion of not more than forty (40) when subjected to the Los Angeles Abrasion Test (A.A.S.H.O. T-96). The crushed gravel shall be so crushed that 80 to 100% of the particles shall have more than one crushed face.

(b) Uncrushed Gravel. The use of uncrushed gravel will be allowed only in Type "J" (Coarse Graded Binder Course) mixture.

(c) Fine Aggregate. The fine aggregate shall be that part of the aggregate passing the No. 10 mesh sieve and shall consist of sand or stone screenings or a combination of sand and stone screenings. Sand shall be composed of 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.

(2) Asphaltic Material.

(a) Paving Mixture. The cut-back asphalt for the paving mixture shall be of the type and grade shown on plans and shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

(b) Tack Coat. The asphalt material for Tack Coat shall meet the requirements for Emulsified Asphalt, EA-11M, or Cut-Back Asphalt, RC-2. If RC-2 cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of not to exceed fifteen (15) per cent of an approved grade of gasoline and/or kerosene, by volume. The asphaltic materials shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

S-309.3. PAVING MIXTURES.

(1) Types.

The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate and asphaltic material. The grading of each constituent of the mineral aggregate shall be such as to produce, when properly proportioned, a mixture, which, when tested in accordance with T.H.D. Bulletin C-14, will conform to the limitations for master grading given below for the type specified. The exact grading of the aggregate and the asphalt content to be used in these mixtures, within the limits specified, will be designated by the Engineer and the mixture produced shall be uniform.

Type "J" (Coarse Graded Binder Course)

Passing 2 1/4" screen	100%
Passing 2" screen	97 - 100%
Passing 2" screen, retained on 1" screen	15 - 40%
Passing 1" screen, retained on 1/2" screen	15 - 40%
Passing 1/2" screen, retained on 1/4" screen	10 - 25%
Passing 1/4" screen, retained on 10-mesh sieve	10 - 20%
Passing 10-mesh sieve, retained on 40-mesh sieve	3 - 10%
Passing 40-mesh sieve, retained on 80-mesh sieve	3 - 10%
Passing 80-mesh sieve	3 - 15%

The cut-back asphalt shall form from 4 1/2 to 7% of the mixture by weight.

Type "K" (Fine Graded Binder or Leveling-up Course)

Passing 1 1/4" screen	100%
Passing 1" screen	97 - 100%
Passing 1" screen, retained on 1/2" screen	25 - 50%
Passing 1/2" screen, retained on 1/4" screen	20 - 40%
Passing 1/4" screen, retained on 10-mesh sieve	10 - 25%
Passing 10-mesh sieve, retained on 40-mesh sieve	5 - 20%
Passing 40-mesh sieve, retained on 80-mesh sieve	5 - 15%
Passing 80-mesh sieve	5 - 15%

The cut-back asphalt shall form from 4 1/2 to 7% of the mixture by weight.

Type "L" (Coarse Graded Surface Course)

Passing 1" screen	100%
Passing 3/4" screen	97 - 100%
Passing 3/4" screen, retained on 1/2" screen	25 - 40%
Passing 1/2" screen, retained on 1/4" screen	25 - 40%
Passing 1/4" screen, retained on 10-mesh sieve	10 - 25%
Passing 10-mesh sieve, retained on 40-mesh sieve	5 - 20%
Passing 40-mesh sieve, retained on 80-mesh sieve	5 - 15%
Passing 80-mesh sieve	5 - 15%

The cut-back asphalt shall form from 5 to 7% of the mixture by weight.

Type "M" (Fine Graded Surface Course)

Passing 5/8" screen	100%
Passing 1/2" screen	97 - 100%
Passing 1/2" screen, retained on 1/4" screen	30 - 60%
Passing 1/4" screen, retained on 10-mesh sieve	20 - 40%
Passing 10-mesh sieve, retained on 40-mesh sieve	5 - 20%
Passing 40-mesh sieve, retained on 80-mesh sieve	5 - 15%
Passing 80-mesh sieve	5 - 15%

The cut-back asphalt shall form from 5 to 7% of the mixture by weight.

The exact percentage of the cut-back asphalt to be introduced into the above mixtures, within the limits specified, shall be as directed by the Engineer.

The type and amount of the mixture used shall be as specified on the plans.

(2) Central Mixing Plants. The materials may be mixed on the job or at some central mixing plant and shipped ready for use.

(3) Extraction to Test Grading of Mineral Aggregate. When required by the Engineer, samples of the mixture may be taken from the trucks or from the finished pavement, and when a sample, whose weight is not less than three thousand (3,000) grams multiplied by the maximum size aggregate in inches, is tested by Extraction Test Method, T.H.D. Bulletin C-14, and subsequent revisions, it shall not vary from the grading proportions of mineral aggregate specified, according to the mix being tested, by more than five (5) per cent in any particular.

Mixing plants that will not continuously produce a mixture meeting all of the above requirements will be condemned and shall be removed from the job.

S-309.4. EQUIPMENT.

(1) Mixing Plants.

Mixing plants may be either the weight-batching type or the continuous mixing type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, and aggregate screens and bins, and shall consist of the following essential pieces of equipment.

(a) Weight-batching Type.

Bin Storage. The various sizes of mineral aggregate as made or received shall be placed in the proper bins or stored or stockpiled separately, and shall be handled in such a manner as to eliminate segregation or contamination with foreign materials. The size of the bins shall coordinate with the full capacity of the plant and shall be sufficient to store the amount of aggregates required to keep the plant in continuous operation. The number of bins used shall be as required for producing the particular type of pavement being mixed.

Bin No. 1--Will contain aggregate, 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 2--Will contain aggregate, 95 to 100% of which will pass the 1/2" screen and 85 to 100% of which will be retained on the 10-mesh sieve.

Bin No. 3--Will contain aggregate, all of which will pass the largest screen size permitted for the type of mixture being produced, and 85 to 100% of which will be retained on the 1/2" screen.

The use of additional bins will be permitted, and if used, the Engineer will specify the aggregate sizes for each bin.

Weigh Box. Bin storage shall be provided with tight cut-off gates so there will be no leakage of the mineral aggregate into the weigh box. The weigh box shall be of sufficient capacity to hold a complete batch of aggregate without wasting or leveling by hand and shall be so designed that the entire batch will quickly discharge into the mixer. The weigh box shall be open at the top so that if, in charging, an excess of one size mineral aggregate is introduced into the weigh box, it may be removed by the operator. The weigh box shall be provided with a close fitting and quick operating cut-off gate, so that there will be no leakage of the mineral aggregate into the mixer.

Batching Scales. The scales used for weighing the different grades of mineral aggregate may be either of the springless dial type or the multi-beam type. If of the springless dial type, an adjustable indicating pointer shall be provided for each grade of the mineral aggregate, allowing accurate setting of the weight for the various sizes. If scales are of the multi-beam type, they shall have sufficient weighing beams to weigh each grade of aggregate separately. All scales shall have a tare beam for balancing. The beam scales must also be equipped with a tell-tale dial indicator of the springless dial type, indicating over and under load of at least fifty (50) pounds. Scales that are not accurate to within four (4) pounds per one thousand (1,000) pounds net load will not be considered satisfactory. In case vibration of the plant interferes with accurate weighing, the scales shall be satisfactorily insulated against shock or vibration.

Asphalt Proportioning Equipment. The draw-off valve at the cut-back asphalt bucket shall be of a quick cut-off type that will not leak any asphalt into the bucket after the required amount of the cut-back asphalt has been drawn. The scales for weighing the cut-back asphalt shall be of the springless dial type or the multi-beam type. If of the springless dial type, they shall be arranged for quick adjustment at zero to provide for the change in tare. A pointer shall be provided to indicate the weight of the cut-back asphalt required for one batch. If of the multi-beam type, they shall be equipped with a tare beam and a tell-tale indicator of the springless dial type. The scales shall be satisfactorily insulated against vibration. The cut-back asphalt shall be sprayed into the mixer through an approved spray bar that will distribute the asphalt uniformly throughout the length of the mixer.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than fifteen hundred (1,500) pounds in a single batch. The number of blades and the position of same

shall be such as to give a uniform and complete circulation of the batch in the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the cut-back asphalt will be condemned as inadequate to produce a satisfactory mix. This determination will be made by mixing the standard batch for the required time, then dumping the mixture and taking samples from different parts of it. These will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock on their discharge gates, and shall be locked for the required mixing period. The dump door or doors of the mixer shall be tight to prevent the spilling of dry mineral aggregate or dust from the pug mill.

(b) Continuous Mixing Type.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than forty (40) tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used. This shall be determined by taking samples from different parts of a truck load and testing by the extraction test. These tests must show that the load is uniform throughout.

The plant shall provide for positive separation of aggregate into at least three parts and these parts shall be properly combined as they enter the pug mill in such manner that control of the combined aggregate is comparable to that obtained by weight-batching.

The pump used to introduce asphalt into the mix shall be provided with an accurate meter or other satisfactory measuring device so that control of the asphalt content of the mixture is comparable to that obtained by weight-batching.

All requirements for determining the temperature of the various ingredients entering into the mixture, as specified for the weight-batching plant, shall be met.

(2) Forms.

The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(3) Motor Grader.

The motor grader shall be a self-propelled power grader; it shall be equipped with pneumatic tired wheels; shall have a blade length of not less than twelve (12) feet; shall have a wheel base of not less than sixteen (16) feet; and shall be tight and in good operating condition and approved by the Engineer.

(4) Pneumatic Tire Rollers.

The pneumatic roller shall be an acceptable roller consisting of pneumatic tired wheels, the weight capable of being varied uniformly from 100 pounds to 325 pounds per inch of width of tire tread. The roller shall be drawn by suitable pneumatic tired equipment.

(5) Two Axle Tandem Roller.

This roller shall be an acceptable power driven tandem roller weighing not less than eight (8) tons.

(6) Three Wheel Roller.

This roller shall be an acceptable power driven three wheel roller weighing not less than ten (10) tons.

(7) Three Axle Tandem Roller.

This roller shall be an acceptable power driven three axle roller weighing not less than ten (10) tons.

(8) Straight Edges and Templates.

The Contractor shall provide acceptable sixteen (16) foot straight edges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(9) Laboratory.
The Contractor shall provide, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and inspecting force. It shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored and roofed weather-tight, containing not less than two windows, two doors and a work bench three (3) feet wide and six (6) feet long. The building shall be so located that the details of the plant are in full view and plainly visible from at least one window of the same.

(10) Truck Scales. A set of standard platform truck scales shall be placed at a location approved by the Engineer. Scales shall be accurate to within four (4) pounds per one thousand (1000) pounds total load. The truck scales shall have a rated capacity of not less than five thousand (5000) pounds more than the total load to be weighed. A weather-tight building of sufficient size to house the checker while operating the scales shall be provided.

All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-309.5. STORAGE, PROPORTIONS, AND MIXING.
(1) Storage of Cut-back Asphalt. The cut-back asphalt storage shall be ample to meet the requirements of the plant. Cut-back asphalt in storage may be heated by steam coils, which shall be absolutely tight in order to prevent leakage of moisture into the asphalt. No direct fire heating of cut-back asphalt will be permitted. Agitation of asphalt with steam or air will not be permitted. The cut-back asphalt shall not be heated to a temperature above the recommended applied temperature for the grade specified under the Item "Asphalts, Oils and Emulsions".

WARNING TO CONTRACTORS. Attention is directed to the fact that the cut-back asphalt is very inflammable. The utmost care shall be taken to prevent open flames from coming into contact with the cut-back asphalt or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

(2) Proportioning.
The proportioning of the various materials entering into the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. The Engineer or his authorized representative shall have access at any time to all parts of the paving plants. Satisfactory equipment and construction methods shall be used as herein specified.

(3) Drying Mineral Aggregate. All mineral aggregate, before being mixed with asphalt, must be dry enough to allow thorough adhesion of the asphalt to the surface of same. If the mineral aggregate has a moisture content greater than its water absorption value when tested in accordance with Bulletin C-14, it shall be considered to contain free moisture and the mixing operations shall be stopped until the mineral aggregate is dried to a point equal to or less than the water absorption value for the mineral aggregate. The Contractor shall use an approved method to dry the mineral aggregate.

If aggregates are mixed before or during drying operations, they shall be proportioned by a mechanical device that will give a uniform and constant feed of each of the sizes incorporated. After drying, the aggregate shall be screened into the bin sizes specified.

(4) Mixing.
In the charging of the weigh box and the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of five (5) to twenty (20) seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than thirty (30) seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

Mixtures that do not remain workable a sufficient period of time to permit proper spreading, blading, and rolling will not be acceptable.

S-309.6. CONSTRUCTION METHODS. The asphaltic mixture, tack coat or prime coat shall be

placed only when the weather conditions, in the opinion of the Engineer, are suitable.

(1) Prime Coat.
If a prime coat is required, it will be applied and paid for as a separate item. The tack coat or asphaltic concrete shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat.
Before the asphaltic mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat meeting the requirements for tack coat under asphaltic materials of this specification. The tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate of not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat.

(3) Placing.
If the mixtures are shipped to the job, the railroad cars shall first be cleaned of all foreign matter, and the material shall be loaded in such a manner as to prevent segregation. The asphaltic 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 so that all material delivered may be placed and shall have received its initial rolling in daylight. The mixture shall be laid only on an approved base course or pavement which has been tack-coated as previously specified and shall be free of all foreign materials. All contact surfaces of curbs and structures and all joints shall be painted with a thin, uniform coating of cut-back or emulsified asphalt as required for tack-coating the base. The mixture shall be thoroughly aerated by blading and then spread into place with a motor grader, in a uniform layer of such depth that after receiving ultimate compaction by rolling, the requirements of the typical cross-sections will have been fulfilled. Hand spreading will be permitted where the mixture is placed on narrow strips or small irregular areas.

Adjacent to flush curbs, gutters, liners, and structures, the surface mixture shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb or flush structure.

(4) Compacting.
(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the pneumatic roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller and at least one three wheel roller as above specified, shall be provided for each job. If the Contractor elects, he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller, but in no case shall less than two rollers be in use on each job. Additional three wheel rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease, cinders, or other foreign matter on the pavement, either when the rollers are in operation or when standing.

(c) Hand Tamping. The edges of the pavement along curbs, headers, and similar structures, and at all places not accessible to the roller, or in such positions as will not allow thorough

compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(d) When more than one course is to be laid, each course shall be allowed to thoroughly cure before placing the succeeding course.

(5) Surface Tests.
The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross-section, and when tested with a 16' straight edge placed parallel to the center line of the roadway, it shall have no deviation in excess of 1/16" per foot from the nearest point of contact. The maximum ordinate measured from the face of the straight edge shall not exceed 1/4" at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(6) Opening to Traffic.
The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

S-309.7. MEASUREMENT.
(1) Cut-back Asphaltic Concrete Pavement will be measured by the ton of 2,000 pounds of the type or types actually used in the completed and accepted work, in accordance with the plans and specifications for the project. Measurement by weight will be made on the truck scales as provided. Records will be kept on tare load, total load, and net load of cut-back asphaltic concrete for each load of same.

(2) Tack Coat will be measured in gallons at the applied temperature at point of application on the road.

S-309.8. PAYMENT.
(1) Work performed and materials furnished as prescribed for this item, measured as provided under "Measurement", will be paid for at the unit prices bid for "Cut-back Asphaltic Concrete Pavement" (Type "J", "K", "L", or "M"), which price shall each be full compensation for furnishing all materials, for all heating, mixing, hauling, cleaning base course, placing asphaltic mixture, all blading, rolling, and finishing, and for all labor, tools, equipment, and incidentals necessary to complete the work.

(2) Tack coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat" of the type specified, which price shall be full compensation for furnishing, preparing, hauling, and placing the ~~cut-back~~ asphalt; for all labor, tools, equipment, and incidentals necessary to complete the work.

(3) The Prime Coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item "Prime Coat".

(4) All templates, straight edges, scales, and other weighing and measuring devices necessary for the proper construction and checking of the work shall be furnished, operated, and maintained by the Contractor at his expense.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-311

CUT-BACK ASPHALTIC CONCRETE PAVEMENT
(Limestone Rock Asphalt Admixture)
(Class F Bituminous Pavements)

S-311.1. DESCRIPTION. This item shall consist of a binder course, a leveling-up course, a surface course, or any combination of these courses as shown on the plans, each of which is to be composed of a compacted mixture of mineral aggregate, limestone rock asphalt and asphaltic material and shall be constructed on the previously completed and approved subgrade, sub-base course, base course, or, in the case of a bridge, on the prepared floor slab, all in accordance with these specifications and in conformity with the lines, grades, quantities, and typical cross-sections shown on the plans.

S-311.2. MATERIALS.

(1) Mineral Aggregate. The mineral aggregate shall be composed of an aggregate of crushed stone, crushed gravel, gravel and sand and limestone rock asphalt. Samples of aggregate and limestone rock asphalt shall be submitted in accordance with the methods prescribed in Item 6, and approval of both the material and of the source of supply must be obtained from the Engineer prior to delivery.

(a) Aggregate. Aggregate shall consist of clean, tough, durable fragments of rock, crushed gravel, gravel or sand, as hereafter specified, of uniform quality throughout; and shall be free from dirt, organic or other injurious matter occurring either free or as a coating on the aggregate. The rock or gravel from which the aggregate is made shall have an abrasion of not more than forty (40) when subjected to the Los Angeles Abrasion Test (A.A.S.H.O. T-96). The crushed gravel shall be so crushed that 80 to 100% of the particles shall have more than one crushed face, Sand shall be composed of durable stone particles free from loam or other injurious foreign matter.

(b) Uncrushed Gravel. The use of uncrushed gravel will be allowed only in Type "N" (Coarse Graded Binder Course) mixture.

(c) Limestone Rock Asphalt. The limestone rock asphalt shall be uniform, well graded, natural limestone rock asphalt consisting of five (5) to nine (9) per cent of asphalt and ninety-one (91) to ninety-five (95) per cent of limestone practically free from sulphates, iron pyrites, alumina, ~~nia,~~ or other objectionable matter. The material shall be the product of a pulverizer, using one-quarter (1/4) inch grates, and when tested with the standard laboratory screens, ninety (90) to one hundred (100) per cent shall pass the one-quarter (1/4) inch screen. If necessary, in order to prevent setting up in transit of the pulverized limestone rock asphalt or the paving mixture, water, not to exceed four (4) per cent by weight of the Limestone Rock Asphalt, may be added.

If the pulverized Limestone Rock Asphalt has consolidated or contains lumps, a suitable beater shall be used to satisfactorily break the consolidated particles or lumps of asphalt apart before being introduced into the No. 1 Bin.

(2) Asphaltic Material.

(a) Paving Mixture. The cut-back asphalt for the paving mixture shall be of the type and grade shown on plans and shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

(b) Tack Coat. The asphalt material for Tack Coat shall meet the requirements for Emulsified Asphalt, EA-11M, or Cut-Back Asphalt, RC-2. If RC-2 cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of not to exceed fifteen (15) per cent of an approved grade of gasoline and/or kerosene, by volume. The asphaltic materials shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

S-311.3. PAVING MIXTURES.

(1) Types. The paving mixture shall consist of a uniform mixture of aggregate, limestone rock asphalt and asphaltic material. The grading of each constituent of the mineral aggregate shall be such as to produce, when properly proportioned, a mixture, which, when tested in accordance with T.H.D. Bulletin C-14, will conform to the limitations for master grading given below for the type specified. The limestone rock asphalt shall form twenty-five (25) per cent of the mixture by weight. The exact grading of the aggregate and the asphalt content to be used in these mixtures, within the limits specified, will be designated by the Engineer and the mixture produced shall be uniform. The gradings shown include the limestone rock asphalt.

Type "N" (Coarse Graded Binder Course)

Passing 2 1/4" screen	100%
Passing 2" screen	97 to 100%
Passing 2" screen, retained on 1" screen	15 to 40%
Passing 1" screen, retained on 1/2" screen	15 to 40%
Passing 1/2" screen, retained on 1/4" screen	10 to 20%
Passing 1/4" screen, retained on 10-mesh sieve	10 to 20%
Passing 10-mesh sieve	10 to 35%

The cut-back asphalt shall form from 3 1/2 to 5 1/2% of the mixture by weight.

Type "O" (Fine Graded Binder or Leveling-up Course)

Passing 1 1/4" screen	100%
Passing 1" screen	97 to 100%
Passing 1" screen, retained on 1/2" screen	25 to 50%
Passing 1/2" screen, retained on 1/4" screen	20 to 40%
Passing 1/4" screen, retained on 10-mesh sieve	10 to 20%
Passing 10-mesh sieve	10 to 35%

The cut-back asphalt shall form from 3 1/2 to 5 1/2% of the mixture by weight.

Type "P" (Coarse Graded Surface Course)

Passing 1" screen	100%
Passing 3/4" screen	97 to 100%
Passing 3/4" screen, retained on 1/2" screen	20 to 40%
Passing 1/2" screen, retained on 1/4" screen	20 to 40%
Passing 1/4" screen, retained on 10-mesh sieve	10 to 25%
Passing 10-mesh sieve	10 to 35%

The cut-back asphalt shall form from 4 to 6% of the mixture by weight.

Type "Q" (Fine Graded Surface Course)

Passing 5/8" screen	100%
Passing 1/2" screen	97 to 100%
Passing 1/2" screen, retained on 1/4" screen	30 to 60%
Passing 1/4" screen, retained on 10-mesh sieve	20 to 40%
Passing 10-mesh sieve	15 to 35%

The cut-back asphalt shall form from 4 1/2 to 6 1/2% of the mixture by weight.

The exact percentage of the cut-back asphalt to be introduced into the above mixtures, within the limits specified, shall be as directed by the Engineer.

The type and amount of the mixture used shall be as specified on the plans.

(2) Central Mixing Plants. The materials may be mixed on the job or at some central mixing plant and shipped ready for use.

(3) Extraction to Test Grading of Mineral Aggregate. When required by the Engineer, samples of the mixture may be taken from the trucks or from the finished pavement, and when a sample, whose weight is not less than three thousand (3,000) grams multiplied by the maximum size aggregate in inches, is tested by Extraction Test Method, T.H.D. Bulletin C-14, and subsequent revisions, it shall not vary from the grading proportions of mineral aggregate specified, according to the mix being tested, by more than five (5) per cent in any particular.

Mixing plants that will not continuously produce a mixture meeting all of the above requirements will be condemned and shall be removed from the job.

S-311.4. EQUIPMENT.

(1) Mixing Plants. Mixing plants may be either the weight-batching type or the continuous mixing type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, and aggregate screens and bins, and shall consist of the following essential pieces of equipment.

(a) Weight-batching Type.

Bin Storage. The various sizes of mineral aggregate as made or received shall be placed in the proper bins or stored or stockpiled separately, and shall be handled in such a manner as to eliminate segregation or contamination with foreign materials. The size of the bins shall coordinate with the full capacity of the plant and shall be sufficient to store the amount of aggregates required to keep the plant in continuous operation. The number of bins used shall be as required for producing the particular type of pavement being mixed.

Bin No. 1--will contain Limestone Rock Asphalt.

Bin No. 2--will contain aggregate, 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3--will contain aggregate, 95 to 100% of which will pass the 1/2" screen and 85 to 100% of which will be retained on the 10-mesh sieve.

Bin No. 4--will contain aggregate, all of which will pass the largest screen size permitted for the type of mixture being produced, and 85 to 100% of which will be retained on the 1/2" screen.

The use of additional bins will be permitted, and if used, the Engineer will specify the aggregate sizes for each bin. Bin storage shall be provided with tight cut-off gates so that there will be no leakage of the mineral aggregate into the weigh box.

Weigh Box. The weigh box shall be of sufficient capacity to hold a complete batch of aggregate without wasting or leveling by hand and shall be so designed that the entire batch will quickly discharge into the mixer. The weigh box shall be open at the top so that if, in charging, an excess of one size mineral aggregate is introduced into the weigh box, it may be removed by the operator. The weigh box shall be provided with a close fitting and quick operating cut-off gate, so that there will be no leakage of the mineral aggregate into the mixer.

Batching Scales. The scales used for weighing the different grades of mineral aggregate may be either of the springless dial type or the multi-beam type. If of the springless dial type, an adjustable indicating pointer shall be provided for each grade of the mineral aggregate, allowing accurate setting of the weight for the various sizes. If scales are of the multi-beam type, they shall have sufficient weighing beams to weigh each grade of aggregate separately. All scales shall have a tare beam for balancing. The beam scales must also be equipped with a tell-tale dial indicator of the springless dial type, indicating over and under load of at least fifty (50) pounds. Scales that are not accurate to within four (4) pounds per one thousand (1,000) pounds net load will not be considered satisfactory. In case vibration of the plant interferes with accurate weighing, the scales shall be satisfactorily insulated against shock or vibration.

Asphalt Proportioning Equipment. The draw-off valve at the cut-back asphalt bucket shall be of a quick cut-off type that will not leak any asphalt into the bucket after the required amount of the cut-back asphalt has been drawn. The scales for weighing the cut-back asphalt shall be of the springless dial type or the multi-beam type. If of the springless dial type, they shall be arranged for quick adjustment at zero to provide for the change in tare. A pointer shall be provided to indicate the weight of the cut-back asphalt required for one batch. If of the multi-beam type, they shall be equipped with a tare beam and a tell-tale indicator of the springless dial type. The scales shall be satisfactorily insulated against vibration. The cut-back asphalt shall be sprayed into the mixer through an approved spray bar that will distribute the asphalt uniformly throughout the length of the mixer.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than fifteen hundred (1,500) pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the cut-back asphalt will be condemned as inadequate to produce a satisfactory mix. This determination will be made by mixing the standard batch for the required time, then dumping the mixture and taking samples from different parts of it. These will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock on their discharge gates, and shall be locked for the required mixing period. The dump door or doors of the mixer shall be tight to prevent the spilling of dry mineral aggregate or dust from the pug mill.

(b) Continuous Mixing Type.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than forty (40) tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used. This shall be determined by taking samples from different parts of a truck load and testing by the extraction test. These tests must show that the load is uniform throughout.

The plant shall provide for positive separation of aggregate into the same number of bins as required for the weight-batch plant and these parts shall be properly combined as they enter the pug mill in such manner that control of the combined aggregate is comparable to that obtained by weight-batching.

The pump used to introduce asphalt into the mix shall be provided with an accurate meter or other satisfactory measuring devive so that control of the asphalt content of the mixture is comparable to that obtained by weight-batching.

All requirements for determining the temperature of the various ingredients entering into the mixture, as specified for the weight-batching plant, shall be met.

(2) Forms. The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(3) Motor Grader. The motor grader shall be a self-propelled power grader; it shall be equipped with pneumatic tired wheels; shall have a blade length of not less than twelve (12) feet; shall have a wheel base of not less than sixteen (16) feet; and shall be tight and in good operating condition and approved by the Engineer.

(4) Pneumatic Tire Rollers. The pneumatic roller shall be an acceptable roller consisting of pneumatic tired wheels, the weight capable of being varied uniformly from 100 pounds to 325 pounds per inch of width of tire tread. The roller shall be drawn by suitable pneumatic tired equipment.

(5) Two Axle Tandem Roller. This roller shall be an acceptable power driven tandem roller weighing not less than eight (8) tons.

(6) Three Wheel Roller. This roller shall be an acceptable power driven three wheel roller weighing not less than ten (10) tons.

(7) Three Axle Tandem Roller. This roller shall be an acceptable power driven three axle roller weighing not less than ten (10) tons.

(8) Straight Edges and Templates. The Contractor shall provide acceptable sixteen (16) foot straight edges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(9) Laboratory. The Contractor shall provide, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and inspecting force. It shall be not less than eight (8) feet by twenty (20)

feet and eight (8) feet high, floored and roofed weather-tight, containing not less than two windows, two doors and a work bench three (3) feet wide and six (6) feet long. The building shall be so located that the details of the plant are in full view and plainly visible from at least one window of the same.

(10) Truck Scales. A set of standard platform truck scales shall be placed at a location approved by the Engineer. Scales shall be accurate to within four (4) pounds per one thousand (1000) pounds total load. The truck scales shall have a rated capacity of not less than five thousand (5000) pounds more than the total load to be weighed. A weather-tight building of sufficient size to house the checker while operating the scales shall be provided.

All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-311.5. STORAGE, PROPORTIONS, AND MIXING.

(1) Storage of Cut-back Asphalt. The cut-back asphalt storage shall be ample to meet the requirements of the plant. Cut-back asphalt in storage may be heated by steam coils, which shall be absolutely tight in order to prevent leakage of moisture into the asphalt. No direct fire heating of cut-back asphalt will be permitted. Agitation of asphalt with steam or air will not be permitted. The cut-back asphalt shall not be heated to a temperature above the recommended applied temperature for the grade specified under the Item "Asphalts, Oils and Emulsions".

WARNING TO CONTRACTORS. Attention is directed to the fact that the cut-back asphalt is very inflammable. The utmost care shall be taken to prevent open flames from coming into contact with the cut-back asphalt or the gases of same. The Contractor shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

(2) Proportioning. The proportioning of the various materials entering into the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. The Engineer or his authorized representative shall have access at any time to all parts of the paving plants. Satisfactory equipment and construction methods shall be used as herein specified.

(3) Drying Mineral Aggregate. All mineral aggregate, before being mixed with asphalt, must be dry enough to allow thorough adhesion of the asphalt to the surface of same. If the mineral aggregate has a moisture content greater than its water absorption value when tested in accordance with T.H.D. Bulletin C-14, it shall be considered to contain free moisture and the mixing operations shall be stopped until the mineral aggregate is dried to a point equal to or less than the water absorption value for the mineral aggregate. The Contractor shall use an approved method to dry the mineral aggregate.

If aggregates are mixed before or during drying operations, they shall be proportioned by a mechanical device that will give a uniform and constant feed of each of the sizes incorporated. After drying, the aggregate shall be screened into the bin sizes specified.

(4) Mixing. In the charging of the weigh box and the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all aggregate shall be introduced first; shall be mixed thoroughly for a period of five (5) to twenty (20) seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than thirty (30) seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

Mixtures that do not remain workable a sufficient period of time to permit proper spreading, blading, and rolling will not be acceptable.

S-311.6. CONSTRUCTION METHODS. The asphaltic mixture, tack coat or prime coat shall be placed only when the weather conditions, in the opinion of the Engineer, are suitable.

(1) Prime Coat. If a prime coat is required, it will be applied and paid for as a separate item. The tack coat or asphaltic concrete shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat. Before the asphaltic mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat meeting the requirements for Tack Coat under Asphaltic Materials of this specification. The tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate of not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat.

(3) Placing. If the mixtures are shipped to the job, the railroad cars shall first be cleaned of all foreign matter, and the material shall be loaded in such a manner as to prevent segregation. The asphaltic 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 so that all material delivered may be placed and shall have received its initial rolling in daylight. The mixture shall be laid only on an approved base course or pavement which has been tack-coated as previously specified and shall be free of all foreign materials. All contact surfaces of curbs and structures and all joints shall be painted with a thin, uniform coating of cut-back or emulsified asphalt as required for tack-coating the base. The mixture shall be thoroughly aerated by blading and then spread into place with a motor grader, in a uniform layer of such depth that after receiving ultimate compaction by rolling, the requirements of the typical cross-sections will have been fulfilled. Hand spreading will be permitted where the mixture is placed on narrow strips or small irregular areas.

Adjacent to flush curbs, gutters, liners, and structures, the surface mixture shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb or flush structure.

(4) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers.

(b) Rolling. Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the pneumatic roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller and at least one three wheel roller, as above specified, shall be provided for each job. If the Contractor elects, he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller, but in no case shall less than two rollers be in use on each job. Additional three wheel rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease, cinders, or other foreign matter on the pavement, either when the rollers are in operation or when standing.

(c) Hand Tamping. The edges of the pavement along curbs, headers, and similar structures, and at all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(d) When more than one course is to be laid, each course shall be allowed to thoroughly cure before placing the succeeding course.

(5) Surface Tests. The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross-section, and when tested with a 16' straight edge placed parallel to the center line of the roadway, it shall have no deviation in excess of 1/16" per foot from the nearest point of contact. The maximum ordinate measured from the face of the straight

edge shall not exceed 1/4" at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(6) Opening to Traffic. The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

S-311.7. MEASUREMENT.

(1) Cut-back Asphaltic Concrete Pavement will be measured by the ton of 2,000 pounds of the type or types actually used in the completed and accepted work, in accordance with the plans and specifications for the project. Measurement by weight will be made on the truck scales as provided. Records will be kept on tare load, total load, and net load of Cut-back Asphaltic Concrete (Rock Asphalt Admixture) for each load of same.

(2) Tack Coat will be measured in gallons at the applied temperature at point of application on the road.

S-311.8. PAYMENT.

(1) Work performed and materials furnished as prescribed for this item, measured as provided under "Measurement", will be paid for at the unit prices bid for "Cut-back Asphaltic Concrete Pavement (Rock Asphalt Admixture)" (Type "N", "O", "P", or "Q"), which price shall each be full compensation for furnishing all materials, for all heating, mixing, hauling, cleaning base course, placing asphaltic mixture, all blading, rolling, and finishing, and for all labor, tools, equipment, and incidentals necessary to complete the work.

(2) Tack Coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat" of the type specified, which price shall be full compensation for furnishing, preparing, hauling, and placing the ~~cut-back~~ asphalt; for all labor, tools, equipment, and incidentals necessary to complete the work.

(3) The Prime Coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item "Prime Coat".

(4) All templates, straight edges, scales, and other weighing and measuring devices necessary for the proper construction and checking of the work shall be furnished, operated, and maintained by the Contractor at his entire expense.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-314

COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT
(Class G Bituminous Pavements)

S-314.1. DESCRIPTION. This item shall consist of a surface course, a leveling-up course, or a combination of these courses as shown on plans, composed of a compacted layer of natural limestone rock asphalt, cold mixed with a prescribed flux and shall be constructed on the completed and approved base course, previously placed surface course, or, in the case of a bridge on the prepared floor slab, all in accordance with these specifications and in conformity with the lines, grades, quantities, and typical cross-sections shown on plans.

S-314.2. MATERIALS.

(1) Rock Asphalt.

The rock asphalt for this item shall be material obtained from deposits which for a period of at least two years have produced raw rock asphalt that has been used as surfacing and proved satisfactory in service when placed in the general manner prescribed herein.

The rock asphalt shall be uniform and well graded and shall be practically free from sulphates, iron pyrites, alumina, or other objectionable matter.

The natural limestone rock asphalt furnished shall have from 5 to 9 per cent of naturally impregnated asphalt and 91 to 95 per cent of limestone.

Prior to delivery of any rock asphalt, the Contractor shall designate to the Engineer in writing a definite per cent of natural asphalt content of the material he desires to use and the natural asphalt content of all acceptable material shall not deviate from this designated per cent by more than 1.5 per cent. The designated natural asphalt content with the permitted variation of 1.5 per cent shall be within the limits allowed by this provision and shall not be changed during construction of the project without the approval of the Engineer.

No material shall be used before the source has been approved and the material has been sampled, tested, and approved for use by the State Highway Engineer. The Contractor shall notify the Engineer in advance if change in source of any material is desired, and both the new source and material shall be approved by the Engineer prior to use.

(2) Asphaltic Material.

(a) Flux. The fluxing material to be used shall have the following characteristics:

	Min.	Max.
Viscosity (Furol) 60 cc at 122°F.	50	100
Flash point (Closed Cup)	250	
Loss 50 gm. 5 hrs., at 325°F.	0	5

It shall be free from foreign matter and practically free from water.

(b) Tack Coat. The asphalt material for Tack Coat shall meet the requirements for Emulsified Asphalt, EA-11M, or Cut-Back Asphalt, RC-2, or shall be a cut-back asphalt made by combining fifty to seventy (50-70) per cent of the asphaltic material as specified for the type of paving mixture with thirty to fifty (30-50) per cent gasoline and/or kerosene; or if RC-2 cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of not to exceed fifteen (15) per cent of an approved grade of gasoline and/or kerosene, by volume; and the asphaltic materials shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

S-314.3. PAVING MIXTURES.

(1) Types.

The paving mixture shall consist of a uniform mixture of crushed limestone rock asphalt, and flux. The grading shall be such as to produce, when properly proportioned, a mixture which, when tested in accordance with T.H.D. Bulletin C-14, will conform to the limitations for grading given below for the type specified. The grading to be used in these mixtures, within the limits specified, shall be approximately as designated by the Engineer, and the mixture produced shall be uniform.

Type "A":

Retained on 1" screen	0%
Retained on 3/4" screen	0 to 15%
Retained on 1/2" screen	15 to 35%
Retained on 1/4" screen	40 to 60%
Passing 10-mesh sieve	20 to 35%

Type "AA":

Retained on 1" screen	0%
Retained on 3/4" screen	0 to 15%
Retained on 1/2" screen	15 to 35%
Retained on 1/4" screen	40 to 60%
Passing 10-mesh sieve	30 to 45%

Type "B":

Retained on 5/8" screen	0%
Retained on 1/2" screen	0 to 10%
Retained on 1/4" screen	35 to 60%
Passing 10-mesh sieve	20 to 35%

Type "BB":

Retained on 5/8" screen	0%
Retained on 1/2" screen	0 to 10%
Retained on 1/4" screen	35 to 60%
Passing 10-mesh sieve	30 to 40%

Type "C":

Retained on 1/2" screen	0%
Retained on 3/8" screen	0 to 10%
Retained on 1/4" screen	35 to 50%
Passing 10-mesh sieve	20 to 35%

Type "CC":

Retained on 1/2" screen	0%
Retained on 3/8" screen	0 to 10%
Retained on 1/4" screen	35 to 50%
Passing 10-mesh sieve	35 to 50%

Type "D":

Retained on 3/8" screen	0%
Retained on 1/4" screen	0 to 10%
Passing 10-mesh sieve	40 to 60%

(2) Water Content.

If the rock asphalt mixture is prepared at some central point and shipped to the work, water may be added to prevent setting-up in transit. If water is added, the total water so added shall not exceed 4% by weight. If the rock asphalt mixture is prepared on or adjacent to the project, the addition of water will not be permitted unless authorized by the Engineer. The amount of water that may be added shall be as designated by the Engineer but shall not exceed 4% by weight. In order to insure uniformity of the rock asphalt mixture a suitable measuring device shall be used to accurately measure the amount of water to be incorporated into each batch. All water in the mixture in excess of 4% by weight at the time of weighing the mixture on the truck scales shall be deducted in determining the tonnage of mixture for payment. The method of determining

the water content of the mixture shall be as prescribed in T.H.D. Bulletin C-14 and subsequent revisions.

(3) Central Mixing Plants.

The materials may be mixed on the job or at some central mixing plant and shipped ready for use. Mixtures that do not remain workable a sufficient period of time to permit proper spreading, blading and rolling will not be acceptable.

The type and amount of the mixture used shall be as specified on the plans.

Mixing plants that will not continuously produce a mixture meeting all of the above requirements will be condemned and removed from the job.

S-314.4. EQUIPMENT.

(1) Mixing Plants.

Mixing Plants may be either the Weight-batching Type or the Continuous Mixing Type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, aggregate screens and bins, and shall consist of the following essential pieces of equipment.

(a) Weight-batching Type.

Measuring Box. The measuring box shall be of sufficient capacity to hold a complete batch of rock asphalt without wasting or leveling by hand and shall be so designed that the entire batch will quickly discharge into the mixer. This box shall be open at the top so that if, in charging, an excess of rock asphalt is introduced into the box, it may be removed by the operator. The box shall be provided with a close fitting and quick operating cut-off gate, so that there will be no leakage of the rock asphalt into the mixer.

Batching Scales. If the Contractor elects to weigh the materials, the scales shall be of the springless dial type or the multi-beam type. If scales are of the springless dial type, they shall be arranged for quick adjustment at zero to provide for the change in tare. A pointer shall be provided to indicate the weight of the material required for one batch. If of the multi-beam type, the scales shall be equipped with a tare beam for balancing and a tell-tale indicator of the springless dial type, indicating over and under load. Scales that are not accurate to within four (4) pounds per one thousand (1000) pounds net load, will not be considered satisfactory. In case vibration of the plant interferes with accurate weighing, the scales shall be satisfactorily insulated against shock or vibration.

Mixer. The mixer shall be of the Pug Mill type and shall have a capacity of not less than 1,500 pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. Any mixer that has a tendency to segregate the rock asphalt or fails to secure a thorough and uniform mixing with the flux will be condemned as inadequate to produce a satisfactory mix. The dump door or doors of the mixer shall be tight to the rock asphalt so that there will be no spilling from the pug mill. The flux shall be sprayed into the mixer through an approved spray bar that will distribute the flux uniformly throughout the length of the mixer.

(b) Continuous Mixing Type.

Mixer. The mixer shall be an approved continuous type, and shall have a capacity of not less than forty (40) tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the materials shall not be used. The pumps used to introduce flux oil and water into the mix shall be provided with accurate recording meters so that control of the flux oil content of the mixture is comparable to that obtained by weight-batching. All requirements for determining the temperature of the various ingredients entering into the mixture, as specified for the weight-batching plant, shall be met.

(2) Spreading and Finishing Machine.

The spreading and finishing machine, if permitted by the Engineer, shall be of the screeding and troweling type, or of a type approved by the Engineer and shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test.

(3) Forms.

The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(4) Motor Grader.

The motor grader shall be a self-propelled power-grader; it shall be equipped with pneumatic tired wheels; shall have a blade length of not less than twelve (12) feet; shall have a wheel base of not less than sixteen (16) feet; and shall be tight and in good operating condition and approved by the Engineer.

(5) Pneumatic Tire Rollers.

The pneumatic roller shall be an acceptable roller consisting of pneumatic tired wheels, the weight capable of being varied uniformly from 100 pounds to 325 pounds per inch of width of tire tread. The roller shall be drawn by suitable pneumatic tired equipment.

(6) Two Axle Tandem Roller.

This roller shall be an acceptable power driven tandem roller weighing not less than eight (8) tons.

(7) Three Wheel Roller.

This roller shall be an acceptable power driven three wheel roller weighing not less than ten (10) tons.

(8) Three Axle Tandem Roller.

This roller shall be an acceptable power driven three axle roller weighing not less than ten (10) tons.

(9) Straight Edges and Templates.

The Contractor shall provide acceptable sixteen (16) foot straight edges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(10) Laboratory.

The Contractor shall provide, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and inspecting force. It shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored and roofed weather-tight,containing not less than two windows, two doors and a work bench three (3) feet wide and six (6) feet long. The building shall be so located that the details of the plant are in full view and plainly visible from at least one window of the same.

(11) Truck Scales.

A set of standard platform truck scales shall be placed at a location approved by the Engineer. Scales shall be accurate to within four (4) pounds per one thousand (1000) pounds total load. The truck scales shall have a rated capacity of not less than five thousand (5000) pounds more than the total load to be weighed. A weather-tight building of sufficient size to house the checker while operating the scales shall be provided.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-314.5. STORAGE, PROPORTIONS AND MIXING.

(1) Storage of Rock Asphalt.

Storage of the crushed limestone rock asphalt, or the rock asphalt mixture upon the ground will not be permitted except in an emergency, and then only with the written consent of the Engineer. Material that comes in contact with earth or other objectionable foreign matter shall be rejected. In case the rock asphalt or the rock asphalt mixture has set in transit or in storage to the extent that it cannot be readily mixed or handled on the road, it shall be reprocessed to conform to its original gradation before being used. Storage or handling of the crushed rock asphalt or the rock asphalt mixture shall be in such manner as to prevent undue segregation.

(2) Storage and Heating of Flux.

The flux storage shall be ample to meet the requirements of the plant. The flux may be heated by steam coil or direct fire to a temperature not to exceed 180°F. If direct fire heating is used, the heating equipment shall be such that it will insure positive circulation of the flux while being

heated and shall be approved by the Engineer. Care shall be taken not to injure the flux by subjecting it to undue continuous heat.

(3) Proportioning.

The crushed limestone rock asphalt and the flux shall be proportioned by weight or by volume based on weight. The exact proportion of each constituent by weight of the paving mixture shall be as directed by the Engineer within the following limits:

Crushed Limestone Rock Asphalt	96 1/2 to 97 1/2%
Flux Material	2 1/2 to 3 1/2%

(4) Mixing.

In introducing the batch into the mixer, the sequence of addition of aggregate and flux oil and the amount of mixing shall be determined by the Engineer and shall be done in a manner to minimize formation of "flux balls" and produce optimum conditions for a homogeneous mix. The mixer shall be equipped with an approved spray bar or other device that will distribute the flux oil quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the rock asphalt aggregate or fails to secure a thorough and uniform mixing with the flux oil shall not be used.

Mixtures that do not remain workable a sufficient period of time to permit proper spreading and rolling will not be accepted.

S-314.6. CONSTRUCTION METHODS. The rock asphalt mixture, tack coat or prime coat shall be placed only when the weather conditions, in the opinion of the Engineer, are suitable.

(1) Prime Coat.

If a prime coat is required, it will be applied and paid for as a separate item. The tack coat or rock asphalt mixture shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat.

Before the rock asphalt mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat meeting the requirements for tack coat under asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate of not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat.

(3) Placing.

If the mixtures are shipped to the job, the railroad cars shall first be cleaned of all foreign matter, and the material shall be loaded in such a manner as to prevent segregation. The rock asphalt 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 so that all material delivered may be placed and shall have received its initial rolling in daylight. The mixture shall be laid only on an approved base course or pavement which has been tack-coated as previously specified and shall be free of all foreign materials. All contact surfaces of curbs and structures and all joints shall be painted with a thin, uniform coating of cut-back or emulsified asphalt as required for tack-coating the base. The mixture shall be aerated and then spread into place with a motor grader, in a uniform layer of such depth that after receiving ultimate compaction by rolling, the requirements of the typical cross-sections will have been fulfilled. Hand spreading will be permitted where the mixture is placed on narrow strips or small irregular areas.

Adjacent to flush curbs, gutters, liners, and structures, the surface mixture shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb or flush structure.

If, in the opinion of the Engineer, the mixture is suitable for placing without aeration, it may be spread with the specified spreading and finishing machine.

(4) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the pneumatic roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller and at least one three wheel roller, as above specified, shall be provided for each job. If the Contractor elects, he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller, but in no case shall less than two rollers be in use on each job. Additional rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease, cinders, or other foreign matter on the pavement, either when the rollers are in operation or when standing.

(c) Hand Tamping. The edges of the pavement along curbs, headers, and similar structures, and pavement mixture at all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(5) Surface Tests.

The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross-section, and when tested with a 16' straight edge placed parallel to the center line of the roadway, it shall have no deviation in excess of 1/16" per foot from the nearest point of contact. The maximum ordinate measured from the face of the straight edge shall not exceed 1/4" at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(6) Opening to Traffic.

The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

S-314.7. MEASUREMENT.

(1) The rock asphalt mixture will be measured by the ton of two thousand (2000) pounds as actually used in the completed and accepted work in accordance with the plans and specifications for the project. Measurement by weight will be made on the truck scales as provided in this specification. Records will be kept on tare load, total load, and net load of rock asphalt mixture for each load of same. All water in excess of four (4) per cent by weight in the mixture at the time of weighing shall be deducted from the net weight to determine the quantity for which payment is made.

(2) Tack coat will be measured in gallons at the applied temperature at point of application on the road. Measurement to be made before adding any additional water to the emulsified asphalt.

When gasoline is added to the cut-back asphalt for tack coat, as ordered, measurement for payment will be made after the gasoline is added.

S-314.8. PAYMENT.

(1) Work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Cold Mix Limestone Rock Asphalt Pavement" of the types specified, which price shall be full compensation for furnishing al'

materials, for all heating, mixing, hauling, cleaning base course, placing rock asphalt mixture, all blading, rolling, and finishing, and for all labor, tools, equipment, and incidentals necessary to complete the work.

(2) Tack Coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", of the type and grade specified, which price shall be full compensation for furnishing, preparing, hauling, and placing the asphaltic material and for all labor, tools, equipment, and incidentals necessary to complete the work. No payment is to be made for additional water added to the emulsified asphalt.

(3) Prime Coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item "Prime Coat".

(4) All templates, straightedges, scales and other weighing and measuring devices necessary for the proper construction and checking of the work shall be furnished, operated, and maintained by the Contractor at his expense.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-315

DURACO PAVEMENT
(Class G Bituminous Pavements)

S-315.1. DESCRIPTION. This item shall consist of a surface course, a leveling-up course, or a combination of these courses as shown on plans, composed of a compacted layer of natural limestone rock asphalt and coarse aggregate, cold mixed with a prescribed flux and shall be constructed on the completed and approved base course, previously placed surface course, or, in the case of a bridge on the prepared floor slab, all in accordance with these specifications and in conformity with the lines, grades, quantities, and typical cross-sections shown on plans.

S-315.2. MATERIALS.

(1) Rock Asphalt. The rock asphalt for this item shall be material obtained from deposits which for a period of at least two years have produced raw rock asphalt that has been used as surfacing and proved satisfactory in service when placed in the general manner prescribed herein.

The rock asphalt shall be uniform, well graded crushed natural limestone rock asphalt, consisting of from seven (7) to nine and one half (9 1/2) per cent of asphalt and ninety and one half (90 1/2) to ninety-three (93) per cent of limestone, practically free from sulphates, iron pyrites, and alumina, or other objectionable matter.

(2) Coarse Aggregate. This material shall consist of a clean, tough, durable, crushed trap rock, having an abrasion of not more than 27.5 when subjected to the Los Angeles Abrasion Test (A.A.S.H.O. T-96).

(3) Asphaltic Material.

(a) Flux. Fluxing material to be used shall have the following characteristics:

	Min.	Max.
Viscosity (Furol) 60 cc at 122°F.	50	100
Flash Point (Closed Cup)	250°F	
Evaporation - 5 hours at 325°F.		5%

It shall be free from foreign matter and practically free from water.

(b) Tack Coat.

The asphalt material for Tack Coat shall meet the requirements for Emulsified Asphalt, EA-11M, or Cut-Back Asphalt, RC-2 or shall be cut-back asphalt made by combining fifty to seventy (50-70) per cent of the asphaltic material as specified for the type of paving mixture with thirty to fifty (30-50) per cent gasoline and/or kerosene; or if RC-2 cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of not to exceed fifteen (15) per cent of an approved grade of gasoline and/or kerosene, by volume; and the asphaltic materials shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

S-315.3. PAVING MIXTURES.

(1) Types.

The paving mixture shall consist of a uniform mixture of crushed limestone rock asphalt, coarse aggregate, and flux. The grading shall be such as to produce, when properly proportioned, a mixture which, when tested in accordance with T.H.D. Bulletin C-14, will conform to the limitations for grading given below for the type specified. The grading to be used in these mixtures, within the limits specified, shall be approximately as designated by the Engineer, and the mixture produced shall be uniform. The crushed natural limestone rock asphalt and coarse aggregate and flux shall be proportioned as prescribed in Article S-315.5, "Storage, Propotioning and Mixing".

(a) Natural Limestone Rock Asphalt.

Type "B":

Retained on 5/8 Inch Screen	0%
Retained on 1/2 Inch Screen	0 - 10%
Retained on 1/4 Inch Screen	35 - 60%
Passing 10 Mesh Sieve	25 - 40%

Type "C":

Retained on 1/2 Inch Screen	0%
Retained on 3/8 Inch Screen	0 - 10%
Passing 10 Mesh Sieve	35 - 65%

(b) Coarse Aggregate.

Type "B":

Retained on 5/8 Inch Screen	0%
Retained on 1/2 Inch Screen	0 - 10%
Retained on 1/4 Inch Screen	70 -100%
Retained on 10 Mesh Sieve	95 -100%

Type "C":

Retained on 1/2 Inch Screen	0%
Retained on 3/8 Inch Screen	0 - 10%
Retained on 10 Mesh Sieve	90 -100%

(2) Water Content. If the Duraco mixture is prepared at some central point and shipped to the work, water may be added to prevent setting-up in transit. If water is added, the total water so added shall not exceed 3 per cent by weight. If the Duraco mixture is prepared on or adjacent to the project, the addition of water will not be permitted unless authorized by the Engineer. The amount of water that may be added shall be designated by the Engineer but shall not exceed 3 per cent by weight. In order to insure uniformity of the Duraco mixture, a suitable measuring device shall be used to accurately measure the amount of water to be incorporated into each batch. All water in the mixture in excess of 3 per cent by weight at the time of weighing the mixture on the truck scales shall be deducted in determining the tonnage of mixture for payment. The method of determining the water content of the mixture shall be as prescribed in T.H.D. Bulletin C-14 and subsequent revisions.

(3) Central Mixing Plants.
The materials may be mixed on the job or at some central mixing plant and shipped ready for use. Mixtures that do not remain workable a sufficient period of time to permit proper spreading, blading and rolling will not be acceptable.

The type and amount of the mixture used shall be as specified on the plans.

(4) Mixing plants that will not continuously produce a mixture meeting all of the above requirements will be condemned and removed from the job.

S-315.4. EQUIPMENT.
(1) Mixing Plants.
Mixing Plants may be either the Weight-batching Type or the Continuous Mixing Type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, aggregate screens and bins, and shall consist of the following essential pieces of equipment.

(a) Weight-batching Type.
Measuring Box. The measuring box or boxes shall be of sufficient capacity to hold a complete batch of rock asphalt and coarse aggregate without wasting or leveling by hand and shall be so designed that the entire batch will quickly discharge into the mixer. The box shall be open at the top so that if, in charging, an excess of material is introduced into the box, it may be removed by the operator. The box shall be provided with a close fitting and quick operating cut-off gate so that there will be no leakage of the materials into the mixer.

Batching Scales. If the Contractor elects to weigh the materials, the scales shall be of the springless dial type or the multi-beam type. If scales are of the springless dial type, they shall be arranged for quick adjustment at zero to provide for the change in tare. A pointer shall be provided to indicate the weight of the material required for one batch. If of the multi-beam type, the scales shall be equipped with a tare beam for balancing and a tell-tale indicator of the springless dial type, indicating over and under load. Scales that are not accurate to within four (4) pounds per one thousand (1,000) pounds net load will not be considered satisfactory. In case vibration of the plant interferes with accurate weighing, the scales shall be satisfactorily insulated against shock or vibration.

Mixer. The mixer shall be of the Pug Mill type and shall have a capacity of not less than one thousand five hundred (1,500) pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. Any mixer that has a tendency to segregate the materials or fails to secure a thorough and uniform mixing with the flux will be condemned as inadequate to produce a satisfactory mix. The dump door or doors of the mixer shall be tight to the materials, so that there will be no spilling from the pug mill. The flux shall be sprayed into the mixer through an approved spray bar that will distribute the flux uniformly throughout the length of the mixer.

(b) Continuous Mixing Type.

Mixer. The mixer shall be an approved continuous type and shall have a capacity of not less than forty (40) tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the materials shall not be used.

The pumps used to introduce flux oil and water into the mix shall be provided with accurate recording meters so that control of the Flux Oil content of the mixture is comparable to that obtained by weight-batching. All requirements for determining the temperature of the various ingredients entering into the mixture, as specified for the weight-batching plant, shall be met.

(2) Spreading and Finishing Machine.

The spreading and finishing machine, if permitted by the Engineer, shall be of the screeding and troweling type, or of a type approved by the Engineer and shall be capable of producing a surface that will meet the requirements of the typical cross-section and the surface test.

(3) Forms.

The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(4) Motor Grader.

The motor grader shall be a self-propelled power grader; it shall be equipped with pneumatic tired wheels; shall have a blade length of not less than twelve (12) feet; shall have a wheel base of not less than sixteen (16) feet; and shall be tight and in good operating condition and approved by the Engineer.

(5) Pneumatic Tire Roller.

The pneumatic roller shall be an acceptable roller consisting of pneumatic tired wheels, the weight capable of being varied uniformly from 100 pounds to 325 pounds per inch of width of tire tread. The roller shall be drawn by suitable pneumatic tired equipment.

(6) Two Axle Tandem Roller.

This roller shall be an acceptable power driven tandem roller weighing not less than eight (8) tons.

(7) Three Wheel Roller.

This roller shall be an accpetable power driven three wheel roller weighing not less than ten (10) tons.

(8) Three Axle Tandem Roller.

This roller shall be an acceptable power driven three axle roller weighing not less than ten (10) tons.

(9) Straight Edges and Templates.
The Contractor shall provide acceptable sixteen (16) foot straight edges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(10) Laboratory.
The Contractor shall provide, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and inspecting force. It shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored and roofed weather-tight, containing not less than two windows, two doors and a work bench three (3) feet wide and six (6) feet long. The building shall be so located that the details of the plant are in full view and plainly visible from at least one window of the same.

(11) Truck Scales. A set of standard platform truck scales shall be placed at a location approved by the Engineer. Scales shall be accurate to within four (4) pounds per one thousand (1000) pounds total load. The truck scales shall have a rated capacity of not less than five thousand (5000) pounds more than the total load to be weighed. A weather-tight building of sufficient size to house the checker while operating the scales shall be provided.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-315.5. STORAGE, PROPORTIONING AND MIXING.
(1) Storage of Materials. Storage of the crushed limestone rock asphalt or the Duraco mixture upon the ground will not be permitted except in an emergency, and then only with the written consent of the Engineer. Materials that come in contact with earth or other objectionable foreign matter shall be rejected. In case the rock asphalt or the Duraco mixture has set in transit or in storage to the extent that it cannot be readily mixed or handled on the road, it shall be reprocessed to conform to its original gradation before being used. Storage or handling of all materials or the Duraco mixture shall be in such manner as to prevent undue segregation.

(2) Storage and Heating of Flux. The flux storage shall be ample to meet the requirements of the plant. The flux may be heated by steam coil or direct fire to a temperature not to exceed 180°F. If direct fire heating is used, the heating equipment shall be such that it will insure positive circulation of the flux while being heated and shall be approved by the Engineer. Care shall be taken not to injure the flux by subjecting it to undue continuous heat.

(3) Proportioning.
The crushed limestone rock asphalt, coarse aggregate, and flux shall be proportioned by weight or by volume based on weight. The exact proportion of each constituent by weight of the paving mixture shall be as directed by the Engineer within the following limits:

Coarse Aggregate	20	to	30%
Crushed Limestone Rock Asphalt	66.5	to	77.5%
Flux Material	2.5	to	3.5%

(4) Mixing.
In introducing the batch into the mixer, the sequence of addition of aggregate and flux oil and the amount of mixing shall be as determined by the Engineer and shall be done in a manner to minimize formation of "flux balls" and produce optimum conditions for a homogeneous mix. The mixer shall be equipped with an approved spray bar or other device that will distribute the flux oil quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the rock asphalt aggregate or fails to secure a thorough and uniform mixing with the flux oil shall not be used. Mixtures that do not remain workable a sufficient period of time to permit proper spreading and rolling will not be accepted.

S-315.6. CONSTRUCTION METHODS. The Duraco mixture, tack coat or prime coat shall be placed only when the weather conditions, in the opinion of the Engineer, are suitable.

(1) Prime Coat.
If a prime coat is required, it will be applied and paid for as a separate item. The tack coat or Duraco mixture shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat.

Before the Duraco mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat meeting the requirements for tack coat under "Asphaltic Materials" of this specification. The tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate of not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat.

(3) Placing.

If the mixtures are shipped to the job, the railroad cars shall first be cleaned of all foreign matter, and the material shall be loaded in such a manner as to prevent segregation. The Duraco 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 so that all material delivered may be placed and shall have received its initial rolling in daylight. The mixture shall be laid only on an approved base course or pavement which has been tack-coated as previously specified and shall be free of all foreign materials. All contact surfaces of curbs and structures and all joints shall be painted with a thin, uniform coating of cut-back or emulsified asphalt as required for tack-coating the base. The mixture shall be aerated and then spread into place with a motor grader, in a uniform layer of such depth that after receiving ultimate compaction by rolling, the requirements of the typical cross-sections will have been fulfilled. Hand spreading will be permitted where the mixture is placed on narrow strips or small irregular areas.

Adjacent to flush curbs, gutters, liners, and structures, the surface mixture shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb or flush structure.

If, in the opinion of the Engineer, the mixture is suitable for placing without aeration, it may be spread with the specified spreading and finishing machine.

(4) Compacting.

As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers.

Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the pneumatic roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller and at least one three wheel roller as above specified, shall be provided for each job. If the Contractor elects, he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller, but in no case shall less than two rollers be in use on each job. Additional three wheel rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease, cinders, or other foreign matter on the pavement, either when the rollers are in operation or when standing.

(5) Hand Tamping. The edges of the pavement along curbs, headers, and similar structures, and the pavement mixture at all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(6) Surface Tests.

The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross-section, and when tested with a 16' straight edge placed parallel to the center line of the roadway, it shall have no deviation in excess of 1/16" per foot from the nearest point of contact. The maximum ordinate measured from the face of the straight edge shall not exceed 1/4" at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(7) Opening to Traffic.

The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

S-315.6. MEASUREMENT.

The Duraco mixture will be measured by the ton of two thousand (2,000) pounds of the type ~~and grade~~ specified, as actually used in the completed and accepted work. Measurement by weight will be made on the truck scales as provided in this specification. Records will be kept on tare load, total load, and net load of Duraco mixture for each load of same. All water in excess of three (3) per cent by weight in the mixture at the time of weighing shall be deducted from the net weight to determine the quantity for which payment is made.

Tack coat will be measured in gallons at the applied temperature at point of application on the road. Measurement is to be made before adding any additional water to the emulsified asphalt.

When gasoline is added to the cut-back asphalt for tack coat, as ordered, measurement for payment will be made after the gasoline is added.

S-315.7. PAYMENT.

Work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Duraco Pavement", of the type ~~and grade~~ specified, which price shall be full compensation for furnishing all materials, for all heating, mixing, hauling, cleaning base course, placing Duraco mixture, all blading, rolling, and finishing, and for all labor, tools, equipment, and incidentals necessary to complete the work.

Tack Coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", of the type and grade specified, which price shall be full compensation for furnishing, preparing, hauling, and placing the asphaltic material and for all labor, tools, equipment, and incidentals necessary to complete the work. No payment is to be made for additional water added to the emulsified asphalt.

Prime Coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item "Prime Coat".

Texas Highway Department
Construction Specification
March, 1950

ITEM S-317

HOT MIX ASPHALTIC CONCRETE PAVEMENT

S-317.1. DESCRIPTION. This item shall consist of a base course, a leveling-up course, a surface course or any combination of these courses as shown on the plans, each to be composed of a compacted mixture of mineral aggregate and asphaltic material. It is the intent of this specification to produce a mixture which, when designed and tested in accordance with these specifications and methods outlined in T.H.D. Bulletin C-14, shall have the following laboratory density and stability.

Density %			Stability (%)
Min.	Max.	Optimum	Not less than 35 except when
94	98	96	otherwise shown on plans

If the mixture produced does not have the specified qualities, it shall be changed until it does. The pavement shall be constructed on the previously completed and approved subgrade, base or in the case of a bridge, on the prepared floor slab, as herein specified and in accordance with the details shown on the plans.

S-317.2. MATERIALS.

(1) Mineral Aggregate.

The mineral aggregate shall be composed of a coarse aggregate and a fine aggregate. Samples of coarse aggregate and fine aggregate shall be submitted in accordance with the methods prescribed in Item 6 of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery.

(a) Coarse Aggregate.

The Coarse Aggregate shall be that part of the aggregate retained on a No. 10 mesh sieve; shall consist of clean, tough, durable fragments of stone, or gravel, as hereinafter specified, of uniform quality throughout, it shall be practically free from clay, organic or other injurious matter occurring either free or as coating on the aggregate. Material removed by decantation (T.H.D. Bulletin C-11) shall not be more than 2% except when the plasticity index of the removed material is less than 6, the amount may be as much as 4%. The coarse aggregate shall have an abrasion of not more than forty (40) when subjected to the Los Angeles Abrasion Test (A.A.S.H.O. T-96) for all types except Type "F" (Non-skid Surface Course), which shall have an abrasion of not more than thirty-five (35) when subjected to the same test. If gravel is used for Type "F", it shall be so crushed that ninety (90) percent of the particles shall have more than one crushed face.

(b) Fine Aggregate.

The fine aggregate shall be that part of the aggregate passing the No. 10 mesh sieve and shall consist of sand or stone screenings or a combination of sand and stone screenings. Sand shall be composed of durable stone particles free from injurious foreign matter. Screenings shall be of the same or similar material as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6.

(c) Mineral Filler.

The mineral filler shall consist of thoroughly dry stone dust, slate dust, Portland cement, or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter. When tested by standard laboratory methods, it shall meet the following grading requirements:

Passing a 30 mesh sieve	100%
Passing a 200 mesh sieve, not less than	65%

(2) Asphaltic Material.

(a) Paving Mixture.

Asphalt for the paving mixture shall be of the types of Oil Asphalt as determined by the Engineer and shall meet the requirements of the Item "Asphalts, Oils, and Emulsions". The grade of asphalt used shall be as designated by the Engineer after design tests have been made using the mineral aggregates that are to be used in the project, and the various grades of asphalt. If more than one type of asphaltic concrete mixture is specified for the project, only one grade of asphalt will be required for all types of mixtures, unless otherwise shown on plans.

(b) Tack Coat.

The asphalt material for Tack Coat shall meet the requirements for Emulsified Asphalt, EA-11M; or Cut Back Asphalt RC-2, or shall be a cut-back asphalt made by combining fifty to seventy (50-70) per cent of the asphaltic material as specified for the type of paving mixture with thirty to fifty (30-50) percent of gasoline and/or kerosene; or if RC-2 Cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of not to exceed fifteen (15) percent of an approved grade of gasoline and/or kerosene, by volume; the asphaltic materials shall meet the requirements of the Item "Asphalts, Oils, and Emulsions".

S-317.3. PAVING MIXTURES.

(1) Types.

The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate and asphaltic material. The grading of each constituent of the mineral aggregate shall be such as to produce, when properly proportioned, a mixture, which, when tested in accordance with Bulletin C-14, will conform to the limitations for master grading given below for the type specified:

Type "A": (Coarse Graded Binder Course)

Passing 2 1/4" screen	100%
Passing 2" screen	97 to 100%
Passing 2" screen, retained on 1" screen	15 to 40%
Passing 1" screen, retained on 1/2" screen	15 to 40%
Passing 1/2" screen, retained on 1/4" screen	10 to 25%
Passing 1/4" screen, retained on 10 mesh sieve	5 to 20%
Total retained on 10 mesh sieve	65 to 80%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 15%
Passing 40 mesh sieve, retained on 80 mesh sieve	3 to 15%
Passing 80 mesh sieve, retained on 200 mesh sieve	3 to 15%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 3 to 6% of the mixture by weight.

Type "B": (Fine Graded Binder or Leveling-up Course)

Passing 1 1/4" screen	100%
Passing 1" screen	97 to 100%
Passing 1" screen, retained on 1/2" screen	20 to 50%
Passing 1/2" screen, retained on 1/4" screen	15 to 40%
Passing 1/4" screen, retained on 10 mesh sieve	5 to 25%
Total retained on 10 mesh sieve	55 to 70%
Passing 10 mesh sieve, retained on 40 mesh sieve	5 to 20%
Passing 40 mesh sieve, retained on 80 mesh sieve	5 to 20%
Passing 80 mesh sieve, retained on 200 mesh sieve	5 to 20%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 3.5 to 7% of the mixture by weight.

Type "C": (Coarse Graded Surface Course)

Passing 1" screen	100%
Passing 3/4" screen	97 to 100%
Passing 3/4" screen, retained on 1/2" screen	15 to 40%
Passing 1/2" screen, retained on 1/4" screen	15 to 40%
Passing 1/4" screen, retained on 10 mesh sieve	10 to 30%
Total retained on 10 mesh sieve	50 to 65%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 25%
Passing 40 mesh sieve, retained on 80 mesh sieve	5 to 25%
Passing 80 mesh sieve, retained on 200 mesh sieve	5 to 25%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 3.5 to 7% of the mixture by weight.

Type "D": (Fine Graded Surface Course)

Passing 5/8" screen	100%
Passing 1/2" screen	97 to 100%
Passing 1/2" screen, retained on 1/4" screen	25 to 50%
Passing 1/4" screen, retained on 10 mesh sieve	15 to 35%
Total retained on 10 mesh sieve	50 to 60%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 25%
Passing 40 mesh sieve, retained on 80 mesh sieve	5 to 25%
Passing 80 mesh sieve, retained on 200 mesh sieve	5 to 25%
Passing 200 mesh sieve	2 to 10%

The asphaltic material shall form from 4.0 to 7.5% of the mixture by weight.

Type "E": (Sheet Asphalt Surface Course)

Passing 1/4" screen	100%
Passing 1/4" screen, retained on 10 mesh sieve	0 to 5%
Passing 10 mesh sieve, retained on 40 mesh sieve	15 to 40%
Passing 40 mesh sieve, retained on 80 mesh sieve	20 to 45%
Passing 80 mesh sieve, retained on 200 mesh sieve	12 to 32%
Passing 200 mesh sieve	10 to 20%

The asphaltic material shall form from 7.5 to 12% of the mixture by weight.

Type "F": (Non-skid Surface Course)

Passing 1/2" screen	100%
Passing 3/8" screen	97 to 100%
Passing 3/8" screen, retained on 10 mesh sieve	60 to 75%
Passing 10 mesh sieve, retained on 40 mesh sieve	3 to 10%
Passing 40 mesh sieve, retained on 80 mesh sieve	6 to 12%
Passing 80 mesh sieve, retained on 200 mesh sieve	4 to 10%
Passing 200 mesh sieve	4 to 8%

The asphaltic material shall form from 3.5 to 5.5% of the mixture by weight.

(2) Tolerances.

The exact grading of the aggregate and the asphalt content to be used in the above mixtures, within the limits specified, will be designated by the Engineer and the mixture produced shall conform to this designed grading and asphalt content within the following respective tolerances:

Passing 2" screen, retained on 1" screen	plus or minus 5%
Passing 1" screen, retained on 1/2" screen	plus or minus 5%
Passing 3/4" screen, retained on 1/2" screen	plus or minus 5%
Passing 1/2" screen, retained on 1/4" screen	plus or minus 5%
Passing 3/8" screen, retained on 1/4" screen	plus or minus 5%
Passing 1/4" screen, retained on 10 mesh sieve	plus or minus 5%
Total retained on 10 mesh sieve	plus or minus 5%
Passing 10-mesh sieve, retained on 40 mesh sieve	plus or minus 3%
Passing 40 mesh sieve, retained on 80 mesh sieve	plus or minus 3%
Passing 80 mesh sieve, retained on 200 mesh sieve	plus or minus 3%
Passing 200 mesh sieve	plus or minus 2%
Asphalt material	plus or minus 0.4%

The type and amount of the mixture used shall be as specified on the plans.

(3) Extraction Test.

When required by the Engineer, samples of the mixture may be taken from trucks, and when tested by the Extraction Test, T.H.D. Bulletin C-14, it shall not vary from the grading proportions of the aggregate and the asphalt content designated by the Engineer by more than the respective tolerances specified above.

Mixing Plants that will not continuously produce a mixture meeting all of the above requirements will be condemned and removed from the job.

S-317.4. EQUIPMENT.

(1) Mixing Plants

Mixing Plants may be either the Weight-batching Type or the Continuous Mixing Type. (See Article 5 also.) Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins, dust collectors, and shall consist of the following essential pieces of equipment.

(a) Weight-batching Type.

Cold Aggregate Bin and Proportioning Device. The cold aggregate bin shall have at least three compartments and shall be of sufficient size to store the amount of aggregate required to keep the plant in continuous operation. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each fine aggregate shall be proportioned in a separate compartment.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that the aggregate will not be injured in drying and heating it to the temperature necessary to secure a mixture of the specified temperature. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. The bin shall be divided into at least five compartments when producing Type "A", Type "B", and Type "C" mixtures and at least four compartments when producing the other types of mixtures. These bins shall contain the following sizes of aggregates:

Type "A": (Coarse Graded Binder Course)

Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1" screen and be retained on the 1/2" screen.

Bin No. 5 will contain aggregates of which at least 85% will be of such size as to pass the 2 1/4" screen and be retained on the 1" screen.

Type "B": (Fine Graded Binder or Leveling-Up Course)

Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/4" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 1/4" screen.

Bin No. 5 will contain aggregates of which at least 85% will be of such size as to pass the 1 1/4" screen and be retained on the 1/2" screen.

Type "C": (Coarse Graded Surface Course)

Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/4" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 1/4" screen.

Bin No. 5 will contain aggregates of which at least 85% will be of such size as to pass the 1" screen and be retained on the 1/2" screen.

Type "D": (Fine Graded Surface Course)
Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/4" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 5/8" screen and be retained on the 1/4" screen.

Type "E": (Sheet Asphalt Surface Course)
Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/4" screen and be retained on the 10-mesh sieve.

Type "F": (Non-Skid Surface Course)
Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 3/8" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 3/8" screen.

Aggregate Weigh Box. The aggregate weigh box shall be of sufficient capacity to hold a complete batch of aggregate without wasting or leveling by hand and shall be so designed that the entire batch will discharge quickly into the mixer. The weigh box shall be open at the top so that if, in charging, an excess of aggregate is introduced into the weigh box, it may be removed by the operator. The weigh box shall be provided with a close fitting and quick operating cut-off gate, so that there will be no leakage of the aggregate into the mixer, and shall be satisfactorily attached to the batching scales.

Aggregate Batching Scales. The scales used for weighing the aggregate may be either of the springless dial type or the multi-beam type. All scales shall have a tare beam for balancing and the beam scales must also be equipped with a tell-tale indicator of the springless dial type, indicating over and under weight of at least fifty (50) pounds. Scales that are not accurate to within four (4) pounds per one thousand (1000) pounds net load will not be considered satisfactory. Scales shall be satisfactorily insulated against vibration.

Asphaltic Material Bucket. The asphaltic material bucket shall be of sufficient size to hold the necessary asphaltic material for one batch. If the material is measured by weight, the bucket shall be properly attached to the asphaltic material scales hereinafter specified. If the proportioning is by volume based on weight, the measuring bucket used shall be of the over-flow type and shall meet the requirements of the Engineer. The valves at the asphaltic material bucket shall be of a quick cut-off type that do not leak.

Asphaltic Material Scales. If the Contractor elects to weigh the asphaltic material instead of proportioning by volume based on weight, the scales for weighing the material shall be of the springless dial type or multi-beam type. If of the springless dial type, they shall be arranged for quick adjustment at zero to provide for any change in tare. A pointer shall be provided to indicate the weight of the asphaltic material required for one batch. If of the multi-beam type, they shall be equipped with a tell-tale indicator of the springless dial type. Scales that are not accurate to within four (4) pounds per one thousand (1000) pounds net load will not be considered satisfactory. Scales shall be satisfactorily insulated against vibration.

Mixer. The mixer shall be of the Pug Mill type and shall have a capacity of not less than fifteen hundred (1500) pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar or other device that will distribute the asphaltic material quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the asphaltic material shall not be used. This shall be determined by mixing the standard batch for the required time, then dumping the mixture and taking samples from its different parts. This will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type.
Cold Aggregate Bin and Proportioning Device: Same as for weight-batching type of plant.

Dryer: Same as for weight-batching type of plant.

Screening and Proportioning: Same as for weight-batching type of plant.

Hot Aggregate Proportioning Device: The hot aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Asphaltic Material Spray Bar: The asphaltic material spray bar shall be so designed that the asphalt will spray uniformly and continuously into the mixer.

Asphaltic Material Meter: An accurate asphaltic material meter shall be placed in the asphalt line leading to the spray bar so that the amount of asphalt being used can be accurately determined.

Mixer: The mixer shall be of the pug mill continuous type and shall have a capacity of not less than forty (40) tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used. This shall be determined by taking samples from different parts of a truck load and testing by the extraction test. These tests must show that the load is uniform throughout.

Truck Scales: A set of standard platform truck scales shall be placed at a location approved by the Engineer. Scales shall be accurate to within four (4) pounds per one thousand (1000) pounds total load. The truck scales shall have a rated capacity of not less than five thousand (5000) pounds more than the total load to be weighed. A weather-tight building of sufficient size to house the checker while operating the scales shall be provided.

(2) Asphaltic Material Heating Equipment.
Asphaltic material heating equipment shall be adequate to heat the amount of asphaltic material required to the desired temperature. Asphaltic material may be heated by steam coils which shall be absolutely tight. Direct fire heating of asphaltic materials will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the asphalt throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the asphaltic material where it is at the highest temperature.

(3) Spreading and Finishing Machine.
The spreading and finishing machine shall be of the screeding and troweling type, or of a type approved by the Engineer and shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test.

(4) Forms.
The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(5) Motor Grader.

The motor grader, if used, shall be self-propelled power motor grader; it shall be equipped with pneumatic tired wheels; shall have a blade length of not less than twelve (12) feet; shall have a wheel base of not less than sixteen (16) feet; and shall be tight and in good operating condition and approved by the Engineer.

(6) Pneumatic Tire Rollers.

The pneumatic roller shall be an acceptable roller consisting of pneumatic tired wheels, the weight capable of being varied uniformly from 100 pounds to 325 pounds per inch of width of tire tread. The roller shall be drawn by suitable pneumatic tired equipment.

(7) Two Axle Tandem Roller.

This roller shall be an acceptable power driven tandem roller weighing not less than eight (8) tons.

(8) Three Wheel Roller.

This roller shall be an acceptable power driven three wheel roller weighing not less than ten (10) tons.

(9) Three Axle Tandem Roller.

This roller shall be an acceptable power driven three axle roller weighing not less than ten (10) tons.

(10) Straight Edges and Templates.

The Contractor shall provide acceptable sixteen (16) foot straight edges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(11) Laboratory.

The Contractor shall provide, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and inspecting force. It shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored and roofed weathertight, containing not less than two windows, two doors and a work bench three (3) feet wide and six (6) feet long. The building shall be so located that the details of the plant are in full view and plainly visible from at least one window of the same.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-317.5. STORAGE, PROPORTIONS AND MIXING.

(1) Aggregate Storage.

If the mineral aggregates are stored or stock-piled, they shall be handled in such a manner as to prevent segregation, the mixing of the various materials or sizes, and the contamination with foreign materials.

(2) Storage and Heating of Asphaltic Material.

The asphaltic material storage shall be ample to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of 400°F. All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such manner that there will be no contamination with foreign matter.

(3) Feeding and Drying of Aggregate.

The feeding of various sizes of aggregate to the dryer shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature.

(4) Proportioning.

The proportioning of the various material entering into the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weigh-batch type of plant is used and by volume using the hot aggregate proportioning device when the continuous mixer type of plant is used. The asphaltic material shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) Mixing.

(a) Batch Type Mixer. In the charging of the weigh box and in the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of five (5) to twenty (20) seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than thirty (30) seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

(b) Continuous Type Mixer. The amount of aggregate and asphaltic material entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and asphalt content will be produced.

(c) The mixture produced from each type of mixer shall not vary from the specified mixture by more than the tolerances herein specified.

(d) The asphaltic mixture shall be at a temperature between 200°F. and 350°F. when dumped from the mixer. The Engineer will determine the lowest temperature, within the above limitations, at which the material can be satisfactorily dried, mixed, transported, spread, and compacted, and the mixture furnished by the Contractor shall be between this temperature and one 30°F. above.

S-317.6. CONSTRUCTION METHODS.

The asphaltic mixture, tack coat, or prime coat, shall be placed only when the weather conditions, in the opinion of the Engineer, are suitable.

(1) Prime Coat.

If a prime coat is required, it will be applied and paid for as a separate item. The tack coat or asphaltic concrete shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat.

Before the asphaltic mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat meeting the requirements for tack coat under asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate of not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat.

(3) Transporting Asphaltic Concrete.

The asphaltic mixture, prepared as specified above, shall be hauled to the work in tight vehicles previously cleaned of all foreign material. The dispatching of the vehicles shall be arranged so that all material delivered may be placed, and shall have received its initial rolling in daylight. In cool weather or for long hauls, canvas covers and insulating of the truck bodies may be required. The inside of the truck body may be given a light coating of oil, if necessary, to prevent mixture from adhering to the body.

(4) Placing

(a) Generally the asphaltic mixture shall be dumped and spread on the approved prepared surface with the specified spreading and finishing machine in such manner that when properly compacted the finished pavement will be smooth, of uniform density and will meet the requirements of the typical cross sections and the surface tests.

(b) In placing a level-up course with the spreading and finishing machine in the forms, binder twine or cord, shall be set to line and grade established by the Engineer. When directed by the Engineer, level-up courses shall be spread with the specified motor grader.

(c) When the asphaltic mixture is placed in a narrow strip along the edge of an existing pavement, or used to level up small areas of an existing pavement or placed in small irregular

areas where the use of a finishing machine is not practical, the finishing machine may be eliminated when authorized by the Engineer, provided a satisfactory surface can be obtained by other approved methods.

(d) Flush Structures. Adjacent to flush curbs, gutters, liners, and structures, the surface shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb and flush structure.

(5) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the pneumatic roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller and at least one three wheel roller as specified above shall be provided for each job. If the Contractor elects he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller; but in no case shall less than two rollers be in use on each job. Additional three wheel rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease, cinders, or other foreign matter on the pavement, either when the rollers are in operation or when standing.

(c) Hand Tamping. The edges of the pavement along curbs, headers, and similar structures, and all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(6) Surface Tests.

The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross-section, and when tested with a 16' straight edge placed parallel to the center line of the roadway, it shall have no deviation in excess of 1/16" per foot from the nearest point of contact. The maximum ordinate measured from the face of the straight edge shall not exceed 1/4" at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(7) Opening to Traffic.

The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

S-317.7. MEASUREMENT.

(1) Asphaltic concrete will be measured separately by the ton of two thousand (2000) pounds of "ASPHALT" and "AGGREGATE" of the type and grade actually used in the completed and accepted work in accordance with the plans and specifications for the project. Measurement, if mixing is done by a continuous mixer, will be made on truck scales. Measurement, if batched by weight, may be made on the batch scales and records of the number of batches, batch designs and weight of "ASPHALT" and "AGGREGATE" shall be kept.

(2) Tack Coat will be measured in gallons at the applied temperature at point of application on the road.

(3) Prime Coat, when required, will be measured in gallons at the applied temperature at point of application on the road and shall comply with the requirements of the Item "Prime Coat".

S-317.8. PAYMENT.

(1) The work performed and materials furnished as prescribed by this item, and measured as provided under "Measurement", will be paid for at the unit prices bid for "Asphalt" and "Aggregate", of the type ~~and grade~~ specified, which prices shall be full compensation for quarrying, furnishing all materials, freight involved, for all heating, mixing, hauling, cleaning the existing base course or pavement, placing asphaltic concrete mixture, rolling and furnishing, and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work except tack coat and prime coat when required.

(2) The tack coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", ~~of the type and grade specified~~, which price shall be full compensation for furnishing, freight involved, preparing, hauling, and placing the asphaltic materials of the grade used and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work.

(3) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item "Prime Coat".

(4) All templates, straightedges, scales, and other weighing and measuring devices necessary for the proper construction, measuring, and checking of the work shall be furnished, operated, and maintained by the Contractor at his expense.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-319

HOT MIX-COLD LAID ASPHALTIC CONCRETE PAVEMENT

S-319.1. DESCRIPTION. This item shall consist of a base course, a leveling-up course, a surface course or any combination of these courses as shown on the plans, each to be composed of a compacted mixture of mineral aggregate and asphaltic material. It is the intent of this specification to produce a mixture which, when designed and tested in accordance with these specifications and methods outlined in T.H.D. Bulletin C-14, shall have the following laboratory density and stability.

Density %			Stability (%)
Min.	Max.	Optimum	Not less than 35 except when otherwise shown on plans.
93	96	95	

If the mixture produced does not have the specified qualtities, it shall be changed until it does. The pavement shall be constructed on the previously completed and approved subgrade, base or in the case of a bridge, on the prepared floor slab, as herein specified and in accordance with the details shown on the plans.

S-319.2. MATERIALS.

(1) Mineral Aggregate.

The mineral aggregate shall be composed of a coarse aggregate and a fine aggregate. Samples of coarse aggregate and fine aggregate shall be submitted in accordance with the methods prescribed in Item 6 of the Standard Specifications, and approval of both material and of the source of supply must be obtained from the Engineer prior to delivery.

(a) Coarse Aggregate.

The Coarse aggregate shall be that part of the aggregate retained on a No. 10 mesh sieve; shall consist of clean, tough, durable fragments of stone, or gravel, as hereinafter specified, of uniform quality throughout, it shall be practically free from clay, organic or other injurious matter occurring either free or as a coating on the aggregate. Material removed by decantation (T.H.D. Bulletin C-11) shall not be more than 2% except when the plasticity index of the removed material is less than 6, the amount may be as much as 4%. The coarse aggregate shall have an abrasion of not more than forty (40) when subjected to the Los Angeles Abrasion Test (A.A.S.H.O. T-96) for all types except Type "FF" and "FFF" (Non-skid Surface Course), which shall have an abrasion of not more than thirty-five (35) when subjected to the same test. If gravel is used for Type "FF" and "FFF", it shall be so crushed that ninety (90) per cent of the particles shall have more than one crushed face.

(b) Fine Aggregate.

The fine aggregate shall be that part of the aggregate passing the No. 10 mesh sieve and shall consist of sand or stone screenings or a combination of sand and stone screenings. Sand shall be composed of durable stone particles free from injurious foreign matter. Screenings shall be of the same or similar material as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6.

(c) Mineral Filler.

The mineral filler shall consist of thoroughly dry stone dust, slate dust, Portland cement, or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter. When tested by standard laboratory methods, it shall meet the following grading requirements:

Passing a 30 mesh sieve	100%
Passing a 200 mesh sieve, not less than	65%

(2) Asphaltic Material.

(a) Paving Mixture.

Asphalt for the paving mixture shall be of the types of Oil Asphalt as determined by the Engineer and shall meet the requirements of the Item "Asphalts, Oils, and Emulsions". The grade of asphalt used shall be as designated by the Engineer after design tests have been made using the mineral aggregates that are to be used in the project, and the various grades of asphalt. If more than one type of asphaltic concrete mixture is specified for the project, only one grade of asphalt will be required for all types of mixtures, unless otherwise shown on plans.

(b) Tack Coat.

The asphalt material for Tack Coat shall meet the requirements for Emulsified Asphalt, EA-11M, or Cut Back Asphalt RC-2, or shall be a cut-back asphalt made by combining fifty to seventy (50-70) per cent of the asphaltic material as specified for the type of paving mixture with thirty to fifty (30-50) percent of gasoline and/or kerosene; or if RC-2 Cut-back asphalt is used, it may, upon instructions from the Engineer, be diluted by the addition of not to exceed fifteen (15) percent of an approved grade of gasoline and/or kerosene, by volume; and the asphaltic materials shall meet the requirements of the Item "Asphalts, Oils, and Emulsions".

S-319.3. PAVING MIXTURES.

(1) Types.

The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate and asphaltic material. The grading of each constituent of the mineral aggregate shall be such as to produce, when properly proportioned, a mixture, which, when tested in accordance with Bulletin C-14, will conform to the limitations for master grading given below for the type specified. The exact grading of the aggregate and the asphalt content to be used in these mixtures, within the limits specified, will be designated by the Engineer and the mixture produced shall be uniform.

Type "AA": (Coarse Graded Binder Course)

Passing 2 1/4" screen	100%
Passing 2" screen	97 to 100%
Passing 2" screen, retained on 1" screen	15 to 40%
Passing 1" screen, retained on 1/2" screen	12 to 40%
Passing 1/2" screen, retained on 1/4" screen	10 to 25%
Passing 1/4" screen, retained on 10 mesh sieve	5 to 20%
Total retained on 10 mesh sieve	65 to 80%
Passing 10-mesh sieve, retained on 40 mesh sieve	0 to 20%
Passing 40-mesh sieve, retained on 80 mesh sieve	3 to 15%
Passing 80 mesh sieve, retained on 200 mesh sieve	3 to 15%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 3 to 6% of the mixture by weight.

Type "BB": (Fine Graded Binder or Leveling-up Course)

Passing 1 1/4" screen	100%
Passing 1" screen	97 to 100%
Passing 1" screen, retained on 1/2" screen	20 to 50%
Passing 1/2" screen, retained on 1/4" screen	10 to 40%
Passing 1/4" screen, retained on 10 mesh sieve	5 to 25%
Total retained on 10 mesh sieve	50 to 70%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 30%
Passing 40 mesh sieve, retained on 80 mesh sieve	4 to 20%
Passing 80 mesh sieve, retained on 200 mesh sieve	4 to 20%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 3.5 to 7% of the mixture by weight.

Type "CC": (Coarse Graded Surface Course)

Passing 1" screen	100%
Passing 3/4" screen	97 to 100%
Passing 3/4" screen, retained on 1/2" screen	15 to 40%
Passing 1/2" screen, retained on 1/4" screen	15 to 40%
Passing 1/4" screen, retained on 10 mesh sieve	10 to 30%
Total retained on 10 mesh sieve	50 to 65%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 30%
Passing 40 mesh sieve, retained on 80 mesh sieve	4 to 25%
Passing 80 mesh sieve, retained on 200 mesh sieve	4 to 25%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 3.5 to 7% of the mixture by weight.

Type "DD": (Fine Graded Surface Course)

Passing 5/8" screen	100%
Passing 1/2" screen	97 to 100%
Passing 1/2" screen, retained on 1/4" screen	20 to 50%
Passing 1/4" screen, retained on 10 mesh sieve	15 to 35%
Total retained on 10 mesh sieve	50 to 60%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 30%
Passing 40 mesh sieve, retained on 80 mesh sieve	4 to 25%
Passing 80 mesh sieve, retained on 200 mesh sieve	4 to 25%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 4.0 to 7.5% of the mixture by weight.

Type "DDD": (Fine Graded Surface Course)

Passing 1/2" screen	100%
Passing 3/8" screen	70 to 100%
Passing 3/8" screen, retained on 1/4" screen	5 to 30%
Passing 1/4" screen, retained on 10 mesh sieve	20 to 50%
Total retained on 10 mesh sieve	40 to 55%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 30%
Passing 40 mesh sieve, retained on 80 mesh sieve	4 to 30%
Passing 80 mesh sieve, retained on 200 mesh sieve	4 to 30%
Passing 200 mesh sieve	1 to 10%

The asphaltic material shall form from 4 to 7.5% of the mixture by weight.

Type "FF": (Non-skid Surface Course)

Passing 5/8" screen	100%
Passing 1/2" screen	97 to 100%
Passing 1/2" screen, retained on 1/4" screen	10 to 35%
Passing 1/4" screen, retained on 10 mesh sieve	20 to 50%
Total retained on 10 mesh sieve	60 to 75%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 25%
Passing 40 mesh sieve, retained on 80 mesh sieve	3 to 12%
Passing 80 mesh sieve, retained on 200 mesh sieve	3 to 10%
Passing 200 mesh sieve	1 to 8%

The asphaltic material shall form from 3.5 to 5.5% of the mixture by weight.

Type "FFF": (Non-skid Surface Course)

Passing 1/2" screen	100%
Passing 3/8" screen	97 to 100%
Passing 3/8" screen, retained on 10 mesh sieve	60 to 75%
Passing 10 mesh sieve, retained on 40 mesh sieve	0 to 25%
Passing 40 mesh sieve, retained on 80 mesh sieve	3 to 12%
Passing 80 mesh sieve, retained on 200 mesh sieve	3 to 10%
Passing 200 mesh sieve	1 to 8%

The asphaltic material shall form from 3.5 to 5.5% of the mixture by weight.

(2) Primer.

The use of an asphalt primer when approved by the Engineer will be permitted. In the event the asphalt primer is used the hydrocarbon volatile content of the asphaltic concrete shall not exceed six-tenths (0.6) of one per cent of the mixture by weight. The asphalt content of the primer shall be included in the total asphalt content of the paving mixture.

(3) Water.

Water in an amount not to exceed three (3) per cent of the mixture by weight may be used in preparing the mixture.

The primer and/or water shall be added as directed by the Engineer during the mixing.

(4) Central Mixing Plants.

The materials may be mixed on the job or at some central mixing plant and shipped ready for use. Mixtures that do not remain workable a sufficient period fo time to permit proper spreading, blading and rolling will not be acceptable.

The type and amount of the mixture used shall be as specified on the plans.

(5) Extraction Test.

When required by the Engineer, samples of the mixture may be taken from trucks, and when tested by the Extraction Test, T.H.D. Bulletin C-14, it shall not vary from the grading proportions of the aggregate specified by the Engineer by more than five (5) percent in any particular. The percentage of asphalt shall not vary more than 0.4 of one percent from the proportions established by the Engineer.

(6) Mixing plants that will not continuously produce a mixture meeting all of the above requirements will be condemned and shall be removed from the job.

S-319.4. EQUIPMENT.

(1) Mixing Plants.

Mixing Plants may be either the Weight-batching Type or the Continuous Mixing Type. (See Article 5 also.) Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins, dust collectors, and shall consist of the following essential pieces of equipment.

(a) Weight-batching Type.

Cold Aggregate Bin and Proportioning Device. The cold aggregate bin shall have at least three compartments and shall be of sufficient size to store the amount of aggregate required to keep the plant in continuous operation. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each fine aggregate shall be proportioned in a separate compartment.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that the aggregate will not be injured in drying and heating it to the temperature necessary to secure a mixture of the specified temperature. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. The bin shall be divided into at least five compartments when producing Type "AA", Type "BB", and Type "CC" mixtures and at least four compartments when producing the other types of mixtures. These bins shall contain the following sizes of aggregates:

Type "AA": (Coarse Graded Binder Course)

Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1" screen and be retained on the 1/2" screen.

Bin No. 5 will contain aggregates of which at least 85% will be of such size as to pass the 2 1/4" screen and be retained on the 1" screen.

Type "BB": (Fine Graded Binder or Leveling-up Course)

Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/4" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 1/4" screen.

Bin No. 5 will contain aggregates of which at least 85% will be of such size as to pass the 1 1/4" screen and be retained on the 1/2" screen.

Type "CC": (Coarse Graded Surface Course)
Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/4" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 1/4" screen.

Bin No. 5 will contain aggregates of which at least 85% will be of such size as to pass the 1" screen and be retained on the 1/2" screen.

Type "DD" and "DDD": (Fine Graded Surface Course)
Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 1/4" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 5/8" screen and be retained on the 1/4" screen.

Type "FF" and "FFF": (Non-Skid Course)
Bin No. 1 will contain the mineral filler.

Bin No. 2 will contain aggregates 90 to 100% of which will pass the 10-mesh sieve.

Bin No. 3 will contain aggregates of which at least 85% will be of such size as to pass the 3/8" screen and be retained on the 10-mesh sieve.

Bin No. 4 will contain aggregates of which at least 85% will be of such size as to pass the 1/2" screen and be retained on the 3/8" screen.

Aggregate Weigh Box. The aggregate weigh box shall be of sufficient capacity to hold a complete batch of aggregate without wasting or leveling by hand and shall be so designed that the entire batch will discharge quickly into the mixer. The weigh box shall be open at the top so that if, in charging, an excess of aggregate is introduced into the weigh box, it may be removed by the operator. The weigh box shall be provided with a close fitting and quick operating cut-off gate, so that there will be no leakage of the aggregate into the mixer, and shall be satisfactorily attached to the batching scales.

Aggregate Batching Scales. The scales used for weighing the aggregate may be either of the springless dial type or the multi-beam type. All scales shall have a tare beam for balancing and the beam scales must also be equipped with a tell-tale indicator of the springless dial type, indicating over and under weight of at least fifty (50) pounds. Scales that are not accurate to within four (4) pounds per one thousand (1000) pounds net load will not be considered satisfactory. Scales shall be satisfactorily insulated against vibration.

Asphaltic Material Bucket. The asphaltic material bucket shall be of sufficient size to hold the necessary asphaltic material for one batch. If the material is measured by weight, the bucket shall be properly attached to the asphaltic material scales hereinafter specified. If the proportioning is by volume based on weight, the measuring bucket used shall be of the over-flow type and shall meet the requirements of the Engineer. The valves at the asphaltic material bucket shall be of a quick cut-off type that do not leak.

Asphaltic Material Scales. If the Contractor elects to weigh the asphaltic material instead or proportioning by volume based on weight, the scales for weighing the material shall be of the springless dial type or multi-beam type. If of the springless dial type, they shall be arranged for quick adjustment at zero to provide for any change in tare. A pointer shall be provided to indicate the weight of the asphaltic material required for one batch. If of the multi-beam type, they shall be equipped with a tell-tale indicator of the springless dial type. Scales that are not accu-

rate to within four (4) pounds per one thousand (1000) pounds net load will not be considered satisfactory. Scales shall be satisfactorily insulated against vibration.

Mixer. The mixer shall be of the Pug Mill type and shall have a capacity of not less than fifteen hundred (1500) pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar or other device that will distribute the asphaltic material quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the asphaltic material shall not be used. This shall be determined by mixing the standard batch for the required time, then dumping the mixture and taking samples from different parts of it. This will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type.
Cold Aggregate Bin and Proportioning Device. Same as for weight-batching type of plant.

Dryer. Same as for weight-batching type of plant.

Screening and Proportioning. Same as for weight-batching type of plant.

Hot Aggregate Proportioning Device. The hot aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Asphaltic Material Spray Bar. The asphaltic material spray bar shall be so designed that the asphalt will spray uniformly and continuously into the mixer.

Asphaltic Material Meter. An accurate asphaltic material meter shall be placed in the asphalt line leading to the spray bar so that the amount of asphalt being used can be accurately determined.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than forty (40) tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used. This shall be determined by taking samples from different parts of a truck load and testing by the extraction test. These tests must show that the load is uniform throughout.

Truck Scales. A set of standard platform truck scales shall be placed at a location approved by the Engineer. Scales shall be accurate to within four (4) pounds per one thousand (1000) pounds total load. The truck scales shall have a rated capacity of not less than five thousand (5000) pounds more than the total load to be weighed. A weather-tight building of sufficient size to house the checker while operating the scales shall be provided.

(2) Asphaltic Material Heating Equipment.
Asphaltic Material heating equipment shall be adequate to heat the amount of asphaltic material required to the desired temperature. Asphaltic material may be heated by steam coils which shall be absolutely tight. Direct fire heating of asphaltic materials will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the asphalt throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the asphaltic material where it is at the highest temperature.

(3) Spreading and Finishing Machine.
The spreading and finishing machine, if permitted by the Engineer, shall be of the screeding and troweling type, or of a type approved by the Engineer and shall be capable of producing a surface that will meet the requirements of the typical cross section and the surface test.

(4) Forms.
The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(5) Motor Grader.
The motor grader shall be a self-propelled power motor grader; it shall be equipped with pneumatic tired wheels; shall have a blade length of not less than twelve (12) feet; shall have a wheel base of not less than sixteen (16) feet; and shall be tight and in good operating condition and approved by the Engineer.

(6) Pneumatic Tire Rollers.
The pneumatic roller shall be an acceptable roller consisting of pneumatic tired wheels, the weight capable of being varied uniformly from 100 pounds to 325 pounds per inch of width of tire tread. The roller shall be drawn by suitable pneumatic tired equipment.

(7) Two Axle Tandem Roller.
This roller shall be an acceptable power driven tandem roller weighing not less than eight (8) tons.

(8) Three Wheel Roller.
This roller shall be an acceptable power driven three wheel roller weighing not less than ten (10) tons.

(9) Three Axle Tandem Roller.
This roller shall be an acceptable power driven three axle roller weighing not less than ten (10) tons.

(10) Straight Edges and Templates.
The Contractor shall provide acceptable sixteen (16) foot straight edges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(11) Laboratory.
The Contractor shall provide, at his entire expense, a weather-tight field laboratory building in which to house and use the testing equipment, said building being for the sole use of the Engineer and inspecting force. It shall be not less than eight (8) feet by twenty (20) feet and eight (8) feet high, floored and roofed weathertight, containing not less than two windows, two doors and a work bench three (3) feet wide and six (6) feet long. The building shall be so located that the details of the plant are in full view and plainly visible from at least one window of the same.

(12) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

S-319.5. STORAGE, PROPORTIONS AND MIXING.

(1) Aggregate Storage.
If the mineral aggregates are stored or stock-piled, they shall be handled in such a manner as to prevent segregation, the mixing of the various materials or sizes, and the contamination with foreign materials.

(2) Storage and Heating of Asphaltic Material.
The asphaltic material storage shall be ample to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of 400°F. All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such manner that there will be no contamination with foreign matter.

(3) Feeding and Drying of Aggregate.
The feeding of various sizes of aggregate to the dryer shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature.

(4) Proportioning.
The proportioning of the various material entering into the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weigh-batch type of plant is used and by volume using the hot aggregate proportioning device when the continuous mixer type of plant is used. The asphaltic material shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) Mixing.

(a) Batch Type Mixer. In the charging of the weigh box and in the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of five (5) to twenty (20) seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than thirty (30) seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

(b) Continuous Type Mixer. The amount of aggregate and asphaltic material entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and asphalt content will be produced.

(c) The mixture produced from each type of mixer shall not vary from the specified mixture by more than the tolerances herein specified.

(d) The asphaltic mixture shall be at a temperature between 145°F. and 275°F. when dumped from the mixer. The Engineer will determine the approximate temperature within the above limitations that the mixture should be produced.

S-319.6. CONSTRUCTION METHODS.

The asphaltic mixture, tack coat, or prime coat, shall be placed only when the weather conditions, in the opinion of the Engineer, are suitable.

(1) Prime Coat.

If a prime coat is required, it will be applied and paid for as a separate item. The tack coat or asphaltic concrete shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat.

Before the asphaltic mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat meeting the requirements for tack coat under asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate of not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat.

(3) Placing.

If the mixtures are shipped to the job, the railroad cars shall first be cleaned of all foreign matter, and the material shall be loaded in such a manner as to prevent segregation. The asphaltic 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 so that all material delivered may be placed and shall have received its initial rolling in daylight. The mixture shall be laid only on an approved base course or pavement which has been tack-coated as previously specified and shall be free of all foreign materials. All contact surfaces of curbs and structures and all joints shall be painted with a thin, uniform coating of cut-back or emulsified asphalt as required for tack-coating the base. The mixture shall be aerated and then spread into place with a power motor grader, in a uniform layer of such depth that after receiving ultimate compaction by rolling, the requirements of the typical cross-sections will have been fulfilled. Hand spreading will be permitted where the mixture is placed on narrow strips or small irregular areas.

If primer and water are not added to the paving mixture it may be placed with the specified spreading and finishing machine.

(4) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side. Rolling with the pneumatic roller shall be done as directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller and at least one three wheel roller as specified above shall be provided for each job. If the Contractor elects he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller; but in no case shall less than two rollers be in use on each job. Additional three wheel rollers shall be provided if needed. Rolling with pneumatic rollers will be required where satisfactory compaction cannot be secured with flat wheel rollers. The motion of the roller shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease, cinders, or other foreign matter on the pavement, either when the rollers are in operation or when standing.

(c) Hand Tamping. The edges of the pavement along curbs, headers, and similar structures, and all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(5) Surface Tests.

The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross-section, and when tested with a 16' straight edge placed parallel to the center line of the roadway, it shall have no deviation in excess of 1/16" per foot from the nearest point of contact. The maximum ordinate measured from the face of the straight edge shall not exceed 1/4" at any point. Any point in the surface not meeting these requirements shall be immediately corrected.

(6) Opening to Traffic.

The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

S-319.7. MEASUREMENT.

(1) Asphaltic concrete will be measured by the ton of two thousand (2000) pounds of the type or types actually used in the completed and accepted work, in accordance with the plans and specifications for the project. Measurement, if batched by weight, may be made on the batch scales and records of the number of batches, batch designs and weight of each truck load will be kept. Measurement, if mixing is done by a continuous mixer, or shipped to job in R.R. cars, will be made on truck scales.

(2) Tack Coat will be measured in gallons at the applied temperature at point of application on the road.

(3) Prime Coat, when required, will be measured in gallons at the applied temperature at point of application on the road and shall comply with the requirements of the Item "Prime Coat".

S-319.8. PAYMENT.

(1) The work performed and material furnished as prescribed by this item, and measured as provided under "Measurement", will be paid for at the unit prices bid for "Hot Mix-Cold Laid Asphaltic Concrete Pavement" of the types specified, which price shall be full compensation for quarrying, furnishing all materials, freight involved, for all heating, mixing, hauling, cleaning the existing base course or pavement, placing asphaltic concrete mixture, rolling and finishing, and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work, except tack coat and prime coat, when required.

(2) The tack coat, measured as provided under "Measurement", will be paid for at the unit price bid for "Tack Coat", ~~of the type and grade specified~~, which price shall be full compensation for furnishing, freight involved, preparing, hauling, and placing materials and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work.

(3) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item "Prime Coat".

(4) All templates, straight edges, scales and other weighing and measuring devices necessary for the proper construction, measuring and checking of the work shall be furnished, operated, and maintained by the Contractor at his expense.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-320

CONCRETE PAVEMENT
(Water Cement Ratio)

S-320.1. DESCRIPTION. This item shall consist of a pavement and/or base of Portland cement concrete, with or without reinforcement as shown on plans, with or without monolithic curbs, constructed as herein specified on the prepared subgrade or other base course in conformity with the thickness and typical cross sections shown on plans and to the lines and grades established by the Engineer. Concrete shall be considered of satisfactory quality provided it is made (a) of materials accepted for the job, (b) in the proportions established by the Engineer, and (c) mixed, placed, finished and cured in accordance with the requirements of this specification and meets the requirements herein specified.

S-320.2. MATERIALS.

(1) Cement. The cement shall be either Type I or Type III of a standard brand of Portland Cement which shall conform to A.S.T.M. Serial Designation C-150. Type I Cement may be used except when the use of Type III Cement is required by plans. The Contractor, if he so elects in order to facilitate his own operations, may use Type III Cement in portions of the work other than where its use is required by plans, and when Type III Cement is used either as required by plans or as an option to Type I Cement, the average tensile strength of briquettes at the age of twenty-eight (28) days shall be higher than that attained at three (3) days.

The Contractor shall furnish to the Engineer with each shipment a statement as to the specific surface of the cement, expressed in square centimeters per gram.

Bulk or sacked cement may be used, and a bag shall contain 94 pounds net. All bags shall be in good condition at the time of inspection. Bags varying more than 5% from the specified weight may be rejected and if the average net weight in any shipment as shown by weighing 50 bags taken at random is less than that specified, the entire shipment may be rejected. Bulk cement shall be weighed on approved scales as herein prescribed.

Any cement which has become partially set or which contains hard lumps or cakes, or cement salvaged from discarded or used bags, shall not be used.

Any cement storage shall be a suitable weather-tight building which will protect the cement from dampness, and cement shall be so placed as to provide easy access for proper inspection and identification of each shipment.

(2) Coarse Aggregate. Coarse aggregate shall consist of durable particles of gravel and/or crushed stone of reasonably uniform quality throughout, free from injurious amounts of salt, alkali, vegetable matter or other objectionable material, either free or as an adherent coating on the aggregate. It shall not contain more than 0.25% by weight of clay lumps, nor more than 1.0% by weight of shale nor more than 5.0% by weight of laminated and/or friable particles.

Coarse aggregate shall have a wear of not more than 45% when tested according to AASHO Method T-96, and when tested by standard laboratory methods shall meet the following grading requirements:

Retained on 3" Screen	0%
Retained on 2" Screen	0 to 20%
Retained on 1/4" Screen	95 to 100%
Loss by Decantation (THD Bulletin C-11)	1.0% Maximum

Where the coarse aggregate is delivered on the job in two or more sizes or types, each type and/or size shall be batched and weighed separately.

All aggregates shall be handled and stored in such a manner as to prevent size segregation and contamination by foreign substances. When segregation is apparent, the aggregate shall be remixed. At the time of its use, the aggregate shall be free from frozen material, and aggregate containing foreign materials shall be rejected. Coarse aggregate that contains more than 0.5% free moisture by weight shall be stock-piled for at least 24 hours prior to use.

(3) Fine Aggregate. Fine aggregate shall consist of sand or a combination of sands, and shall be composed of clean, hard, durable, uncoated grains.

Fine Aggregate Exclusive of Mineral Filler: Fine aggregate shall be free from injurious amounts of salt, alkali or vegetable matter. It shall not contain more than 0.5% by weight of clay lumps. When subjected to the color test for organic impurities (A.S.T.M. Designation C-40), the fine aggregate shall not show a color darker than the standard.

When the fine aggregate is mixed with Type III Cement in the proportion of 1:3, the average tensile strength of not less than three standard mortar briquettes at the age of three days shall be equal to or greater than the strength of Ottowa sand mortar briquettes of the same proportions and consistency when tested at the age of three days.

Fine aggregate when tested by standard laboratory methods shall meet the following grading requirements:

Retained on 3/8" Screen	0%
Retained on 1/4" Screen	0 to 5%
Retained on 20 Mesh Sieve	15 to 50%
Retained on 100 Mesh Sieve	85 to 100%

Material removed by decantation (THD Bulletin C-11) shall not exceed 3.0% by weight. An additional 2.0% loss by decantation will be allowed provided the additional material removed by this test is of the same quality as that specified for fine aggregate or for mineral filler.

Mineral Filler. Mineral Filler shall consist of clean stone dust, crushed sand, crushed shall or other approved inert material. When tested by standard laboratory methods it shall meet the following requirements:

Retained on 30 Mesh Sieve	0%
Retained on 200 Mesh Sieve	0 to 35%

Where fine aggregate is delivered to the job in two or more sizes or types, each type and/or size of material shall be batched and weighed separately. Where mineral filler is used, it shall be batched and weighed separately. At the time of its use the fine aggregate shall be free from frozen material, and aggregate containing foreign material shall be rejected. All fine aggregate shall be stockpiled for at least 24 hours prior to use.

(4) Water. Water shall be reasonably clean and free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances. Water suitable for drinking may be accepted for use without being tested. If in the opinion of the Engineer, the water is of questionable quality, it shall be tested in accordance with A.A.S.H.O. Method T-26.

(5) Asphalt. The bituminous material for sealing joints, when required, shall be of the type and grade shown on plans and shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

(6) Traffic Stripe Pigment. The traffic stripe pigment when used shall be the crystalline pigment known as black magnetic oxide of iron or Ferroso-Ferric Oxide made by a process of chemical precipitation so as to form a pigment of uniformly small particle size. The standard for color comparison shall be the magnetic oxide of iron known commerically as Raven Black, manufactured by the Geo. S. Mephan Corp., East St. Louis, Illinois. The mass tone and tinting strength shall be equal to the standard in black intensity and blue tone when compared by the THD standard method.

Specific gravity of the pigment shall not be less than 4.68; not more than 2.0% shall be retained on a 325 mesh sieve by the water washing method; and the material shall meet the THD test for solubility.

(7) Joint Filler. Boards for expansion joint filler and for contraction and longitudinal joints shall be of the size, shape and type indicated on the plans.

Boards shall be obtained from Redwood, Cypress, Gum, Southern Yellow Pine or Douglas Fir Timber. They shall be sound heartwood and shall be free from sapwood, knots, clustered birdseye, checks and splits. Occasional sound or hollow birdseye, when not in clusters, will be permitted provided the board is free from any other defects that will impair its usefulness as a joint filler. With the exception of Redwood and Cypress, all boards shall have a creosote or pentachlorphenol treatment of six (6) pounds per cubic foot. When oven dried at 230°F. to a constant weight, the weight of the board per cubic foot (minus creosote) shall not be less than twenty (20) pounds nor more than thirty-five (35) pounds.

(8) Load Transmission Devices for Expansion and Contraction Joints. Approved load transmission devices, if used in accordance with provisions of project plans and specifications shall meet the requirements specified herein.

(a) Cantilever Type.

Load transmission devices of the cantilever type shall be of cast malleable iron or cast steel of the type and size shown on plans, and shall be "Star-Lug Load Transmission Unit" or equal.

The castings forming each of the two sections of the load transmission devices shall be manufactured of malleable iron meeting the requirements of the Standard Specifications for Malleable Iron Castings, A.S.T.M. Designation A 47-33, Grade 35018, or cast steel meeting the requirements of the Standard Specifications for Cast Steel Castings, A.S.T.M. Designation A 27-39, Grade A-1.

Each load transmission device shall be a unit consisting of two identical castings providing a cantilever arm on which the other half of the unit shall bear, and each casting shall have an upper tension anchor and a lower compression anchor, all constructed in accordance with the general dimensions shown on the plans. The castings shall be cleaned and ground as necessary in order that each may be in conformity with the required dimensions and shall assemble into a complete unit providing coincidence of bearing on both the vertical and horizontal sliding faces. The castings shall be sufficiently smooth that there will be no interference with smooth sliding operation.

Load transmission devices installed at expansion joints shall have blocks of a compressible material such as fibre or a soft wood of proper dimension to fill the space at the end of the cantilever arm created by the assembly of the unit in an extended position. Each unit for installation in either an expansion joint or a contraction joint shall be assembled with a thin lubricating pad between the two castings comprising the unit. This pad, of paper or similar material, shall be thoroughly lubricated before placing in the unit assembly. The load transmission device shall be assembled into a complete unit, including compression blocks as required, and the entire assembly firmly held in position by means of wires, sheet metal holders and wires, or similar devices.

(b) Steel Dowel Bars. Steel bar dowels, if used in accordance with provisions of project plans, shall be of the size and type indicated on plans and shall be open hearth, new billet steel of intermediate or hard grade conforming to requirements specified therefor under Article 2(10) of this specification item. The free end of dowel bars shall be smooth and free of shearing burs.

When required by plans, one end of each dowel bar shall be encased in an approved cap having an inside diameter of one-sixteenth (1/16) inch greater than the diameter of the dowel bar. The cap shall be of such strength, durability and design as to provide free movement of the dowel bar and shall be approved by the Engineer prior to use. One end of the cap shall be filled with a soft felt plug or shall be void in order to permit free movement of the dowel bar for a distance equivalent to one hundred and fifty (150) per cent of the width of the expansion joint used. The dowel caps and dowel bars shall be held securely in place by bar ties as shown on plans, or an approved equivalent thereof.

Where red lead and oil bar coating is required by plans, the red lead may be of any standard commercial grade and the oil shall be clean and no lighter than Standard No. 30 S. A. E. grade. Approved thinner and dryer may be added to the red lead, but the material upon application shall be of such consistency that will provide a uniform and heavy coating on the bar. Where asphalt bar coating is required by plans, the material may be any standard grade of oil and shall be applied hot. Cut-back asphalt will not be permitted for bar coating.

(9) Metal Installing Devices for Joint Assembly. Metal installing devices for expansion and contraction joint assemblies (such as welded wire bar chairs, bar stakes, end marker channels, channel caps, etc.) shall be as shown on plans or may be similar devices of equivalent or greater strength, approved by the Engineer, that will secure the joint assembly in correct position during the placing and finishing of concrete. Load Transmission Units used in joint assemblies shall be secured in position by a transverse metal brace of the type and design shown on plans, or may be secured by other approved devices of equivalent or greater strength that will provide positive mechanical connection between the brace and each unit (other than by wire tie) and prevent transverse movement of each load transmission unit.

(10) Steel Bar Reinforcement. Steel reinforcing bars as required, including Tie Bars, shall be of the type and size as shown on plans and shall be open hearth new billet steel of structural, intermediate, or hard grade, or shall be rail steel concrete reinforcement bars. All steel shall be bent cold. When tie bars are to be bent, they shall be of structural or intermediate grade.

New Billet steel shall conform to the requirements of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars, A.S.T.M. Designation A-15.

Rail steel shall conform to the requirements of the Standard Specifications for Rail-Steel Concrete Reinforcement Bars, A.S.T.M. Designation A-16, (Bars produced by the piling method will not be accepted).

When deformed bars are specified, the form of the bar shall be such as to provide a net sectional area at all points equivalent to that of a plain square or round bar of equal nominal size.

When fabricated steel bar or rod mats are specified, the mats shall meet the current requirements of specifications for "Fabricated Steel Bar or rod Mats for Concrete Reinforcement", Serial Designation A-184 of the A.S.T.M.

When Steel Wire Fabric Reinforcement is permitted, the wire fabric shall be of the gauge and spacing shown on the plans and shall conform to the requirements of the Standard Specifications for Cold-Drawn Wire for Concrete Reinforcement, A.S.T.M. Designation A-82. Longitudinal and transverse wires shall be electrically welded together at all points of intersection and the welds shall be of sufficient strength that they will not be broken during handling or placing. All welding and fabrication of the fabric sheets shall conform to the requirements of the Standard Specifications for Welded Steel Wire Fabric for Concrete Reinforcement, A.S.T.M. Designation A 185-37. Welded Steel Wire Fabric shall be furnished in sheets as per plan dimensions, and steel having been previously bundled into rolls will not be accepted. If wire fabric is used, it will replace only the longitudinal and transverse bars. The tie bars and load transmission units at joints will not be affected.

In cases where the provisions of this item are in conflict with the provisions of the A.S.T.M. Designations to which reference is made, the provisions of this item shall govern.

The nominal size, area and the theoretical weight of steel reinforcing bars covered by this specification are as follows:

(NOTE: Wherever bars of a given diameter or size are specified herein or shown on the plans, bars other than round or square but providing an equivalent nominal area and weight will be considered acceptable unless otherwise specifically noted on plans).

Size	Nominal Area Sq. In.	Weight Per Linear Foot
1/4" Round	0.049	0.167
3/8" Round	0.110	0.376
1/2" Round	0.196	0.668
5/8" Round	0.307	1.043
3/4" Round	0.442	1.502
7/8" Round	0.601	2.044
1" Round	0.785	2.670
1/2" Square	0.250	0.850
1" Square	1.000	3.400
1-1/8" Square	1.266	4.303
1-1/4" Square	1.563	5.313

The weight of any lot (see note) of bars shall not vary more than 3-1/2 per cent under the theoretical weight for bars 3/8" and over in nominal size or diameter; nor more than 5 per cent under for bars under 3/8" in nominal size or diameter. The weight of any individual bar shall not vary more than 6 per cent under the theoretical weight for bars 3/8" and over in size or diameter; nor more than 10 per cent under the theoretical weight for bars under 3/8" in size or diameter. The theoretical weight of deformed bars shall be the same as the theoretical weight of plain round or square bars of the same nominal size. Bars or lots which vary more than the above limits shall be rejected.

(NOTE: The term "lot" used in the above paragraph shall mean all of the bars of the same nominal weight per linear foot in a carload or in a consignment if less than a carload).

(11) Steel Tongue-and-Groove Form for Longitudinal Joints. The trapezoidal key joint form shall conform to plan requirements and shall be made from flat hot-rolled carbon steel sheets conforming to minimum requirements of A.S.T.M. Designation A 245-42T, or an approved equivalent thereof. The gauge or thickness of the material shall be at least the minimum indicated on plans.

(12) Asphalt Board. Asphalt Board when used in accordance with plans shall be of required size and uniform thickness and, when used in transverse joints, shall conform approximately to the shape of the pavement crown as shown on plans. Asphalt Board shall consist of two liners of 0.016 asphalt impregnated Kraft filled with a mastic mixture of asphalt and vegetable fiber and/or mineral filler. Boards shall be smooth, flat and straight throughout, and shall be sufficiently rigid to permit easy installation. Boards that crack or shatter during installing and finishing operations will not be acceptable. Boards shall be furnished in lengths equal to one-half the pavement width or in lengths equal to the width between longitudinal joints, and may be furnished in strips or scored sheets of the required shape. When tested in accordance with the following method, the asphalt board shall not deflect from the horizontal more than 3/4" in 3-1/2 inches.

Test Procedure. A sample of the board, 2" wide and 6" long, flat, straight, and cut with its length parallel to the lay of the fiber, shall be clamped between two blocks in the direction of its thickness in such manner that a 3-1/2" length of the sample will extend unsupported and at right angles from a common plane of the block faces. The sample and clamp thus assembled shall be maintained at a temperature of 180°F. for two hours with the length and width of the clamped portion of the sample horizontal, after which the deflection from horizontal of the unclamped portion shall be measured immediately.

(13) Joint Sealing Compound.

(a) General Requirements. The material shall melt to the proper consistency for pouring and shall solidify on cooling to atmospheric temperatures. It shall adhere to the sides of the concrete joint or crack. The material shall not crack or break when exposed to low temperatures.

(b) Detailed Requirements. A sample of the material weighing approximately 300 grams shall be selected in such manner as to avoid inclusion of the surface layer. Of this quantity, 100 grams shall be melted slowly, with continued stirring to a pouring consistency, in a clean container using an oil bath or similar heating unit, to avoid local overheating. The remaining 200 grams shall be added in quantities of approximately 50 grams at a time to the melted material

until the entire quantity is of a sufficiently fluid consistency to be poured satisfactorily.

The melting of the total quantity of material shall be completed within sixty (60) minutes of the initial heating of the material. At no time shall the temperature exceed 450°F.

Penetration. The penetration of the material sampled and molten (as herein described) when tested with a Penetrometer according to A.S.T.M. Designation D5-25 with a grease cone (D 217-38 T) attachment, shall be as follows:

0°	-C (32°F.)	200 g. weight	60 secs.	not less than 0.28 cm.
25°	-C (77°F.)	150 g. weight	5 secs.	0.45--0.75 cm.

Flow. A portion of the molten sample shall be poured into a suitable amalgamated mold 4 cm. wide by 6 cm. long, on a bright tin panel to a uniform depth of 0.32 cm. After cooling at room temperature for two (2) hours, the mold shall be removed and the panel placed in an oven at 140°F. + or - 2° at an incline of 75 degrees for five (5) hours. The material shall not flow more than 0.5 cm. as a result of this test.

(c) Special Requirements. The joint sealing filler shall be melted in an approved oil-bath kettle with continued mechanical agitation. The oil-bath kettle shall be equipped with temperature gauges and thermostatic control. The Engineer will determine the optimum temperature for proper pouring fluidity and the Contractor shall keep the material within close range of that temperature. At no time shall the temperature exceed 450°F. and any material heated above 450°F. shall be rejected.

Test Specimen. A test specimen shall consist of two (2) cement mortar pieces, approximately one (1) by two (2) by three (3) inches (1"x2"x3") made of a cement mortar, consisting of one (1) part by weight of Portland Cement to two (2) parts by weight of clean, uniformly graded sand, 100 per cent passing a number four (4) sieve and zero (0) to five (5) passing a number one hundred (100) sieve. The cement mortar mix shall be made to a consistency of 50 (+ or -5) as measured by the Standard A.S.T.M. mortar flow table.

After having been cured for seven (7) days, the wet mortar pieces shall be resurfaced by grinding with a standard number 30 H.D. Carborundum stone on a Standard Delemeter at a pressure of fifteen (15) to twenty (20) pounds. The surfaces of the mortar pieces shall upon examination, show that the aggregate is uniformly exposed. The concrete pieces shall then be permitted to air dry at room temperature (77°F.) for twenty-four (24) hours prior to use.

The complete mortar pieces shall be spaced one (1) inch apart on a plate of amalgamated metal and shall be held apart by amalgamated metal strips spaced at such distances from the ends that a space one (1) inch by two (2) inches by two (2) inches (1"x2"x2") is formed for pouring with the joint sealing filler material to be tested. The test joint form may be held together by rubber bands or suitable clamps.

Freezing. A test specimen (as herein described) shall be allowed to cool in air at room temperature for two (2) hours, thereafter, placed in a refrigerating unit being maintained at 15°F. (+ or - 2°) for a minimum of six (6) hours.

Bond and Extension While Frozen. The specimen while at a temperature of 15°F. (+ or - 2°) shall be removed from the amalgamated plate and strips and then immediately placed in the self-aligning clamps of the Extension Machine (described below) maintained at a temperature of 15°F. (+ or - 2°) in a refrigerating unit. The Extension Machine shall then extend the width of the specimen at the rate of approximately one-eighth inch per hour to a width fifty (50) per cent greater than its original poured width.

Extension Machine. The Extension Machine shall be so designed that the specimen can be expanded uniformly at the rate of approximately one-eighth inch per hour. The Extension Machine shall consist essentially of one or two screws rotated by an electric motor through suitable gear reduction units. The screw or screws shall carry a threaded moving self-aligning plate to which, and to a stationary plate, the specimen is clamped.

Compression. After having been extended to the required width, the specimen shall be removed and placed at room temperature (approximately 77°F.) for two (2) hours, thereafter compressed to its thickness before extension at the rate of one-tenth (0.1) inch per minute. During this compression, the specimen is to be maintained in a horizontal position.

The specimen is then again placed in the refrigerating unit and the extension and compression tests repeated for four (4) cycles, as described above.

There shall be no cracking of the joint sealing filler material or break in the bond between the joint sealing filler material and the mortar pieces.

S-320.3. EQUIPMENT.

(1) General. All equipment necessary for the construction of this item shall be on the project and shall have been approved by the Engineer as to condition before the Contractor will be permitted to begin construction operations on which the equipment is to be used.

(2) Field Laboratory. The Contractor shall provide, for the sole use of the Engineer, a field laboratory building not less than 8' x 16' and 8' high, or its approved equivalent. The building shall be substantially constructed and weather-tight with a wooden floor, one door, not less than three windows, and shall have a work bench constructed as directed. The building shall be so located that the scales of the batching plant and other details of the plant are plainly visible from within. Adequate facilities for curing of all concrete test specimens shall be located adjacent to the laboratory and shall be constructed and maintained by the Contractor as described in T.H.D. Bulletin C-11.

(3) Aggregate Weighing Equipment. Aggregate bins shall be substantial and tight enough to prevent leakage of aggregates.

The weigh box shall be of suitable size and tight enough to prevent leakage of aggregate. It shall be supported entirely upon the scales and shall be otherwise free. This box shall be so constructed that excess material may be readily removed. The discharge gate shall have a substantial latch holding it tightly closed while the weigh box is being filled.

The scales for weighing aggregates may be of either the horizontal beam or the springless dial type, designed as an integral unit of the batching plant, of rugged construction to withstand hard usage due to working conditions and with a maximum allowable error of 0.5% of net load and with minimum graduations not greater than 5 pounds. When beam type scales are used, provision such as "tell-tale" dial, shall be made for the purpose of indicating to the operator that the required load in the weigh box is being approached, which device shall indicate at least the last 200 pounds of load. A device on weighing beams shall indicate critical position clearly. Poises shall be designed for locking in any position and to prevent unauthorized changes. Dial type scales shall be provided with pointers to indicate full load for each aggregate, these pointers to be enclosed by the glass cover in front of the dial. The dial or "tell-tale" device shall be in full view of the operator while charging the weigh box and he shall have convenient access to all controls. The Contractor shall install in the field laboratory a satisfactory sound warning device actuated by the scales to indicate overload. The signal shall continue to operate until the overload is removed.

The scales shall be tested prior to beginning operations and at such other times as deemed necessary by the Engineer. Aggregate bins and weigh boxes shall be erected and left fully loaded over night before testing the scales.

(4) Cement Weighing Equipment. Where bulk cement is used it shall be batched by weight, and scales shall be of either the beam or springless dial type, of rugged construction, with a maximum allowable error of 0.5% of the net load and with minimum graduations not greater than 2 pounds. Provision shall be made for indicating to the operator that the required load in the weigh box or container is being approached, which device shall indicate at least the last 50 pounds of load. Dial type scales shall be provided with a pointer to indicate full load, this pointer to be enclosed by the glass cover in front of the dial. Where a closed type cement weigh box is used, the cement weighing scales shall be provided with a springless dial indicator or tare beam to indicate when the weigh box is empty. This indicator for the empty condition of the weigh box shall be in continuous operation. The weigh box shall be fitted with an approved vent, a tightly covered

inspection opening not less than 12" x 12", and the box and scales shall be maintained in a condition to meet the requirements for accuracy of weight.

(5) Mixer. The size of the paving mixer shall not be less than that of a 27-E paver, as established by the Mixer Manufacturer's Bureau of the Associated General Contractors. The mixer shall be equipped with a power controlled boom and bucket, so designed as to permit uniform distribution of the concrete on the entire subgrade. The mixer shall be operated at a drum speed not less than 16 revolutions per minute and not more than 20 revolutions per minute. Pick-up and throw-over blades in the drum of the mixer shall be replaced when worn down three-fourths of an inch or more.

The mixer shall be equipped with an approved automatic device for satisfactorily timing the mix and locking the discharging device in order to prevent the discharging of the mixer before the end of the required mixing period. This timing device shall operate a bell to signal plainly the completion of the mixing time.

Dual drum mixers will be permitted provided their operation is properly synchronized and the mixing time shall be determined exclusive of the time required to transfer concrete from the first to the second drum.

The paver shall be equipped with a water measuring device so constructed that it will measure the water within 1% of the total amount required for each batch, unless the water is to be weighed, the water measuring equipment shall include an auxiliary tank with a capacity greater than that of the measuring tank, and from which the measuring tank will be filled by gravity flow. The measuring tank shall be open to the atmosphere and shall be so placed and constructed that the water for a batch can be discharged into a calibrated tank or weighing device attached to the paver for checking the accuracy of water measurement without seriously delaying the paving operations.

(6) Hauling Equipment. Batch hauling equipment for the transportation of measured materials from the batching plant to the mixer shall be tight and so covered as to prevent excessive evaporation of moisture or any loss of material.

(7) Subgrade Planer and Templates. An approved subgrade planer shall be provided, mounted on visible rollers riding on the forms, and having adjustable cutting blades which shall trim the subgrade to the exact section shown on the plans. The planer frame shall be heavy enough to remain on the forms at all times, and shall be of such strength and rigidity that, under a test made by changing the support from the wheels to the center, it shall not develop a deflection of more than 1/8 inch. Tractive power equipment used on the subgrade to pull the planer shall not be such as to produce ruts or indentations in the subgrade.

A template for checking the contour of the subgrade shall be provided and operated by the Contractor. The template shall rest upon the side forms and shall be of such strength and rigidity that under a test made by changing the support to the center, it shall not show a deflection of more than 1/8 inch. It shall be provided with accurately adjustable rods projecting downward to the subgrade at 1-foot intervals, and these rods shall be adjusted to the required cross-section of the bottom of the slab when the template is resting upon the side forms.

(8) Forms. Side forms shall be of metal of approved cross-section. The preferred depth of the form shall be equal to the required edge thickness of the pavement. Forms with depths greater or less than the required edge thickness of the pavement will be permitted provided the difference between the form depth and the edge thickness is not greater than 1-inch, and further provided that forms of a depth less than the pavement edge are brought to the required edge thickness by securely attaching wood or metal strips of approved section to the bottom of the form.

The length of form sections shall not be less than 10 feet, and each section shall provide for staking in position with not less than 3 pins. Flexible or curved forms of wood or metal of proper radius shall be used for curves of 100 foot radius or less. Forms shall be of ample strength and shall be provided with adequate devices for secure setting so that when in place they will withstand without visible springing or settlement the impact and vibration of the finishing machine. In no case shall the base width be less than 8 inches for a form 8 inches or more in height. The forms shall be free from warps, bends, or kinks, and shall be sufficiently true to provide a

reasonably straight edge on the concrete, and the top of each form section, when tested with a straightedge, shall conform to the requirements specified for the surface of the completed pavement. Sufficient forms shall be provided for satisfactory prosecution of the work.

Outside curb forms shall be of wood or metal of a section satisfactory to the Engineer, straight, free of warp, and shall be of a depth at least equal to the depth of the curb. They shall be mounted on the paving forms and securely attached thereto and maintained in true position during the placing of the concrete. Inside curb forms, if required, shall be of approved material and of such design as to provide the curb required and shall be rigidly attached to the outside forms.

(9) Finishing Equipment. All pavement mixtures shall be finished by machine except as hereinafter provided.

The Transverse Finishing Machine shall be provided with two screeds accurately adjusted to the crown of the pavement, shall be power driven and mounted in a substantial frame equipped to ride on the forms, and shall be so designed and operated as to strike off and consolidate the concrete.

The Longitudinal Finishing Machine shall be provided with a longitudinal float not less than 10 feet in length, adjusted to a true plane, shall be power-driven and mounted in a substantial frame equipped to ride on the forms, and shall be so designed and operated as to finish the pavement to the required grade.

Finishing machines shall be maintained in a tight and good operating condition, accurately adjusted to the required crown or profile, and free from deflection, wobble, or vibration tending to affect the precision of finish. Machines failing to meet these requirements will be condemned by the Engineer, and the Contractor shall provide approved equipment.

Where hand finishing is permitted under this specification, the Contractor shall provide a strike template and a tamping template both of 4" x 10" lumber or equivalent metal section and at least 2 feet longer than the width of the pavement. Both templates shall conform to the crown section of the pavement, and the tamp, if of wood, shall have a steel face not less than 3/8 inch in thickness. The Contractor shall also provide a longitudinal float of approved design and not less than 14 feet in length.

The Contractor shall furnish a canvas or canvas-rubber composition belt for finishing the pavement, to be of 2 to 4 ply construction, not less than 6 inches nor more than 10 inches wide, and at least 2 feet longer than the width of the pavement.

The Contractor shall furnish, operate and maintain at least 2 standard 10-foot steel straightedges.

The Contractor shall furnish a sufficient number of bridges equipped to ride on the forms and span the pavement for finishing operations and for the installation and finishing of joints and center strips. All necessary finishing and edging tools shall be furnished as may be required to complete the pavement in accordance with plans.

S-320.4. PROPORTIONING OF CONCRETE.

(1) Proportions. The concrete shall be composed of Type I or Type III Portland cement as specified, Coarse Aggregate, Fine Aggregate, Mineral Filler, if required, and Water mixed and proportioned as the Engineer determines as outlined in T.H.D. Bulletin C-11, and in accordance with definite requirements hereinafter outlined. The Concrete shall contain not less than five (5) sacks of cement per cubic yard with not more than six and one-half (6 1/2) gallons of water, net, per sack of cement, and shall be uniform and workable. The addition of mineral filler may be required as hereinafter provided to improve the workability or plasticity of the concrete. The amount of coarse aggregate (dry-loose volume) shall not be more than eighty-five (85) per cent per cubic foot of concrete.

(2) Concrete Strength. The concrete mix will be designed with the intention of producing concrete which will, at the age of seven (7) days, have a flexural strength of at least six hundred and

fifty (650) pounds per square inch when Normal Portland Cement is used, and at least seven hundred (700) pounds per square inch when High Strength Portland Cement is used.

(3) Workability. When gauged by the Standard Slump Test, the settlement of the concrete shall not be less than one and one-half (1 1/2) inches, nor more than three (3) inches.

If the characteristics of the aggregates furnished are such that when using the minimum allowable amount of cement with the maximum allowable amount of water, the specified slump and workability requirements are not met, or if free water comes to the surface of the slab when being finished as specified hereinafter, the Engineer shall change the mix design to correct these conditions by adding mineral filler or cement (or both) as may be required; when the specified finishing machine has gone over an area twice and all surface voids are not filled, the workability shall be considered unsatisfactory, and the Engineer shall change the mix design to correct this condition.

(4) Mix Design. The net amount of water will be the amount added at the mixer plus the free water in aggregates, and minus the absorption of aggregates based on a thirty (30) minute absorption period (tests to be made in accordance with instructions in T.H.D. Bulletin C-11). No water allowance will be made for evaporation after batching.

(5) Test Specimens. While concrete pavement work is in progress, beam specimens of such dimensions and numbers as may be required shall be made by the Engineer each day as prescribed in Texas Highway Department Bulletin C-11. These beams shall be continuously cured in water until tested.

S-320.5. SUBGRADE AND FORMS.

(1) Preparation of Subgrade. The subgrade shall be excavated as required, all unstable or otherwise objectionable material removed, and all holes, ruts, and depressions filled with approved material. Rolling and sprinkling shall be performed when, and to the extent directed, and the roadbed shall be completed to or above the plane of the typical sections shown on plans and the lines and grades established by the Engineer. Material excavated in the preparation of the subgrade shall be utilized in the construction of adjacent shoulders and slopes, and any additional material required for the completion of the sections shall be secured from sources indicated on plans or designated by the Engineer. Drainage of the roadbed shall be maintained at all times.

The subgrade planer shall be operated from approved forms immediately ahead of paving operations, and the subgrade shall be finished to the exact section of the bottom of the pavement as shown on plans. It shall be tested with the approved template, operated and maintained by the Contractor. The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required section and established grade until the pavement is placed and shall be kept thoroughly wetted down sufficiently in advance of placing any pavement to insure its being in a firm and moist condition for at least 2 inches below the prepared surface. Sufficient subgrade shall always be prepared in advance to insure satisfactory prosecution of the work. No equipment or hauling shall be permitted on the prepared subgrade, except on special permission of the Engineer, which will be granted only in exceptional cases and only where suitable protection in the form of two-ply timber mats or other approved material is provided.

(2) Placing and Removing Forms. The subgrade under the forms shall be firm and cut true to grade so that each form section when placed will be firmly in contact for its whole length and base width, and exactly at the established grade. Any subgrade under the forms below established grade shall be corrected, using suitable material, placed, sprinkled and rolled as directed. Forms shall be staked with at least three pins for each ten-foot section. A pin shall be placed at each side of every joint. Form sections shall be tightly joined and keyed to prevent relative displacement. Forms shall be cleaned and oiled each time they are used.

Forms shall be set for a sufficient distance in advance of the point where concrete is being placed to permit a finished and approved subgrade length of not less than 300 feet ahead of the mixer. Conformity of the grade and alignment of forms shall be checked immediately prior to placing concrete, and all necessary corrections made by the Contractor. Where any form has been disturbed or any subgrade becomes unstable, the form shall be reset and rechecked. In exceptional cases, the Engineer may require suitable stakes driven to the grade of the bottom of the

forms to afford additional support. Sufficient stability of forms to support the equipment operated thereon and to withstand its vibration without springing or settlement shall be required. If forms settle over one-eighth (1/8) inch under finishing operations, paving operations shall be stopped and the forms shall be reset to line and grade.

Forms shall remain in place for not less than 8 hours after the concrete has been placed. They shall be carefully removed in such a manner that little or no damage will be done to the edge of the pavement. Any damage resulting from this operation shall be immediately repaired. After the forms have been removed, the ends of all joints shall be cleaned, and any honeycombed areas pointed up with approved mortar. Immediately after pointing is complete, the form trench shall be filled with earth from the shoulders in such manner as to shed water from rainfall or curing away from the edge of the pavement. On completion of the required curing, the subgrade or shoulders adjacent to the pavement shall be placed in condition to maintain drainage.

S-320.6. CONCRETE MIXING AND PLACING.

(1) Mixing Methods. The concrete shall be mixed in a mixer conforming to the requirements of Article 3 (5) of this specification item. Central mixed concrete or transit mixed concrete may be used only when specifically permitted in the proposal by the inclusion of Item S-532 in the list of "Governing Specifications and Special Provisions".

(2) Mixing. The aggregates, mineral filler if required, cement and water shall be measured separately, introduced into the mixer, and mixed for a period of not less than fifty (50) seconds, measured from the time the last aggregate enters the drum to the time discharge of the concrete begins. The required water shall be introduced into the mixing drum during the first 15 seconds of mixing. The entire contents of the drum shall be discharged before any materials of the succeeding batch are introduced.

The maximum size of the concrete batch, absolute volume, shall not exceed 120% of the rated size of the mixer (32.4 cubic feet maximum batch for the 27-E paver). Spilling of material from the mixer drum shall be corrected by reducing the size of the batch. Retempering or remixing of concrete shall not be permitted.

(3) Placing. Any concrete not placed as herein prescribed within thirty (30) minutes after mixing shall be rejected and disposed of as directed. Except by specific written authorization of the Engineer, concrete shall not be placed when the temperature is below 40°F. and falling; but may be placed when the temperature is above 35°F. and rising, the temperature being taken in the shade and away from artificial heat. When such permission is granted, the Contractor shall furnish an approved enclosure, such as canvas-covered framework, to enclose and protect all pavement so placed, and shall maintain the temperature of the air surrounding the concrete at not less than 50°F. for not less than five days. When concrete is being placed in cold weather, other than under the conditions stated above, the Contractor shall have available a sufficient supply of an approved covering material to immediately protect concrete when the air temperature falls to 32°F. before concrete has been placed 4 hours. Such protection shall remain in place during the period the temperature continues below 32°F., or for a period of not more than five days. Neither salt nor other chemical admixtures shall be added to the concrete to prevent freezing. The Contractor shall be responsible for the quality and strength of concrete under cold weather conditions, and any concrete damaged by freezing shall be removed and replaced at his expense.

Concrete shall not be placed before the time of sunrise, and shall not be placed later than will permit the finishing of the pavement during sufficient natural light.

Concrete shall be placed only on approved subgrade, and unless otherwise indicated on plans, the full width of the pavement shall be constructed monolithically. The concrete shall be deposited on the subgrade in such manner as to require as little rehandling as possible. Where hand spreading is necessary, concrete shall be distributed to the required depth by the use of shovels. The use of rakes shall not be permitted. Workmen shall not be permitted to walk in the concrete with any earth or foreign material on their boots or shoes. The placing of concrete shall be rapid and continuous.

When the concrete is to be placed in separate lanes, the junction line shall not deviate from the true line more than 1/2 inch at any point and shall be finished as shown on plans. The mixer shall

not be located on completed pavement but may be located on the subgrade of that lane of the pavement being constructed, as provided under "Preparation of Subgrade".

Concrete shall be distributed to such depth that when consolidated and finished, the slab thickness required by plans will be obtained at all points and the surface shall not, at any point, be below the established grade. Special care shall be exercised in placing and spading concrete against forms and at all joints to prevent the forming of honeycombs and voids.

Concrete for the monolithic curbs shall be the same as for the pavement and if carried back from the paving mixer shall be placed within 20 minutes after being mixed. It may be placed from a separate and smaller mixer if desired but in any case must be placed while the pavement concrete is still plastic.

(4) Reinforcing Steel and Joint Assemblies. All reinforcing steel, tie bars, dowel bars, and load transmission units used in accordance with plan provisions shall be accurately placed and secured in position in accordance with details shown on plans. Reinforcing bars shall be securely wired together at all intersections and splices, and shall be securely wired to each dowel and load transmission unit intersected. Tie bars shall be installed in required position by the method and device shown on plans, or by approved method and device equivalent thereto. Bar coatings required by plans, and for material specified, shall be completed and the bars and coatings shall be free of rust, dirt or other foreign matter at the time of installation in the concrete.

Where plans require an assembly of parts at pavement joints, the assembly shall be completed, placed at required location and elevation, and all parts rigidly secured in required position by the method and devices shown on plans, or by approved method and devices equivalent thereto. Dowel bars shall be accurately installed in joint assemblies in accordance with plans, each parallel to the pavement surface and to the centerline of the pavement, and shall be rigidly secured in required position by such means (as shown on plans, or approved equivalent thereto) that will prevent their displacement during placing and finishing of the concrete. The assembled units comprising the load transmission devices shall be accurately installed in joint assemblies in accordance with plans, each unit vertical with its length parallel to the centerline of the pavement, and all units shall be rigidly secured in required position by such means (as shown on plans, or approved equivalent thereof) that will prevent their displacement during placing and finishing of the concrete. Header boards, joint filler and other material used for forming joints shall be accurately notched to receive each load transmission unit. All load transmission units shall be free of rust and clean when installed in the concrete.

(5) Construction Joints. Intentional stoppage of the placing of the concrete shall be at either an expansion joint, warping joint or contraction joint. The following provisions shall govern for each type of joint at which the placing of concrete is stopped.

(a) When the placing of concrete is stopped at an expansion joint, the complete joint assembly shall be installed and rigidly secured in required position as shown on plans. A bulkhead of sufficient cross sectional area to prevent deflection, accurately notched to receive the load transmission units or dowels, as the case may be, and shaped accurately to the cross section of the pavement shall be provided and installed as a back-up for the joint filler and rigidly secured in required position to permit accurate finishing of the concrete up to the joint. After the concrete has been finished to the joint, formation of the joint seal space and finishing of the joint shall be executed as specified herein and in accordance with plan requirements. The back-up bulkhead shall remain in place until immediately prior to the time when concrete placing is resumed, when it shall then carefully be removed in such manner that no element of the joint assembly will be disturbed. The exposed portions of the joint assembly shall be free of adherent concrete, dirt or other material at the time placing of concrete is resumed.

(b) When placing of concrete is stopped at a warping joint, all applicable provisions of paragraph 6 (5) (a) shall apply in addition to the following requirements:

The face of the bulkhead at the joint shall be grooved or recessed as necessary to provide the required spaces for the top and bottom breaker strips when shown on plans. The bulkhead shall be either drilled or notched to receive the tie bars. Tie bars shall be secured in required position by use of adequate transverse bracing and vertical supports meeting the approval of the Engineer.

(c) When placing of concrete is stopped at a contraction joint all applicable provisions of paragraph 6 (5) (a) shall apply in addition to the following requirements:

The face of the bulkhead adjoining the slab end shall be notched and grooved to fit the exposed half-section of the joint assembly and shall be shaped to form the slab end at the center of joint as shown on plans. The half-width of joint seal-space may be formed by a strip of required section placed and removed in accordance with plan requirements for construction of transverse contraction joints. The Contractor shall have available a bulkhead shaped to the section of the pavement, and of a section to form a key not less than 1 inch in depth and 2 inches in height at the center of depth of the pavement. This bulkhead must be drilled to permit the continuation of all longitudinal reinforcing steel through the construction joint, and shall be of sufficient section and strength to prevent deflection.

Immediately upon the unintended stoppage of the placing of concrete, the Contractor shall place the available concrete to a line, and install the above described bulkhead at right angles to the centerline of the pavement perpendicular to the surface and at required elevation. Concrete shall be placed and finished to this bulkhead. Any concrete remaining on the subgrade ahead shall be removed and disposed of as directed. When placing of concrete is resumed before the concrete has set to the extent that the concrete will stand on removal of the bulkhead, the new concrete shall be rodded with the first; otherwise, the key in the first concrete must be carefully preserved. An edge created by a construction joint of this type shall have a joint seal space and shall be sealed as required for contraction joints.

S-320.7. JOINTS.

(1) General. All transverse and longitudinal joints when required in the pavement shall be of the type or alternate type shown on plans, shall be constructed at required location, on required alignment, in required relationship to tie bars and joint assemblies, and in accordance with details shown on plans.

(2) Expansion Joints. Transverse expansion joints shall be formed perpendicular to the center line and surface of the pavement, and shall be constructed in accordance with the sequence of operations shown on plans. After the transverse finishing machine and before the longitudinal finishing machine has passed over the joint, the Contractor shall test the joint filler for correctness of position and make any required adjustment in position of the filler, and shall install the joint seal space form in accordance with plans. After removal at the joint seal form as required by plans, the joint seal space above the joint filler shall be thoroughly cleaned and the concrete faces of the joint seal space shall be left true to line and section throughout the entire length of the joint. On completion of curing of the pavement, the joint sealing filler of the type specified shall be placed in accordance with plans. The faces of the joint seal space shall be clean and surface dry at the time joint sealing filler is placed. On completion of the joint seal, the pavement adjacent to the joint shall be left free of joint sealing material. The joint seal space shall not be narrower than the joint filler and shall be exactly above the joint filler with no concrete overhanging the filler.

(3) Contraction Joints. Transverse contraction joints shall be formed perpendicular to the centerline and surface of the pavement, and shall be constructed by the method, use of devices, and in the sequence of operations, as shown on plans. Forming, finishing and sealing of the joint seal space shall be in accordance with applicable provisions of paragraph 7 (2) and details shown on plans.

(4) Warping Joints. Warping joints shall be formed perpendicular to the center line and surface of the pavement with each part comprising the joint in its required position, and shall be constructed of specified materials in accordance with provisions of the plans.

(5) Longitudinal Joints. Longitudinal joints shall be of the type or alternate types shown on plans and shall be constructed of specified materials in accordance with provisions of the plans. Longitudinal joints shall be constructed accurately to required lines, shall be perpendicular to the pavement surface at the joint, and the pavement surface over and adjacent to the joint shall be finished as specified.

(6) Curbs. The curb shall be constructed in lengths equal to the adjoining pavement slab length, and expansion joints shall be provided in the curb opposite each transverse expansion

joint in the pavement. Expansion joint material shall be of the same thickness, type and quality as specified for the pavement and shall be of the section as shown for the curb. All expansion joints shall be carried through the curb and the curb shall be grooved at all points where contraction and warping joints are provided in the pavement.

S-320.8. SPREADING AND FINISHING.

(1) Machine Finishing. All concrete pavement shall be finished mechanically with approved power-driven machines, except as herein provided. Hand finishing will be permitted on the transition from a crowned section to a super-elevated section without crown on curves, and on straight-line superelevation sections less than 300 feet in length. Hand finishing will also be permitted on that portion of a widened pavement outside the normal pavement width, on sections where the pavement width is not uniform, or required monolithic widths are greater than that of available finishing machines.

Machine finishing of pavement shall include the use of a power-driven transverse strike-off, and screed, and a power-driven longitudinal float.

The transverse finishing machine shall first be operated to compact and finish the pavement to the required section and grade, without surface voids. The machine shall be operated over each area as many times and at such intervals as directed. At least two trips will be required, and the last trip over a given area shall be a continuous run of not less than 40 feet.

After completion of finishing with the transverse finishing machine, the longitudinal mechanical float shall be operated to smooth and finish the pavement to the required grade. The float shall be operated parallel to the centerline of the pavement with a short, quick motion, and shall travel slowly across the pavement, maintaining contact with the surface at all points. If this result is not attained, additional concrete shall be placed if required, and screeded, and the float shall operate over the same area until a satisfactory surface is produced. The advance along the length of the pavement between successive passes of the float across the surface shall be such that the float shall continuously lap its previous position by not less than one-fourth its length.

After floating is complete, and the concrete still workable, the surface shall be tested for trueness with an approved 10-foot steel straight-edge. The straight-edge shall be operated from the side of the pavement, placed parallel to the pavement centerline and passed across the slab to reveal any high spots or depressions. The straight-edge shall be advanced along the pavement in successive stages of not more than one-half its length. Practically perfect contact of the straight-edge with the surface will be required, and the pavement shall be leveled to this condition, in order to insure conformity with the surface test required below after the pavement has fully hardened. Any correction of the surface required shall be accomplished by adding concrete if required and by operating the longitudinal float over the area. The surface test with the straight-edge shall then be repeated.

Finish on curbs shall have the same gritty texture as the pavement proper and all radii and other surfaces shall be true to line and grade and completed in a neat and presentable manner. The upper edge of the pavement shall not be rounded where curbs are to be constructed.

After completion of the straight-edge testing, and just before the concrete becomes non-plastic, the surface shall be belted with an approved belt, operated with short transverse strokes and a rapid advance longitudinally. This operation shall produce a uniform surface of a gritty texture.

After completion of belting and about the time the concrete becomes hard, the edge of the slab and joints shall be carefully finished with an edger of the radius required by plans, and the pavement edge shall be left smooth and true to line.

(2) Hand Finishing. Hand finishing shall be resorted to only in those conditions provided for above, and upon specific authorization by the Engineer. When hand finishing is permitted, the concrete shall be struck off with an approved strike-off screed to such elevation that when consolidated and finished the surface of the pavement shall conform to the required section and grade. The strike template shall be moved forward with a combined transverse and longitudinal motion in the direction the work is progressing, maintaining the template in contact with the forms, and maintaining a slight excess of material in front of the cutting edge. The concrete shall then be

tamped with an approved tamping template to compact the concrete thoroughly, and eliminate surface voids, and the surface screeded to required section.

After completion of a strike-off, consolidation, and transverse screeding, a hand-operated longitudinal float shall be operated to test and level the surface to the required grade. Workmen shall operate the float from approved bridges riding on the forms and spanning the pavement. The longitudinal float shall be held in contact with the surface and parallel to the center-line, and operated with short longitudinal strokes while being passed from one side of the pavement to the other. If contact with the pavement is not made at all points, additional concrete shall be placed if required, and screeded, and the float shall be used to produce a satisfactory surface. Care shall be exercised to keep the ends of the float from digging into the surface of the pavement. After a section has been smoothed so that the float maintains contact with the surface at all points in being passed from one side to the other, the bridges may be moved forward half the length of the float, and the operations repeated.

Other operations and surface tests shall be as required for machine finishing.

(3) Surface Test. After the concrete has been placed 12 hours or more, the Engineer will test the surface of the pavement with a ten-foot straight-edge placed parallel to the center-line. The surface shall not vary from the straight-edge by more than one-sixteenth (1/16) inch per foot from the nearest point of contact, and in no case shall the maximum ordinate from a ten-foot straight-edge to the pavement be greater than one-eighth (1/8) inch. Any high spots causing a departure from the straight-edge in excess of that specified shall be ground down by the Contractor to meet the surface test requirements.

S-320.9. TRAFFIC STRIPE. When required by plans, a traffic stripe shall be applied along the center-line of the pavement for its entire length (or as indicated on plans) and along such other lines shown on plans. It shall be 6" in width unless otherwise shown on plans. The stripe shall be constructed by applying the specified traffic stripe pigment on the newly finished concrete as soon as job conditions will permit, but in no event later than two hours after the concrete is placed. The pigment shall be applied dry, then lightly sprinkled with water and worked into the surface of the fresh concrete by wooden floats, steel trowels, or other approved methods to secure a penetration of 1/8" to 1/4" over the entire surface of the stripe. The pigment shall be applied at the rate directed by the Engineer, of not less than 3 nor more than 4 pounds of oxide per 100 linear feet of 6" traffic stripe. The Contractor shall use approved forms or resort to other satisfactory methods to produce a neat, true edge on the stripe. Before covering traffic stripe with wet-method curing materials it shall be protected by one layer of paper similar to butcher's paper applied to secure complete coverage, and this paper removed on completion of curing.

S-320.10. CURING.

(1) General. All concrete pavement shall be cured by protecting it against loss of moisture for a period of not less than 72 hours from the beginning of curing operations. Immediately after finishing operations have been completed, the entire surface of the newly laid concrete shall be covered and cured in accordance with the requirements specified for whichever one of the following methods the Contractor may elect. In all cases in which curing requires the use of water, the curing shall have prior right to all water supply or supplies. Failure to provide sufficient cover material of the type the Contractor elects to use, failure to maintain saturation in wet curing methods, lack of water to adequately take care of both curing and other requirements, or other failures to comply with curing requirements shall be cause for immediate suspension of concreting operations. The covering material used in curing shall be removed as necessary to comply with the requirements for "Surface Test", the concrete surface maintained wet with a water spray if required, and the covering material replaced immediately on completion of testing and any required surface correction.

(2) Cotton Mat Curing. Immediately after the finishing of the surface has been completed, and the concrete has taken its initial set, the surface shall be completely covered with cotton mats, thoroughly saturated before application, in such manner that they will contact the surface of the pavement equally at all points. Immediately upon removal of side forms, drainage shall be established as specified, and the pavement edges completely covered with either saturated cotton mats, or saturated earth.

The cotton mats shall remain on the pavement for not less than the specified curing period, and shall be kept saturated so that, when lightly compressed, water will drip freely from them. Earth banked against pavement edges, or cotton mat covering of edges, shall be kept saturated. The cotton mats used for curing shall meet the following requirements:

Each mat shall have a finished width of approximately 5 feet 6 inches, and after shrinkage, shall be at least 6 inches longer than the width of the pavement to be cured.

The mats shall be composed of a single layer of cotton filler completely enclosed in a cover of cotton cloth. The cotton filler shall be of low grade cotton, cotton linters, or such cotton waste as comber noils or card flat strips. The mats shall contain not less than three-fourths (3/4) of a pound of cotton filler per square yard of mat, uniformly distributed. The cotton cloth used for covering material shall be osnaburg, weighing not less than six and three-tenths ounces per square yard.

All mats shall be stitched longitudinally with continuous parallel rows of stitching at intervals of not more than 4 inches or shall be tufted both transversely and longitudinally at intervals of not more than 3 inches. The sewing or tufting shall not be done so tightly that the mat will not contact the surface of the pavement at all points when saturated with water.

To insure the complete covering of the pavement where the mats fit together, there shall be a flap extending all along one side of each mat. This flap shall be composed of two thicknesses of the cover material and shall be at least six (6) inches in width.

(3) Waterproofed Paper Curing. Immediately after the finishing of the surface has been completed, and the concrete has taken its initial set, it shall be wetted with water applied in the form of a fine spray, and covered with waterproofed paper so placed and weighted as to cause it to remain in intimate contact with the surface. Waterproofed paper used for the curing of concrete pavement shall be of a type and quality approved by the Engineer. It shall be sufficiently strong and tough to permit its use under the conditions existing on highway paving work without being torn or otherwise rendered unfit for the purpose during the curing period. The paper covering shall be maintained in place continuously for not less than the specified curing period.

The waterproofed paper shall be prepared to form blankets of sufficient width to cover the entire surface and both edges of the pavement slab, and such blankets shall not be more than 60 feet in length. All joints in the blankets occasioned by joining paper sheets shall lap not less than 5" and shall be securely sealed with asphalt cement having a melting point of approximately 180°F. Blankets shall be placed to secure an overlap of at least 12", and this lap securely weighted to form a closed joint.

The waterproofed paper blankets shall be adequately weighted to prevent displacement or billowing due to wind and the paper folded down over the side of the pavement shall be secured by a continuous bank of earth. Plowing of this windrow into place will not be permitted.

All tears or holes appearing in the paper during the curing period shall be immediately repaired by cementing patches over such defects. It shall be the Contractor's responsibility to prevent damage to the paper blankets which would affect their serviceability and effectiveness as a concrete curing method. Blankets may be rejected by the Engineer at any time when, in his opinion, they do not provide an airtight covering.

Paper blankets rejected on account of pin holes or minor tears may be continued in service by folding the blanket over lengthwise, first thoroughly spraying one-half the blanket with the asphalt cement used for seams. The two thicknesses shall be firmly pressed together and well cemented. All blankets shall be of a width sufficient to cover the pavement surface and both edges. Doubled blankets may be rejected for the same cause as provided for single blankets. All paper blankets condemned by the Engineer shall be immediately marked by the Contractor for identification, and then destroyed or stored entirely separate from approved blankets.

No walking on the paper shall be permitted at any time, and in locations where pedestrian traffic cannot be entirely controlled, the Contractor shall provide walkways and barricades or shall substitute other permissible curing methods on such sections of pavement.

S-320.11. PROTECTION OF PAVEMENT AND OPENING TO TRAFFIC.

(1) Protection of Pavement. The Contractor shall erect and maintain the barricades required by plans, and such other standard barricades and approved devices as will exclude public traffic and traffic of his employees and agents from the newly placed pavement for the periods of time hereinafter prescribed. Portions of the roadway, or crossings of the roadbed required to be maintained open for use by traffic, shall not be obstructed by the above required barricades. Crossings of the pavement required by plans, or by construction sequence, during the period prior to opening to traffic as herein specified, shall be provided with an adequate and substantial bridge, approved by the Engineer.

(2) Opening Pavement to Traffic. The pavement shall be closed to all traffic, including vehicles of the Contractor, until the concrete is at least seven (7) days old and has attained a minimum average modulus of rupture as required under Article 4 of these specifications. This period of closure to all traffic may be extended if in the opinion of the Engineer, weather or other conditions make it advisable to provide an extension of the time of protection.

At the end of the seven (7) day period and as long thereafter as ordered by the Engineer, and if so desired by the Contractor, the pavement may be opened for use by vehicles of the Contractor provided the gross weight (vehicle plus load) of such vehicles does not exceed fourteen thousand (14,000) pounds. Such opening, however, shall in no manner relieve the Contractor from his responsibility for the work in accordance with Items 7.7, 7.11 and 7.12 of the Standard Specifications. On those sections of the pavement thus opened to traffic, all joints shall first be sealed, the pavement cleaned and earth placed against the pavement edges before permitting vehicles thereon.

After the concrete in any section is fourteen (14) days old, or as long thereafter as ordered by the Engineer, such section of pavement may be opened to all traffic as required by plans or when so directed by the Engineer. On those sections of the pavement thus opened to traffic, all joints shall first be sealed, the pavement cleaned, earth placed against the pavement edges and all other work performed as required for the safety of traffic. Such opening of pavement to all traffic shall constitute acceptance of the section of pavement affected, subject to the provisions of Article 12 of these specifications. Such opening, however, shall in no manner relieve the Contractor from his responsibility for the work in accordance with Items 7.7 and 7.11 of the Standard Specifications.

When High Early Strength Concrete, resulting from the use of Type III Cement either as required by plans or as an option to Type I Cement, is used the pavement may be opened to all traffic after the concrete is seven (7) days old, or as long thereafter as ordered by the Engineer, subject to the same provisions governing the opening after fourteen (14) days as above prescribed.

Where the Contractor desires to move any equipment not licensed for operation on public highways, on or across any pavement opened to traffic, he shall protect the pavement from all damage by means of two-ply timber mats of 2" stock, or runways of heavier material, laid on a layer of earth, all as approved by the Engineer.

(3) Emergency Opening to Traffic. The Engineer may require the opening of pavement to traffic prior to the minimum time specified above under conditions of emergency which in his opinion, require such action in the interest of the public. In no case shall the Engineer order opening of the pavement to traffic within less than 72 hours, after the last concrete in the section is placed. The Contractor shall remove all curing materials, place earth against the pavement edges, and perform other work involved in providing for the safety of traffic as required by the Engineer in ordering emergency opening. Orders for emergency opening of the pavement to traffic will be issued by the Engineer in writing.

S-320.12. PENALTY FOR DEFICIENT PAVEMENT THICKNESS. The adjustment in unit prices provided for this article will apply only when measurement for payment is by the square yard.

(1) It is the intent of this specification that the pavement be constructed in strict conformity with the thickness and typical sections shown on plans. Where any pavement is found not so constructed, the following rules relative to adjustment of payment for acceptable pavement and to replacement of faulty pavement shall govern.

(2) The pavement will be core drilled by the Highway Department prior to final acceptance. The thickness of the pavement will be determined by measurement of the cores taken at such points as the Engineer may select. Cores will be drilled from the width of normal thickness of section, and the thickness of individual cores will be determined by averaging at least three measurements.

(3) Pavement of a thickness within 1/4 inch of the thickness required by plans will be considered of a satisfactory thickness, and the contract unit price bid shall be used in payment.

(4) Pavement of a thickness less than the thickness shown on plans by more than 1/4 inch, but less than 1/2 inch, will be considered of a deficient thickness, and an adjusted unit price shall be used in payment, which price shall bear the same ratio to the contract unit price as the square of the actual average thickness of the slab bears to the square of the thickness shown on plans. The length of the area of such deficient thickness shall be determined by additional cores taken at intervals of ten feet along the length of the pavement in each direction until cores are obtained which are at least plan thickness. The width of such area shall be the entire width of pavement within the length thus determined.

(5) Payment will not be made for pavement which is found deficient in thickness 1/2 inch or more. The length of the area of such unsatisfactory thickness shall be determined by additional cores taken at intervals of ten feet along the length of the pavement in each direction until cores are obtained which are at least plan thickness less 1/2 inch. The width of such area shall be the entire width of pavement within the length thus determined. Such pavement shall be removed and replaced by the Contractor with pavement of the specified thickness at his entire expense for removal and replacement. Provided the deficiency in thickness is not more than 3/4 inch, the Contractor, if he so elects, may leave such pavement in place, relinquishing thereby any claim for any compensation incurred in its construction.

(6) No additional payment over the contract unit price will be made for any pavement of a thickness exceeding that required by plans.

S-320.13. MEASUREMENT.

(1) When provided by plans, and proposal, concrete pavement will be measured by the square yard of surface area of completed and accepted work. When concrete pavement is to be measured by the square yard and monolithic curb is required, measurement for "Monolithic Curb" will be by the linear foot complete in place.

(2) When provided by plans, and proposal, concrete pavement, including monolithic curb when required, will be measured by the cubic yard of absolute volume of all materials entering the mixture as prescribed in T.H.D. Bulletin C-11 and subsequent revisions.

S-320.14. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Pavement", "Concrete Pavement (High Strength)" and "Monolithic Curb" (when pavement is measured by the square yard), as required, or the adjusted unit price for pavement of deficient thickness as provided under "Penalty for Deficient Pavement Thickness", which price shall be full compensation for shaping and fine grading the roadbed, including furnishing and applying all water required; for furnishing, loading and unloading, storing, hauling and handling all concrete ingredients, including all freight and royalty involved; for mixing, placing, finishing and curing all concrete; for furnishing and installing all reinforcing steel; for furnishing all materials for and placing longitudinal, warping, expansion, and contraction joints, including all steel dowel caps and load transmission units required, and wire and devices for placing, holding, and supporting the steel bars, load transmission units, and joint filler material in proper position; for coating steel bars where required by plans, for furnishing materials for and constructing the traffic stripe if required; and for all manipulations, labor, equipment, appliances, tools, traffic provisions and incidentals necessary to complete the work.

Excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage shall be measured and paid for once only, regardless of the manipulation involved; or, where shown on plans, such work will be measured and paid for in accordance with the provisions

governing the Item of "Blading". Measurement of subgrade excavation for payment shall be limited to a total width of that of the pavement plus one foot on each side. Payment under excavation items will not be allowed within the areas designated for "Blading".

Sprinkling and rolling required for the compaction of the rough subgrade in advance of fine grading, performed as ordered by the Engineer, will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively. Maintenance of a moist condition of the subgrade in advance of fine grading and concrete placing will not be paid for directly, but shall be considered subsidiary work, as provided above.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-320A

CONCRETE PAVEMENT
(Strength Design)

S-320A.1. DESCRIPTION. This item shall consist of a pavement and/or base of Portland cement concrete, with or without reinforcement as shown on plans, with or without monolithic curbs, constructed as herein specified on the prepared subgrade or other base course in conformity with the thickness and typical cross sections shown on plans and to the lines and grades established by the Engineer. Concrete shall be considered of satisfactory quality provided it is made (a) of materials accepted for the job, (b) in the proportions established by the Engineer, and (c) mixed, placed, finished and cured in accordance with the requirements of this specification and meets the requirements herein specified.

S-320A.2. MATERIALS. The provisions of Article 2 of the Item S-320, "Concrete Pavement (Water Cement Ratio)", shall govern except a change in the specific surface area of cement of more than 100 square centimeters per gram will require a new mix design and preliminary flexural strength tests, as provided by the requirements under "Mix Design".

S-320A.3. EQUIPMENT. The provisions of Article 3 of the Item S-320, "Concrete Pavement (Water Cement Ratio)", shall govern.

S-320A.4. PROPORTIONING OF CONCRETE.

(1) Proportions. Concrete shall be composed of Portland Cement, coarse aggregate, fine aggregate, mineral filler if required, and water, mixed in the proportions designated by the Engineer and in the manner set forth in this specification. On the basis of job and laboratory investigations of the proposed materials, the Engineer will fix the proportions by weight of water, coarse aggregate, fine aggregate, cement, and mineral filler where required, in order to produce concrete of the specified strength and workability.

(2) Concrete Strength. The concrete mix will be designed with the intention of producing a minimum average flexural strength (modulus of rupture) of 650 pounds per square inch at the age of 7 days using a standard testing machine in which the load is applied at the center of the beam span. The coarse aggregate factor (dry, loose volume of coarse aggregate per unit volume of concrete) shall not exceed 0.85. The water-cement ratio (net gallons of water per sack or 94 lbs. of cement) shall not exceed 7.5 gallons. If necessary to produce a workable mix reasonably free from bleeding, the cement content shall be increased by such amount as necessary to secure a satisfactory mix.

(3) Concrete Strength for High Strength Pavement. Where high strength concrete pavement is required, the concrete mix will be designed with the intention of producing a minimum average flexural strength of 700 pounds per square inch at the age of 7 days. The water-cement ratio for this design shall not exceed 7.5 gallons. Other provisions of this specification will not be modified by these requirements.

(4) Workability of Concrete. Concrete shall be uniformly plastic, cohesive, and workable. Workable concrete is defined as concrete which can be placed without honeycomb and without voids in the surface of the pavement after the specified finishing machine has been over a given area twice. Workability shall be obtained without producing a condition such that free water appears on the surface of the slab when being finished as specified.

The mix will be designed with the intention of producing concrete which will have a slump of 1-1/2 inches when tested by standard methods. The slump shall not be less than 1 inch nor more than 3 inches.

(5) Mix Design. It is the intent of this specification to develop and use the most economical mix design possible which will fulfill all requirements of this specification when using acceptable materials as furnished by the Contractor.

Prior to the beginning of concrete placement, and thereafter before any change in source or characteristics of any of the ingredients except mineral filler, adequate quantities of cement and aggregates proposed for use shall be supplied the Engineer for mix design tests. A change in the specific surface of the cement of more than 100 square centimeters per gram from that furnished for preliminary tests shall be considered a change in the characteristics of the cement. In the event this change is a decrease in the specific surface of the cement of more than 100 square centimeters per gram, a new mix design will be set based upon new flexural strength tests. In the event the change is an increase in the specific surface of the cement, and upon written request of the Contractor, a new mix design will be set based upon new flexural strength tests.

Concrete mixes will be designed by the absolute volume method in accordance with the procedure outlined in Texas Highway Department Bulletin C-11. Mixes will be designed and made in sufficient number to represent a wide range of water-cement ratios. These mixes shall comply with the requirements herein prescribed for workability.

From the concrete of each mix design test beams will be made, cured, and tested as outlined in T.H.D. Bulletin C-11 to determine the flexural strength of the concrete at the age of 7 days. From these preliminary tests the water-cement ratio required to produce concrete of the specified strength will be selected by the Engineer. The Contractor may at any time present in writing a suggested mix design and the Engineer will make the tests necessary to determine its acceptability under these specification requirements.

For mixing the concrete to be used in making the preliminary test specimens, the Contractor shall furnish and operate the specified paver approved for use on this project and shall produce batches of the size to be used in paving operations. No additional compensation will be allowed for equipment, materials, or labor involved.

After the mixproportions and water-cement ratio required to produce concrete of the specified strength have been determined, placing of concrete may be started. The strength of the concrete in the completed pavement will be determined by flexural strength test specimens, made, cured, and tested as provided in T.H.D. Bulletin C-11. Modifications of the mix design will be made by the Engineer on the basis of the conformity of the strength of these test specimens with the requirements and intent of this specification.

Changes in the water-cement ratio and the mix design will be made by the Engineer when the average 7-day flexural strength of the concrete, as indicated by the last 10 flexural strength values (modulus of rupture) obtained from tests of beams made from concrete of the same water-cement ratio, departs from the desired minimum average strength by more than 4.0%. The Engineer, at his option, may reject as non-representative any individual flexural strength value in each group of ten where strengths more than 10% above or below the average for the group are indicated, and compute the average flexural strength on the basis of the remaining values. When the concrete fails to meet any of the requirements for workability, the Engineer will attempt to correct this condition by changing the mix design, or by requiring the use of mineral filler. In case it is necessary to change aggregates, or to use an additional aggregate, preliminary strength tests will be required. Should tests representing three (3) days production consistently indicate a considerable departure from the minimum specified strength, even though within the above limits, appropriate changes in the water-cement ratio and mix proportions will be made.

The Contractor or his duly authorized superintendent shall sign each daily paving report of the Texas Highway Department inspector to signify his acceptance and approval of the mix designs used.

(6) Test Specimens. Two test beams for a flexural strength value shall be taken from the concrete for each 500 square yards or less of pavement placed each day. A flexural strength value shall be the average of the strengths of the two beams. Additional beams may be made as required by concrete placing conditions, or for adequately determining the strength of concrete where the early opening of the pavement to traffic is dependent upon concrete strength tests. No extra compensation will be allowed for materials and work involved in fulfilling these requirements.

The provisions of Articles 5, 6, 7, 8, 9, 10, 11, and 12, respectively, of Item S-320, "Concrete Pavement (Water Cement Ratio)", shall govern on the articles listed below.

S-320A.5. SUBGRADE AND FORMS.

S-320A.6. CONCRETE MIXING AND PLACING.

S-320A.7. JOINTS.

S-320A.8. SPREADING AND FINISHING.

S-320A.9. TRAFFIC STRIPE.

S-320A.10. CURING.

S-320A.11. PROTECTION OF PAVEMENT AND OPENING TO TRAFFIC.

S-320A.12. PENALTY FOR DEFICIENT PAVEMENT THICKNESS.

S-320A.13. MEASUREMENT.

(1) When provided by plans, and proposal, concrete pavement will be measured by the square yard of surface area of completed and accepted work. When "Monolithic Curb" is required, measurement will be by the linear foot complete in place.

(2) When provided by plans, and proposal, concrete pavement, including monolithic curb when required, will be measured by the cubic yard of absolute volume of all materials entering the mixture as prescribed in T.H.D. Bulletin C-11 and subsequent revisions.

S-320A.14. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Pavement", or "Concrete Pavement, High Strength", as required, or the adjusted unit price for pavement of deficient thickness as provided under "Penalty for Deficient Pavement Thickness", and "Monolithic Curb" when payment is measured by the square yard, which prices shall each be full compensation for shaping and fine grading the roadbed, including furnishing and applying all water required; for furnishing, loading and unloading, storing, hauling and handling all concrete ingredients, including all freight and royalty involved; for mixing, placing, finishing and curing all concrete; for furnishing and installing all reinforcing steel; for furnishing all materials for and placing longitudinal, warping, expansion, and contraction joints, including all steel dowel caps and load transmission units required, and wire and devices for placing, holding, and supporting the steel bars, load transmission units, and joint filler material in proper position; for coating steel bars where required by plans, for furnishing materials for and constructing the traffic stripe if required; and for all manipulations, labor, equipment, appliances, tools, traffic provisions and incidentals necessary to complete the work.

Excavation required by this item in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage shall be measured and paid for once only, regardless of the manipulation involved; or, where shown on plans, such work will be measured and paid for in accordance with the provisions governing the Item of "Blading". Measurement of subgrade excavation for payment shall be limited to a total width of that of the pavement plus one foot on each side. Payment under excavation items will not be allowed within the areas designated for "Blading".

Sprinkling and rolling required for the compaction of the rough subgrade in advance of fine grading, performed as ordered by the Engineer, will be measured and paid for in accordance with the provisions governing the Items of "Sprinkling" and "Rolling", respectively. Maintenance of a moist condition of the subgrade in advance of fine grading and concrete placing will not be paid for directly, but shall be considered subsidiary work, as provided above.

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ITEM S-320B

CONCRETE PAVEMENT
(Class "A" Concrete)

S-320B.1. DESCRIPTION. This item shall consist of a pavement and/or base of Portland cement concrete, with or without reinforcement as shown on plans, with or without monolithic curbs, constructed as herein specified on the prepared subgrade or other base course in conformity with the thickness and typical cross sections shown on plans and to the lines and grades established by the Engineer.

S-320B.2. MATERIALS. All concrete and concrete ingredients shall conform to the requirements for Class "A" Concrete as specified in Item S-403, "Concrete for Structures", and pertinent special provisions thereto.

All other materials shall conform to the requirements of Articles 2(5) to 2(16) inclusive of Item S-320, "Concrete Pavement (Water Cement Ratio)", which is made a part of these specifications.

S-320B.3. PROPORTIONING AND MIXING. Proportioning and mixing of concrete shall be in accordance with the provisions of Item S-403, "Concrete for Structures", and pertinent special provisions, and all concrete shall meet the strength and quality requirements required by that item.

S-320B.4. CONSTRUCTION METHODS. Preparation of subgrade, and placing, finishing and curing of concrete shall conform to the requirements of the Item S-320, "Concrete Pavement (Water Cement Ratio)", and pertinent special provisions, except that equipment and construction methods, satisfactory to the Engineer, which will produce the desired results may be used in lieu of those specified.

Hand finishing will be permitted.

S-320B.5. MEASUREMENT. "Concrete Pavement (Class "A" Concrete)", including Monolithic Curb, when required, will be measured by the cubic yard complete in place.

S-320B.6. PAYMENT. The work performed and materials furnished, as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Pavement (Class "A" Concrete)", which price shall be full compensation for loading, hauling, utilizing and/or disposing of all excavated materials; for shaping and fine-grading the roadbed, including furnishing and applying all water required; for coating steel bar dowels, if dowels are required; for furnishing all materials and constructing all joints, for all reinforcing steel, and for all manipulations, labor, equipment, appliances, tools, and incidentals necessary to complete the work.

All excavation required by this item in preparation of subgrade and for the completion of the shoulders and slopes shall be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage will be measured and paid for once only, regardless of the manipulations involved.

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ITEM S-322

BITUMINOUS FILLED BRICK PAVEMENT

S-322.1. DESCRIPTION.

This item shall consist of a wearing course composed of vitrified brick pavement with a bituminous filler, the pavement being on a sand bed. It shall be constructed on an approved base in accordance with these specifications and in conformity with the lines and grades established by the Engineer and typical cross-section shown on the plans.

S-322.2. MATERIALS

(1) Brick. All brick shall be of the lug type and shall conform to the following sizes:

Sizes in Inches
3 x 4 x 8 1/2
3 1/2 x 4 x 8 1/2
2 1/2 x 4 x 8 3/4

Bricks which vary from the nominal sizes above specified by more than one-eighth (1/8) inch in either transverse dimension or more than one-fourth (1/4) inch in length shall be rejected.

If the edges of the brick are rounded, the radius shall not exceed three-sixteenths (3/16) of an inch. They shall be thoroughly annealed, tough, and durable, regular in size and shape, and evenly burned. When broken, the brick shall show a dense stone-like body, free from lime, air pockets, cracks, or marked laminations. Kiln marks shall not exceed three-sixteenths (3/16) inch, and the wearing surface shall show only slight kiln marks. Only one kind of brick shall be used on a continuous section of roadway.

Representative samples of brick shall meet the following requirements when subjected to the Rattler Test specified under A.A.S.H.O. Standard Method T-31:

Sizes in Inches	Loss-Max.Per Cent
3 x 4 x 8 1/2	24
3 1/2 x 4 x 8 1/2	22
2 1/2 x 4 x 8 3/4	26

If the percentage of loss on any sample exceeds the maximum specified by two (2) per cent or less, the lot shall not be rejected but two (2) additional tests shall be made. If the average of the three (3) tests is equal to or less than the maximum loss allowed, the entire lot shall be accepted provided no test used in computing the average of the three (3) tests exceeds the maximum by more than two (2) per cent.

The brick shall have not less than two (2) lugs on one side. These lugs shall project from the surface of the brick not less than one-eighth (1/8) inch nor more than one-fourth (1/4) inch, and the total area of contact shall not exceed thirty (30) per cent of the area of the side of the brick. If lettering appears on the brick, the letters shall be depressed, not raised. Inspection shall be made at the point of origin unless otherwise specified by the Engineer.

The bricks shall be subjected to visual inspection subsequent to delivery at the place of use, prior to and during laying. The inspector shall cull out and reject all bricks not meeting the following requirements:

Failure to meet general and dimension clauses herein given.

All bricks which are broken through or bricks that are chipped so that neither wearing surface remains substantially intact, or so that the lower or bearing surface is reduced in area by more than one-eighth.

All bricks which are cracked to a depth greater than three-eighths (3/8) inch on any surface, or which are cracked on the wearing surface.

All bricks which are so off-size or so misshaped, bent, twisted or kiln marked that they will not form a proper surface or align properly with other bricks.

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

(2) Sand. Sand for bedding and cover shall consist of hard, durable grains, free from vegetable and other deleterious substances. When dry it shall pass a one-quarter (1/4) inch laboratory screen and shall be well graded from coarse to fine. The material removed by the elutriation test shall not exceed five (5) per cent by weight. Granulated slag, slag screenings or limestone screenings meeting the above specifications may be used in place of sand.

(3) Asphalt. The asphalt used for filler shall be of the type and grade shown on plans and shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

S-322.3. CONSTRUCTION METHODS.

The prepared base shall be cleaned of all loose and foreign materials, and the sand shall be spread to the thickness shown on the plans.

The sand bedding shall be shaped to a true surface parallel with the proposed surface of the finished roadway by means of a template extending the entire width of the roadway, drawn forward upon the curbs or other guide rails as provided. When the width of the roadway precludes the use of a template spanning the entire distance, the bedding shall be shaped in sections, using scantling laid upon the base as guide rails. The bedding course shall be struck off at least twice with the template. Any depressions which develop shall be filled and that area again struck off with the template. This operation shall be continuous until a smooth surface, true to section, is secured.

The bedding course shall be compacted as directed with a hand roller after shaping with a template. The roller shall be not less than thirty-six (36) inches in diameter, twenty-four (24) inches in width, and weigh not less than ten (10) pounds per inch of width. All depressions which develop during rolling shall be filled in, struck off with the template, and re-rolled. This operation shall be repeated until a smooth surface, true to section, is secured.

When the use of the template and guide is impracticable in finishing the bedding surface, it shall be shaped to the surface required by hand lutes.

The bedding shall not be disturbed after final shaping prior to laying the brick. Sand bed which is injured or displaced shall be satisfactorily replaced.

(1) Laying Brick. Brick shall be handled carefully. When piled by the roadside, they shall be so protected that they will not become spattered with earth or mud. All brick shall be kept scrupulously clean until the pavement is finished. No wheeling in barrows will be allowed directly on the brick surface. Brick shall be carried on pallets, in brick clamps, or on mechanical conveyors in such order that when delivered to the dropper they will lie so that in the regular operation of placing them on the sand bed the better face or side will be upward.

The bricks shall be laid immediately upon the sand bed with the best face up, lugs in the same direction from one side of the pavement to the other, in parallel straight courses at right angles to the center line, except at intersections and on curves where they shall be laid as directed by the Engineer. The bricks shall be laid with both ends and sides in contact, breaking joints not less than three (3) inches. The courses shall be straightened by striking lightly with a sledge on a four by four inch timber three feet long, (4" x 4" x 3') placed against every fourth course, all thick bricks being removed. At the ends of courses, and where necessary between courses, closures shall be made by carefully placing bricks cut accurately to give close joints. Cut or broken bricks shall be used only at the ends of courses, placed with the cut end turned toward the adjacent whole brick and shall be not less than three (3) inches in length. While laying bricks the

pavers shall not walk or stand on the bed. The spaces between the bricks shall be kept clean and open to the bottom until the filler is applied. After laying, the bricks shall be inspected, culled and approved before rolling, and if any section contains more than ten (10) per cent of culls, the bricks shall be removed, the bed reshaped, and satisfactory brick placed.

Hillside bricks shall be laid as above specified with the grooves across the line of traffic and the square edge upgrade. Suitable nose brick of quality approved by the Engineer shall be used on the gauge side of trolley rails, as shown on plans.

(2) Rolling. The surface of the bricks shall be swept clean and shall then be rolled with a tandem roller weighing not less than three (3) nor more than five (5) tons, commencing at the sides and proceeding slowly back and forth, parallel to the sides, until the center of the pavement is reached; then passing to the opposite side the rolling shall be repeated in the same manner until the center is again reached, after which the speed may be increased and the rolling continued until the bricks are bedded firmly. The rolling shall then be done obliquely from one side of the pavement to the other side, repeating this operation in the opposite direction. All bricks which are broken or injured during rolling shall be removed and replaced with perfect ones, which likewise shall be brought to the true surface. The brick adjacent to curbing and other areas inaccessible to the roller shall be tamped to grade by the use of a hand tamper, applied upon a two (2) inch board. If the bed is forced up between the bricks more than one-half (1/2) inch, the bricks shall be removed and the bed reshaped.

After final rolling, the pavement shall be tested with a template laid transversely and a ten (10) foot straightedge, laid parallel with the side of the pavement, and any depressions exceeding the allowance of the surface test hereinafter prescribed shall be corrected, and if necessary, the entire surrounding surface again rolled.

(3) Asphalt Filler. After the bricks have been rolled thoroughly, inspected, and approved, the spaces between them shall be filled with the hot asphalt filler.

The filler shall be heated in kettles so designed as to admit of an even heating of the entire mass, with an efficient and positive control of the heat at all times. The asphalt filler shall be applied as directed at a temperature between the minimum and maximum recommended in the Item "Asphalts, Oils and Emulsions". Material heated above 400°F. shall be rejected.

The Contractor shall provide a sufficient number of accurate and suitable thermometers for determining the temperature of the filler material.

Filler shall be applied on the day brick are laid. If required, the surface of the brick shall be swept clean immediately before filling the joints. In order to prevent adhesion of the bituminous material to the exposed brick surface and insure a neat, clean surface, upon completion of the work, prior to placing the filler material, a coating of suitable bond breaking material shall be applied on the top surface of the brick. Other approved means of accomplishing this result will be permitted. Filler shall be worked into the joints by means of squeegees operated slowly backward and forward at an angle with the joints. Squeegeeing shall continue until the joints are completely filled. Any surplus filler material on the surface shall be removed.

Filler shall not be applied if the bricks are wet nor if the air temperature is such that the filler will not flow freely into the joints. When such conditions prevail, all operations shall cease until, in the opinion of the Engineer, weather conditions are suitable.

While the filler is still soft and pliable the pavement shall be covered with a thin layer of sand, and the pavement shall be rolled thoroughly.

(4) Surface Test. The finished pavement surface 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 straightedge shall be placed parallel to the center line of the roadway, so as to bridge any depression, and touch all high spots, and ordinates measured from the face of the straightedge to the surface of the pavement shall at no place exceed one-sixteenth (1/16) inch for each foot in distance from the nearer point of contact.

(5) Traffic Control. Traffic shall not be permitted on the pavement until the filler has cooled to the air temperature. Not less than three (3) days thereafter all surplus sand shall be swept from the surface of the pavement.

S-322.4. MEASUREMENT.

Work and accepted materials as prescribed for this item will be measured by the square yard of surface area of completed and accepted pavement.

S-322.5. PAYMENT.

The work performed and material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Bituminous Filled Brick Pavement", which price shall be full compensation for furnishing, delivering, preparing and placing all materials; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-350

ASPHALTS, OILS, AND EMULSIONS

S-350.1. DESCRIPTION. This item establishes the requirements for oil asphalts, cut-back asphalts, road oils, emulsified asphalts, flux oils, crude oil and cracked fuel oil, to be used.

S-350.2. MATERIALS.

(1) Oil Asphalt. The material shall be homogeneous, shall be free from water, shall not foam when heated to 347°F., and shall meet the following requirements:

TYPE-GRADE	OA-30		OA-55		OA-90		OA-135		OA-175		OA-230	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Penetration at 32°F.,200g.,60 sec.	15	-	-	-	-	-	-	-	-	-	-	-
Penetration at 77°F.,100g.,5 sec.	25	35	50	60	85	100	120	150	150	200	210	250
Penetration at 115°F., 50g.,5 sec.	-	65	-	-	-	-	-	-	-	-	-	-
Ductility at 77°F.,5 cm/min.,cms.	2	-	100	-	100	-	100	-	70	-	70	-
Flash Point C.O.C., °F.	450	-	450	-	450	-	450	-	450	-	450	-
Softening Point, R. & B., °F.	185	-	113	140	113	140	104	140	95	130	86	122
Loss at 325°F., 50 gms., 5 hrs., %	-	0.75	-	0.75	-	0.75	-	0.75	-	0.75	-	0.75
Penetration of Residue at 77°F.,100 g., 5 sec.	15	-	30	-	50	-	70	-	90	-	125	-
Solubility in CCl_4, %	99.5	-	99.5	-	99.5	-	99.5	-	99.5	-	99.5	-

(2) Cut-Back Asphalt. The material shall be free from water and shall meet the following requirements:

TYPE-GRADE	RC-1		RC-2		MC-1		MC-2		MC-3		MC-5	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Flash Point T.O.C. °F.	80	-	80	-	80	-	150	-	150	-	150	-
Furol Viscosity at 77°F., Sec.	-	-	-	-	110	150	-	-	-	-	-	-
Furol Viscosity at 122°F.,Sec.	100	160	200	275	-	-	-	-	-	-	-	-
Furol Viscosity at 140°F.,Sec.	-	-	-	-	-	-	150	250	300	500	-	-
Furol Viscosity at 180°F.,Sec.	-	-	-	-	-	-	-	-	-	-	300	500

When distilled by A.A.S.H.O. Method T-78 (A.S.T.M. Method D-402), the distillate shall be as follows, expressed as per cent of total cut-back:

Off at 437°F.	12	-	10	-	-	10	-	2	-	2	-	-
Off at 500°F.	-	-	-	-	-	-	-	-	-	-	-	4
Off at 600°F.	25	-	-	-	25	-	10	20	8	20	4	14
Off at 680°F.	-	40	-	30	-	50	-	27	-	25	-	18
Off between 600°F. and 680°F.	-	-	-	5	-	-	-	-	-	-	-	-
Tests on residue:												
Penetration at 77°F.,100g.,5 sec.	70	100	120	150	100	200	100	200	100	200	100	200
Ductility at 77°F., 5 cm/min.,cms.	100	-	100	-	100	-	100	-	100	-	100	-
Solubility in CCl_4, %	99.5	-	99.5	-	99.5	-	99.5	-	99.5	-	99.5	-

(3) Road Oils. The material shall be free from water and shall meet the following requirements:

TYPE-GRADE	RO-3		RO-4		RO-95		RO-Special	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Asphalt content of 85 to 115 penetration (*)	60	-	55	-	-	-	55	-
Specific Gravity at 77°F./60°F.	0.95	-	0.94	-	-	-	-	-
Flash Point, C.O.C., °F.	225	-	175	-	250	-	225	-
Furol Viscosity at 122°F., Sec.	-	-	100	160	-	-	-	500
Furol Viscosity at 140°F., Sec.	200	320	-	-	-	-	-	-
Loss at 212°F., 20 gms. 5 hrs., %	-	6.0	-	6.0	-	-	-	6.0
Loss at 325°F., 50 gms. 7 hrs., %	-	-	-	-	2.0	6.0	-	-
Water and Sediment - %	-	-	-	-	-	-	-	2.0
Penetration of residue after evaporation loss, 100 gms., 5 sec.	-	-	-	-	175	250	-	-
Ductility of residue at 77°F., 5 cm/min., cms.	100	-	100	-	-	-	-	-
Solubility in CCl_4, %	99.5	-	99.5	-	99.5	-	-	-
Float Test at 122°F., Sec.	-	-	-	-	140	175	-	-

(*) Determined by vacuum Distillation according to T.H.D. No. 131-45.

Note: RO-Special may be uncracked, partially cracked or cracked.

Note: When tested in accordance with the A.A.S.H.O. Standard Method of Test of Asphaltic Materials by Oliensis Spot Method T-102-38, oil asphalts, cut-back asphalts, and road oils excepting RO-Special shall show a negative result unless it is definitely proved that the parent crude cannot be processed to yield asphaltic material which will give a negative result regardless of how carefully the crude is processed. When such proof is furnished, the use of the following modified solvent will be permitted, and no other clauses or requirements of the standard tests are waived or changed.

The modified solvent shall be distillate from the parent crude from which the asphaltic material under test was made, and shall have the following distillation characteristics:

Initial boiling point	Above 300°F.
50 per cent off at	335 to 355°F.
End point	Below 410°F.

(4) Cracked Fuel Oils and Crude Oils. These materials shall meet the following requirements:

	CRACKED FUEL OIL		CRUDE OIL	
	Min.	Max.	Min.	Max.
Asphalt Content of 100 Penetration @ 77°F., %	65	80	-	-
Asphalt Content of 260 Penetration @ 77°F., %	-	-	65	80
Flash Point T.O.C. , °F.	-	-	80	-
Flash Point C.O.C., °F.	250	-	-	-
Furol Viscosity at 77°F., Sec.	-	-	-	500
Furol Viscosity at 122°F., Sec.	-	500	-	-
Loss at 212°F., 20 gms. 5 hrs., %	-	3.0	-	-
Loss at 325°F., 50 gms. 7 hrs., %	-	-	-	3.0
Water and Sediment - %	-	2.0	-	2.0
Penetration of Residue after Evaporation Loss	-	-	-	300

(5) Emulsions. The material shall be homogeneous. It shall show no separation of asphalt after thorough mixing and shall meet the viscosity requirements at any time within thirty (30) days after delivery.

TYPE-GRADE	EA-HVRS		EA-9SS		EA-10S		EA-11M	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Furol Viscosity at 77°F., Sec.	-	-	30	100	30	100	30	100
Furol Viscosity at 122°F., Sec.	100	600	-	-	-	-	-	-
Residue by Distillation, %	65	-	57.5	65.0	57.5	65.0	57.5	65.0
Oil Portion of Distillate, %	-	-	-	2.0	-	2.0	-	2.0
Sieve Test, %	-	0.1	-	0.05	-	0.05	-	0.05
Miscibility (Standard Test)	-	-	Passing		Passing		Passing	
Coating	-	-	-	-	-	-	Passing	
Cement Mixing, %	-	-	-	2.0	-	2.0	-	-
Demulsibility % (*)	-	-	-	-	-	-	-	70.0
Demulsibility 35 c.c of N/50 $CaCl_2$	30	-	-	-	-	-	-	-
Settlement, 5 days, %	-	3.0	-	3.0	-	3.0	-	3.0
Freezing Test 3 Cycles (**)	-	-	Passing		Passing		Passing	
Tests on Residue	-	-	-	-	-	-	-	-
Penetration at 77°F., 100 g., 5 sec.	100	200	65	100	100	175	100	175
Solubility in CS_2, %	97	-	-	-	-	-	-	-
Solubility in CCl_4, %	-	-	97.5	-	97.5	-	97.5	-
Ductility at 77°F., 5 cm./min.,cms.	40	-	40	-	40	-	40	-

(*) 50 ml. of 0.10 N $CaCl_2$.
(**) Applies only when engineer designates material for winter use.

(6) Flux Oil. Fluxing material shall be free from foreign matter, practically free from water and shall meet the following requirements:

	Min.	Max.
Furol Viscosity at 122°F., sec.	50	100
Flash Point, C.O.C., °F.	250	-
Loss on Heating, 50 gms. 5 hrs. at 325°F. %	0	5

Note: In the above requirements for oil asphalts, cut-back asphalts, road oils, emulsions and flux oils all tests shall be made in accordance with 1938 A.A.S.H.O. methods except where otherwise specified.

S-305.3. APPLICATION TEMPERATURES. Emulsified Asphalts, Oil Asphalts, Cut-back Asphalts, Road Oils, Crude Oils and Cracked Fuel Oil should be applied at the temperatures that provide optimum fluidity for uniform and easy application. No Rapid Curing Cut-Back Asphalt shall be applied at a temperature in excess of 200°F. and no Medium Curing Cut-Back Asphalt shall be applied at a temperature in excess of 275°F. Recommended application temperature ranges for the types and grades of asphalts are as follows:

TYPE		GRADE	APPLICATION TEMPERATURES Minimum	Maximum
Oil Asphalts	All Types	All Grades	275°F.	375°F.
Cut-Back Asphalts	Rapid Curing	RC-1	80°F.	150°F.
		RC-2	100°F.	175°F.
	Medium Curing	MC-1	70°F.	150°F.
		MC-2	100°F.	200°F.
		MC-3	175°F.	250°F.
		MC-5	225°F.	275°F.
Emulsified Asphalts	All Types	All Grades	50°F.	140°F.
Road Oils, Crude Oils and Cracked Fuel Oils.	All Types	All Grades	175°F.	250°F

All asphaltic materials which have been heated above 400°F. will be rejected.

S-350.4. MEASUREMENT AND PAYMENT. All asphaltic materials included in this specification will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

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Construction Specification
March, 1950

ITEM S-351

AGGREGATE FOR SURFACE TREATMENTS

S-351.1. DESCRIPTION. This item establishes the requirements for aggregates to be used in the construction of surface treatments.

S-351.2. MATERIALS. Aggregates shall be composed of sound and durable particles of gravel, crushed gravel, broken stone, crushed slag or natural limestone rock asphalt. These materials shall be free from organic matter, clays, loam or pebbles coated therewith and shall contain not more than five (5) percent of slate, shale, schist or soft particles of sandstone. The various types and grades of aggregate are identified as follows:

S351.3. TYPES. Type A aggregate shall consist of gravel, broken stone, crushed slag, or natural limestone rock asphalt.

Type B aggregate shall consist of crushed gravel, broken stone, crushed slag or natural limestone rock asphalt.

Crushed gravel shall have a minimum of eighty-five (85) percent fragments with at least one crushed face.

Natural limestone rock asphalt shall contain four (4) to eight (8) percent of asphalt and ninety-two (92) to ninety-six (96) percent of limestone practically free from sulphates, iron pyrites, alumina or other objectionable matter and shall be uniform as to quality and asphalt content.

The percent of wear, as determined by the Los Angeles Abrasion Test of Coarse Aggregate, A.A.S.H.O. Designation T-96 with subsequent revisions, for each of the materials shall not exceed the following:

Material	Max. Percent of Wear
Gravel	35
Crushed Gravel	35
Broken Stone	35
Crushed Slag	40
Natural Limestone Rock Asphalt	45

S-351.4. GRADES. The gradation requirements for the several grades of aggregates shall be as follows:

Grade 1:	Retained on 1" screen	0%
	Retained on 3/4" screen	15 to 45%
	Retained on 1/2" screen	85 to 100%
	Retained on 1/4" screen	95 to 100%
	Retained on 10 mesh sieve	97 to 100%
Grade 2:	Retained on 3/4" screen	0%
	Retained on 1/2" screen	30 to 70%
	Retained on 1/4" screen	80 to 100%
	Retained on 10 mesh sieve	97 to 100%
Grade 3:	Retained on 3/4" screen	0%
	Retained on 1/2" screen	25 to 50%
	Retained on 10 mesh sieve	97 to 100%

Grade 4:	Retained on 3/4" screen	0%
	Retained on 1/2" screen	5 to 20%
	Retained on 10 mesh sieve	97 to 100%
Grade 5:	Retained on 5/8" screen	0%
	Retained on 1/2" screen	0 to 10%
	Retained on 1/4" screen	60 to 100%
	Retained on 10 mesh sieve	97 to 100%
Grade 6:	Retained on 5/8" screen	0%
	Retained on 1/2" screen	0 to 10%
	Retained on 1/4" screen	35 to 60%
	Retained on 10 mesh sieve	97 to 100%
Grade 7:	Retained on 1/2" screen	0%
	Retained on 3/8" screen	5 to 20%
	Retained on 10 mesh sieve	97 to 100%
Grade 8:	Retained on 1/2" screen	0%
	Retained on 3/8" screen	0 to 10%
	Retained on 10 mesh sieve	97 to 100%
Grade 9:	Retained on 1/2" screen	0%
	Retained on 1/4" screen	5 to 35%
	Retained on 10 mesh sieve	70 to 100%
	Retained on 20 mesh sieve	98 to 100%
Grade 10:	Retained on 3/8" screen	0%
	Retained on 1/4" screen	2 to 20%
	Retained on 10 mesh sieve	70 to 100%
	Retained on 20 mesh sieve	98 to 100%

S-351.5. MEASUREMENT AND PAYMENT. Aggregates will be measured and paid for in accordance with the governing specifications for the items of construction in which these materials are used.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-402

CONCRETE STRUCTURES

S-402.1. DESCRIPTION. These specifications shall govern for the construction of culverts, retaining walls, abutments, bents, piers, slabs, girders, and incidental structures involving the use of concrete.

All concrete structures shall be constructed in accordance with the design requirements and details shown on the plans; conforming to the pertinent provisions of the Items for "Structural Excavation", "Piling", "Railing", "Reinforcing Steel", "Concrete for Structures", and other incidental items of the specifications which are applicable to the completed structure; and in conformity with the requirements herein.

S-402.2. MATERIALS. (a) Concrete. All concrete shall conform to the provisions of Item S-403, "Concrete for Structures", and pertinent Special Provisions thereto. The class of concrete for each unit shall be as specified on the plans or in the pertinent specifications.

(b) Expansion Joint Material.

(1) Premolded Material.
Premolded expansion joint material shall be of the dimensions specified or shown on plans. The material shall be of such character that it will not be deformed or damaged by ordinary handling during hot or cold weather. Not over two thin strips of stiffener will be allowed. Pieces of the joint material which have been damaged shall be rejected. The material shall be any one of the following types unless specifically noted otherwise on the plans:

TYPE I. "Pre-formed Cork Material" shall be formed from approved clean cork particles bound together by synthetic resin and shall conform to the requirements of the "Standard Specification for Pre-formed Expansion Joint Fillers for Concrete", A.S.T.M. Designation D-544, Type I, Cork.

TYPE II. "Pre-formed Cork-Asphalt Material" shall be of asphalt or tar composition of approved quality and the bitumen shall be uniformly impregnated with suitable granulated cork particles. The material shall meet the following requirements when tested in accordance with A.A.S.H.O. T-42-42:

1. Dimensions shall be as specified in the plans and a tolerance of $\pm$ 1/16 inch in thickness, $\pm$ 1/8 inch in width and $\pm$ 1/4 inch in length shall be permitted.

2. Distortion: Not more than 1 inch.

3. Brittleness: The joint material shall not crack or shatter when subjected to the test for brittleness.

4. Compression: The load required to compress the sample to 50% of its thickness before test shall be not less than 100 nor more than 750 pounds per square inch.

5. Recovery: The test specimen shall be given three applications of a load sufficient to compress the material to 50% of its thickness before test. The load shall be immediately released after each application. At the end of one hour after the third application, the joint shall have recovered to at least 75% of its thickness before test.

6. Absorption: The absorption shall be not more than 15% by volume.

TYPE III. "Pre-formed Bituminous Fiber Material" shall be formed from cane or other suitable fibers of a cellular nature securely bound together and uniformly impregnated with a suitable asphaltic binder and shall meet the requirements of the "Standard Specifications for Pre-formed Expansion Joint Filler for Concrete (Bituminous Fiber Type), A.A.S.H.O. Designation; M 59-42.

TYPE IV. "Pre-formed Cork Rubber Material" shall be formed from approved clean granulated cork particles bound together by a durable elastic rubber compound and shall conform to the requirements of the "Standard Specification for Pre-formed Expansion Joint Fillers for Concrete", A.S.T.M. Designation D-544, Type IV.

TYPE V. "Pre-formed Bituminous Material" shall be of asphalt or tar composition of approved quality and the bitumen shall be uniformly impregnated with a suitable filler to reduce its brittleness at low temperatures to a minimum.

The material shall meet the following requirements when tested in accordance with A.A.S.H.O. T-42-42:

1. Absorption, not more than 5% by weight.
2. Distortion, not more than 1 1/2 inches.
3. Brittleness: The material shall not crack or shatter when subjected to the test for brittleness.

(2) Poured Joint Material. Poured joint material shall consist of an asphalt or a joint sealing compound meeting the respective requirements set out herein. The Contractor may use either of these materials unless otherwise noted on the plans.

(A) Asphalt. Asphalt for use in poured joint shall be homogeneous, shall be free from water, and shall not foam when heated to 200° Centigrade (392° Fahrenheit). 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 grms., 60 sec., not less than - - -	10
Penetration at 25° C. (77° F.), 100 grms. 5 sec. - - - - - - - - - - -	30 to 50
Penetration at 46° C. (115° F.), 50 grms., 5 sec., not more than - - -	110
Loss on heating at 163° C. (325° F.), 50 grms., 5 hrs., not more than - -	1.0%
Penetration at 25° C. (77° F.), 100 grms., 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%

(B) Joint Sealing Compound. Joint sealing compound used in expansion joints shall meet the following requirements:

General Requirements: The material shall melt to the proper consistency for pouring and shall solidify on cooling to atmospheric temperatures. It shall adhere to the sides of the concrete joint or crack. The material shall not crack or break when exposed to low temperatures.

Material Requirements: A sample of the material weighing approximately 300 grams shall be selected in such manner as to avoid inclusion of the surface layer. Of this quantity, 100 grams shall be melted slowly, with continued stirring to a pouring consistency, in a clean container using an oil bath or similar heating unit, to avoid local overheating. The remaining 200 grams shall be added in quantities of approximately 50 grams at a time to the melted material until the entire quantity is of a sufficiently fluid consistency to be poured satisfactorily.

The melting of the total quantity of material shall be completed within sixty (60) minutes of the initial heating of the material. At no time shall the temperature exceed 450° F.

Penetration: The penetration of the material sampled and molten (as herein described) when tested with a Penetrometer according to A.S.T.M. Designation D 5-25 with a grease cone (D 217-38 T) attachment, shall be as follows:

25° -C (77°F) 150 g. Weight 5 Sec. 0.45-0.75 cm.

Flow: A portion of the molten samples shall be poured into a suitable amalgamated mold 4 cm. wide by 6 cm. long, on a bright tin panel to a uniform depth of 0.32 cm. After cooling at room temperature for two (2) hours, the mold shall be removed and the panel placed in an oven at 140° F. ± 2 at an incline of 75 degrees for five (5) hours. The material shall not flow more than 0.5 cm. as a result of this test.

Adhesion: A test specimen for the adhesion test shall consist of a four (4) cubic inch sample of the joint sealing material poured between cement pieces as described below:

Two (2) cement mortar pieces each approximately one (1) by two (2) by three (3) inches (1"x2"x3") shall be made of cement mortar, consisting of one (1) part by weight of Portland Cement to two (2) parts by weight of clean, uniformly graded sand, 100 percent passing a number four (4) sieve and zero (0) to five (5) percent passing a number one hundred (100) sieve. The cement mortar mix shall be made to consistency of 50 (+ or - 5) as measured by the Standard A.S.T.M. mortar flow table.

After having been cured for seven (7) days, the wet mortar pieces shall be resurfaced by grinding with a standard number 30 H.D. Carborundum stone on a Standard Delemeter, at a pressure of fifteen (15) to twenty (20) pounds. The surfaces of the mortar pieces shall upon examination, show that the aggregate is uniformly exposed. The concrete pieces shall then be permitted to air dry at room temperature (77° F.) for twenty-four (24) hours prior to use.

The complete mortar pieces shall be spaced one (1) inch apart on a plate of amalgamated metal and shall be held apart by amalgamated metal strips spaced at such distances from the ends that a space one (1) inch by two (2) inches by two (2) inches (1"x2"x2") is formed for pouring with the joint sealing filler material to be tested. The test joint form may be held together by rubber bands or suitable clamps.

Freezing: A test specimen (as herein described) shall be allowed to cool in air at room temperature for two (2) hours, thereafter, placed in a refrigerating unit being maintained at 15° F. (+ or - 2°) for a minimum of six (6) hours.

Bond and Extension while Frozen: The specimen while at a temperature of 15° F. (+ or - 2°) shall be removed from the amalgamated plate and strips and then immediately placed in the self-aligning clamps of the Extension Machine (described above) maintained at a

temperature of 15° F. (+ or - 2°) in a refrigerating unit. The extension Machine shall then extend the width of the specimen at the rate of approximately one-eight inch per hour to a width fifty (50) per cent greater than its original poured width.

Extension Machine: The Extension Machine shall be so designed that the specimen can be expanded uniformly at the rate of approximately one-eight inch per hour. The Extension Machine shall consist essentially of one or two screws rotated by an electric motor through suitable gear reduction units. The screw or screws shall carry a threaded moving self-aligning plate to which, and to a stationary plate, the specimen is clamped.

Compression: After having been extended to the required width, the specimen shall be removed and placed at room temperature (approximately 77° F.) for two (2) hours, thereafter compressed to its thickness before extension at the rate of one-tenth (0.1) inch per minute. During this compression, the specimen is to be maintained in a horizontal position.

The specimen is then again placed in the refrigerating unit and the extension and compression tests repeated for four (4) cycles, as described above.

There shall be no cracking of the joint sealing filler material or break in the bond between the joint sealing filler material and the mortar pieces.

(c) Traffic Stripe Pigment.

The pigment for traffic stripes shall be composed of the crystalline pigment known as Black Magnetic Oxide of Iron or Ferroso-Ferric Oxide made by process of chemical precipitation so as to form a pigment of uniform small particle size.

Not more than two (2) per cent shall be retained on a 325 mesh sieve when tested by the water washing method.

The specific gravity shall not be less than 4.68.

When a 10.0 gram sample is digested for 15 minutes in a hot mixture of 75 ml. concentrated hydrochloric acid and 24 ml. of concentrated nitric acid, only a slight trace of insoluble residue shall remain after dilution to 250 ml. with distilled water.

The standard pigment for color comparison shall be the Magnetic Oxide of Iron, known commercially as Raven Black, manufactured by the Geo. S. Mepham Corp., East St. Louis, Illionis.

The material shall have a blue-black color and not a brownish hue. The mass tone shall be equal to the standard in black intensity and blue tone when compared in the following manner:

Make a paste from 35.0 grams of the sample and 15.0 grams of alkali refined linseed oil by rubbing these materials together with a spatula or muller on a smooth or frosted glass slab or lithographer's stone. Make a mixture of identical size and proportions using the standard pigment and linseed oil using the same kind and number of rubs. The linseed oil used shall be the same type as that mixed with the sample, and shall be taken from the same container. Compare the colors of the two pastes by viewing the underside of adjacent smears placed upon a colorless microscopic glass slide.

The tinting strength shall be equal to the standard in strength and blue tone when compared in the following manner:

Mix 2.0 grams of the black pastes, prepared as provided for the above color comparison, each with 25.0 grams of Zinc Oxide Paste prepared by grinding 2.75 parts by weight of finely ground Lead-Free Zinc Oxide with 1.0 part by weight of alkali refined linseed oil. Compare the tints on glass in the same manner as that required for the color comparison.

For test purposes, a representative sample of the proposed pigment, weighing approximately one-half pound, shall be forwarded to the Laboratory.

(d) Other Materials. All other materials such as reinforcing steel and structural steel shall conform to the requirements of pertinent specifications.

S-402.3. GENERAL CONSTRUCTION REQUIREMENTS. Before starting work, the Contractor shall inform the Engineer fully as to the methods of construction he proposes to follow and as to the amount and character of equipment he proposes to use, the adequacy of which shall be subject to the approval of the Engineer.

Before constructing forms and falsework for concrete piers and for concrete superstructure spans over twenty (20) feet in length, form and falsework plans shall be submitted to the Engineer for review and approval. Similar plans shall be submitted for other units of the structure if requested by the Engineer. The plans shall be prepared on standard sheets twenty-two (22) inches by thirty-six (36) inches overall size and shall be sufficiently complete to show all essential details of the proposed forms, falsework, and bracing for same. In general, not over six sets of such plans will be required.

Concurrence on the part of the Engineer in any proposed construction methods, approval of equipment, or approval of form and falsework plans shall not be considered as relieving the Contractor of the responsibility for the safety or correctness of his methods and adequacy of his equipment or from carrying out the work in full accordance with the contract.

Unless otherwise provided, the following requirements shall govern for the time sequence in which construction operations may be carried on and for the opening of completed structures to traffic.

Steel I-beams or forms and falsework for superstructures shall not be erected on concrete substructures until the concrete in the substructure has cured at least four (4) curing days. Concrete for concrete slab or girder spans or concrete slabs on steel I-beam spans shall not be placed until the substructure has cured at least seven (7) curing-days.

Steel trusses or plate girders to be erected from the ground on approved falsework may be erected when the substructure has cured four (4) curing-days, but the falsework shall not be removed until the substructure has cured at least seven (7) curing-days. Erection by means of a traveler on the span will not be permitted until the substructure has cured at least seven (7) curing days.

Forms for walls or columns shall not be erected on concrete footings until the concrete in the footing has cured at least two (2) curing-days. Concrete may be placed in the wall or column as soon as the forms and reinforcing steel placement are approved.

The use of completed portions of a structure as the site for mixing operations or for storage of materials will not be permitted until the particular portion of the structure has aged at least seven curing-days.

A curing-day shall be as defined in Section S-402.22. In continued cold weather the construction operations may be authorized at the end of a period of calendar days equal to twice the number of curing-days specified above.

Structures shall not be opened to construction traffic or to the traveling public until authorized by the Engineer. Such authorization may be given when the last concrete placed has cured at least seven curing-days but not until the requirements for form and falsework removal have been fulfilled. This authorization shall cover only such traffic that complies with legal load limitations.

S-402.4. FOUNDATIONS. Excavation for foundations shall be made in accordance with the requirements of the pertinent specifications for Structural Excavation.

Caissons shall be constructed of the materials and to the dimensions and details shown on the plans. Forms for concrete caissons may be of wood or metal meeting the hereinafter specified requirements, Section S-402.9. The operation of sinking will be permitted to proceed immediately after form removal.

Where necessary, falsework shall be provided to support the caisson during the construction and lowering period. Such falsework shall be of the strength required to support the caisson in combination with the forces of wind, water currents and drift.

Concrete foundation seals, if required, shall be of the thickness shown on the plans. Unless otherwise specified, the seals shall be Class E Concrete and shall be placed in accordance with the requirements herein for concrete placed in water, Section S-402.13. The completed seal shall not be higher or lower than the plan grade or the grade established by the Engineer, by more than one-sixteenth (1/16) times the least inside caisson, cofferdam, or dredge well dimension at such grade.

The seal shall be allowed to set for at least thirty-six (36) hours before the caisson or cofferdam is unwatered. After unwatering, the top of seal shall be cleaned off, all laitance or other soft material readily loosened with a pick shall be removed, and all high spots which exceed the above limitation shall be cut off and removed.

In general, foundation piling shall be cut off reasonably square at the elevation shown on plans. A tolerance of not more than two (2) inches above or below established cut-off grade will be permitted.

S-402.5. DRAINS. Weep hole drains shall be installed in abutments and retaining walls, and roadway drains or scuppers shall be installed in the roadway slabs in accordance with the details shown on the plans.

S-402.6. EXPANSION JOINTS AND DEVICES. Expansion joints and devices to provide for expansion and contraction shall be constructed where and as indicated on the plans.

Unless otherwise provided on the plans, the bridge seat under the expansion ends of concrete slab spans shall be finished with a steel trowel, and the surfaces of substructure and spans shall be separated by layers of roofing felt or a combination of roofing felt and sheet metal. Before installation, the contact areas of such roofing felt or sheet metal shall be coated with graphite grease. Layers of roofing felt or sheet metal shall be carefully placed so that concrete or mortar will not be worked around or under the material.

All joints constructed open, to be left open or filled with poured joint material, shall be constructed using forms adaptable to loosening or early removal. In order to avoid jamming such forms by the expansion action of the spans and the consequent likelihood of injury to the adjacent concrete, these forms shall be removed or loosened as soon as practicable after the concrete has attained its final set. A provision for loosening the forms to permit free expansion of the span without the necessity for full removal is preferred.

Armored joints shall be carefully constructed in order to avoid defective anchorage to the steel and to avoid porous or honeycombed concrete adjacent to same.

When premolded joint material is used in vertical joints of roadway and sidewalk slab, the tops of such joints shall be adequately sealed with poured joint material meeting the requirements of Section S-402.2(b)(2). To accomplish this sealing the top one inch depth (or greater depth when so shown on plans) shall be constructed open or the premolded material shall be plowed out and the space filled with the poured joint material. Prior to placing the joint sealing material, the faces of the joint shall be cleaned of all laitance by wire brushing, chipping or other approved methods, and broomed clean of all dust, chips and other foreign material. Asphalt poured joint material shall be heated to the desired fluidity in equipment suitable for that purpose and approved by the Engineer. Joint Sealing Compound shall be melted in an approved oil-bath kettle, with continuous mechanical agitation. The oil-bath kettle shall be equipped with a recording thermometer. The

Engineer will determine the optimum temperature for proper pouring fluidity and the Contractor shall keep the material within close range of that temperature. Asphalt material shall not be heated above 400° F and Joint Sealing Compound shall not be heated above 450° F at any time. Material heated above the specified temperatures shall be rejected.

Premolded material, if specified, shall be used in expansion or contraction joints in abutment walls, wing walls and retaining walls. Metal flashing strips for the prevention of water seepage through wall joints shall be provided and installed in accordance with the plan provisions.

Premolded materials, wherever used, shall be anchored to the concrete on one side of the joint by means of copper wire not lighter than No. 12 B. & S. gauge. Such anchorage shall be sufficient to preclude the tendency of the material to fall out of the joint.

Careful workmanship shall be exercised in the construction of all joints to insure that the concrete sections are completely separated by an open joint or by the joint materials and to insure that the joints will be true to the outline indicated. Immediately after the removal of forms and again where necessary after surface finishing, all projecting concrete shall be removed along the exposed edges of premolded materials in order to secure full effectiveness of the expansion joints.

Where roofing felt or premolded materials are specified for horizontal joints, the material shall, if practicable, extend two (2) inches beyond the form for the top member. The projecting portions shall be subsequently trimmed to the face of the member after the forms are removed.

S-402.7. CONSTRUCTION JOINTS. The joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set shall be deemed a construction joint. When concrete in a structure or a portion of a structure is specified to be placed monliithic, the term monolithic shall be interpreted to mean that the manner and sequence of concrete placing shall be such that construction joints will not be incurred.

Construction joints shall be of the type and spacing shown on the plans. Additional joints shall not be provided without written authorization from the Engineer. Any additional construction joints shall have details equivalent to those shown on the plans for joints in similar locations.

Unless otherwise provided, construction joints shall be square and normal to the forms. Bulkheads shall be provided in the forms for all joints except horizontal joints.

The top surface of a concrete placement which terminates at a horizontal construction joint shall have the surface cement film removed and shall be thoroughly roughened as soon as practicable after the concrete has attained initial set. The surfaces at bulkheads shall be roughened as soon as the bulkhead forms are removed.

Before joining plastic concrete to concrete that has already set, the surface of the concrete in place shall be free from all loose material, laitance, dirt or foreign matter; shall be washed and scrubbed clean with stiff brooms and thoroughly drenched with water until saturated, and shall be kept wet until the plastic concrete has been placed. Immediately prior to the placing of additional concrete, all forms shall be drawn tight against the concrete in place, and the surface of the concrete in place shall be flushed with a coating of grout mixed in the proportions of one part of cement to two parts of sand.

If shown on the plans, construction joints shall be provided with concrete keyways, reinforcing steel dowels, and/or metal flashing strips. The method of forming keys in keyed joints shall be such as to permit the easy removal of forms without chipping, breaking, or damaging the concrete in any manner.

S-402.8. FALSEWORK. All falsework shall be designed and constructed so that no excessive settlement or deformation will occur, and so that the necessary rigidity will be provided. Details of falsework construction shall be subject to review and approval by the Engineer in accordance with the provisions of Section S-402.3.

For calculating the loads on falsework, a weight of one hundred and fifty (150) pounds per cubic foot shall be assumed for concrete, and a live load allowance of fifty (50) pounds per square foot of horizontal surface of the form work shall be included. The maximum unit stresses shall not

exceed one hundred and twenty-five (125) per cent of the allowable stresses used by the State Highway Department for the design of structures.

All timber used in falsework centering shall be sound, in good condition, and free from defects which will impair its strength. All timber for wedges shall be hardwood.

Timber piling may be of any species of wood which will withstand driving satisfactorily and which will adequately support the superimposed load.

Steel members shall be of adequate strength and of such shape as to be suitable for the purpose intended.

Where sills or timber grillages are used to support falsework columns, such sills and grillages, unless founded on solid rock, shale or other hard materials, shall be placed in excavated pits and backfilled to prevent the softening of the supporting material by drip from the forms or by rains that may occur during the construction process. Sills or grillages shall be of ample size to support the superimposed load without settlement.

Falsework which cannot be founded on a satisfactory spread footing shall be supported on piling which shall be driven to a bearing capacity sufficient to support the superimposed load without settlement. The safe bearing capacity of piling shall be determined by test loads or by formula given in the pertinent specifications for "Piling".

In general, each falsework bent shall be capped transversely at the proper elevation by a cap of adequate size. If desired by the Contractor, however, a short cap section forming a T-head may be substituted at the top of each pile or column in order to permit the removal of portions of the forms without disturbing the falsework. Caps shall be adequately fastened to each pile or column in the bent and shall be set at the proper elevation to produce, in conjunction with the use of approved hardwood wedges or jacks, permanent camber indicated on the plans or specified, plus a construction camber covering allowance for deformation of the forms and falsework. The use of wedges to compensate for incorrectly cut bearing surfaces will not be permitted. Wedges shall be used in pairs and shall be so arranged as to insure uniform bearing. Each falsework bent shall be securely braced to adjacent bents by bracing material of ample size to provide the stiffness required. The bracing shall be securely spiked or bolted to each pile or column it may cross.

Unless otherwise provided, each slab or girder span shall be constructed with a permanent camber at the center equal to one-eighth (1/8) inch for each ten (10) feet of span length with a proper additional allowance being made for settlement.

S-402.9. FORMS.

(a) General Requirements. Except where otherwise specified, forms may be constructed of either timber or metal as elected by the Contractor. The use of material other than timber or metal will be permitted in special cases when suitable to the intended purposes and when approved by the Engineer.

Forms shall be built mortar-tight and of material sufficient in strength to prevent bulging between supports and shall be set and maintained to the lines designated until the concrete is sufficiently hardened to permit form removal. During the elapsed time between the building of the forms and the placing of the concrete, the forms shall be maintained in a manner to eliminate warping and shrinkage. All details of form construction shall be subject to the approval of the Engineer, and permission to place concrete will not be given until all of such work is complete to his satisfaction.

Forms shall be designed for the pressure exerted by a liquid weighing one hundred and fifty (150) pounds per cubic foot. The rate of placing the concrete shall be taken into consideration in determining the depth of the equivalent liquid. An additional live load of fifty (50) pounds per square foot shall be allowed on horizontal surfaces. The maximum unit stresses shall not exceed one hundred and twenty-five (125) per cent of the allowable stresses used by the State Highway Department for the design of structures.

If, at any stage of the work, the forms show signs of bulging or sagging, that portion of the concrete causing such condition shall be immediately removed, if necessary, and the forms shall be reset and securely braced against further movement.

(b) Timber Forms. Lumber for forms shall be properly seasoned and of good quality. It shall be free from loose or unsound knots, knot holes, twists, shakes, decay, and other imperfections which would affect its strength or impair the finished surface of the concrete. The lumber used for facing or sheathing shall be surfaced on at least one side and two edges and shall be sized to uniform thickness.

The use of nominal two (2) inch lumber as a minimum thickness will be required for forms for the bottoms of all superstructure girders except that in case of special forming of girders, as for curved-bottom girders where facing boards are transverse to beam, the Engineer may permit the use of one (1) inch lumber. Nominal one (1) inch thickness lumber will be permitted for general use on other portions of the structure if backed by a sufficient number of studs and wales.

Timber forms for exposed concrete surfaces which are to receive either a Type 1 or Type 2 Surface Finish under the provisions of Section S-402.24, shall be face lined with an approved type of form lining material such as masonite, plywood or equal except that no lining will be required on any portions of the areas inside of culvert barrels nor will lining be required on any concrete surfaces of such dimensions that the face form is constructed of a single smooth board or plank of a width equal to or greater than the surface to be finished.

If desired by the Contractor, forms may be constructed of plywood not less than one-half (1/2) inch in thickness, and in this case no form lining will be required. The clear spacing of the supporting studs or joists shall not exceed twenty times the actual thickness of the plywood. The grain of the face plies on such plywood forms shall be laid parallel to the span between the supporting studs or joists.

No form lining will be required for surfaces which are to receive a Type 3 Surface Finish under the provisions of Section S-402.24.

Forms or form lumber to be re-used shall be maintained clean and in good condition as to accuracy, shape, strength, rigidity, tightness, and smoothness of surface. Any lumber which is split, warped, bulged, marred, or has defects that may produce work inferior to that resulting from using new material shall not be re-used.

Studs and joists shall not be less than two (2) inches by four (4) inches nominal section and shall be spaced so that the clear span of the facing lumber between them shall not be more than twenty (20) times the actual thickness of the facing lumber. Wherever practicable, studs shall be capped at the top with a plate of not less than two (2) inches by four (4) inches, nominal size, carefully selected as to straightness. All joints in plates shall be scabbed at least four (4) feet each way to provide continuity.

Wales shall be spaced at such intervals as to hold forms securely to the designated lines. All wales shall be scabbed at least four (4) feet on each side of joints to provide continuity. A row of wales shall be placed within six (6) inches of the bottom of each placement.

Forms shall be rigidly braced to prevent movement while placing the concrete.

All face form material shall be fastened to all studs and shall have true horizontal and vertical joints. Facing material on horizontal and other surfaces shall be placed with parallel and square joints.

Molding specified for chamfer strips or other uses shall be made of redwood, cypress or pine materials of such grade that will not split when nailed and which can be maintained to a true line without warping. The molding shall be mill cut and dressed on all faces. Unless otherwise provided, forms shall be filleted at all sharp corners and edges with triangular chamfer strips. The strips shall be three-fourths (3/4) inch measured on the sides.

Forms for railings and ornamental work shall be constructed to standards equivalent to first class mill work. All moldings, panel work, and bevel strips shall be straight and true with neatly mitered joints and of such design that the finished work shall be true, sharp, and clean cut.

All forms shall be so constructed as to permit removal without damage to the concrete. Particular and special care must be exercised in framing forms for copings, offsets, railing and all

ornamental work, so that there will be no damage to or marring of the concrete when the forms are removed. If desired by the Contractor, the forms may be given a slight draft to permit ease of removal.

Metal form ties of an approved type or a satisfactory substitute shall be used to hold forms in place. Such ties shall be of a type as to permit ease of removal of the metal as hereinafter specified.

All metal appliances used inside of forms to hold them in correct alignment shall be removed to a depth of at least one-half (1/2) inch from the surface of the concrete and shall be so constructed that the metal may be removed without undue injury to the surface by chipping or spalling. Such devices, when removed, shall leave a smooth opening in the concrete surface. Burning off of rods, bolts, or ties will not be permitted.

Metal ties shall be held in place by devices attached to wales. Each device shall be capable of developing the strength of the tie.

Pipe spreaders will not be permitted.

Metal and wooden spreaders which are separate from the forms shall be entirely removed as the concrete is being placed.

Where wire ties are used, all wires, upon removal of the forms, shall be cut back at least one-half (1/2) inch from the face of the concrete with a sharp chisel or nippers.

All cavaties produced by the removal of metal ties shall be carefully cleaned and completely filled with re-tempered sand cement mortar mixed in proportion of one to three, and the concrete shall be left smooth and even.

Whenever practicable, forms shall be erected complete before the reinforcement is placed.

For narrow walls and other locations where access to the bottom of the forms is not readily attainable otherwise, adequate clean-out openings shall be provided.

At the time of placing concrete, the forms shall be clean and entirely free from all chips, dirt, sawdust, and other extraneous matter.

The facing of all forms shall be treated with oil before concrete is placed. In hot weather, both sides of face forms may be required to be treated with oil to prevent warping and to secure tight joints. The oil must be applied before the reinforcement is placed. The oil used for this purpose shall be a light clear oil which will not discolor or otherwise injuriously affect the concrete surface.

In general, all forms shall be thoroughly wetted before the concrete is placed therein.

(c) Metal Forms. The foregoing specifications for "Timber Forms" as regards design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, re-use, oiling and wetting shall apply with equal force to metal forms.

The metal used for forms shall be of such thickness that the forms will remain true to shape. The minimum thickness of metal used in forms for cylindrical columns or shafts shall be 3/16 inch. Forms may be made in sections of such lengths as will facilitate the placing of concrete and the removal of forms. The joints of sections must be closely fitted so as not to result in off-set joints. All bolt and rivet heads on the facing sides shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used. Special care shall be exercised to keep metal free from rust, grease, or other foreign material such as will tend to discolor the concrete.

S-402.10. PLACING REINFORCEMENT. Reinforcement in concrete structures shall be carefully and accurately placed and rigidly supported as provided in Item S-405, "Reinforcing Steel".

S-402.11. PLACING CONCRETE, GENERAL. The Contractor shall give the Engineer sufficient advance notice before starting to place concrete in any unit of the structure to permit the inspection of forms, the reinforcing steel placement, and preparations for casting. Unless authorized by the Engineer, no concrete shall be placed in any unit prior to the completion of the formwork and the placement of the reinforcement. No concrete shall be placed before the completion of all adjacent pile driving or other operations which might prove detrimental to the concrete.

Whenever it is necessary to continue the mixing, placing, and finishing of concrete after the daylight hours, the site of the work shall be brilliantly lighted so that all operations are plainly visible. In general, however, concrete placing shall be so regulated as to permit finishing operations to be completed in the daylight hours.

The Engineer reserves the right to order postponement of the placing operations when, in his opinion, impending weather conditions may result in rainfall or low temperatures which will impair the quality of the finished work. In case rainfall should occur after placing operations are started, the Contractor shall provide ample covering to protect the work. In case of drop in temperature, the provisions set forth in Section S-402.12 shall be applied.

The sequence of placing concrete shall be as provided on the plans or in the specifications. The operation of depositing and compacting the concrete shall be conducted so as to form a compact, dense, impervious mass of uniform texture which shall show smooth faces on all surfaces. The placing shall be so regulated that the pressures caused by the plastic concrete shall not exceed the loads used in the design of forms.

The method and manner of placing shall be such as to avoid the possibility of segregation or separation of the aggregate or the displacement of the reinforcement. Concrete shall not have a free fall of more than three (3) feet except in the case of thin walls such as culvert walls. The spattering of forms or reinforcement bars shall be prevented if the concrete so spattered will dry or harden before being incorporated in the mass.

Each part of the forms shall be filled by depositing concrete directly as near its final position as possible. The coarse aggregate shall be worked back from the face and the concrete forced under and around the reinforcement bars without displacing them. Depositing large quantities at one point in the forms and running or working it along the forms will not be allowed.

After the concrete has taken initial set, the forms shall not be jarred or any strain placed on projecting reinforcement.

Chutes, troughs, or pipes used as aids in placing concrete shall be arranged and used so that the ingredients of the concrete will not be separated. When steep slopes are necessary, the chutes shall be equipped with baffle boards or be made in short lengths that reverse the direction of movement. Open troughs and chutes shall extend, if necessary, down inside the forms or through holes left in the forms, or the ends of such chutes shall terminate in vertical downspouts. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by a thorough flushing with water before and after each placement. Water used for flushing shall be discharged clear of the concrete in place. The use of chutes in excess of thirty-five (35) feet total length for conveying concrete will not be permitted except by specific authorization from the Engineer.

Where the Contractor's operations involve the placing of concrete from above, that is, directly into an excavated area or through the completed forms, particularly in the case of abutments, piers, columns, retaining walls, and deep girders, and excepting thin walls such as culvert walls, all concrete so placed shall be deposited through a vertical sheet metal or other approved pipe not less than six (6) inches nor more than ten (10) inches in diameter. The pipe shall be made in sections so that the outlet may be adjusted to proper heights during placing operations.

Concrete shall be placed in continuous horizontal layers approximately 12 inches in thickness. Not more than one hour shall elapse between the placing of successive layers of concrete in any portion of the structure included in a continuous placement. The Contractor shall avoid unauthorized construction joints by placing required portions of abutments, piers, walls or superstructures in one continuous operation. Laitance or foreign matter of any kind shall not be permitted to accumulate inside the forms; and openings in forms necessary for removal of same shall be provided.

All concrete shall be well compacted and the mortar flushed to the surface of the forms by continuous working with concrete spading implements or mechanical vibrators of an approved type. Vibrators of the type which operate by attachment to forms or reinforcement will not be permitted. The vibrators shall be applied to the concrete immediately after deposit and shall be moved throughout the mass, thoroughly working the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms until it has been reduced to a plastic mass. The mechanical vibrator shall not be operated so that it will penetrate or disturb layers placed previously which have become partially set or hardened. The vibration shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures but shall not be done to an extent that will cause segregation. Vibration shall be supplemented by hand spading if necessary to insure the flushing of mortar to the surface of all forms.

Holes for anchor bolts in piers, abutments, bents, or pedestals may be drilled or may be formed by the insertion of oiled wooden plugs or metal sleeves in the plastic concrete. The plugs or sleeves shall be withdrawn after the concrete has set. When the holes are formed, they shall be of such diameter to permit horizontal adjustment of the bolts. The bolts shall be carefully set in mortar. In lieu of the above methods of placing, anchor bolts may be set to exact locations in the concrete when it is placed.

The placing of concrete for floor slabs of slabspans, I-beam spans, girder spans, or truss spans preferably shall be done from a mixing plant located off the structure. 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 in place for a length of time less than that specified in Section S-402.3. Carting or wheeling concrete batches on a completed concrete floor slab will not be permitted until the slab has aged at least two (2) full curing-days. Unless pneumatic tired carts are used, the carts shall be wheeled on timber planking so that the loads and impact will be distributed over the slab. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.

Stock piling of concrete aggregate or cement on bridge floors will be permitted only when authorized by the Engineer, and when permitted, the stock piles shall be uniformly distributed and shall be limited to not over two (2) feet maximum depth. The storing of reinforcing or structural steel on completed roadway slabs shall generally be avoided, and, when permitted, such storage shall be limited to quantities and distribution that will not induce excessive stresses.

S-402.12. PLACING CONCRETE IN COLD WEATHER. No concrete shall be placed when the atmospheric temperature is at or below 40° F. (taken in the shade away from artificial heat) unless permission to do so is given in writing by the Engineer. When such permission is given or in cases where the temperature drops below 40° F. after the concreting operations have been started, the Contractor shall furnish sufficient canvas and frame work or other type of housing to enclose and protect the structure in such way that the air around the forms and fresh concrete can be kept at a temperature not less than 50° F. for a period of five days after the concrete is placed. Sufficient heating apparatus such as stoves, salamanders, or steam equipment and fuel to furnish all required heat shall be supplied. The treatment of mixing water and aggregates used in mixing concrete shall be as specified in Item S-403.

It is understood that the Contractor is responsible for the protection of concrete placed under any and all weather conditions. Permission given by the Engineer to place concrete during freezing weather will in no way relieve the Contractor of the responsibility for satisfactory results. Should concrete placed under such conditions prove unsatisfactory, it shall be removed and replaced.

S-402.13. PLACING CONCRETE IN WATER. Concrete shall be deposited in water only when specified on the plans or with the permission of the Engineer. The forms, cofferdams, or caissons shall be sufficiently tight to prevent any water current passing through the space in which the concrete is being deposited. Pumping will not be permitted while the concrete is being placed, nor until it has set for at least thirty-six (36) hours.

The concrete shall be carefully placed in a compact mass by means of a tremie, closed bottom-dumping bucket or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. Depositing shall be regulated to maintain approximately horizontal surfaces at all times.

When a tremie is used, it shall consist of a tube having a diameter of not more than ten (10) inches, constructed in sections having water-tight connections. The means of supporting the

tremie shall permit the movement of the discharge end over the entire top surface of the work and shall permit the tremie to be rapidly lowered when necessary to choke off or retard the flow. The number of times it is necessary to shift the location of the tremie, for any continuous placement of concrete, shall be held to a minimum. During the placing of concrete, the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the level of the bottom of the hopper. The flow shall then be stopped by lowering the tremie. The placing operations shall be continuous until the work is complete.

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

S-402.14. PLACING CONCRETE IN SLAB SPANS. Concrete in slab spans shall be placed in longitudinal strips. Placing preferably shall be started at a point in the center of the span adjacent to one curb and the longitudinal strip thus started shall be completed by depositing concrete uniformly in both directions toward the ends of the span. The width of longitudinal strips shall be such that the concrete in any strip will not take its initial set before the adjacent strip is placed. The concrete in the curbs shall be placed in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs.

The forms for the bottom surface of the slab shall be maintained true to the required vertical alignment during the placing of concrete in the span. For convenience in checking the vertical alignment, an approved system of "tell-tales" shall be installed and maintained by the Contractor. The "tell-tales" shall be attached to the form and shall provide a convenient means of matchmarking with reference to points set on stakes or other suitable reference points set independent of the forms and falsework for the span being placed.

On completion of the filling of the curb forms, the curbs shall be brought to the correct camber and alignment, and then they shall be struck off and float finished as described in Section S-402.19.

As soon as concrete is placed in a longitudinal section of the slab of finished width to permit finishing operations, the slab shall be finished in accordance with the requirements of Section S-402.20.

S-402.15. PLACING CONCRETE IN DECK GIRDER SPANS. Unless otherwise provided, the girders, slab and curbs of deck girder spans shall be placed in one continuous operation. Concrete shall be placed in longitudinal sections. Placing preferably shall commence with a section adjacent to one curb, and successive sections continuing across the roadway shall follow. The width of each longitudinal section shall be governed by the size of the mixing apparatus and shall be such that each successive section shall be placed before the adjacent completed section shall have attained its initial set. The placing of concrete in curbs shall be in the proper sequence to be monolithic with the adjacent slab or girder section. Except for spans on a grade of one and one-half (1.5) per cent or more, concreting in each longitudinal section preferably shall be started at the middle of the span and shall be continued in both directions to the ends of the span. For spans on a grade of one and one-half (1.5) per cent or more, concreting shall be commenced at the low end of the span. The filling of the girder stems ahead of placing the concrete in the slab will be permitted provided the slab is placed not later than one hour after the filling of the girder stem.

During the operations of placing concrete in the span, the bottoms of girders and overhanging slabs shall be maintained true to required vertical alignment. For convenience in checking the vertical alignment, the Contractor shall attach to the form for each girder an approved system of "tell-tales" which shall provide a means of matchmarking for reference to establish grades fixed on stakes or other suitable reference points set independent of the forms and falsework for the span being placed. Care shall be exercised to assure that the "tell-tale" system is not altered or destroyed after the matchmarking is done.

On completion of the filling of the curb forms, the curbs shall be brought to the correct camber and alignment, and then shall be struck off and float finished as described in Section S-402.19.

The surface of the floor slab shall be finished as provided in Section S-402.20. The finishing shall be done as soon as possible after the placing of concrete is completed in a section of slab of sufficient width to permit finishing operations.

S-402.16. PLACING CONCRETE FLOOR ON STEEL SPANS. The location of construction joints and the sequence of placements of concrete floor slab shall be as shown on the plans. Where plans do not specify a particular sequence of placement, any logical sequence which will not result in the overstressing of any of the steel supporting members will be permitted subject to the approval of the Engineer.

The placing of the concrete in each individual panel or section of floor as bounded by the construction joints and/or expansion joints shown on the plans shall be in accordance with the provisions of Section S-402.14 for placing concrete in slab spans.

On steel truss spans the falsework under the span shall be released and the span swung free on its permanent supports before placing any concrete in floor slab.

Concrete placed around steel shapes shall be deposited on one side of the shape and shall be spaded or vibrated until it flushes up over the bottom flange on the opposite side of the member, after which, it may be placed on both sides to completion.

On completion of the filling of the curb forms, the curbs shall be brought to the correct camber and alignment, and they shall then be struck off and float finished as described in Section 402.19.

The surface of the floor slab shall be finished as provided in Section S-402.20. The finishing shall be done as soon as possible after the placing of concrete is completed in a section of slab of sufficient width to permit finishing operations.

S-402.17. PLACING CONCRETE IN BOX CULVERTS. In general, construction joints will be permitted only at the points shown on the plans. Where haunched side - walls are used the lower haunches shall be placed monolithic with the bottom slab and the upper haunches monolithic with the top slab. Curbs shall be placed monolithic with top slab.

Where the top slab and sidewalls are placed monolithic in culverts more than four feet in clear height, an interval of not less than one hour nor more than two hours shall elapse between the placing of the concrete in the walls and that in the top slab; such interval is to allow for shrinkage in the wall concrete.

The footing area joining the walls shall be thoroughly cleaned of all shavings, sticks, sawdust, or other extraneous material before placing concrete in the walls.

The top surface of the base slab and the top surface of top slabs which do not carry direct traffic shall be accurately finished by hand floating methods before the concrete has attained its initial set. The top surface of top slabs which are intended to carry direct traffic shall be finished and surface tested in accordance with the provisions for finishing roadway slabs in Section S-402.20.

S-402.18. PLACING CONCRETE IN FOUNDATIONS AND STRUCTURES. Concrete shall not be placed in footings until the depth and character of the foundation has been inspected by the Engineer and permission has been given to proceed.

The placing of concrete bases above seal courses will be permitted after the caissons or cofferdams are free from water and the seal course cleaned. Any necessary pumping or bailing during the concreting operation shall be done from a suitable sump located outside the forms.

All temporary wales or braces on the inside of cofferdams or caissons shall be constructed or adjusted as the work proceeds to the end that construction joints in bases or shaft in addition to those shown on the plans will not be necessary.

Concrete in deep foundations shall be placed in a manner that will avoid separation of the aggregates or displacement of the reinforcement. Suitable chutes or vertical pipes shall be provided.

When footings can be placed in dry foundation pits without the use of cofferdams or caissons, forms may be omitted, if desired by the Contractor and approved by the Engineer, and the entire

excavation filled with concrete to the elevation of the top of footing. Where this procedure is followed, no measurement for payment will be made for concrete placed outside of the footing dimensions shown on the plans.

Concrete in columns shall be placed monolithic unless otherwise provided. Unless a construction joint is provided at the top of columns, an interval of not less than one hour or more than two (2) hours shall elapse between the placing of concrete in columns and the placing of concrete above the top of columns. Such interval is intended to allow for shrinkage of the column concrete.

S-402.19. TREATMENT AND FINISHING OF HORIZONTAL SURFACES EXCEPT ROADWAY SLABS. All upper surfaces not covered by forms, such as tops of railing posts, railings, caps, curbs, parapets, copings, bridge seats, and sidewalk areas shall be completed by placing excess material in the forms and removing or striking off such excess with a wooden template forcing the coarse aggregate below the mortar surface. The use of mortar topping for surfaces under this classification will not be permitted.

After the concrete has been struck off as described above, the surface shall be thoroughly worked and floated with a wooden, canvas, or cork float. After floating and before the finish has set, all surface, except sidewalks so finished, shall be lightly striped with a fine brush to remove the surface cement film, leaving a fine grained, smooth but sanded texture. That portion of curbs or parapets which is to be the seat for concrete rail posts or webs of concrete railings shall be roughened in an approved manner.

S-402.20. FINISH OF ROADWAY SLABS. As soon as concrete placing operations have been completed for a longitudinal roadway slab section of sufficient width to permit finishing operations, the concrete shall be approximately leveled and then struck off, screeded and tamped by a longitudinal screed. The screed shall be of a design adaptable to the purpose intended. It shall have provisions for adjustment to the desired camber and be sufficiently rigid to hold true to shape during use.

The first strike-off operation shall leave the concrete surface at an elevation above grade so that when consolidation and finishing operations are completed, the slab will be at the exact grade elevation shown on the plans with proper allowance for finished camber as hereinafter provided. The tamping and screeding operations shall be continued until the concrete is properly consolidated and surface voids eliminated. The surface shall then be brought to a smooth true alignment by means of longitudinal screeding, floating, belting, and/or other methods approved by the Engineer. Spans over forty (40) feet in length may be screeded in two or more sections if suitable intermediate templates are installed. Unless otherwise provided, the templates shall be of such design as to permit early removal in order to avoid construction joints and to permit satisfactory finishing at and adjacent to the site of the template.

After the finishing operations are completed and while the concrete is still plastic, the surface shall be straightedged by the Contractor, using a standard ten (10) foot metal straightedge. Any deviation from the face of the straightedge greater than those prescribed under the following surface test shall be corrected before the concrete has attained its initial set. The final belting of the slab shall be done after this straightedging is completed.

After the concrete has attained its final set, the roadway surface shall be tested again with a standard ten (10) foot metal straightedge for irregularities, and the surface shall be corrected, if necessary, to conform to the following:

> The straightedge shall be placed parallel to the centerline of road so as to bridge any depression and touch high spots. Ordinates measured from the face of the straightedge to the surface of the slab shall not exceed one-sixteenth (1/16) inch per foot from the nearest point of contact and the maximum ordinate shall not be greater than one-eighth (1/8) inch. The surface shall be corrected by grinding off the high spots as may be required in order to conform to these limits.
>
> In case of concrete slab or girder spans, the floor shall be finished so as to provide a camber sufficient to off-set the load deflection of the span; other spans shall be so finished if directed by the Engineer. Unless otherwise shown on the plans, the camber at the center of the span shall be made one-eighth (1/8) inch for each ten (10) feet of span length with a maximum camber of one-half (1/2)

inch. When camber is provided, the ordinate to the straightedge may be as much as three-sixteenth (3/16) inch at the end of the straightedge but shall not exceed one-sixteenth (1/16) inch under its center.

S-402.21. CURING CONCRETE. Careful attention shall be given by the Contractor to the proper curing of all concrete in the structure. All upper surfaces not formed, except roadway and sidewalk slabs, shall be covered by cotton mat coverings immediately following the floating operations and shall be kept thoroughly wet for a period of four curing-days after the concrete is placed. When forms are removed from any portion of structures other than caissons in less than four curing-days after the concrete is placed, the formed surfaces shall be covered with wet cotton mats immediately after the forms are removed and shall be kept covered and wet until the concrete has aged at least four curing-days. Intermission will be permitted as needed to permit the surface finishing of those surfaces on which such finishing is required.

When forms are removed from concrete caissons in less than four (4) curing-days and when the sinking operations do not immediately follow the form removal, the caissons shall be cured by being covered with wet cotton mats which shall remain in place until the caissons have aged at least four (4) curing days.

Immediately following the finishing operations, concrete roadway and sidewalk slabs shall be cured for a period of not less than six curing days. The slabs shall be covered with wet cotton mats or with a temporary covering of canvas or burlap. The temporary covering will be required in all cases where the size of span, size of mats, or other factors are such that the mats cannot be placed immediately following the finishing operation without marring the finish of the slab. The canvas or burlap covering material shall weigh not less than ten (10) ounches per square yard and the sections shall be placed with a lap at the edges of at least eight (8) inches. The material shall be saturated with water previous to placing and shall be kept saturated as long as it remains in place. Care shall be exercised in the placing of the cover material in order that the concrete surface shall not be disturbed. When a temporary covering is used, it shall remain in place only until the slab has sufficiently hardened that a cotton mat covering can be substituted without disturbing the finish of the slab. Cotton mats shall be thoroughly saturated before placing and shall be maintained in a saturated condition for a period of at least six curing-days after the concrete is placed.

All water used for curing shall be free from injurious amounts of oil, acid, alkali, salt, or other deleterious substances.

Cotton mats shall meet the following requirements:

Mats shall be of a size convenient for handling and shall be composed of a single layer of cotton filler completely enclosed in a cover of cotton cloth.

The filler may be of a low grade cotton, cotton linters, or such cotton waste as comber noils or card flat strips.

Mats shall contain not less than three-fourths (3/4) of a pound of cotton filler per square yard of mat, uniformly distributed.

The cloth used for covering material shall be osnaburg weighing not less than six and three-tenths (6 3/10) ounces per square yard.

All mats shall be stitched longitudinally with continuous parallel rows of stitching at intervals of not more than three (3) inches. The sewing shall not be done so tightly that the mat, when saturated with water, will not contact the surface of the slab at all points.

To insure the complete covering of the slabs where the mats fit together, there shall be a flap extending all along one side of each mat.

The flap shall be composed of two thicknesses of the cover material and shall be approximately six (6) inches wide. The flap shall be strongly stitched along the edge.

Ponding may be used for curing roadway, sidewalk slabs, and top slabs of culverts instead of the cotton mat covering above described.

S-402.22. REMOVAL OF FORMS AND FALSEWORK. Except as hereinafter provided, forms for surfaces required to be finished shall be removed when the concrete has aged not less than one-half (1/2) nor more than two (2) curing-days after the concrete is placed. In order to facilitate slab finishing, forms for inside curb faces on roadway slabs may be removed in not less than three (3) hours if the concrete has set sufficiently to permit form removal without damage to the curbs.

Forms and falsework for the portions of structures which do not require surface finish may be removed as soon as the concrete has attained the flexural strength specified in the following table, as evidenced by strength tests made in accordance with the provisions of S.H.D. Bulletin C-11 using test specimens made from the same concrete and cured under the same conditions as the portion of the structure involved.

Class of Concrete	Required Flexural Strength
A	500 Lbs. per Sq. In.
B	375 Lbs. per Sq. In.
C	500 Lbs. per Sq. In.
D	250 Lbs. per Sq. In.
E	500 Lbs. per Sq. In.

When the Contractor does not elect to follow the method of determining time for removal of forms as provided in preceding paragraph, forms and falsework on portions of structures which do not require surface finish shall remain in place until the concrete has aged for the minimum number of curing-days set forth in the following table:

Forms and falsework under slabs or girders having span lengths of 10 feet and less - - - - - - - - - - - - - - - - - -	7 days
Forms and falsework under slabs or girders having span lengths over 10 feet and less than 17 feet - - - - - - - - - - -	7 days plus one day for each foot of span over 10 feet
Forms and falsework under slabs or girders having spans over 17 feet in length -	14 days
Forms and falsework under the portions of slabs that cantilever more than one foot beyond the outside beams - - - - - -	4 days
Forms and falsework under caps or tie beams of framed bents -	5 days
Forms under caps of pile bents - - - - - - - - - - - - - - - - - - -	2 days
Forms and falsework under webwalls of piers - - - - - - - - - - - -	7 days
Forms for walls, columns, sides of beams and under slabs that cantilever one foot or less beyond the outside beam - - - - - - -	2 days
Forms for concrete caissons -	2 days

The foregoing specifications for the removal of forms and falsework from portions of structures which do not require surface finish shall apply to the forms and falsework under the portions of slabs that cantilever more than one foot beyond the outside beams, to the forms and falsework under girders and to the forms and falsework under bent caps of framed bents regardless of whether or not those surfaces are required to be finished.

The above provisions relative to form removal shall apply only to forms or parts of forms which are so constructed as to permit removal without disturbing forms or falsework which are required to be left in place for a longer period on other portions of the structures.

The term "curing-day" will be interpreted as any calendar day on which the temperature is above 50° F. for at least nineteen (19) hours. Colder days may be counted if satisfactory provision is made to maintain the air temperature adjacent to the concrete constantly above 50° F. throughout the entire day. In continued cold weather, when artificial heat is not provided, the Engineer may permit the removal of forms and falsework at the end of a period of calendar days equal to twice the number of curing days stated in the preceding table.

S-402.23. DEFECTIVE WORK. Any defective work discovered after the forms have been removed shall be repaired immediately. If the surface of the concrete is bulged, uneven, or shows excess honeycombing or form marks, which defects, in the opinion of the Engineer, cannot be repaired satisfactorily, the entire section shall be removed and replaced. In repairing honeycombed areas, all loose material shall be removed before the repair work is started. No extra compensation will be allowed for the extra work or materials involved in repairing or replacing defective concrete.

S-402.24. FINISHING EXPOSED SURFACES. The type of surface finish shall be one of the three types herein described as called for on the plans or in the special provisions. Where neither the plans or special provisions specify the type of surface finish, Type 1 Surface Finish shall be used.

Type 1 Surface Finish. All railing, curbs, the underside of overhanging slabs, the outside and bottom of exterior girders or fascia beams, and all portions of piers, columns, bents, abutments, retaining walls, and culverts which are exposed to view after backfill and roadway embankments are placed shall be surface finished with a first and second rubbing as hereinafter described. The area inside of culvert barrels including both sidewalls and the underside of the top slab for a distance equal to one-third (1/3) the clear height but not less than eighteen (18) inches shall be considered as exposed to view.

Forms for all surfaces which are to be surface finished as specified above shall be face lined in accordance with the provisions of Section S-402.9(b) except that no lining will be required on the area inside of culvert barrels.

Type 2 Surface Finish. All concrete portions of railing and the top and roadway faces of all curbs, including ear walls, on bridges and culverts shall be surface finished with a first and second rubbing as hereinafter described.

The following concrete surfaces, while not required to be rubbed, shall be made of smooth and uniform texture by face lining the forms in accordance with the provisions of Section S-402.9(b):- the outside vertical faces of curbs and slabs, the underside of overhanging slabs, the outside and bottom faces of exterior girders and fascia beams, and all portions of piers, columns, bents, abutments, culverts and retaining walls which are exposed to view after backfill. No portion of culvert barrels will be considered as exposed to view.

Type 3 Surface Finish. All concrete portions of railing and the top and roadway faces of all curbs on bridges and culverts shall be surface finished with a first rubbing only as hereinafter described. No other rubbing will be required except as hereinafter specified for patching and correcting defective surfaces. No face lining of forms will be required with Type 3 Surface Finish.

The First Rubbing shall be performed as follows: As soon as forms are removed all necessary pointing shall be done. When the pointing has set sufficiently to permit it, all surfaces requiring surface finish shall be wet with a brush and given a first surface rubbing with a No. 16 Carborun-

dum Stone or an abrasive of equal quality. The rubbing shall be continued sufficiently to bring the surface to a paste, to remove all form marks and projections, and to produce a smooth dense surface without pits or irregularities. The use of cement to form a surface paste will not be permitted.

Where a second rubbing is not specified, chamfered corners shall be rubbed in the first rubbing and the material which has been ground to a paste in the rubbing process shall be spread uniformly over all rubbed surfaces by striping with a brush and the mortar on the surface shall be allowed to take a re-set. The surface shall then be washed down with clean water and all rubbed surfaces shall be left with a clean, neat, and uniform appearing appearance and shall be uniform in color.

Where a second rubbing is to follow the first rubbing, the material ground into a paste during the first rubbing shall be carefully spread or brushed uniformly over the surface and allowed to take a re-set, but washing down following this first rubbing will not be required. Also, chamfered corners generally shall not be rubbed in the first rubbing if a second rubbing is to follow.

The Second Rubbing, when required, shall be performed as follows: During the process of conditioning the completed structure for final acceptance, the surfaces of the entire structure requiring finish shall be cleaned free from drip marks and discolorations and shall be given a final finish rubbing with a No. 30 Carborundum Stone or an abrasive of equal quality. On completion of this rubbing, the surface shall be neatly striped with a brush, and the mortar on the surface shall be allowed to take a reset. The surface shall then be washed down with clean water. The entire structure shall be left with a clean, neat, and uniform appearing finish and shall be uniform in color.

The surfaces of concrete roadway and sidewalk slabs shall be finished by floating, screeding, and belting as provided in Section S-402.20.

Rubbing of surfaces other than those herein specified will not be required unless such surfaces are not true or have porous spots or honeycombed areas. In case these defects occur, the areas immediately affected shall be given a first surface rubbing. Such rubbing shall extend over a sufficient area around the blemished portions to blend the rubbed area into the surrounding unfinished surface but this shall not be construed to require the rubbing of large areas of unblemished surfaces to gain absolute uniformity of color and texture on the entire surface of the portion of the structure in question.

S-402.25. SPECIAL SURFACE FINISHES. When so specified, special surface finishes shall be employed for ornamental panels, copings, and like construction. In general, the method and manner of performing this work will be fully provided for in the plans or special provisions to these specifications.

In case of special finishes, the Contractor will be required to prepare test or sample panels showing the method and manner of finish. The choice and selection of the aggregate and other features affecting the work shall be approved before any further work is done.

S-402.26. TRAFFIC STRIPE. When required by the plans, a traffic stripe shall be applied along the centerline of roadway of each bridge for its entire length (or as indicated on plans) and along such other lines shown on plans. All stripes shall be 6 inches in width unless otherwise specified. Stripes shall be constructed by applying the specified pigment on the newly finished concrete floor, following the belting operations as soon as job conditions will permit, but in no event later than two hours after the concrete is placed. The pigment shall be applied dry then lightly sprinkled with water and then worked into the surface of the fresh concrete by wooden floats, steel trowels or other approved methods to secure a penetration of 1/8 inch to 1/4 inch over the entire surface of the stripe. The pigment shall be applied at the rate directed by the Engineer not to exceed 3 pounds of pigment per 100 linear feet of 6 inch traffic stripe. The final finish of the stripe shall be done with a wood float. The Contractor shall use approved forms or resort to other satisfactory methods to produce a neat, true edge on the stripe. During the traffic striping operations, unnecessary marring of the adjacent slab surfaces shall be avoided. All disturbed areas shall be restored to a neat appearance by hand floating and belting as may be necessary. The striping operations shall not be permitted to interfere with the curing provisions on the remainder of the slab surface. The surface of the traffic stripe shall be cured in accordance with the standard curing provisions as soon as practicable after the striping has been completed.

This traffic stripe is patented. Provision has been made for its use by the State free of royalty charge to the Contractor.

S-402.27. MEASUREMENT AND PAYMENT. No direct compensation will be made for "Concrete Structures". Measurement and payment for quantities of concrete, reinforcement, railing, piling, excavation and other proposal items which constitute the completed and accepted structures will be made in accordance with the provisions of pertinent specifications.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-403

CONCRETE FOR STRUCTURES

S-403.1. DESCRIPTION. These specifications shall govern for the materials used: for the storing, measuring and handling of materials; and for the proportioning and mixing of concrete for bridges, culverts, and incidental construction.

The concrete shall be composed of Portland Cement or Air-Entraining Portland Cement, mineral filler if necessary, fine aggregate, coarse aggregate, and water, proportioned and mixed as hereinafter provided in these specifications.

Where references are made herein to specifications or tests as described in designations of the A.S.T.M., the designations as amended to the date of receipt of bids on which the contract award is made shall apply.

Where references are made herein to wear of aggregates, the test for the wear as specified shall be made in accordance with "Standard Method of Test for Abrasion of Coarse Aggregate by the Use of the Los Angeles Testing Machine", Method T-96, of the A.A.S.H.O., as amended to the date of receipt of bids on which the contract award is made.

Where references are made herein to State Highway Department Bulletin C-11, the bulletin as revised prior to the date of receipt of bids on which the contract award is made shall apply.

As used herein, screens shall be construed to have circular openings.

As used herein, sieves shall be construed to have square openings.

S-403.2. MATERIALS.

(a) Cement. The cement shall be either Type I or Type III of a standard brand of Portland Cement which shall conform to A.S.T.M. Designation C-150, or Type IA of a standard brand of Air-Entraining Portland Cement which shall conform to A.S.T.M. Designation C-175. Type I Portland Cement or Type IA Air-Entraining Portland Cement may be used except where Type III Portland Cement (High Early Strength Cement) is required by the plans. The Contractor, if he so elects in order to facilitate his own operations, may use Type III Cement in portions of the work other than where its use is required by plans, and when Type III Cement is used either as required by plans or as an option to Type I or IA Cement, the average tensile strength of briquettes at the age of twenty-eight (28) days shall be higher than that attained at three (3) days.

Different types of cement, as prescribed above, may be used in the same structure, but all cement used in any one monolithic placement shall be of the same type and brand. Only one brand of each type will be permitted in any one structure except when otherwise authorized by the Engineer.

Cement for ready-mixed concrete may be delivered in bulk. All other cement shall be delivered in bags which shall be marked plainly with brand and name of the manufacturer. Similar information shall be provided in the shipping advices accompanying each shipment of packaged or bulk cement. In general, bags shall contain 94 pounds net. All bags shall be in good condition at time of delivery.

Bags varying more than five (5) per cent from the specified weight may be rejected and if the

average weight of bags in any shipment, as shown by weighing fifty (50) bags taken at random, is less than ninety-four (94) pounds, the entire shipment may be rejected.

All cement shall be properly protected against dampness, and no cement will be accepted which has become caked.

All cement shall be sampled and tested in accordance with the standard A.S.T.M. methods prescribed in the governing specifications, A.S.T.M. Serial Designations C-150 and C-175. Cement remaining in bulk storage at the mill, prior to shipment, for a period greater than six months after completion of the tests may be retested and rejected, if it fails to conform to any of the requirements of these specifications.

Upon receipt of shipments of cement, the Engineer shall be notified in order that he may witness the opening of the car. Failure to comply with this requirement may be cause for the rejection of the entire shipment.

(b) Mixing Water. Water for use with cement shall be reasonably clean and free from injurious amounts of oil, acid, alkali, salt, organic matter, or other deleterious substances. When comparative tests are made with water of known satisfactory quality, any indication of unsoundness, marked change in the time of set, or reduction of more than ten (10) per cent in mortar strength shall be sufficient cause for the rejection of the water under test. Water which is suitable for drinking or for ordinary household use may be accepted for use without being tested.

Tests required by these specifications shall be made in accordance with the "Standard Method of Test for Quality of Water to be used in Concrete" (AASHO Method T-26) except wherein such methods are in conflict with the definite provisions of this specification.

Water from doubtful sources shall not be used until tested and approved. The Contractor shall not take water for use in concrete from shallow, muddy, or marshy sources unless provision is made for the intake of the suction pipe to be enclosed in such manner as to exclude silt, mud, grass, and other foreign materials. The depth of the water shall be maintained at least two (2) feet below the intake of the suction pipe. In case the water is not reasonably clear, the Contractor shall make provision to free it of suspended matter before use.

(c) Coarse Aggregate.

The coarse aggregate shall consist of gravel, crushed stone, blast-furnace slag or combinations thereof.

Gravel shall consist of durable particles of crushed or uncrushed gravel of reasonably uniform quality throughout. It shall have a wear of not more than forty (40) per cent when tested according to AASHO Method T-96.

Crushed stone shall consist of durable particles of stone of reasonably uniform quality throughout, having a wear of not more than forty (40) per cent when tested according to AASHO Method T-96.

Blast-furnace slag shall consist of durable particles of crushed blast-furnace slag of reasonably uniform quality throughout, having a wear of not more than forty (40) percent when tested according to AASHO Method T-96. Slag shall be preferably 100% air cooled but slag air cooled for the first 48 hours after removal from the furnace and subsequently water cooled will be acceptable if it meets the wear test requirement.

The coarse aggregate shall be free from an excess of salt, alkali, vegetable matter, or other objectionable material, either free or as an adherent coating on the aggregate. It shall not contain more than twenty-five hundredths (0.25) per cent of weight of clay lumps, nor more than one (1.0)

per cent by weight of shale, nor more than five (5.0) per cent by weight of laminated and/or friable (soft) particles.

The maximum size of aggregate shall be governed by the type of structure in which the concrete is to be used. The maximum size of aggregate for bridge superstructures, culverts, retaining walls, piling, and railing will be one and one-half (1-1/2) inches unless otherwise shown on the plans. For bridge substructures other than those included above, in which the spacing between the centers of the main reinforcing steel and the surface of the concrete is two and one-half (2-1/2) inches or more, either two and one-half (2-1/2) inches or one and one-half (1-1/2) inch maximum size aggregate may be used.

When tested by approved methods, coarse aggregate shall conform to the following grading requirements:

1. 1-1/2 Inch Maximum Size Aggregate

Retained on 2"	screen		0%
Retained on 1-1/2"	screen	0 to	5%
Retained on 3/4"	screen	25 to	60%
Retained on 1/4"	screen	95 to	100%
Loss by decantation (S.H.D. Bulletin C-11)		0 to	1%

2. 2-1/2 Inch Maximum Size Aggregate

Retained on 3"	screen		0%
Retained on 2-1/2"	screen	0 to	5%
Retained on 1-1/4"	screen	10 to	40%
Retained on 3/4"	screen	40 to	75%
Retained on 1/4"	screen	95 to	100%
Loss by decantation (S.H.D. Bulletin C-11)		0 to	1%

(d) Fine Aggregate.

Fine aggregate shall consist of sand, a combination of sand and not more than fifty (50) per cent by weight of stone screenings and/or a combination of sand and mineral filler, or sand, stone screenings, and mineral filler.

The fine aggregate, prior to the addition of mineral filler, shall conform to the following:

At the time of its use, all fine aggregate shall be free from frozen material and all foreign materials, such as wood, hay, burlap, paper or dirt which may become mixed with the aggregate in the stock piles.

The fine aggregate shall be free from an excess of salt, alkali, or vegetable matter. It shall not contain more than five-tenths (0.5) per cent by weight of clay lumps.

When subjected to the color test for organic impurities (ASTM C-40), the fine aggregate shall not show a color darker than the standard.

When the fine aggregate is mixed with High Early Strength Portland Cement in the proportion of 1:3, the average tensile strength per square inch of not less than three (3) standard mortar briquets shall be equal to or greater than the strength of Ottawa Sand Mortar briquets of the same proportions and consistency when tested at the age of three days.

When tested by approved methods, the fine aggregate shall conform to the following grading requirements:

Retained on 3/8" screen			0%
Retained on 1/4" screen	0	to	5%
Retained on No. 20 sieve	15	to	50%
Retained on No. 100 sieve	85	to	100%

Fine aggregate, meeting the above grading requirements, may or may not be satisfactory for concrete production without admixture of a finer sand or mineral filler.

Sand shall consist of clean, hard, durable, uncoated grains. The material removed by decantation (S.H.D. Bulletin C-11) shall not exceed five (5) per cent.

Stone screenings shall consist of clean, hard, durable, uncoated fragments resulting from the crushing of stone.

(e) Mineral Filler.

Mineral filler shall consist of stone dust, clean crushed shell, crushed sand, or other approved inert material.

When tested by approved methods, the mineral filler shall conform to the following grading requirements:

Retained on No. 30 sieve	0%
Retained on No. 200 sieve	0 to 35%

(f) Air-entraining Admixture.

An air-entraining admixture may be used with Type I or Type III Portland Cement in lieu of an Air-Entraining Portland Cement.

Should the use of an air-entraining admixture be elected, the particular admixture selected shall have had the prior approval of the Engineer. The Engineer will determine by trial the amount of the admixture selected by the Contractor that will produce concrete having the specified air content and this amount shall not be varied except as directed by the Engineer.

S-403.3. STORAGE OF CEMENT. Unless otherwise provided, all cement shall be stored in well ventilated, weatherproof buildings which will protect the cement from dampness. The floor supporting the cement shall clear the ground a sufficient distance to prevent the absorption of moisture by the cement. Provision for storage shall be ample, and the shipments of cement shall be segregated in such a manner as to provide easy access for identification and inspection of each shipment.

The Engineer may permit small quantities of cement to be stored in the open for a short period of time (maximum of 48 hours) if a raised storage platform and adequate waterproof covering are provided.

No cement shall be used which has become lumped or caked.

The Contractor shall keep accurate records of the deliveries of cement and of its use in the work. Copies of these records shall be supplied or made available to the Engineer.

S-403.4. STORAGE OF AGGREGATE. The handling and storage of concrete aggregate shall be

such as to prevent the admixture of foreign materials. If the aggregates are stored on the ground, the sites for the stock piles shall be grubbed, cleared of all weeds and grass, and leveled off. The bottom layer of aggregate shall not be disturbed or used without recleaning.

When the contract requires the use of two (2) or more sizes of aggregates, the different sizes shall be stored in such a manner as to prevent intermixing.

Materials in all stock piles shall be handled and placed in such manner that segregation of materials within the pile will be avoided.

Unless otherwise authorized by the Engineer, all fine aggregate shall be stockpiled at least twenty-four (24) hours to reduce the free moisture content.

S-403.5. MEASUREMENT OF MATERIALS. The measurement of the materials, except water, used in batches of concrete shall be by weight. The fine aggregate, coarse aggregate, and mineral filler shall be weighed separately. Where bulk cement is used it shall be weighed separately but batch weighing of sacked cement will not be required, since a full sack as hereinafter specified may be used as a basis of measurement. Where sacked cement is used, the quantities of material per batch shall be based upon using full bags of cement. Batches involving the use of fractional bags will not be permitted.

Allowance shall be made for the water content when moist aggregates are used. The quantities of each component material of the batch shall be determined by the Engineer, and no change shall be made therein except by his order.

Bags of cement varying more than five (5) per cent from the specified weight of ninety-four (94) pounds may be rejected; and when the average weight per bag in any shipment, as determined by weighing fifty (50) bags taken at random, is less than the net weight specified, the entire shipment shipment may be rejected. If the shipment is accepted, the Engineer will adjust the concrete mix to a net weight per bag fixed by an average of all individual weights which are less than the average weight determined from the total number weighed. When a central batching plant is used, the cement shall be transported in bags, and the bags shall be emptied at the site of the mixer.

S-403.6. WEIGHING AND MEASURING EQUIPMENT. The capacity of the weighing equipment shall be adequate to permit the required weighing of materials without delaying the production of the mixer. The equipment used shall comply with the following requirements:

(a) Types of Equipment Permitted.

(1) Portable Platform Scales - Type A. This type shall consist of a portable platform scale having a container fastened securely to the platform.

(2) Portable Platform Scales - Type B. This type shall consist of a portable platform scale having a platform sufficiently large to permit the weighing of loaded wheelbarrows or carts.

(3) Suspended Hopper - Type C. This type shall consist of a weighing container or hopper completely suspended from the scale equipment.

(4) Other Types. Other types of weighing equipment shall be used only with the written approval of the Engineer.

(b) General Requirements. The following general requirements shall apply to all types of weighing equipment:

(1) Weighing Container. The weighing container shall be of suitable size and shape and shall be tight enough to hold the aggregate for which it is to be used.

(2) Container. The weighing container and its appurtenances shall be designed and constructed so as to eliminate the retentions of varying tare materials on any of its parts and shall be capable of being discharged fully and quickly without shaking and jarring the scales.

(3) Types of Scales. The scales, that is, the balance or weighing mechanism, shall be of the beam or springless dial type and shall be the product of an established manufacturer. They shall be suited for supporting weighing containers and shall be of simple rugged design with a minimum number of adjustments consistent with the accuracy required.

(4) Scale Levers. The scale levers shall be of such design, construction, and materials as to permit frequent handling without damage incident to moving the equipment from one location to another.

(5) Pivots. Pivots shall be of steel properly hardened and tempered to obtain minimum wear under repeated weighing. They shall be accurately set in substantial mountings which will insure a permanent spacing of the knife edges under all conditions of loading and prevent them from working loose from the vibration incident to the service for which the scales are intended.

(6) Connections. All connections shall be of such construction as to prevent the displacement of scale parts without restricting movement of working parts. All adjustable or bolted connections or hangers shall be provided with suitable locking devices to prevent nuts working loose with resulting displacement of parts.

(7) Poise Stops. Full capacity weigh beams shall be fitted with suitable poise stops for locating the poise to indicate predetermined weights.

(8) Weighing Position of Beam. The weighing position of the weigh beam shall be horizontal. The trig loop shall allow movement of the weigh beam above and below the horizontal position, and the free end of the weigh beam shall be equipped with a suitable device for indicating clearly and accurately the horizontal position of the weigh beam.

(9) Indicators. Scales of the suspended hopper type shall be equipped with a tell-tale dial or similar device for indicating to the scale operator that the required load in the weighing container is being approached. Such device shall indicate at least the last fifty (50) pounds of load.

(10) Poises. Poises shall be so constructed that they cannot be easily removed from the beam and shall be equipped with a suitable device for holding them firmly in position. Poise and weigh beams shall be of material that will not corrode or wear excessively on the contact surfaces.

(11) Graduated Dials. Graduated dials shall have suitable markers, located inside the glass cover and closely in front of the dial, which may be set to indicate the positions of the dial indicator for predetermined loads in weighing container. Proper provision shall be made to prevent dirt from collecting in and around the dial mechanism. Suitable provision shall be made for obtaining and maintaining proper alignment between the dial and the part of the scale which transmits load to the dial. The dial face shall be of material not affected by moisture.

(12) Minimum Graduation. The value of the minimum graduation shall not be greater than two (2) pounds for scales of two thousand (2,000) pound capacity and less or greater than five (5) pounds for scales over two thousand (2,000) pound capacity.

(13) Tell-tale Dials. The over-travel of tell-tale dials shall be at least one-third (1/3) of the loading travel. They shall give positive indication of overload on the scales. The dial faces shall be made of a material not affected by moisture. Where tell-tale dials are used to indicate the last increment of load, the minimum graduation shall not be greater than two (2) pounds.

(14) Accuracy. Scales shall be so designed and built that they may be maintained within a maximum tolerance of one (1) per cent of the net load being weighed.

(15) Clearance. Clearance shall be provided between the scale parts and the weighing container to prevent displacement of or friction between the scale parts due to vibration or any other cause.

(16) Test Weights. Each scale installation shall be provided with standard fifty (50) pound test weights, made of high quality cast iron, cast and finished in such manner that no foreign material will adhere to the surface and sealed in the manner prescribed by the United States Bureau of Standards. The minimum number of test weights required shall be of a weight equivalent to ten (10) per cent of the net load capacity of the scales to the nearest greater fifty (50) pounds, but in no case less than two (2) test weights.

(17) Number of Scales Required. Unless the scale is equipped with a multiple weigh beam which permits the weighing of more than one kind of material on the same scale without changing the settings on the weigh beams, separate scale units shall be furnished for each kind of material to be weighed.

(18) Working Parts. All working parts of scales, particularly knife edges, shall be protected so as to prevent any material except wind-borne material from falling upon or against them. All working parts shall be readily accessible for inspection and cleaning.

(19) Foundation and Leveling. Scales shall be mounted upon a firm foundation and shall be kept level during use.

(20) Varying Tare Equipment. Weighing containers, not an assembled part of the weighing equipment, shall be brought to uniform tare weight by rigidly attaching to the lighter containers such weights as will bring each to the weight of the heaviest container being used on any operation.

(c) Detailed Requirements for Portable PlatformsScales - Type A. The capacity of this type of scale shall be not less than five hundred (500) pounds. The weighing capacity may be obtained by means of a weigh beam and loose weights.

When this type of scale is used, the Contractor shall provide a container of approximately the same size as the platform for weighing the aggregate, or he may provide an elevated hopper, the base of which is approximately the size of the platform, from which the aggregates may be discharged.

If the hopper is provided, it shall be of such design that the aggregates will be

completely and quickly discharged and shall be of such construction that the position of the aggregates while being weighed will not affect the accuracy of the weights.

The Contractor will not be permitted to increase the size of the original platform by constructing another platform on top of the original. When this type of scale is used, a double weigh beam is recommended in order that the tare weight of the container or hopper may be set on the weigh beam separately from the batch weight. Separate scales for fine and coarse aggregate will be required.

(d) Detailed Requirements for Portable Platform Scales - Type B. The capacity of this type of scale shall be not less than eight hundred (800) pounds. The weighing capacity may be obtained by means of a weigh beam and loose weights. The scale shall preferably be equipped with a double weigh beam, in order that the tare weight of the wheelbarrow or other vehicle for transporting the aggregates may be set off on the weigh beam separately from the batch weights. When the scale is equipped with a single beam or a single beam and a tare beam, separate scales shall be provided for fine and coarse aggregates.

When this type of equipment is designed to weigh more than one kind material on the same scale, it shall be equipped with separate charging beams and a tare beam. Each charging beam shall be equipped with a release lever to throw the beam in and out of service. This type of scale may also be equipped with a telltale dial meeting the requirements of these specifications.

(e) Detailed Requirements for Suspended Hopper - Type C. The detailed requirements for this type of scale shall comply with the provisions of Paragraph (b) above. Suitable provisions shall be made for leveling the scale equipment.

The appliances used for placing materials within or upon the weighing equipment shall so regulate and control the quantity supply that accurate adjustment to the weights required can be secured with little expenditure of time and labor. A convenient means shall be provided for the addition or the removal of small amounts of material to adjust the quantity to the exact weight per batch.

Water. The device used for measuring the quantity of water shall indicate the quantity in gallons and fractions thereof. The operating mechanism shall regulate the quantity required for any given batch within one (1) per cent and the supply inlet shall be cut off automatically when water is being discharged into the mixer.

S-403.7. CONDITION OF EQUIPMENT. All equipment, tools, and machinery used for hauling materials and performing any part of the work shall be maintained in condition to insure completion of the work under way without excessive delays for repairs or replacements.

S-403.8. CLASSIFICATION AND PROPORTIONS. Concrete shall be proportioned as determined by the Engineer, using methods outlined in S.H.D. Bulletin C-11 for Design of a Concrete Batch to meet a Definite Specification, Absolute Volumes Methods, and in accordance with the requirements hereinafter set forth. On isolated structures containing less than 25 C.Y. of concrete, the Engineer may waive the requirements for absolute volume batch design, in which case mix proportion shall be determined by trial mixes, but the requirements for weighing and measuring materials shall not be waived, except that, on projects where the total amount of concrete involved in entire project is less than 25 C.Y., the Engineer may waive requirements for weighing provided an acceptable method of measuring ingredients by volume is substituted.

The Concrete shall be uniform and workable. The minimum cement content, maximum allowable water content, and maximum slump of the various classes of mixes shall conform to the following:

Class of Concrete	Min.Cement (Bags per Cu.Yd.)	Max.Water (Net Gal. per bag)	Maximum Slump (Inches) For Hand Tamping	Maximum Slump (Inches) For Mach. Vibration
A	5.00	7.0	4	2
B	4.00	9.0	3	1-1/2
C	6.00	6.25	4	2
D	3.00	11.00	2-1/2	-
E	6.60	6.25	6	-

The dry loose volume of coarse aggregate shall not exceed 0.82 cubic foot per cubic foot of finished concrete, except in cases where the voids in the coarse aggregate as determined by standard test methods exceed forty-eight (48) per cent of the total dry loose volume. Where the voids exceed forty-eight (48) per cent of the total dry loose volume, the dry loose volume of coarse aggregate shall not exceed 0.87 cubic foot of finished concrete.

When seal courses are required the concrete shall be Class "E", unless otherwise specified on the plans.

The net amount of water will be the amount added at the mixer, plus the free water in the aggregate, and minus the absorption of the aggregate based on a thirty minute absorption period (Tests to be made in accordance with S.H.D. Bulletin C-11). No allowance will be made for evaporation of water after batching.

The concrete mix will be designed with the intent of producing concrete which, when cured and tested by approved methods, will have either 28-day compressive strength, or 7-day flexural strength equal to or greater than the following:

Class of Concrete	28-Day Compressive Strength (Lb.per Sq.In.)	7 Day Flexural Strength (Lb. per Sq.In.)
A	3000	500
B	2000	375
C	3000	500
D	1500	250
E	3000	500

If the strength required for the class of concrete being produced is not secured with the minimum cement content specified, additional cement shall be used or other aggregates provided at the Contractor's expense.

During the progress of the work the Engineer will maintain a careful check on the quantity of cement used in each structural unit. In calculations for the theoretical quantity of cement required, allowance shall be made for embedded reinforcing steel, embedded structural steel, and all panelling or chamfers more than three (3) inches in width. Where the absolute volume mix design and the weighing of ingredients has been waived, the Engineer shall make adjustments in the proportions of the ingredients to correct for any variations of more than two (2) per cent between the actual and the theoretical cement content when such variations are attributable to mix design. Cement wasted during the placing operations will not be included in calculations of the theoretical quantity of cement required.

In making such adjustments as may be necessary by reason of air-entrainment, the Engineer will use the minimum quantity of fine aggregate and the minimum quantity of water which, in his judgment, will produce concrete of the desired workability.

Air-entrained concrete, in addition to conforming to the requirement of the Class or Classes specified, shall contain not more than 5 percent and preferably, not less than 3 percent entrained air, determined by means of the test for aid content, A.S.T.M. Designation C-138, except that air content made from blast-furnace slag shall be determined by means of the Indiana Hook Gauge Method. Tests for entrained air shall be made by the Engineer on concrete containing the materials to be used in the work and employing the type of mixer and mixing procedure that will be used in construction.

S-403.9. CONSISTENCY. Concrete shall be of such consistency as to insure the required workability and result in compact masses having dense, uniform surfaces. The quantities of the ingredients shall be varied only with the authority of the Engineer. In cases where the characteristics of the aggregates are such that, with the maximum allowable amount of water the consistency requirements cannot be satisfied, the Contractor may furnish additional aggregates, mineral filler or aggregates of a different character which will produce the desired results. If the Contractor does not provide these materials, the Engineer will modify the mix design to insure proper workability by adding additional cement.

In general, the consistency of concrete mixtures shall be such that:

(a) The mortar will cling to the coarse aggregate.
(b) The aggregates will not segregate in the concrete when it is transported to the place of the deposit.
(c) The concrete, when dropped directly from the discharge chute of the mixer, will flatten out at the center of the pile, but the edges of the pile will stand and not flow.
(d) The concrete and mortar will show no free water when removed from the mixer.
(e) The concrete will slide and not flow into place when transported in metal chutes at an angle of thirty (30) degrees with the horizontal.
(f) The surface of the finished concrete will be free from a surface film of "laitance".

Any concrete mix failing to meet the above outlined consistency requirements, although meeting the slump requirements, will be considered unsatisfactory; and the mix shall be changed to correct such unsatisfactory conditions. In cases where the characteristics of the aggregates furnished are such that, with the maximum allowable amount of water, the specified slumps and consistency requirements are not met, the Contractor may provide aggregates of an improved grading, or the Engineer will modify the mix design to meet the slump and consistency requirements by adding either cement or mineral filler, or both, as may be necessary. In case mineral filler is used, the combined total quantity of mineral filler and fine aggregate passing the 100 mesh sieve shall not exceed twenty (20) per cent of the weight of the fine aggregate.

The slump test will be made by the Engineer in accordance with the methods outlined in A.S.T.M. C-143.

The limits allowed for slump are set forth in Section S-403.8. The slump mold will be furnished by the State Highway Department.

S-403.10. QUALITY OF CONCRETE. Concrete made of acceptable materials, of the proportions specified by the Engineer, and in complete accordance with the requirements of the construction methods and details specified for the class of work involved, will be considered as of satisfactory quality.

During the progress of the work the Engineer will cast test cylinders or beams of the number and

type he may desire for testing to maintain a check on the compressive and flexural strength of the concrete actually being placed.

The Contractor shall provide and maintain curing facilities as described in Bulletin C-11 for the purpose of curing concrete test specimens. Provision shall be made to maintain the water in the curing tank at temperatures between 70° F. and 90° F. The cost of all materials used in test specimens and the cost of providing and maintaining curing facilities shall be included in the unit price bid for concrete of the various classes.

S-403.11. MIXING CONDITIONS. The concrete shall be mixed in quantities required for immediate use, and any concrete which is not in place within thirty (30) minutes after being discharged from the mixer shall not be used. Retempering of concrete will not be permitted.

In threatening weather, which in the opinion of the Engineer may result in conditions that will adversely affect quality of the concrete to be placed the Engineer may order postponement of the work. Where work has been started and changes in weather conditions require protective measures to be used, the Contractor shall furnish adequate shelter to protect the concrete against damage from rainfall or damage due to freezing temperatures. In case it is necessary to continue mixing operations during rainfall, the Contractor shall provide protective coverings for the material stock piles as well as for the concrete being placed. The covering for aggregate stock piles will be required only to the extent as may be necessary to control the moisture conditions in the aggregates so that adequate control of the consistency of the concrete mix may be maintained.

No concrete shall be mixed without the approval of the Engineer when the air temperature is at or below 40° F. (taken in the shade away from artificial heat) and falling. If authorized by the Engineer, concrete may be mixed when the air temperature is at 35° F. and rising. When permission is given for mixing when the temperature is below 40° F., the following requirements shall govern:

> All water used for mixing shall be heated to a temperature of at least 70° F. but not over 150° F. Aggregates shall be heated either by steam or by dry heat to a temperature of at least 70° F. but not over 150° F. The heating apparatus shall be such as to heat the mass of aggregates uniformly and preclude the occurrence of hot spots which will burn the material. Temperature of mixed concrete shall not be less than 60° F. at the time of placing in forms.

S-403.12. MIXING AND MIXING EQUIPMENT. The mixing shall be done in a batch mixer of approved type and size which will insure the uniform distribution of the material throughout the mass so that the mixture will be uniform in color and smooth in appearance. The minimum rated size of mixer permissible will be a five (5) cubic foot batch mixer, which size may be used only on structures or units of structures involving a maximum continuous placement of not over fifteen (15) cubic yards of concrete. A ten (10) cubic foot or larger batch mixer shall be used where continuous placements of fifteen (15) to fifty (50) cubic yards of concrete are involved. For larger placements, a fourteen (14) cubic foot batch mixer or larger shall be used. The use of more than one five (5) cubic foot or ten (10) cubic foot batch mixer to produce results equivalent to the above requirements as to sizes of mixers will be permitted. The absolute volume of the concrete batch shall not exceed one hundred and twenty (120) per cent of the nominal capacity of the mixer. The continuous placements which govern the size of mixers required shall be the placements between construction joints shown on the plans.

After all the ingredients are assembled in the drum, the mixing shall continue for a minimum time of one and one-half ($1\frac{1}{2}$) minutes for fourteen (14) cubic foot mixers and smaller, and for a minimum time of one (1) minute for twenty-one (21) cubic foot mixers and larger. During the mixing time, the drum shall revolve at a speed of fourteen (14) to twenty (20) revolutions per minute. The mixer shall be equipped with a speed regulator to hold the mixer to its normal speed of revolution.

The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch. The first batch of concrete materials placed in the mixer for each placement shall contain an extra quantity of sand, cement, and water sufficient to coat the inside surface of the drum without diminishing the mortar content of the mix. Upon the cessation of mixing for any considerable length of time, the mixer shall be thoroughly cleaned.

The concrete mixer shall be equipped with an automatic timing device so constructed that it is put into operation when the skip is raised to its full height and dumping. This device shall satisfactorily lock the discharging mechanism to prevent emptying of the mixer until all the materials have been mixed together for the minimum time required, and it shall ring a bell after the specified time of mixing in the drum has elapsed.

The water tank shall be arranged so that the amount of water can be accurately measured, and while the tank is discharging, the inlet supply shall be automatically cut off.

Whenever a concrete mixer is not adequate or suitable for the work, it shall be removed from the site upon a written order from the Engineer and a suitable mixer provided by the Contractor. Pick-up and throw-over blades in the drum of the mixer which are worn down more than twenty-five (25) per cent in depth shall be repaired or replaced by new blades.

Concrete improperly mixed shall not be placed in the structure.

The use of ready-mixed concrete will be permitted provided the batching plant meets the requirements set forth under Item S-403.7, "Condition of Equipment", and the mixing complies with the following requirements:

(a) Central-mixed concrete shall be mixed completely in a stationary mixer in accordance with these specifications, and the mixed concrete transported to the point of delivery in a truck agitator or in a truck mixer operating at agitator speed except that air-entrained concrete may be transported in non-agitating equipment subject to the following restrictions. Bodies of non-agitating equipment shall be self-cleaning, smooth, watertight, metal containers with well rounded corners free of re-entrant angles, and equipped with a baffle or baffles to insure discharge from the bottom of the load. Containers shall be equipped with gates that will permit control of the discharge of the concrete, and watertight covers shall be provided when required.

Concrete transported in non-agitating equipment shall be delivered to the site of the work in a thoroughly mixed and uniform mass; free from segregation and discharged with a satisfactory degree of uniformity. Slump test of individual samples taken at approximately the one-quarter and the three-quarter points of the load during discharge shall not exceed the slump specified in Section S-403.8 nor shall the two slump tests vary from each other by more than one and one-half (1-1/2) inches.

(b) Shrink-mixed concrete shall be partially mixed in a stationary mixer, and the mixing completed in a truck mixer.

(c) Transit-mixed concrete shall be completely mixed in a truck mixer.

Mixers and agitators shall be operated within the limits of capacity and speed of rotation as designated by the manufacturers. Non-agitating bodies shall not be loaded in excess of the manufacturers rated capacity.

When a stationary mixer is used for partial mixing of the concrete, the mixing time in the stationary mixer may be reduced to the minimum required to intermingle the ingredients (about 30 sec.).

When a truck mixer is used either for complete mixing or to finish partial mixing in a stationary mixer, each batch of concrete shall be mixed not less than 50 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as mixing speed. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed.

When a truck mixer or truck agitator is used for the transportation of central mixed concrete, mixing during transportation shall be at the speed designated by the manufacturer of the equipment as agitating speed.

Delivery of concrete to the site of the work and its discharge from the truck mixer, agitator or non-agitating equipment shall be completed within 1/2 hour after the introduction of the mixing water to the cement and aggregates, or the cement to the aggregates, unless otherwise authorized in writing by the Engineer.

Hand mixing of concrete will be permitted only for small placements or in the case of an emergency and then only on the authorization of the Engineer. When hand mixing is permitted, it shall be done on a water-tight platform. The fine aggregate and cement shall first be mixed until a uniform color is attained and then spread over the mixing board in a thin layer. The coarse aggregate shall be thoroughly saturated with water, and it shall then be spread over the fine aggregate and cement in a uniform layer and the whole mass turned as the additional water is added. After all ingredients have been added, the mass shall be turned at least six times, or more if necessary, to make the mixture uniform in color and smooth in appearance. Hand-mixed batches shall not exceed a two (2) bag batch in volume.

S-403.13. PLACING, CURING AND FINISHING. The placing of concrete, including construction of forms and falsework, curing, and finishing, shall be in accordance with Item S-402.

S-403.14. MEASUREMENT. The quantities of concrete of the various classifications which constitute the completed and accepted structure will be measured by the cubic yard in place. Only accepted work will be included, and the dimensions used will be those shown on the plans or ordered in writing by the Engineer. No deductions in measurement will be made for paneling less than three (3) inches in width by one (1) inch depth, for chamfers less than two (2) inches, for embedded reinforcing steel, for embedded portions of structural steel members, or for embedded portions of steel H piling. Deductions will be made for embedded portions of all piling other than steel H piling.

S-403.15. PAYMENT. The concrete quantities, measured as provided above, will be paid for at the unit prices bid per cubic yard for the various classifications of concrete shown, which prices shall be full compensation for furnishing, hauling and mixing all concrete materials; placing, curing and finishing all concrete; all grouting and pointing; furnishing and placing all drains and expansion joints, except as hereinafter provided; furnishing and placing metal flashing strips; furnishing and placing materials for Traffic Stripe where shown on plans; and for all forms and falsework, labor, tools, equipment, and incidentals necessary to complete the work.

The above provisions for payment shall not be interpreted to provide payment for concrete in railings, piling, concrete culvert pipe or other concrete items for which provision is otherwise made in the contract.

The above provisions for payment for drains and expansion joints shall not be interpreted to provide payment for cast iron or structural steel shapes used in drains; for structural steel, cast iron or cast steel bearing plates; or for steel members used in armoring roadway joints. Payment for these materials is provided for in the item for "Metal for Structures"

Texas Highway Department
Construction Specification
March, 1950
(Rev. August 1950)

ITEM S-405

REINFORCING STEEL

S-405.1. DESCRIPTION. This item shall provide for the furnishing and placing of reinforcing steel of the type, size, and quantity designated for use in structures as shown on the plans and in accordance with these specifications.

S-405.2. MATERIALS. All bar reinforcement shall be open hearth new billet steel of structural, intermediate, or hard grade or shall be rail steel concrete reinforcement bars.

New billet steel shall conform to the requirements of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars, A.S.T.M. Designation A-15.

Rail-steel reinforcement shall conform to the requirements of the Standard Specifications for Rail-Steel Concrete Reinforcement Bars, A.S.T.M. Designation A-16, (Bars produced by the piling method will not be accepted).

Unless otherwise shown on the plans, all reinforcing steel shall be deformed bars conforming to the requirements of A.S.T.M. Specification A-305. Twisted bars are not considered deformed and shall not be used. The form of deformed bars shall be such as to provide a net sectional area at all points equivalent to that of plain square or round bars of equal nominal size.

Wire for fabric reinforcement shall be cold-drawn from rods hot-rolled from open-hearth billets. Wire shall conform to the requirements of the Standard Specifications for Cold-Drawn Wire for Concrete Reinforcement, A.S.T.M. Designation A-82.

Throughout this item, when the Standard Specifications of the American Society for Testing Materials (A.S.T.M.) are specified, the latest standard or tentative specification issued by the Society prior to the date of receipt of bids on which the contract is awarded shall govern.

In cases where the provisions of this item are in conflict with the provisions of the A.S.T.M. Designations to which reference is made, the provisions of this item shall govern.

The nominal size and area and the theoretical weight of reinforcing steel bars covered by this specification are as follows:

Size	Bar Size Number	Nominal Area Sq.In.	Weight per Linear Foot
1/4" Round	2	0.049	0.167
3/8" Round	3	0.110	0.376
1/2" Round	4	0.196	0.668
5/8" Round	5	0.307	1.043
3/4" Round	6	0.442	1.502
7/8" Round	7	0.601	2.044
1" Round	8	0.785	2.670
1" Square	9	1.000	3.400
1 1/8" Square	10	1.266	4.303
1 1/4" Square	11	1.563	5.313

Wherever a bar of given diameter or square size is shown on plans or called for in specifications, either a round, square, oval or similarly shaped bar of equivalent area and weight may be used. Wherever $\frac{1}{2}$" square bars are specified 5/8" round bars or equal shall be substituted directly therefor with no change in spacing.

The weight of any lot (see note) of bars shall not vary more than three and one-half ($3\frac{1}{2}$) per cent under the theoretical weight for bars three-eighths (3/8) inches and over in nominal size or diameter; nor more than five (5) per cent under theoretical weight for bars under three-eighths (3/8) inch in nominal size or diameter. The weight of any individual bar shall not vary more than six (6) per cent under the theoretical weight for bars three-eighths (3/8) inch and over in size or diameter; nor more than ten (10) per cent under the theoretical weight for bars under three-eighths (3/8) inch in size or diameter. The theoretical weight of deformed bars shall be the same as the theoretical weight of plain round or square bars of the same nominal size. Bars or lots which vary more than the above limits shall be rejected.

(Note: The term "lot" used in the above paragraph shall mean all of the bars of the same nominal weight per linear foot in a carload or in a consignment if less than a carload.)

When wire is ordered by gauge numbers, the following relation between number and diameter, in inches, shall apply unless otherwise specified:

Gauge Number	Equivalent Diameter, Inches	Gauge Number	Equivalent Diameter Inches,
0	.3065	8	.1620
1	.2830	9	.1483
2	.2625	10	.1350
3	.2437	11	.1205
4	.2253	12	.1055
5	.2070	13	.0915
6	.1920	14	.0800
7	.1770		

The dimensions of the wire on any diameter shall not vary more than 0.003 inches from the specified nominal diameter. The difference between the maximum and minimum diameters, as measured on any given cross-section of the wire, shall not be greater than 0.003 inches. Wire having a diameter which varies more than 0.003 inches under the theoretical diameter shall be rejected.

S-405.3. BENDING. The reinforcement shall be bent cold to shapes indicated on the plans. All bending of hard grade and rail-steel bars shall be done in the shop. Bending of other grades shall preferably be done in the shop. Bends shall be true to the shapes indicated, and irregularities in bending shall be cause for rejection.

Unless otherwise shown on the plans, bends for stirrups and ties shall be made around a pin having a diameter of not less than two (2) times the minimum thickness of the bar.

S-405.4. STORING. Steel reinforcements 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, rust, paint, oil, or other foreign material.

S-405.5. SPLICES. 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 twenty (20) times the nominal size or diameter of the reinforcement, except in the case of welded splices, and shall be well distributed or else located at points of low tensile stress. No splices other than welded 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.

Where shown on the plans or required by the provisions of this item or other pertinent specifications, welded bar splices shall be used. All welding operations, processes, equipment, materials, workmanship and inspection shall conform to the requirements of the current Specifications for Welded Highway and Railway Bridges published by the American Welding Society. All splices

shall be of such dimensions and character as to develop the full strength of the bar being spliced. In general, bars smaller than 1" square shall be lap-spliced and bars 1" square and larger shall be butt-spliced. All lap splices shall be made by means of fillet welds on both sides of the surfaces of the bars in contact and the fillets shall be of such length and thickness as to develop an allowable working stress in the bar of 18000 pounds per square inch at the rate of 1,000 pounds per linear inch of weld for each 1/8" thickness of fillet, with a minimum length of fillet of 4". Where bars are placed end to end and connected by a splice bar, the length of weld shall extend a minimum of 4 inches each way from the ends of the bars and the ends of the bars shall also be connected by a butt weld. All butt welds shall be of either the single or double "V" type and ends of bars shall be prepared in accordance with the provisions of the American Welding Society Specifications quoted above for these types of welds.

S-405.6. 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 shall be spaced its proper distance from the face of the forms by means of approved galvanized metal spacers or approved precast mortar or concrete blocks. Unless provision for welding is made, all reinforcing steel shall be wired together at all intersections. Before any concrete is placed, all mortar shall be cleaned from the reinforcement. Precast mortar or concrete blocks to be used for holding steel in position adjacent to formed surfaces shall be cast in individual molds meeting the approval of the Engineer and shall be cured by covering with wet burlap until aged sufficiently to be removed from the molds, at which time the blocks shall be immersed in water for the remainder of at least a four-day curing period. The blocks shall preferably be cast with the sides beveled and in such manner that the size of the block increases away from the area to be placed against the forms. Blocks in the form of a frustum of a cone or pyramid are preferred. A suitable tie wire shall be provided in each block, such wire to be used for anchoring the block to the steel in order to avoid displacement in placing the concrete. Except in unusual cases, and when specifically otherwise authorized by the Engineer, the size of the surface to be placed adjacent to the forms shall not exceed two and one-half inches square or the equivalent thereof in cases where circular or rectangular areas are provided. Blocks shall be accurately cast to the thickness required, and the surface to be placed adjacent to the forms shall be a true plane free of surface imperfections.

Sheets of wire mesh or fabric 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.

S-405.7. MEASUREMENT. The measurement of the quantities of bar or fabric reinforcement furnished and placed will be based on the calculated weights of the steel actually placed in accordance with the plans and these specifications, with no allowance made for added bar lengths for splices requested by the Contractor nor for extra metal used when bars larger than those specified are substituted with the permission of the Engineer. Tie wires and supporting devices will not be included in the calculated weights. The calculated weight for bar reinforcement will be determined, using the theoretical bar weights set forth in Section S-405.2, with no allowance for overruns or underruns. The calculated weight for fabric reinforcement will be based on the theoretical weight of the fabric based on the nominal gauge of the wires and on the basis of steel weighing 0.2833 pounds per cubic inch. No allowance will be made for metal in welds, or for overruns or underruns due to variations from the nominal gauges set forth in Section S-405.2.

S-405.8. PAYMENT. Reinforcing steel used in structures, measured as provided above, will be paid for at the unit price bid per pound of "Reinforcing Steel" or "Reinforcing Fabric", as the case may be, which price shall be full compensation for furnishing, bending, fabricating, welding and placing the reinforcement, for all clips, blocks, metal spacers, ties, wire or other materials used for fastening reinforcement in place, and for all tools, labor, equipment, and incidentals necessary to complete the work.

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

ITEM S-406

STEEL STRUCTURES

S-406.1. DESCRIPTION. These specifications shall provide for the fabrication and erection of structural steel and other metals, except reinforcing steel, which are used for steel structures or steel portions of structures.

S-406.2. MATERIALS. The metal used for the various portions of the structure shall be as specified and shall conform to the requirements of Item S-407, "Metal for Structures".

Paint and painting shall be in accordance with Item S-408, "Paint and Painting".

FABRICATION

S-406.3. 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 twenty-two (22) by thirty-six (36) inches. The margin at the left end shall be one and one-half ($1\frac{1}{2}$) inches wide, and the others one-half ($\frac{1}{2}$) inch. Each sheet shall have a title in the lower right-hand corner. The title shall include the sheet index data shown on the lower right-hand corner of the project plans, sheet numbering for the shop drawings, name of stream, span length, name of Fabricator and name of Contractor.

Inked linen tracings or legible reproductions made on linen of the approved shop drawings shall be furnished to the Engineer upon completion of the work of fabricating the steel.

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: four (4) for State Projects and six (6) for Federal Aid Projects. In special cases additional copies may be required.

The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fits and field connections, although the drawings may have been approved by the Engineer.

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.

S-406.4. NOTICE OF BEGINNING 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 authorized fabrication. Any purchase of material prior to fabrication authorization shall be at the Contractor's risk.

S-406.5. INSPECTION AND TESTING. The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and he shall furnish the Inspector with as many helpers as may be needed to properly inspect the work. The Inspectors shall be allowed free access to the necessary parts of the works.

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

If the scale weight of any member is more than two (2) per cent less than the computed weight, it may be cause for rejection.

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 shall be replaced promptly or made good by the Contractor.

S-406.6. WORKMANSHIP, GENERAL. Structural material, either plain or fabricated, shall be stored 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.

Roller material, before being laid off or worked, shall 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.

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

S-406.7. PITCH OF RIVETS. The minimum allowable distance between centers of rivets shall be three times the diameter of the rivet but preferably shall be not less than the following:

For 7/8 inch diameter rivets. . . . . 3 inches
For 3/4 inch diameter rivets. . . . . $2\frac{1}{2}$ inches
For 5/8 inch diameter rivets. . . . . 2 1/4 inches

The maximum allowable pitch in the line of stress shall not exceed six (6) inches or sixteen (16) times the thickness of the thinnest outside plate or angle connected, except in angles having two gage lines with rivets staggered, where the pitch in each line may be twice the above with a maximum of ten (10) inches.

In webs of members composed of two or more plates in contact, the rivets shall be spaced not more than ten (10) inches between centers in gage and pitch, provided such rivets serve no other purpose than to hold the plates in close contact. Tension members composed of two angles in contact shall be stitch riveted using a pitch not greater than twelve (12) inches.

S-406.8. PITCH IN ENDS OF COMPRESSION MEMBERS. In the ends of built compression members, the pitch of rivets connecting the component parts of the member shall not exceed four (4) times the diameter of the rivet for a length equal to one and one-half ($1\frac{1}{2}$) times the maximum width of the member Beyond this point, the rivet pitch shall be gradually increased for a length equal to one and one-half ($1\frac{1}{2}$) times the maximum width of the member until the maximum spacing is reached. In angles having two (2) lines of staggered rivets in one leg, the pitch on each line may be twice that specified above but not greater than that allowed for the body of the member.

S-406.9. EDGE DISTANCE OF RIVETS. The minimum distance from the center of any rivet to a sheared edge shall be:

For 7/8 inch diameter rivets . . . . . 1 1/2 inches
For 3/4 inch diameter rivets . . . . . 1 1/4 inches
For 5/8 inch diameter rivets . . . . . 1 1/8 inches

The minimum distance from rolled or planed edges, except flanges of beams and channels, shall be:

For 7/8 inch diameter rivets . . . . . 1 1/4 inches
For 3/4 inch diameter rivets . . . . . 1 1/8 inches
For 5/8 inch diameter rivets . . . . . 1 inch

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

S-406.10. PUNCHED WORK. If general reaming is not required, all main material forming parts of a member composed of not more than five (5) thicknesses of metal may be punched full size if no thickness is more than three-quarter (3/4) inch. If there are more than five (5) thicknesses or if any thickness is more than three-quarter (3/4) inch, the holes in all of the thicknesses shall be punched three-sixteenths (3/16) inch smaller and be reamed, after assembling, one-sixteenth (1/16) inch larger than the nominal diameter of the rivet, except that if any thickness is more than the nominal diameter of the rivet, the holes in that thickness shall be drilled.

Holes punched full-size shall be one-sixteenth (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 three-thirty-seconds (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 one-eighth (1/8) inch smaller than the nominal diameter of the punched hole may be passed through at least seventy-five (75) of any group of one hundred (100) contiguous holes, or in like proportion for any smaller group of holes. If this requirement is not fulfilled, the badly punched pieces shall be rejected. If ten (10) per cent of any group of one hundred (100) or fewer holes will not pass a pin three-sixteenths (3/16) inch smaller than the nominal diameter of the punched holes, the mis-punched pieces shall be rejected.

S-406.11. REAMED WORK. General reaming will be required if shown on the plans or specified.

In reamed work, all holes shall be sub-punched 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. After assembling, sub-punched holes shall be reamed to a diameter one-sixteenth (1/16) inch larger than the nominal diameter of the rivet. Holes shall be drilled in material thicker 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 unless the material is thicker than the nominal diameter of the rivet, in which case the holes shall be drilled.

Sub-punched and reamed holes for rivets having diameters greater than three-fourths (3/4) inch shall be punched three-sixteenths (3/16) inch smaller than the nominal diameter of the rivet. For rivets having diameters of three-fourths (3/4) inch, the holes shall be punched eleven-sixteenths (11/16) inch in diameter. For rivets having diameters of five-eights (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-sized punched holes.

Reaming shall be done after the pieces forming a built member are assembled and firmly bolted together. Reamed parts shall not be interchanged. Match marks shall be placed on the members at the time reaming is done.

Reaming of rivet holes shall be done with twist drills or with short taper reamers. Reamers preferably shall not be directed by hand. No oil or grease shall be used as a lubricant when reaming. Burrs resulting from reaming shall be removed. Accuracy of reamed work is given in Section S-406.12.

S-406.12. DRILLED WORK. Drilled holes shall be one-sixteenth (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, eighty-five (85) of any group of one hundred (100) contiguous holes, or in like proportion for any smaller group of holes, shall not show an offset greater than one-thirty-second (1/32) inch between adjacent thickness of metal.

S-406.13. 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. Spot welding for the purpose of eliminating bolts for assembling will not be permitted. 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 deformations.

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 three-thirty-seconds (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 or clamped firmly in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts, insofar as practicable, to prevent damage in shipment and handling.

The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

S-406.14. REAMING OF FIELD CONNECTIONS. All riveted trusses and skew portals shall be completely assembled in the shop, the parts adjusted to line and fit, and the holes for field connections reamed or drilled while so assembled. Holes for other field connections, except in lateral, longitudinal and sway bracing, and diaframs for I-beam spans, shall be reamed or drilled with the connecting parts assembled, or else reamed or drilled to a metal template not less than one (1) inch thick.

While trusses are completely assembled at the shop, all connecting parts shall be matchmarked in accordance with the erection diagram.

S-406.15. SHOP RIVETS AND RIVETING. Rivets, before heating, shall be of diameter specified. They shall be free from furnace scale.

Rivets for field driving shall be furnished in excess of the nominal number required to the amount of ten (10) per cent plus ten (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 after driving.

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.

S-406.16. BOLTED CONNECTIONS. Bolted connections shall not be used unless specifically authorized. If bolted connections are permitted, the bolts shall be 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 one-fourth (1/4) inch beyond. Bolts in tension shall have two (2) nuts.

Unfinished bolts in shear shall have not more than one (1) thread within the grip. The diameter of the unfinished bolt shall not be more than one-sixteenth (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 one-fourth (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 one-thirty-second (1/32) inch greater than the diameter of the finished bolts.

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

Special types of lock bolts may be used with written approval of the Engineer.

S-406.17. PLANING, FACING, AND FIT OF MEMBERS. Sheared edges of plates more than five-eighths (5/8) inch thickness and carrying calculated stress shall be planed to a depth of one-fourth (1/4) inch. Re-entrant cuts shall be filleted before cutting.

Flame cutting of structural steel will not be permitted unless equipment is used as will produce cut edges equivalent in appearance and workmanship to a sheared edge.

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

Sole plates of beams and girders shall have full contact with the flanges. Sole plates and masonry plates shall be planed or hot straightened, if necessary, to insure full and even bearing. Cast pedestals shall be planed on surfaces to be in contact with steel and shall have rough finish surfaces to be in contact with masonry. Rough finish specified above shall be interpreted to mean one rough cut of the planer to true up the surface.

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 plans, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed one-fourth (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 plans.

The ends of lacing bars shall be neatly rounded unless otherwise shown on the plans. Lacing bars having a single rivet connection shall have the ends rounded to a radius equal to one-half ($\frac{1}{2}$) the width of the bar.

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 one-eight (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 one-half ($\frac{1}{2}$) 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 three-eighths (3/8) inch. The clearance at the top and bottom ends of web splice plates shall not exceed one-fourth (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 one-fourth (1/4) inch at each end.

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

S-406.18. 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 seven (7) inches and less in diameter may be manufactured from cold rolled shafting.

Pins more than seven (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 one-thirty-second (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 one-fiftieth (1/50) inch for pins five (5) inches or less in diameter, or one-thirty-second (1/32) inch for larger pins.

Two (2) pilot nuts and two (2) driving nuts for each size of pin shall be furnished, unless otherwise specified.

S-406.19. CAST STEEL BEARING PLATES. Cast steel bearing plates for steel I-beam spans or concrete girder spans shall be finished on all surfaces that are intended for sliding contact; the planing shall be in the direction of expansion. Surfaces in contact with masonry bridge seats shall be rough finished. Contact surfaces separated by a lead sheet shall be ground or milled sufficiently smooth in order that the lead plate provided between these surfaces will fully compensate for all irregularities. Each bearing plate unit shall be assembled and fitted in the shop and the component parts matchmarked for field erection.

S-406.20. WELDING. All welding operations, processes, equipment, materials, workmanship and inspection shall conform to the requirements of the latest Specifications for Welded Highway and Railway Bridges published by the American Welding Society.

When directed by the Engineer, weld metal shall be drilled, chipped or cut away so as to expose the interior of the weld for visual inspection. When the weld so exposed is acceptable, the portions removed shall be re-built to the original dimensions and when the weld so exposed is faulty, it shall be removed and replaced with an acceptable weld in accordance with Items 5.9 "Inspection" and 5.11 "Removal of Defective and Unauthorized Work." No compensation will be allowed the Contractor because of any delay in the work resulting directly or indirectly from this inspection.

After cleaning and inspecting and within twenty-four (24) hours after depositing, welds shall be spot painted with a paint conforming to pertinent provisions of the paint specifications. Welds shall be flushed thoroughly with clean water to remove any alkaline residue and the flushed surface allowed to become dry before paint application.

Qualification of welders will be required. If no welded splices of main stress-carrying members are involved, the tests will consist of the performance of a few sample welds by the welder and the fracture and visual inspection thereof by the Engineer. If splices of main stress-carrying members are involved, qualification procedure shall conform to the latest Specifications for Welded Highway and Railway Bridges published by the American Welding Society. The expense of qualification tests shall be borne by the Contractor.

S-406.21. SHOP PAINTING. Unless otherwise provided the application of shop paint shall conform to the requirements of Item S-408 "Paint and Painting".

Surfaces to be in contact after shop riveting is completed shall be cleaned but shall not be painted.

S-406.22. MARKING 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. Matchmarks shall be made with paint.

Members weighing more than three (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 three hundred (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

S-406.23. METHODS AND EQUIPMENT. Before starting work, the Contractor shall inform the Engineer fully as to the method of erection he proposes to follow and as to the amount and character of the equipment he proposes to use, the adequacy of 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 or adequacy of his methods 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.

Spot welding for the purpose of eliminating field erection bolts or for holding steel parts together while riveting will not be permitted.

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. Drift pins sufficient to fill at least one-fourth (1/4) of the field holes for main connections shall be provided.

S-406.24. STORING MATERIALS. All material shall be handled in such manner that no injury will result. Material to be stored shall be placed on skids above the ground and 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.

S-406.25. FALSEWORK. The falsework shall be properly designed for the loads to be supported and shall be substantially constructed and maintained. The Contractor shall prepare and submit plans for falsework to the Engineer for approval. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility.

S-406.26. BEARING AND ANCHORAGE. Castings or bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished. Castings or bearing plates shall be set in exact position and shall have a full and even bearing upon the masonry, and, unless otherwise directed by the Engineer, 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 (3) layers of twelve (12) to fourteen (14) ounce canvas, each layer being thoroughly swabbed on its top surface with red lead paint. Place the castings or bearing plates in position while the paint is plastic.

The milled and finished surfaces of castings or bearing plates shall have the shop coat of tallow, white lead, and oil removed immediately prior to placing in the structure. Surfaces designed for sliding movement one upon the other shall be given a field coat of graphite grease when placed in the structure.

The Contractor shall drill the holes and set the anchor bolts, except where the holes are formed or the bolts are built into the masonry. The bolts shall be accurately set and fixed with Portland Cement grout completely filling the holes.

S-406.27. 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, the surface of the metal shall be carefully inspected for evidence of fracture.

S-406.28. HANDLING AND ASSEMBLING MATERIAL. The parts shall be accurately assembled as shown on the plans and matchmarks 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 rail connections shall not be driven until the span has been swung. Main connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before swinging the span. 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 one-thirty-second (1/32) inch larger.

S-406.29. RIVETING. Pneumatic hammers shall be used for field riveting. 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 symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out.

S-406.30. PIN AND BOLT CONNECTIONS. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing. 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.

S-406.31. 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 Engineer, and his approval of the method of correction shall be obtained. The correction shall be made in the presence of the Engineer, who will check the material. Such work is to be done at the entire expense of the Contractor.

S-406.32. PAINT AND PAINTING. Unless otherwise provided, the application of field paints shall conform to the requirements of Item S-408, "Paint and Painting".

S-406.33. MEASUREMENT AND PAYMENT. No direct compensation will be made for "Steel Structures". Measurement and payment for quantities of structural metal, concrete, reinforcement, railing, and other proposal items which constitute the completed and accepted structures will be made in accordance with the provisions of pertinent specifications.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-407

METAL FOR STRUCTURES

S-407.1. DESCRIPTION. These specifications shall govern for the materials such as structural and rivet steel, steel forgings, steel castings, gray-iron castings, malleable castings, wrought-iron, bronze, and other metals used in structures except reinforcing steel and metal culvert pipe.

Throughout this item, where the Standard Specifications of A.S.T.M. are specified, the latest standard or tentative specification issued by the Society prior to the date of receipt of bids on which the contract is awarded shall govern.

S-407.2. STRUCTURAL AND RIVET STEEL. All structural and rivet steel shall conform to the requirements of the current Standard Specifications for Steel for Bridges and Buildings, A.S.T.M. Designation A7.

S-407.3. 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, A.S.T.M. Designation A-20.

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

S-407.4. STEEL CASTINGS. Steel castings shall conform to the specifications for Mild to Medium Strength Carbon Steel Castings for General Application, A.S.T.M. Designation A27. Grade 70-36 shall be furnished unless otherwise specified.

No sharp unfilleted angles or corners will be allowed.

Castings which do not come within the above limitations shall be rejected.

S-407.5. GRAY-IRON CASTINGS. Iron castings shall conform to the requirements of the Standard Specifications for Gray-Iron Castings, A.S.T.M. Designation A 48. Unless otherwise provided, A.S.T.M. Class 20 providing for a minimum ultimate tensile strength of 20,000 pounds per square inch shall be used.

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.

S-407.6. MALLEABLE CASTINGS. Malleable castings shall conform to the requirements of the Standard Specifications for Malleable Iron Castings, A.S.T.M. Designation A 47.

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.

S-407.7. WROUGHT-IRON. Wrought-iron shall conform to the requirements of the Standard Specifications for Refined Iron Bars, Wrought-Iron Plates or Welded Wrought-Iron Pipe, A.S.T.M. Designations A 41, A 42 and A 72 respectively. Transverse ductility of wrought-iron plates shall not be less than three (3) per cent nor more than eight (8) per cent.

S-407.8. BRONZE. Bronze castings shall conform to the requirements of the Specifications for

Bronze Castings for Turntables and Movable Bridges, A.S.T.M. Designation B 22. Bronze Bearings and Expansion Plates shall conform to the requirements of the Specifications for Wrought Phosphor Bronze Bearings and Expansion Plates for Bridges and Structures, A.S.T.M. Designation B 100.

The class of metal shall be as shown on the plans.

S-407.9. GALVANIZING. Galvanizing of metal, other than sheet metal, shall conform to the requirements of the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products, A.S.T.M. Designation A 123.

S-407.10. LEAD. Lead sheets shall be uniform in thickness, free from surface imperfections, and shall be manufactured from commercially pure, virgin pig lead.

S-407.11. COPPER. Copper furnished under these specifications shall be free from flaws or surface imperfections and shall be manufactured from commercially pure, soft copper bars.

S-407.12. FABRICATION, ERECTION, AND PAINTING. Fabrication and erection of structural metal shall be in accordance with Item S-406. Paint and painting shall be in accordance with Item S-408.

S-407.13. MEASUREMENT. Measurement of the quantity of structural metal furnished and placed will be based on the weight of metal in the fabricated structure, including the quantity of field rivets provided in Item S-406. The weight of erection bolts, paint, and all boxes, crates or other containers used for packing, together with sills, blocking and rods used for supporting or protecting members during transportation shall be excluded. Where increases in size or weights of members have been made which were not ordered by the Engineer but approved by him, measurement will be made on the sizes or weights given on the project plans. No measurement will be made of deposited weld metal.

In determining the weight of structural metal in truss spans, I-beam spans and plate girder spans, such items as castings, bearing plates, lead sheets, anchor bolts, drains, and all other metal for which no separate measurement is specified shall be considered as "Structural Steel".

The quantity of "Structural Steel" for concrete girder or slab spans shall include the weight of all cast iron or structural shapes and plates used in drains and structural shapes and plates used in armoring roadway joints.

The quantity for "Cast Steel Bearing Plates" for concrete girder spans shall include the weight of all cast steel plates and lead sheets used in the bearing plate assembly.

Weight of metal to be paid for shall be based on computed weights.

Computed weights shall be 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 0.2604 pounds per cubic inch. The weight of wrought iron shall be assumed at 0.2777 pounds per cubic inch. The weight of bronze shall be assumed at 0.3150 pounds per cubic inch. The weight of lead shall be assumed at 0.4085 pounds per cubic inch. The weights of rolled shapes and of plates shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop plans, deducting for copes, cuts, and open holes. The weight of castings shall be computed from the dimensions shown on the approved shop drawings.

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

Diameter of Rivet	Weight for 100 Heads
1/2"	5.0 lbs.
5/8"	9.7 lbs.
3/4"	16.0 lbs.
7/8"	24.0 lbs.
1"	35.0 lbs.

Before final payment is made, the Contractor shall furnish the Engineer four sets of shop bills showing the calculated weights of all parts of the structure. The weights shall be computed from the approved shop detail drawings.

S-407.14. PAYMENT. Structural metal measured as provided above will be paid for at the unit price bid per pound for "Structural Steel", "Cast Steel Bearing Plates", or for other classifications of structural metal shown on the plans and in the proposal, which prices shall be full compensation for furnishing all materials and for all fabrication, shop work, transportation, erection, paint and painting, and for furnishing all equipment, tools, labor, and incidentals necessary to complete the work.

To avoid the grouping of materials and workmanship of a widely different character into a single bid item, the plans and proposal may show "Structural Steel" subdivided into items relating to individual structures, to parts of structures or to groups of structures, as for example, "Structural Steel—Truss Spans", "Structural Steel—I-beam Spans" or "Structural Steel—Concrete Girder Spans".

The above provisions shall not provide for measurement and payment for metal in railings and connections for railings on I-beam, deck plate, and deck truss spans when the plans indicate that the metal in railings on these types of individual bridges will be paid for on the linear foot basis under the Item of "Railing".

Texas Highway Department
Construction Specification
March, 1950

ITEM S-408

PAINT AND PAINTING

S-408.1. SCOPE. This item shall govern for finished paints, their source, and for the application of paint to structures. The painting of structures shall include, unless otherwise provided in the contract, the proper preparation of the surfaces, the application, protection and drying of the paint coatings, the protection of pedestrian, vehicular or other traffic upon or underneath the 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.

S-408.2. INTENT. The coating design herein specified has been effected by means of carefully controlled formulation and durability testing methods. The intent is to procure the paints in place on structures so that the durability and protective value of these designs will be realized in service. Accordingly, the best quality materials and workmanship are implied throughout.

S-408.3. SOURCE OF SUPPLY. The Contractor shall purchase acceptable paints from the State Highway Department. Paints are available in five gallon containers from State stock at prices shown on Paint Price List included in the proposal. For small quantities these paints are available in one gallon cans at the same prices. All paints will be charged to the Contractor at prices listed. Reimbursement to the State will be accomplished by making deduction from the Contractor's estimates for the actual cost of paints purchased. Shipments will be made from Camp Hubbard, Austin, Texas, direct to the Contractor at the destination designated by the Contractor with transportation charges to be paid by the consignee. The Contractor shall place his order for paint with the District Engineer. The Contractor shall not use any of these paints on any work which is not required by and which does not constitute a part of this contract. Paints in unopened containers, which were purchased from the Department shall be returned to the District Warehouse upon completion of the contract and credit accepted.

S-408.4. GENERAL. The intent is to procure full adhesion of paint to clean, dry, firm surfaces, and between coats. This will require careful attention to preparation of surface, to prevention of contamination and marring of coating during and after drying, and to uniform, skilled application. All painting shall be done in a neat, workmanlike manner. Portions of structures which will be difficult of access for application of the two field coats after erection, may be completely painted before assembling or erection at the discretion of the Engineer. It shall be permissible to use lambswool applicators for painting portions inaccessible to brushes or spray.

S-408.5. DESCALING, CLEANING AND PREPARATION OF SURFACE. Throughout paint application, including shop and field painting, no paint shall be applied over a surface which evidences a loose or scaly condition. Every effort shall be made by means of the most effective and practical methods to remove all loose millscale, rust and dirt as well as all other foreign substances which would be deleterious to the procurement of a firm paint coating. The bulk of this cleaning and preparation of surface necessarily must be done at the fabricating plant before application of the shop coat, but the same general requirements for painting over a clean, firm surface shall be applicable to all coats. The Engineer will look for evidence of faulty surface preparation preceding the shop coat by close inspection of the surface directly prior to application of first field coat; likewise, between first and second field coats. This careful inspection directly in advance of paint application may disclose not only loose, scaly conditions on the surface as result of faulty preparation but also failure of the paint to harden because of contamination and changes which have taken place beneath the paint film as a result of rusting and loosening of millscale after paint has been applied. Therefore, whenever the Engineer has the slightest doubt as to the firm condition of the surface at any time throughout the application of any coats, he will be expected to explore underneath the surface of any paint coats already applied so as to uncover evidences of infirmity and to direct remedial measures. Any effective methods for removal of rust, scale and dirt, such as through the use of sand blast, hand or rotating metal brushes, scrapers, chisels, hammers, flame-cleaning, or other effective means will be acceptable. Undesirable contaminants

which must not be allowed to be present on the surface directly prior to paint application and which will prevent proper hardening and adhesion of the paint film are grease, oil, oily grime, and moisture. Condensed moisture shall be avoided as directed in Section S-408.6; the other grease-like contaminants shall be removed with clean petroleum solvents, such as gasoline, applied with clean rags in such manner that the oil substance is actually removed and not simply diluted or spread out over a greater area. Proper grease removal requires at least two distinct steps: first, the contaminated area must be sponged with cloths wet with gasoline or naphtha so as to remove most of the grease; second, the area must be vigorously wiped with separate, clean cloths which have been dampened by pouring uncontaminated fresh gasoline or naphtha onto them and not by dipping grease contaminated cloths into the solvent. If grease, oil and grime are not thoroughly removed in this manner, the paint will be prevented from securing proper adhesion, it will not harden properly and consequently these deficiencies are certain to evidence themselves before final completion of the finishing field coat with the result that the Engineer may be forced to require expensive removal of improper paint film at the expense of the Contractor. Particular attention shall be paid to cleaning of fillets, riveted areas, rivet heads, and drilled holes where loose mill-scale, rust and oil are most likely to be present. All welds shall be flushed thoroughly with clean water before painting so as to remove any alkaline residue; the flushed surfaces shall then be allowed to become thoroughly dry before paint application.

Concrete surfaces to be painted shall be brushed free of loose, scaling matter, with a stiff bristled brush followed by dusting with a soft bristled brush. If the contract stipulates the painting of new concrete surfaces, less than six months old, these shall be treated with a solution of two pounds Zinc Sulfate Crystals (Hydrated) dissolved in one gallon of clean water; this solution shall be brushed over the entire surface so as to thoroughly wet it, then after the solution has thoroughly reacted with the free lime and the surface is completely dry, i.e., after 24 hours from application in favorable weather, the resultant loose matter shall be brushed off as stipulated above.

S-408.6. WEATHER CONDITIONS AND DRYNESS OF SURFACE. Paint shall not be applied to any surface containing moisture discernible with the eye or by the following test for condensation: If it is suspected that temperature and humidity conditions are such that moisture is condensing upon the surface, the latter shall be moistened with a damp cloth so as to apply a clearly defined, thin film of water; if this thin film evaporates and decreases after fifteen minutes, the surface shall be considered safe to paint from the standpoint of continued condensation at that particular time. Paint shall not be applied at air temperatures below 40°F., nor when there is likelihood of change in weather conditions within two hours after application which would result in air temperatures below 40°F., or deposition of moisture in the form of rain, snow, condensation, etc., upon the surface. The Engineer reserves the right to order paint not to be applied when in his opinion, impending weather conditions may result in injury to the fresh paint.

S-408.7. NUMBER OF COATS AND COLOR. Except for surfaces hereinafter specified, all new structural metal shall be painted, unless otherwise provided on the plans or in the special provisions, with one shop coat of #700 Shop Coat, one field coat of #701 paint and one field coat of #703 Aluminum Paint. Gr-3 Finish Coat is to be used only when called for on plans or in special provisions. Where GR-3 Finish Coat is used all new structural metal, except for surfaces hereinafter specified, shall be painted with one shop coat of #700 Shop Coat and one field coat of GR-3 Finish Coat. Timber structures or timber portions of structures shall be painted as provided on the plans or in the special provisions. Metal blast plates and fastening shall be furnished with one shop coat of #700 Shop Coat and after erection shall be trowel coated to an average of 1/16 inch with the following Plastic Asphalt Cement, or its approved equal in a commercial plastic cement:

Plastic Asphalt Cement	Pounds
Cut-back Asphalt, RC-1, Item S-303	400
Tall Oil, Acid Refined	10
Hydrated Lime	10
Mineral Spirits	100
Asbestos Fibre, Short	120
Water	3
	643

S-408.8. STIRRING, MIXING, AND CARE OF PAINTS. All mixed paints shall be made ready for use through reincorporating settled pigment by means of thorough stirring, boxing, and straining so that the paint is in its original homogeneous form, free from large agglomerates and skins greater than one-fourth millimeter in diameter. Paint in mixing pots shall be kept covered while not in use so as to reduce volatile losses and skinning; it always shall be in a completely mixed condition when filled into painter's pots and this filling always shall be through a strainer of 20 mesh cloth or wire, or finer. Paint from painter's pots shall be concentrated into covered mixing pots at the end of the day, shall at no time during application contain skins or large agglomerates, and the interior sides of pots shall be periodically cleaned free of soft skins which might cling to brushes.

S-408.9. THINNING. At temperature above 70°F., all of the paints furnished for use, when freshly opened from sealed containers and thoroughly stirred, are of normal consistency, suitable for good brush application, without thinning; at temperatures below 70°F., the consistency may be heavy enough to require some thinning for proper brush application. Adjustment of paint consistency by thinning so as to meet any and all conditions shall be done only at the discretion of the Engineer and only after procuring his specific permission. Either mineral spirits or turpentine may be used as thinner. The general rule which shall be applied for thinning paints shall be that a full hiding coat can be applied without sags and runs, so as to thoroughly obscure the surface being painted, whether bare metal or under-coat. Proper care of paints should remove the necessity for thinning because of evaporated volatiles as a result of allowing the paints to stand in uncovered containers.

S-408.10. BRUSH APPLICATION. It shall be mandatory to apply the shop coat by brushing: spraying of this coat shall not be permitted. Painting shall be done by workmen skilled in the craft of structural metal painting. Good workmanship by skilled workmen is evidenced by the following outstanding features; all crevices, such as around rivet heads, sharp angles, etc., are first traced; the entire surface is then coated without attempt to "lay-off" the paint in one direction; lastly, runs from crevices are picked up and the paint is laid-off in one direction so as to leave a uniform film, free from runs, sags or brush-mars caused by not "feathering" or blending one lap into another. Brushes, preferably shall be round or oval in shape but if flat brushes are used, they shall not exceed 4" in width; brushes should be springy and not flabby. Brushes shall not be permitted to become "seedy" from skins--this will happen unless they are washed out at the end of each day with naphtha, turpentine, or benzol and stored in a linseed oil pot.

S-408.11. SPRAY APPLICATION. The field coats may be applied with either spray or brush or a combination of the two except that GR-3 Finish Coat shall be applied by spray only. The equipment used for spray painting shall meet with the approval of the Engineer and shall have adequate provision for separation of moisture from the air-stream in contact with the paint. The equipment used in applying paints other than GR-3 Finish Coat shall deliver at least 50 pounds per square inch air pressure at the gun. An Alemite Versatal Booster Pump, Model 7804-D, or equal, delivering a feed pressure of 80 to 100 pounds per square inch and an atomizing pressure at the spray gun of 80 to 100 pounds per square inch, shall be used in applying GR-3 Finish Coat. All spray guns shall be adequate for the type of paint being used and shall be equipped with suitable spray heads as necessary to obtain the application of an even, smooth coat of paint. Thinning of paint for spray application will be permitted only when specifically approved by the Engineer, and the Engineer shall assure that the equipment being used is adequate and suitable for the type of paint in question, that gun is not clogged with dried or semi-dried paint and that the required air-pressure is being delivered at gun before approving such thinning.

Some of the paints are highly harmful to the health of humans and animals if allowed to enter the alimentary tract by way of nose or mouth. Therefore, if spray application is used, workmen shall be adequately protected with respirators and provisions shall be made to prevent infliction of harm upon all other humans and/or animals which might be exposed to the fumes or might eat food upon which the fumes have deposited. This warning shall absolve the State from blame in the event of harm to persons or property from the above named cause and full responsibility for any such harm shall rest upon the Contractor.

S-408.12. SHOP COAT. When all fabrication work is completed and has been tentatively accepted as such, all surfaces not painted before assembling shall be cleaned as provided in Section S-408.5 and painted with one coat of #700 Shop Coat. 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. Surfaces to be

in contact after shop riveting shall not be painted. Machine finished surfaces which are to be in closed, sliding contact in the structure shall be coated, as soon as practicable after being accepted, with a hot mixture of white lead and tallow before being removed from the shop. This refers particularly to pins and holes for pins. The composition used for coating these machine finished surfaces shall be mixed in the following proportions:

4 lbs. pure tallow
2 lbs. pure white lead
1 quart pure raw linseed oil

All metal surfaces which will be within two inches of field welds shall be coated with linseed oil in advance of the application of shop coat paint and left bare of paint until field welding is completed. All surfaces other than those above mentioned shall receive a shop coat of paint regardless of whether or not the surface in question will be in direct contact with concrete or other masonry in the finished structure. The surfaces to be shop-painted will include the rolling faces of rockers and base plates, all surfaces of bearing plates for the ends of I-beam spans and all surfaces of iron or steel castings regardless of whether or not such surfaces are milled except those surfaces in closed, sliding contact as described above.

S-408.13. FIELD CLEANING AND SPOT PAINTING. When the erection work is complete, including all riveting, straightening of bent metal, etc., the shop coated surface shall be restored to a serviceable condition acceptable to the Engineer by means of preparation of surface as outlined in Section S-408.5 and by smoothing and touching up marred places in the shop coat film with #700 Shop Coat. Heads of field rivets and bolts, field welds and surrounding unpainted areas, and any other surfaces to be painted which have not yet been shop coated shall be painted with #700 Shop Coat. The coating of white lead and tallow specified in Section S-408.12 shall be thoroughly removed, as directed for removal of grease and oil in Section S-408.5 immediately prior to erection.

S-408.14. FIRST FIELD COAT. When field cleaning and restoration of shop coat has been completed and all shop coat is thoroughly dry, the first field coat of Paint may be applied. Finished surfaces intended for sliding contact shall be given a coat of approved graphite grease immediately prior to being placed in the structure. Graphite grease shall be composed of dry graphite flakes mixed with sufficient light grease or heavy oil so as to form a thick paste suitable for the purpose. Field coats will not be required on the bottom surfaces of shoe castings or bearing plates in direct contact with concrete nor on the top surfaces of beams, girders, etc., on which a concrete slab is to be placed in direct contact.

S-408.15. #703 ALUMINUM PAINT FINISH COAT. When the first field coat, including all touched-up marred places has thoroughly hardened, the finishing field coat of Aluminum Paint may be applied. Cracks and cavities which have not been sealed in a water-tight manner by the first field coat shall be filled with Red Lead Paste, containing 92-94% Red Lead and 8-6% Linseed Oil, and this shall be allowed to sufficiently surface-dry before the second field coat is applied so as not to work up into the Aluminum Paint. After application of the finishing field coat, the painted portion of the structure shall present a uniform color appearance throughout.

S-408.16. GR-3 FINISH COAT. The shop coat shall be restored as prescribed by Section S-408.13 of this Specification. After the necessary spot painting has thoroughly dried the surfaces which are to receive the GR-3 Finish Coat shall be cleaned and the GR-3 Finish Coat applied by spraying. The rate of application will be one-half gallon per one hundred square feet of surface of metal and shall be applied in accordance with Section S-408.11 of this Specification.

S-408.17. REMOVAL OF PAINT IMPROPERLY APPLIED. All applied paint which has been improperly applied and fails to dry and harden properly, or to adhere tightly to underlying metal or other paint film, or does not evidence a normal, workmanlike appearance in conformance with the intent of these specifications shall be remedied or thoroughly removed and replaced at the expense of the Contractor. When the final field coat does not have a uniform color and appearance throughout the structure, it shall be corrected by the use of whatever additional coats are necessary. Removal of freshly applied paint which has not yet set shall be effected with the use of naptha, gasoline or turpentine. Removal of dried paint films shall be effected either by means of sand blast, scraping or flame torches meeting the approval of the Engineer.

S-408.18. PAYMENT. Unless otherwise provided on the plans or in the special provisions, payment for furnishing all paint materials and all tools, equipment, labor, scaffolding and incidentals necessary to complete the work, and for cleaning all surfaces and for the application of paint shall be included in the unit price bid per pound of structural metal, or per linear foot of steel piling or railing or per M.F.B.M. of timber, as the case may be.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-409

TIMBER STRUCTURES

S-409.1. DESCRIPTION. These specifications shall govern for the construction of all culverts, bridges, bulkheads, retaining walls, piers, bents, fenders or any portion thereof which involves the use of timber materials whether treated or untreated. This item shall not include temporary timber construction which is not a part of the finished work.

S-409.2. MATERIALS. All materials used in the construction of timber structures shall conform to the requirements of Item S-410, "Timber for Structures", or other pertinent specifications.

S-409.3. 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 the quantity of preservative as shown on the plans in the manner and by one of the processes specified in Item S-411, "Timber Preservative and Treatment", or other pertinent specifications.

S-409.4. STORAGE OF MATERIALS. Lumber and timber at the site of the work shall be stored in piles.

Untreated material shall be open-stacked at least twelve (12) inches above the ground surface and piled to shed water and prevent warping. It shall be protected from the weather by suitable covering.

Treated timber shall be close-stacked, piled to prevent warping and the tops of the stacks shall be covered with a two (2) inch layer of earth.

The ground underneath and in the vicinity of all material piles shall be cleared of weeds and rubbish.

S-409.5. HANDLING. Timber shall be carefully handled without sudden dropping, breaking of outer fibers, or bruising. The surface of treated timbers shall not be penetrated with tools. Timbers shall be handled with rope slings or other approved methods. Use of cant dogs, hooks, or pike poles will not be permitted.

S-409.6. WORKMANSHIP. Workmanship shall be first class throughout. None but competent bridge carpenters shall be employed and all framing shall be true and exact. Nails and spikes shall be driven with just sufficient force to set the heads flush with the 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.

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.

Countersinking shall be done wherever smooth faces are required.

S-409.7. FRAMED BENTS. Mud sills of treated or 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 for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them.

S-409.8. SILLS. Sills shall have true and even bearing on piling or pedestals. When possible all

earth shall be removed from around sills so that there will be free air circulation around them.

S-409.9. POST COVERS. The tops of posts in framed bents, if untreated material, shall be given a thick coat of red lead and oil, hot tar, hot asphaltum or hot coal-tar and covered with a sheet of roofing felt weighing fifty-five (55) pounds per one hundred (100) square feet or twenty (20) gauge galvanized metal as indicated on the plans. The cover shall measure at least six (6) inches more in each dimension than the diameter or side of the post. The edges shall be bent down over the post and 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 thoroughly saturated with 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.

S-409.10. CAPS. Timber caps shall be placed so as to secure an even and uniform bearing over the tops of the supporting posts or piling and to secure an even alignment of their ends. All caps shall be secured to the posts or piling in accordance with the details shown on the plans. No shimming on tops of piling or posts will be permitted.

S-409.11. BRACING. Sway bracing shall be placed diagonally on bents and connected to the cap and all piling or posts as shown on the plans.

Sash bracing and longitudinal bracing shall be placed and fastened to the piling or posts as shown on the plans.

Bracing shall be fitted to the bents in a satisfactory manner without dapping or cutting the posts or piling.

S-409.12. STRINGERS. Stringers shall be sized to uniform depth at beatings and shall be placed in a position so that knots near the edges will be in the top portions of the stringers.

Stringers may have butt joints or lapped joints as shown on the plans. The lapped ends of untreated stringers shall be separated at least one-half ($\frac{1}{2}$) inch to permit the circulation of air. When stringers are two panels in length, adjacent stringers shall be lapped at alternate bents. All stringers shall be securely fastened by bolts where shown on plans.

S-409.13. BRIDGING. Cross bridging or diaframs 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.

S-409.14. FLOORING. Plank for single plank floors shall be placed with the heart side down with one-fourth (1/4) inch openings between them for seasoned materials and with tight joints for unseasoned material. Unless otherwise provided, each plank shall be spiked to each stringer or nailing strip with not less than two (2) spikes, the length of which shall be at least three (3) inches greater than the thickness of the plank. The ends of the plank shall be cut off on a straight line parallel with the center line of the roadway. The planks shall be carefully selected according to thickness and so laid that no two adjacent planks shall vary in thickness more than one-eighth (1/8) inch.

Where double plank floors are indicated on the plans, the top course shall be laid diagonal or parallel to the center line of the roadway as shown and, unless otherwise provided, each plank shall be spiked to the lower course at intervals of not more than two (2) feet with two (2) spikes, the length of which shall be at least three (3) inches greater than the thickness of the plank. Joints shall be staggered at least three (3) feet. Where the planks are placed parallel to or diagonally with the center line of the roadway, special care shall be exercised to securely fasten the ends, and at the ends of the bridge, the ends of all plank shall be cut to a straight line parallel to the end of the bridge.

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. Unless otherwise provided, each strip shall be spiked to the adjacent strip at intervals of two (2) feet the spikes being staggered eight (8) inches in adjacent strips. The spikes shall be of sufficient length to pass completely through two (2) adjacent strips and approximately half way through the third strip. In addition, unless otherwise provided, the strips shall be toe-nailed to the stringer with spikes not less than four (4) inches in length. The toe-nailing of successive strips shall be staggered so that the spacing of spikes along each stringer shall be not less than six (6) inches. For strips three (3) inches in thickness spikes driven vertically through the strips and extending into the stringer not less than three (3) inches may be substituted for toe-nailing, with the approval of the Engineer.

S-409.15. WHEEL GUARDS. Wheel guards, as shown on the plans, shall be constructed on each side of the roadway.

S-409.16. RAILINGS. Railings shall be constructed as shown on the plans. All connections shall be bolted wherever possible. Railings shall be so constructed that no two butt joints occur on the same post.

S-409.17. CUTTING, FRAMING HOLES FOR BOLTS, DOWELS, RODS, AND LAG SCREWS. All cutting, framing, and boring of treated timbers shall be done before treatment insofar as is practicable.

Holes for round drift bolts and dowels shall be bored with a bit one-sixteenth (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 one-sixteenth (1/16) inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit no larger than the root of the thread and shall be one-half ($\frac{1}{2}$) inch deeper than the penetration of the lag screws.

For treated timber hot creosote oil shall be injected under pressure into the bolt hole in such a bolt hole in such a manner that the entire surface of the hole shall receive a coating of the oil before the insertion of the bolt.

All cuts in treated piling or timbers and all abrasions, after having been carefully trimmed, shall be brush coated with at least two (2) applications of hot creosote oil and covered with hot roofing pitch.

S-409.18. HARDWARE. Machine bolts, drift bolts and dowels may be either wrought iron or medium steel; washers may be O-gee cast or malleable iron, or they may be cut from medium steel or wrought iron plate, as specified.

Machine bolts shall have square heads and nuts unless otherwise specified. Wire nails and spikes shall be of steel, of circular cross-section without taper, with a head and point, and of good quality. Boat spikes shall be of steel or wrought iron with forged heads and wedge-shaped points.

Washers of the size and type specified shall be used at all points where bolt heads and nuts 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 thickness shall be equal to one-half ($\frac{1}{2}$) the diameter of the bolt, and the sides of the square shall be equal to four times the diameter of the bolt.

All bolt threads shall be properly checked after the final adjustment of the nuts. All bolt stock projecting beyond one-fourth (1/4) inch from the top of the nut shall be removed.

All hardware, including nails, except cast iron washers, shall be galvanized by the hot dip method

In accordance with A.S.T.M. Specifications, Designation A 153-33T, with subsequent revisions thereto, issued by the Society prior to the date of the receipt of bids on which the contract award is made.

S-409.19. PAINTING. After completion of the structure, all bolt heads, threads, nuts, washers, and exposed portions of bolts shall be given a thorough coating of hot asphalt.

Creosote oil used for treatment of cuts, bolt holes, etc., shall conform to the requirements of Grade 1 creosote oil as provided in the pertinent specifications for "Timber Preservative and Treatment".

Railings shall be painted as provided on the plans. The materials and application shall conform to the requirements of Item S-408, "Paint and Painting".

For untreated timber structures, the following surfaces shall be thoroughly coated with a thick coat of red lead and oil, hot tar, hot asphaltum or hot coaltar creosote before assembling: the ends, tops, and all contact surfaces of pile caps; floor beam and stringer ends; joints and all contact surfaces of truss members; and 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.

All bolts passing through non-resinous wood shall be painted with two (2) coats of red lead and oil.

S-409.20. MEASUREMENT AND PAYMENT. No direct compensation will be made for "Timber Structures". Measurement and payment for quantities of timber, piling, excavation and other proposal items which constitute the completed and accepted structures will be made in accordance with the provisions of pertinent specifications.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-410

TIMBER FOR STRUCTURES

(SOUTHERN YELLOW PINE)

S-410.1. DESCRIPTION. This item shall govern for the materials for treated or untreated timber used in the construction of timber structures or portions of structures, as shown on the plans. This item shall not include temporary timber construction which is not a part of the finished work.

S-410.2. MATERIALS. Unless otherwise specified, the material shall be Southern Yellow Pine, Longleaf or Shortleaf.

The quality and kind of material shall be in accordance with the grades described in the current Standard Specifications for Grades of the Southern Pine Inspection Bureau (SPIB) of The Southern Pine Association (S.P.A.)

The dressing of all timber shall be as indicated on plans or bills of material. When not otherwise indicated, all strip flooring from 2"x4" to 3"x6" in size shall be dressed S1S1E, full size, hit or miss. Under this requirement all pieces which are more than 1/8" in excess of full nominal width or thickness or more than 1/4" scant of full nominal width or thickness at any point will be rejected.

S-410.3. STRUCTURAL GRADES. All Stringers, Caps, and Flooring (except 2"x4" strip flooring, shall be Structural Square Edge and Sound Longleaf or Dense Structural Square Edge and Sound as required by the applicable SPIB paragraphs named below.

a. Paragraphs 317 and 398, (1800 F), Joists and Planks (2" to 4" thick, 4" and wider).

b. Paragraphs 318 and 399, (1800 F), Beams and Stringers (5" and thicker)

All Nailing Strips, Rail Posts, Railing and Wheel Guards shall be Structural Square Edge and Sound Longleaf or Dense Structural Square Edge and Sound as required by the applicable SPIB paragraphs named below:

a. Paragraphs 317 and 398, (1800 F), Joists and Planks (2" to 4" thick, 4" and wider).

b. Paragraphs 319 and 400, (1300 C), Posts and Timbers (5" x 5" and larger).

All Bracing, Bulkhead Plank, Bridging, 2"x4" Strip Flooring, Edging Strips, Cleats and Blocks shall be No. 1 Structural Longleaf or Dense No. 1 Structural as required by the applicable SPIB paragraphs named below:

a. Paragraphs 320 and 401, (1600 F), Joists and Planks (2" to 4" thick, 4" and wider).

b. Paragraphs 321 and 402, (1600 F), Beams and Stringers (5" and thicker).

S-400.4. TREATED TIMBER. Treated timber shall be impregnated with the kind of preservative specified, in the amount and by the process designated on the plans.

S-410.5. WORKMANSHIP. Timber structures, whether treated or untreated, shall be constructed in accordance with the requirements of Item S-409.

S-410.6. MEASUREMENT. The quantities of timber of the various classifications used in the completion of the structure in accordance with the plans and specifications shall be computed in feet board measure on nominal sizes and the shortest commercial lengths practicable of use. The measurement shall not include timber used for erection purposes such as forms, falsework and temporary bracing.

S-410.7. PAYMENT. The timber quantities as measured above shall be paid for at the unit price bid per thousand feet board measure (M.F.B.M.) for "Treated Timber" or "Untreated Timber", as the case may be, which prices shall be full compensation for all materials, hardware, equipment, tools, labor, painting, preservative treatment and incidentals necessary to complete the work.

The payment provided above shall not be interpreted to include payment for timber piling, bituminous or concrete wearing surfaces, or other portions of the completed structure for which payment is provided elsewhere in the contract.

Texas Highway Department
Construction Specifications
March, 1950

ITEM S-410A

TIMBER FOR STRUCTURES

(DOUGLAS FIR AND SOUTHERN YELLOW PINE)

S-410A.1. DESCRIPTION. This item shall govern for the materials for treated or untreated timber used in the construction of timber structures or portions of structures, as shown on the plans. This item shall not include temporary timber construction which is not a part of the finished work.

S-410A.2. MATERIALS. Unless otherwise specified, the material shall be either Southern Yellow Pine (Longleaf or Shortleaf), or Coast Region Douglas Fir.

The quality and kind of pine timber shall be in accordance with the grades described in the current Standard Specifications for Grades of the Southern Pine Inspection Bureau (SPIB) of The Southern Pine Association (S.P.A.). The quality and kind of Douglas Fir timber shall be in accordance with the grades described in the current Standard Grading and Dressing Rules of the West Coast Lumbermen's Association.

The dressing of all timber shall be as indicated on plans or bills of material. When not otherwise indicated, all strip flooring from 2"x4" to 3"x6" in size shall be dressed S1S1E, full size, hit or miss. Under this requirement all pieces which are more than 1/8" in excess of full nominal width or thickness or more than 1/4" scant of full nominal width or thickness at any point will be rejected.

S-410A.3. STRUCTURAL GRADES.

(a) Southern Yellow Pine. All Stringers, Caps, and Flooring (except 2"x4" strip flooring) shall be Structural Square Edge and Sound Longleaf or Dense Structural Square Edge and Sound as required by the applicable SPIB paragraphs named below.

(1). Paragraphs 317 and 398, (1800 F), Joists and Planks (2" to 4" thick, 4" and wider).

(2). Paragraphs 318 and 399, (1800 F), Beams and Stringers (5" and thicker)

All Nailing Strips, Rail Posts, Railing and Wheel Guards shall be Structural Square Edge and Sound Longleaf or Dense Structural Square Edge and Sound as required by the applicable SPIB paragraphs named below:

(1). Paragraphs 317 and 398, (1800 F), Joists and Planks (2" to 4" thick, 4" and wider).

(2). Paragraphs 319 and 400, (1300 C), Posts and Timbers (5" x 5" and larger).

All Bracing, Bulkhead Plank, Bridging, 2"x4" Strip Flooring, Edging Strips, Cleats and Blocks shall be No. 1 Structural Longleaf or Dense No. 1 Structural as required by the applicable SPIB paragraphs named below:

(1). Paragraphs 320 and 401, (1600 F), Joists and Planks (2" to 4" thick, 4" and wider).

(2). Paragraphs 321 and 402, (1600 F), Beams and Stringers (5" and thicker).

(b) Douglas Fir. All Stringers, Caps, Bridging, and Flooring shall be Select Structural as required by the applicable WCLA paragraphs named below.

(1). Paragraph 202 (1900f,1450c) Framing, Joists, Plank and Small Timbers, 2" to 4" thick, 4" and wider.

(2). Paragraph 212 (1900f,1450c) Beams and Stringers 5" and thicker, 6" and wider.

All Nailing Strips, Rail Posts, Railing and Wheel Guards shall be Select Structural as required by the applicable WCLA paragraphs named below:

(1). Paragraph 202 (1900f,1450c) Framing, Joists, Plank and Small Timbers, 2" to 4" thick, 4" and wider.

(2). Paragraph 216 (1450c) Posts and Timbers 5"x5" and larger.

All Bracing, Bulkhead Plank, Edging Strips, Cleats and Blocks shall be Dense No. 1 as required by the applicable WCLA paragraphs named below.

(1). Paragraph 203 (1700f,1325c) Framing, Joists, Plank and Small Timbers 2" to 4" thick, 6" and wider.

(2). Paragraph 213 (1700f,1325c) Beams and Stringers 5" and thicker, 6" and wider.

S-410A.4. TREATED TIMBER. Treated timber shall be impregnated with the kind of preservative specified, in the amount and by the process designated on the plans.

S-410A.5. WORKMANSHIP. Timber structures, whether treated or untreated, shall be constructed in accordance with the requirements of Item S-409.

S-410A.6. MEASUREMENT. The quantities of timber of the various classifications used in the completion of the structure in accordance with the plans and specifications shall be computed in feet board measure on nominal sizes and the shortest commercial lengths practicable of use. The measurement shall not include timber used for erection purposes such as forms, falsework and temporary bracing.

S-410A.7. PAYMENT. The timber quantities as measured above shall be paid for at the unit price bid per thousand feet board measure (M.F.B.M.) for "Treated Timber" or "Untreated Timber", as the case may be, which prices shall be full compensation for all materials, hardware, equipment, tools, labor, painting, preservative treatment and incidentals necessary to complete the work.

The payment provided above shall not be interpreted to include payment for timber piling, bituminous or concrete wearing surfaces, or other portions of the completed structure for which payment is provided elsewhere in the contract.

Texas Highway Department
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March, 1950

ITEM S-411

TIMBER PRESERVATIVE AND TREATMENT

(CREOSOTE OIL)

S-411.1. DESCRIPTION. This item shall govern for the seasoning, preparation, preservative and treatment of lumber, timber, piling and posts where creosote treatment is specified on plans or called for in Specifications. The amounts of treatment to be used are shown on plans or in Specifications and are based on the use of Southern Yellow Pine. Where Douglas Fir is permitted by the Specifications and is used, the amount of treatment shall be as follows: Where 12 lb. treatment is specified, 8 lb. treatment shall be used for Douglas Fir; where 16 lb. or heavier treatment is specified, 12 lb. treatment shall be used for Douglas Fir.

Except as otherwise provided herein the following specifications or current revisions thereof shall govern for materials and methods of treatment:

A.W.P.A. T1-48 Standard Specifications for Preservative Treatments by Pressure Processes.

A.W.P.A. T2-48, Standard Specifications for the Preservative Treatment of Lumber by Pressure Processes.

A.W.P.A. T3-48, Standard Specifications for the Preservative Treatment of Piles by Pressure Processes.

A.W.P.A. T5-48, Standard Specifications for Preservative Treatment of Posts by Pressure Processes.

S-411.2. SEASONING. Timber, piling and posts may be seasoned by air or steam. Piling should preferably be cut during the winter season and the maximum air-seasoning period shall be limited to 120 days, except by special permission from the Engineer. Pre-treated stock will not be accepted by the Inspector except in emergencies, and even then, special permission must be obtained from the Engineer. Re-treatment of a portion in a charge may be permitted for Southern Yellow Pine only, subject to provisions under A.W.P.A. T1-48, Paragraph 6, which allows 10% of a charge to be re-treated material under limitations contained therein. This provision is not to be construed as permitting the use of pre-treated stock, but it is intended only to conform to the usual practice of securing proper penetration where the plant procedure has failed to produce required results in a specific charge.

S-411.3. INCISING. No incising will be required on any Southern Yellow Pine material, nor on sawn Douglas Fir material where the least nominal dimension is less than two inches. Unless otherwise specified on plans, all sawn Douglas Fir material with least nominal dimension two inches or over, shall be incised in a suitable power driven machine. When material has a nominal thickness of three inches or more, it shall be incised on all four sides. Material of nominal thicknesses from two inches up to three inches shall be incised on the wide faces only. The spacing and shape of the cutting teeth and the method of incising shall be such as to produce a uniform penetration. The depth of the incision shall be in accordance with the following schedule with intermediate sizes in proportion.

NOMINAL THICKNESS	MINIMUM DEPTH OF INCISION
2"	3/8"
3"	7/16"
4"	1/2"
8"	9/16"
10"	5/8"
12"	3/4"

Douglas Fir piling will not require incising.

S-411.4. PRESERVATIVES. The preservatives used for the treatment of timber, piling and posts shall be Standard Grade I Creosote Oil as designated under A.W.P.A. T1-48, Standard Specifications for Creosote, unless otherwise indicated by special provisions.

S-411.5. LOADING AND TREATMENT. Piling shall be loaded on trams, so that a minimum of distortion will result during the conditioning process. Requirements for straightness before treatment will apply after treatment. If there is any question regarding the conformity of piling after treatment, they shall be laid down on skids so they can be checked. The bottom piling in a charge that is to be steam conditioned shall be protected from the metal trams if necessary to prevent serious tram marking.

S-411.6. CUBIC VOLUME. The average volume used for each size and length of piling shall be determined by measuring each piling to arrive at the average butt and tip of each group.

S-411.7. TREATMENT RESULTS. In addition to the penetration requirements under A.W.P.A. Specification T3-48, if less than 16 of the first 20 borings taken from a charge of treated piling meet the requirements of the specifications, the entire charge may be rejected for non-compliance.

S-411.8. INCREMENT BORING HOLES. All test holes shall be circled with aluminum keel. The holes shall then be plugged tightly with creosoted plugs.

S-411.9. INSPECTION. Inspectors shall have access to all parts and facilities to plants used in the conditioning and treating of forest products, for the purchaser represented, and shall be present during the treating procedure to make sure that the process is being carried on as specified. Inspectors are expected to follow the A.W.P.A. Standard Instructions for the Inspection of Preservative Treatment of Wood, R2-48, wherein they are applicable and do not conflict with these specifications.

S-411.10. MEASUREMENT AND PAYMENT. Payment for all work prescribed herein shall be included in the unit prices bid for timber, piling or guard fence, as the case may be.

Texas Highway Department
Construction Specifications
March, 1950

ITEM S-411A

TIMBER PRESERVATIVE AND TREATMENT

(PENTACHLOROPHENOL)

S-411A.1. DESCRIPTION. This item shall govern for the seasoning, preparation, preservative and treatment of lumber, timber, and posts where pentachlorophenol treatment is specified on plans or called for in Specifications. The amounts of treatment to be used are shown on plans or in Specifications and are based on the use of either Southern Yellow Pine or Douglas Fir.

Except as otherwise provided herein the following specifications or current revisions thereof shall govern for materials and methods of treatment:

A.W.P.A. T1-49, Standard Specifications for Preservative Treatment by Pressure Processes.

A.W.P.A. T2-49, Standard Specifications for the Preservative Treatment of Lumber by Pressure Processes.

A.W.P.A. T5-49, Standard Specifications for Preservative Treatment of Posts by Pressure Processes.

A.W.P.A. P8-49, Standard Specifications for Oil-borne Preservatives.

A.W.P.A. P9-49, Standard Specifications for Petroleum for Use With Pentachlorophenol and Copper Napthenate.

S-411A.2. SEASONING. Timber and posts may be seasoned by air or steam. Pretreated stock will not be accepted by the Inspector except in emergencies, and even then, special permission must be obtained from the Engineer. Re-treatment of a portion in a charge may be permitted for Southern Yellow Pine only subject to provisions under A.W.P.A. T1-49, Paragraph 6, which allows 10% of a charge to be re-treated material under limitations contained therein. This provision is not to be construed as permitting the use of pre-treated stock, but it is intended only to conform to the usual practice of securing proper penetration where the plant procedure has failed to produce required results in a specific charge.

S-411A.3. INCISING. No incising will be required on any Southern Yellow Pine material, nor on sawn Douglas Fir material where the least nominal dimension is less than two inches. Unless otherwise specified on plans, all sawn Douglas Fir material with least nominal dimension two inches or over, shall be incised in a suitable power driven machine. When material has a nominal thickness of three inches or more, it shall be incised on all four sides. Material of nominal thicknesses from two inches up to three shall be incised on the wide faces only. The spacing and shape of the cutting teeth and the method of incising shall be such as to produce a uniform penetration. The depth of the incision shall be in accordance with the following schedule with intermediate sizes in proportion.

NOMINAL THICKNESS	MINIMUM DEPTH OF INCISION
2"	3/8"
3"	7/16"
4"	1/2"
8"	9/16"
10"	5/8"
12"	3/4"

S-411A.4. PRESERVATIVE. The preservative shall consist of a five percent solution of pentachlorophenol in a suitable petroleum solvent. Pentachlorophenol shall comply with the requirements of A.W.P.A. Specification P8-49 and current revision thereto. Where the treated timber is not required to be paintable the petroleum solvent shall comply with the requirements of A.W.P.A. Specification P9-49 and current revisions thereto. Where the treated timber is required to be paintable the petroleum solvent shall comply with the following requirements:

(a) Specific gravity at 60 degrees F shall be not less than .825 (not greater than 40A.P.I.)
(b) Water and sediment content (B.S&W.) shall not exceed 0.5%. (Current A.S.T.M. Standard D98).
(c) Flash point shall be not less than 145 degrees F as determined by the Pensky-Martens closed tester. (Current A.S.T.M. Standard D93).
(d) The total volume of the fractions distilling below 500 degrees F shall not exceed 60% and the total distilling below 625 degrees F shall be not less than 90%.
(e) Pentachlorophenol solvency shall be not less than 10% by weight at 75 degrees F.
(f) Solvent shall be of such character as will prevent staining the wood to a darker color than light brown and the discoloration of paints of suitable type when applied to the timber.

S-411A.5. RETENTION OF PRESERVATIVE. Unless otherwise shown on plans or in special provisions the amount of the preservative retained shall be as follows:

Guard Fence Posts: Not less than 8 lbs/cu. ft.
Bridge Timbers: Not less than 12 lbs/cu. ft.
Lumber other than Bridge Timbers: Not less than 8 lbs/cu. ft.

S-411A.6. PAINTABILITY. All guard posts and sign lumber shall be cleaned and treated in such manner and with such materials as will permit satisfactory painting thereof. Timber other than guard posts and sign lumber shall be paintable when so required by plans or special specifications. Steam cleaning will be required when necessary to assure the paintability of the treated timber.

S-411A.7. TREATMENT OF CUTS. When it is necessary to bore holes or cut the timbers after treatment, or when any treated surface has been badly scarred, the hole, cut or scarred surfaces must be given a three-coat treatment of the concentrated solution as specified, applied with a brush; and this solution must be between one hundred thirty-five degrees (135°) F. and one hundred sixty-five degrees (165°) F when applied.

S-411A.8. INSPECTION. Inspectors shall have access to all parts and facilities to plants used in the conditioning and treating of forest products, for the purchaser represented, and shall be present during the treating procedure to make sure that the process is being carried on as specified. Inspectors are expected to follow the A.W.P.A. Standard Instructions for the Inspection of Preservative Treatment of Wood, R2-48, wherein they are applicable and do not conflict with these specifications.

S-411A.9. MEASUREMENT AND PAYMENT. Payment for all work prescribed herein shall be included in the unit prices bid for timber, lumber or guard fence, as the case may be.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-412

REINFORCED CONCRETE PIPE

S-412.1. DESCRIPTION. These specifications shall govern for the furnishing and placing of reinforced concrete pipe. The pipe shall be installed in accordance with the requirements of these specifications, to the line and grades shown on the plans, and shall be of the classes, sizes and dimensions shown thereon. The installation of pipe shall include all joints or connections to new or existing pipes, manholes, catch basins, headwalls, etc. as may be required to complete the work.

S-412.2. MATERIALS. (a) General. Materials, manufacture and design of pipes shall be as prescribed in the standard specifications for "Reinforced Concrete Culvert Pipe", A.S.T.M. Designation C-76, and in the additional provisions contained herein. All pipe 60" diameter and under shall be machine made. Pipe over 60" diameter shall preferably be machine made but may be made by other approved processes. The Manufacturing equipment used shall provide uniform and continuous placement of the concrete in the forms. During placement the concrete shall be consolidated by mechanical devices, other than hand tamping, which will provide a dense concrete without disturbing or displacing the steel reinforcement. The pipe shall be of two classes known respectively as "Standard Reinforced Concrete Pipe" and "Extra Strength Reinforced Concrete Pipe". For reference purposes, the shell thickness, the amount of circumferential reinforcement and the strength of the pipe are summarized in Tables I and II herein, taken from A.S.T.M. C 76-41.

(b) Physical Test Requirements. The acceptability of the pipe shall be determined by the results of the strength and absorption tests specified herein and by inspection to determine whether the pipe conforms to the specifications in design and freedom from defects. The requirements for tests and the methods of testing shall be as prescribed in the Standard Specifications for Reinforced Concrete Culvert Pipe, A.S.T.M. Designation C 76.

(c) Sizes, Dimensions and Permissible Variations. Pipe of the internal diameters listed in Tables I and II shall be the standard sizes for this type of construction. In elliptical pipe, the inside diameter of the minor axis shall be equal to the diameter of the corresponding size of circular pipe. Variations of the internal diameter shall not exceed $\pm$ 1 per cent for pipe of 36 inches or less size and shall not exceed $\pm$ 0.75 per cent for larger pipe. The shell thickness shall not be less than that intended in the design by more than 5 per cent at any point. Variations of the position of the reinforcement shall not exceed 1/4 inch from the position provided in the design for pipe of 48 inches size or less, and shall not exceed 1/2 inch for larger pipe; but the cover on the reinforcement shall not be less than 3/4 inch at any point.

(d) Workmanship and Finish. Pipe shall be substantially free from fractures, large or deep cracks, laminations and surface roughness. The planes of the ends of pipe shall be perpendicular to the longitudinal axis. The ends of the pipe shall be of such design that when laid, the pipe sections will form a continuous conduit with a smooth and uniform interior surface.

(e) Marking. The following shall be clearly stencilled on the pipe:

(1) The pipe class, (by an "S-C" for Standard Pipe and by an "X-C" for Extra Strength Pipe)
(2) The date of manufacture;
(3) The name or trade mark of the manufacturer;
(4) Elliptical pipe with circular reinforcing and circular pipe with elliptical reinforcing shall have the word "Top" or "Bottom" placed on the inside of the pipe at the correct place to indicate the proper position when laid;
(5) Inspector's identification mark.

TABLE I - DESIGN AND STRENGTH TEST REQUIREMENTS OF STANDARD-STRENGTH REINFORCED CONCRETE CULVERT PIPE

Internal Diameter of pipe Inches	Minimum Shell Thickness Inches	Concrete, 3500 lb. per sq. in. Minimum Reinforcement sq. in. per linear foot of pipe: Circular Reinforcement in Circular Pipe	Concrete, 3500 lb. per sq. in. Minimum Reinforcement sq. in. per linear foot of pipe: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Minimum Shell Thickness Inches	Concrete, 4500 lb. per sq. in Minimum Reinforcement sq. in. Per linear foot of pipe: Circular Reinforcement in Circular Pipe	Concrete, 4500 lb. per sq. in Minimum Reinforcement sq. in. Per linear foot of pipe: Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Strength Test Requirements lb. lineal ft. of Pipe, Three Edge Bearing*: Load to Produce a 0.01 inch Crack	Strength Test Requirements lb. lineal ft. of Pipe, Three Edge Bearing*: Ultimate Load
12	2	1 line 0.07		1 3/4	1 line 0.08		2250	3500
15	2 1/4	1 line 0.09		2	1 line 0.11		2625	4065
18	2 1/2	1 line 0.12	1 line 0.10	2 1/4	1 line 0.14		3000	4500
21	2 3/4	1 line 0.15	1 line 0.12	2 1/2	1 line 0.17		3000	4750
24	3	1 line 0.17	1 line 0.13	2 1/2	1 line 0.20	1 line 0.17	3000	5000
27	3 1/4	2 lines, ea. 0.17	1 line 0.17	2 3/4	1 line 0.24	1 line 0.18	3200	5450
30	3 1/2	2 lines, ea. 0.17	1 line 0.17	3	1 line 0.28	1 line 0.21	3375	5750
33	3 3/4	2 lines, ea. 0.18	1 line 0.18	3 1/4	2 lines, ea. 0.22	1 line 0.22	3725	6100
36	4	2 lines, ea. 0.18	1 line 0.18	3 3/8	2 lines, ea. 0.22	1 line 0.22	4050	6600
39	4 1/4	2 lines, ea. 0.20	1 line 0.20	3 5/8	2 lines, ea. 0.23	1 line 0.23	4375	6800
42	4 1/2	2 lines, ea. 0.21	1 line 0.21	3 3/4	2 lines, ea. 0.25	1 line 0.25	4725	7350
45	4 3/4	2 lines, ea. 0.23	1 line 0.23	4	2 lines, ea. 0.28	1 line 0.28	5050	7500
48	5	2 lines, ea. 0.25	1 line 0.25	4 1/4	2 lines, ea. 0.31	1 line 0.31	5400	8000
54	5 1/2	2 lines, ea. 0.30	1 line 0.30	4 5/8	2 lines, ea. 0.37	1 line 0.37	5850	9000
60	6	2 lines, ea. 0.33	1 line 0.33	5	2 lines, ea. 0.41	1 line 0.41	6000	10000
66	6 1/2	2 lines, ea. 0.37	1 line 0.37	5 1/2	2 lines, ea. 0.45	1 line 0.45	6300	11000
72	7	2 lines, ea. 0.40	1 line 0.40	6	2 lines, ea. 0.48	1 line 0.48	6600	12000
78	7 1/2	2 lines, ea. 0.43	1 line 0.43	6 1/2	2 lines, ea. 0.51	1 line 0.51		
84	8	2 lines, ea. 0.46	1 line 0.46	7	2 lines, ea. 0.54	1 line 0.54		

*Test loads for sand bearing Tests shall be one and one-half times those specified in these tables for the three-edge-bearing tests.

TABLE II- DESIGN AND STRENGTH TEST REQUIREMENTS OF EXTRA - STRENGTH REINFORCED CONCRETE CULVERT PIPE

Internal Diameter of pipe Inches	Minimum Shell Thickness Inches	Concrete, 4500 lb. per. sq. in. Minimum Reinforcement sq. in. per linear foot of pipe: Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Strength Test Requirements lb. Lineal ft. of Pipe, Three Edge Bearing*: Load to Produce a 0.01 inch Crack	Ultimate Load
24	3	1 line 0.26	1 line 0.20	4000	6000
27	3 1/4	2 lines, ea. 0.22	1 line 0.22	4500	6750
30	3 1/2	2 lines, ea. 0.24	1 line 0.24	5000	7500
33	3 3/4	2 lines, ea. 0.26	1 line 0.26	5500	8250
36	4	2 lines, ea. 0.28	1 line 0.28	6000	9000
39	4 1/4	2 lines, ea. 0.30	1 line 0.30	6500	9750
42	4 1/2	2 lines, ea. 0.33	1 line 0.33	7000	10500
45	4 3/4	2 lines, ea. 0.35	1 line 0.35	7500	11250
48	5	2 lines, ea. 0.39	1 line 0.38	8000	12000
54	5 1/2	2 lines, ea. 0.44	1 line 0.44	9000	13500
60	6	2 lines, ea. 0.50	1 line 0.50	9000	15000
66	6 1/2	2 lines, ea. 0.56	1 line 0.56	9500	16500
72	7	2 lines, ea. 0.60	1 line 0.60	9900	18000
78	7 1/2	2 lines, ea. 0.65	1 line 0.65		
84	8	2 lines, ea. 0.72	1 line 0.72		

*Test loads for sand bearing Tests shall be one and one-half times those specified in these tables for the three-edge - bearing tests.

(f) Minimum Age for Shipment. Pipe shall be considered ready for shipment when they conform to the requirements, as indicated by the specified tests.

(g) Inspection. All materials, processes of manufacture and finished pipe shall be subject to inspection by the Engineer at the factory and/or trench or other point of delivery. The purposes of the inspection shall be to cull and reject pipes which fail to conform to the requirements of the specifications. The manufacturer, when directed by the Engineer, shall have holes cut in such sections of the finished pipe (not exceeding one hole in every 50 sections delivered), as desired so that a proper inspection may be made of the quantity and placement of the reinforcement. In testing pipes for strength or absorption, inspection of the reinforcement shall be made on the pipe sections used for those tests, and in no case shall the total number of pipes cut open for inspection exceed the number to which the Engineer is entitled under the provisions of paragraph (b), Section S-412.2 of these specifications.

(h) Causes for Rejection. Pipe shall be subject to rejection on account of failure to meet any of the specification requirements or on account of any of the following:

(1) Fractures or cracks passing through the shell, except that a single end-crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end-crack that does not exceed the depth of the joint exists in more than 10 per cent of the pipe, however, the defective pipe shall be rejected.

(2) Defects which indicate imperfect placing, mixing and curing of the concrete.

(3) Spalls deeper than one-half the depth of the joint or extending more than 4 inches around the circumference. If spalls not deeper than one-half of the depth of the joint or extending not more than 4 inches around the circumference exist in more than 10 per cent of the pipe, however, the defective pipe shall be rejected.

(4) Exposure of the reinforcement when such exposure would indicate that the reinforcement is misplaced.

(5) The complete absence of distinct web-like markings, which is indicative of a possible deficiency of water in the concrete mix, from the external surface of the pipe made by any process in which the forms are removed immediately after the concrete has been placed.

All rejected pipes shall be plainly marked by the Engineer and shall be replaced by the Contractor with pipes which meet the requirements of these specifications. Such rejected pipes shall be immediately removed from the site of the work.

(i) Jointing Materials. Mortar for joints shall be composed of sand, cement and water conforming to the requirements for these materials as specified in the pertinent specifications for Concrete for Structures included in the contract, except that the sand shall be properly graded for the required work.

S-412.3. CONSTRUCTION METHODS. Reinforced concrete pipe culverts and storm sewers shall be constructed from the specified materials in accordance with the following method and procedure:

(a) Excavation. All excavation shall be in accordance with the requirements of Item S-104 "Structural Excavation", except where tunneling or jacking methods are shown on the plans or permitted by the Engineer. When pipes are laid in a trench, the trench when completed and shaped to receive the pipe, shall be of sufficient width to provide free working space for satisfactory bedding and jointing and thorough tamping of the backfill and bedding material under and around the pipe. The Contractor shall make such temporary provision as may be necessary to insure adequate drainage of the trench and bedding during the construction operation.

(b) Foundation. The pipe shall be bedded in a foundation of stable earth material carefully and accurately shaped to fit the lower part of the pipe exterior for at least ten per cent of its overall height. When requested by the Engineer, the Contractor shall furnish a simple template for each size and shape of pipe to be placed for use in checking the shaping of bedding. Template shall consist of a thin plate or board cut to match the lower half of the cross-section of the pipe. Where rock, in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such manner as to provide a compacted earth cushion having a thickness under the pipe of not less than one-half inch per foot height of fill over the top of the pipe, with the minimum allowable thickness of eight inches. Where the soil encountered at the established grade is a quicksand, muck or similar unstable material, unless other special construction methods are called for on the plans or in special provisions, such unstable soil shall be removed and replaced in accordance with the requirements of Item S-104, "Structural Excavation".

(c) Laying Pipe. Unless otherwise authorized by the Engineer, the laying of pipes on the prepared foundation shall be started at the outlet and with the spigot or tongue ends pointing in the direction of flow and shall proceed toward the inlet end with the abutting sections properly matched, true to the established lines and grades. Where bell or hub and spigot pipes are used, cross trenches shall be cut in the foundation to allow the barrel of the pipe to rest firmly upon the prepared bed. These cross trenches shall be not more than two inches larger than the bell or hub ends of the pipes. Proper facilities shall be provided for hoisting and lowering the sections of pipe into the trench without disturbing the prepared foundation and the sides of the trench. The ends of the pipes shall be carefully cleaned before the pipes are placed. As each length of pipe is laid, the mouth of the pipe shall be protected to prevent the entrance of earth or bedding material. The pipes shall be fitted and matched so that when laid in the bed they shall form a smooth, uniform conduit. When elliptical pipe with circular reinforcing or circular pipe with elliptical

reinforcing is used, the pipe shall be laid in the trench in such manner that the markings "Top" or "Bottom", as prescribed in paragraph (e), Section S-412.2, will be in correct position.

Multiple installations of reinforced concrete pipe shall be laid with the center lines of individual barrels parallel. When not otherwise indicated on plans, the following clear distances between outer surfaces of adjacent pipes shall be maintained:

Diameter of Pipe	Clear Distance between Pipes
18"	0'-9"
24"	0'-11"
30"	1'-1"
36"	1'-3"
42"	1'-5"
48"	1'-7"
54"	1'-11"
60" to 84"	2'-0"

(d) Jointing. All pipe shall be closely jointed and sealed with stiff mortar, composed of one part Portland cement and two parts sand, so placed as to form a durable water-tight joint. The ends of the pipe shall be thoroughly cleaned and wetted before making the joint. After any section of pipe is laid and before any succeeding section is laid, the lower half of the bell of the pipe last laid shall be thoroughly platered by troweling on an even layer of mortar. The spigot end of the next section of pipe shall then be inserted, holding it as high as possible until it is fully inserted and then lowering it gently on the mortar. After the section is laid and uniformly matched and the sections have been fitted as close as the construction of the pipe will permit, the lower half of the inner circumference of the joints of pipes over 18" in diameter shall be sealed and packed with mortar and finished smooth and even with the adjacent sections of pipe. Before this mortar has attained initial set, additional mortar shall then be applied from the outside and forced into the unfilled portion of the bell or groove to fill completely the annular space around the spigot or tongue. For bell and spigot pipe, a bead shall be formed on the outside by troweling on mortar downward at an angle of 45° from the outer edge of the bell to the spigot of the last laid section. For tongue and groove pipe, a bead shall be formed extending at least 1" on either side of the joint and of approximately semi-circular cross-section or triangular cross-section. If the triangular cross-section is used, it shall be formed by placing the mortar at approximately 45° outward from the extreme edges of the bead. For pipes too small to permit finish of the inside surface of the joint, a tight stopper of burlap or other equivalent materials shall be dragged through the pipe past the new joint to remove any fins of mortar. Special care shall be exercised in placing adjacent pipe sections to avoid movement of the pipe in place and the breaking of the mortar bond at completed joints. After the initial set, the mortar on the outside shall be protected from air and sun with a thoroughly wetted earth or burlap cover or acceptable equivalent, which shall be kept wet for a minimum of 48 hours or until the backfill has been completed. No jointing shall be done when the atmospheric temperature is at or below 40° F, and when necessary, because of a sudden drop in temperature, joints shall be protected against freezing for at least twenty-four hours. After placing, any pipe which is not in true alignment or which shows any undue settlement after laying or is damaged, shall be taken up and relaid or replaced without extra compensation.

(e) Backfilling. Backfilling shall be in accordance with the provisions of Item S-104, "Structural Excavation", and with the additional requirement that no backfill shall be placed until the jointing affected has been cured for at least twenty-four hours.

(f) End Finish and Connections. The upstream ends of culverts shall be formed to a smooth rounded lip entrance by filling the recess in the bell with joint mortar which shall be placed and cured in accordance with the provisions for jointing in these specifications. Where new culverts are constructed as extensions to culverts or sewers in place, the construction shall include all work necessary to provide a proper connection between the new structure and the old, as indicated on the plans.

(g) Minimum and Maximum Fills. Reinforced concrete pipe culverts constructed in accordance with these specifications may be used for primary cross-drainage under the following fill limitations:

Minimum Depths of Fill or Ballast Over Pipe
(Measured from crown of finished roadway to shell of pipe)

One-third the nominal diameter of the pipe with a minimum 1.0 feet.

Class of Pipe	Maximum Allowable Depth of Fill in Feet — Diameter of Pipe					
	12"	15"	18"	21"	24"	27-84"
Standard	35	34	32	29	25	23
Extra Strength					35	35

S-412.4. METHOD OF MEASUREMENT. Reinforced Concrete Pipe shall be measured by the linear foot of pipe complete in place in accordance with these specifications. Such measurement shall be made between the ends of the pipe barrel along the central axis as installed. Where spurs or branches, or connections to existing pipe lines are involved, measurement of the spur or new connecting pipe shall be made from the intersection of its central axis with the outside surface of the pipe into which it connects. Where inlets, catch basins, manholes, junction chambers or other structures are included in lines of pipe, that length of pipe provided for tie into the structure wall shall be included for measurement but no other portion of the structure length or width shall be so included.

Excavation in natural ground for installing concrete pipe and excavation for installing headwalls will be measured as prescribed in Item S-104, "Structural Excavation".

S-412.5. BASIS OF PAYMENT. Payment for Concrete Pipe measured as prescribed above will be made at the contract unit price bid for the various sizes of the items of "Standard Reinforced Concrete Pipe", and "Extra Strength Reinforced Concrete Pipe", which payment shall be full compensation for furnishing and transporting the pipe; the excavation, hauling and placing of select material where required for bedding pipe in rock excavation; the preparation and shaping of beds; hauling, placing and jointing of pipes; for end finish; for all connections to existing structures and for all other items of materials, labor, equipment, tools and incidentals necessary to complete the culvert or storm sewer in accordance with the plans and these specifications, except excavation and backfill; which will be paid for in accordance with Item S-104 "Structural Excavation". Where pipes are laid on a skew, full compensation for cutting the ends parallel with the centerline of the highway shall be considered as included in the price paid per linear foot for the designated item of pipe and no additional allowance will be made therefor.

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Construction Specification
March, 1950

ITEM S-413

CORRUGATED GALVANIZED METAL PIPE

S-413.1. DESCRIPTION. This specification shall govern for furnishing sheet metal pipe conforming to these specifications and of the sizes and dimensions required on the plans, and installing such pipe where and as designated on the plans or by the Engineer and in conformity with the lines and grades given. This item shall include the furnishing and construction of such joints, and such connections to new or existing pipes, catch basins, endwalls, etc., as may be required to complete the work as shown on the plans. Pipe furnished under this specification shall be of the riveted type, with lap joint construction, and shall be perforated when specified by the Engineer. Pipe shall be full circle or arch type as shown on the plans.

S-413.2. MATERIALS AND MANUFACTURE. (a) General. Corrugated metal pipe shall be fabricated from corrugated galvanized sheets, the base metal of which shall be made by either the open hearth process or a process which produces genuine wrought iron. The base metal shall conform to one of the following chemical requirements.

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

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

(b) 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.

A coating of prime western spelter or equal shall be applied at the rate of not less than two ounces per square foot of double exposed surface. If the average spelter coating as determined from the required samples is less than two ounces of spelter per square foot, or if any one specimen is less than 1.8 ounces of spelter per square foot of double exposed surface, the lot sampled shall be rejected. The finished sheets shall be of first class commercial quality, free from injurious defects, such as blisters, flux and uncoated spots.

(c) 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. Mis-

branding or other misrepresentation, and nonuniformity 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 pipe 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.

(d) 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 a typical analysis showing the percentage of carbon, manganese, phosphorus, sulphur, silicon, and copper; also molybdenum, when provided for under the particular kind of base metal. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company.

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

(f) Identification. No pipe will be accepted unless the metal is identified by a stamp on each section showing the following:

First. Name of sheet manufacturer.
Second. Name of brand and kind of base metal.
Third. Gage number.
Fourth. Weight of spelter coating.
Fifth. Identification symbols showing (Heat No.
(Pot No.

Identification symbols showing heat numbers will not be required for wrought iron. However, identification by pot number will be required. The identification brands shall be placed on the sheets by the manufacturers of the sheets in such a way that when rolled into pipes 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 "Kind of Base Metal," enumerated in the table. The designation of the "Kind of Base Metal," may be accomplished by placing on the sheets the initials of the exact name of the base metal given in the table as follows:

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

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

(h) Perforated Pipe. Pipe shall be perforated when so designated on the plans. Perforations shall be approximately 1/4 inch in diameter, punched 1-1/2 inch centers lengthwise in the sheet so as to be inside ridges of all but the end corrugations of each pipe section. The number of longitudinal rows of perforations shall conform to the following table:

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

(i) Gage Determination and Tolerances. The gage of the pipe metal shall be determined from the weight of the galvanized sheets. The theoretical weights per square foot, together with permissible tolerances, on the flat galvanized sheets, shall be as indicated in the following:

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

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

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

(j) Dimensions and Weights. The length of sheets, widths of laps, gages, and computed weights per linear foot of the finished pipes, shall be as specified in the following table. The nominal diameters given refer to net inside diameters. The average weight per linear foot of a finished pipe, exclusive of end finish, shall not underrun the computed weight specified by more than five per cent:

Nominal Diameter	Length of Sheet before Forming	Minimum Width of Lap	Galvanized Sheet Gage Number	Computed Weight Per Linear Foot of Finished Pipe Exclusive of End Finish Pounds	Connecting Bands Galvanized Sheet Gage Number (or heavier)
Inches	Inches	Inches			
8	28-1/2	1-1/2	16	7.3	16
10	35	1-1/2	16	9.0	16
12	41	1-1/2	16	10.5	16
15	50-1/2	1-1/2	16	12.9	16
18	60	1-1/2	16	15.3	16
21	69-1/2	1-1/2	16	17.7	16
24	80	2	14	25.2	16
30	98	2	14	30.9	16
36	117	2	12	51.0	14
42	137	3	12	59.5	14
48	156	3	12	68.0	14
54	1-80 1-98	3	12	77.8	14
60	2-98	3	10	108.9	12
66	2-107	3	10	120.6	12
72	2-117	3	10	130.4	12
78	2-126	3	8	172.8	12
84	2-137	3	8	185.2	12

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

(2) The gage of the sheets shall be increased if required in "Special Provisions" for the pipes under high fills.

(k) Rivets. Rivets shall be of the following diameters for the gages specified:

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

All rivets shall be driven cold in such a manner that the plates shall be drawn tightly together throughout the entire lap. The center of no rivet shall be closer than twice its diameter from the edge of the metal. All rivets shall have neat, workmanlike, and full hemispherical heads of a form acceptable to the Engineer, shall be driven without bending, and shall completely fill the hole. Longitudinal seams shall be riveted with one rivet in the valley of each corrugation.

The longitudinal seams of all pipes 42 inches or more in diameter shall be double riveted. Circumferential shopriveted seams shall have a maximum rivet spacing of six inches except that six rivets will be sufficient in 12-inch pipe.

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

(m) End Finish. The inlet and outlet of all culverts fabricated of 16 or 14 gage sheets shall be reinforced in a manner approved by the Engineer, when specified.

(n) Field Joints. Field Joints shall be made with bands of the same base metal as the pipe. Bands shall be not less than 7 inches wide for diameters of 8 to 30 inches, inclusive; 12-inches for pipes with diameters 36 to 48 inches, inclusive; and 24-inches for pipes with diameters 54 to 84 inches, inclusive. Such bands shall be so constructed as to lap on an equal portion of each of the pipe sections to be connected, and preferably shall be connected at the ends by galvanized angles having minimum dimensions of 2"x2"x3/16". The 7-inch band shall have at least two galvanized bolts not less than 1/2-inch diameter. The 12-inch band shall have three and the 24-inch band shall have five 1/2-inch bolts. Other equally effective methods of connecting the coupling bands may be used if approved by the Engineer.

(o) Workmanship. Pipe on which the spelter coating has been bruised or broken either in the shop or in shipping, or which show defective workmanship, shall be rejected. Among others, the following defects are specified as constituting poor workmanship, and the presence of any or all of them in any individual pipe or in general in any shipment shall constitute sufficient cause for rejection: uneven laps; irregular shaping; variation from a straight center line; ragged, or diagonal-sheared edges; loose, unevenly lined or spaced rivets; poorly formed rivet heads; unfinished ends; illegal brands; lack of rigidity; bruised, scaled, or broken spelter coating; dents or bends in the metal itself.

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

(q) Mill & 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 sheet. The inspection, either in the mill or in the shop, shall be under the direction of the Engineer. The Engineer or his representative shall have free access to the mill or shop for inspection, and every facility shall be extended to him for this purpose. Any material or pipe which has been previously rejected at the mill or shop and included in a later lot, will be considered sufficient cause for the rejection of the entire lot.

(r) Sampling. Chemical analysis of the basemetal of the finished sheet, when required, may be made of the samples taken for weight of spelter coating test. For testing the coating of sheets before fabricating, a sample strip about 3 inches wide shall be cut crosswise or diagonally across the full width of one sheet of each lot of the same identification symbol. From this strip and along the newly sheared edge, samples 2-1/4 inches square, or of equivalent area, shall be cut from the middle and near each end. For testing coating of fabricated pipes at least one sample 2-1/4 inches square, or a sample of equivalent area, shall be selected from each 20 pipes of a shipment, provided that not less than three samples, each from a different section, shall represent any one shipment.

(s) Analysis of Finished Sheet. When not otherwise provided chemical analysis, when required, shall be in accordance with the standard Method, A.S.T.M. E30.

(t) Tests for Spelter Coating. The tests for weight of spelter coating shall be made in accordance with A.A.S.H.O. Standard Method of Test, T-95.

(u) Pipe Arches. Pipe arches shall conform to all the requirements of the equivalent size of the full circle, riveted type, with lap joint construction, except that they shall be manufactured into an essentially arch shape so that the rise shall not be less than 56% nor more than 64% of the span. The invert of pipe arches shall be so manufactured that a trough in the center of the pipe shall be produced, each side of which shall have a pitch of approximately 1 inch in 12.

Pipe arches and the equivalent sizes of full circle pipes are as follows:

Design Size	Minimum Area Square Feet	Maximum Rise Inches	Equivalent Diameter Full Circle Pipe Inches
1	1.0	11.5	15
2	1.5	13.5	18
3	2.5	18.0	24
4	4.0	22.5	30
5	6.0	27.0	36
6	8.0	31.5	42
7	10.5	36.0	48
8	13.5	40.5	54
9	16.5	45.0	60

S-413.3. CONSTRUCTION METHODS. Corrugated galvanized metal pipe culverts shall be constructed from the specified materials in accordance with the following method and procedure.

(a) Excavation. All excavation shall be in accordance with the requirements of Item S-104 "Structural Excavation", except where tunneling or jacking methods are shown on the plans or permitted by the Engineer. When pipes are laid in a trench, the trench when completed and shaped to receive the pipe, shall be of sufficient width to provide free working space for satisfactory bedding and jointing and thorough tamping of the backfill and bedding material under and around the pipe. The Contractor shall make such temporary provision as may be necessary to insure adequate drainage of the trench and bedding during the construction operation.

(b) Foundation. The pipe shall be bedded in a foundation of stable earth material carefully and accurately shaped to fit the lower part of the pipe exterior for at least ten per cent of its overall height. When requested by the Engineer, the Contractor shall furnish a simple template for each size and shape of pipe to be placed for use in checking the shaping of bedding. Template shall consist of a thin plate or board cut to match the lower half of the cross-section of the pipe. Where rock, in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such manner as to provide a compacted earth cushion having a thickness under the pipe of not less than one-half inch per foot height of fill over the top of the pipe, with the minimum allowable thickness of eight inches. Where the soil encountered at the established grade is a quicksand, muck or similar unstable material, unless other special construction methods are called for on the plans or in special provisions, such unstable soil shall be removed and replaced in accordance with the requirements of Item S-104, "Structural Excavation."

(c) Laying Pipe. Unless otherwise authorized by the Engineer, the laying of pipes on the prepared foundation shall be started at the outlet end with the separate sections firmly joined together, with outside laps of circumferential joints pointing upstream and with longitudinal laps on the sides. Any metal in joints which is not protected by galvanizing shall be coated with a suitable asphaltum paint. Proper facilities shall be provided for hoisting and lowering the sections of pipe into the trench without damaging the pipe or disturbing the prepared foundation and the sides of the trench. Any pipe which is not in alignment or which shows any undue settlement after laying, or is damaged, shall be taken up and relaid without extra compensation. Unless otherwise specified, perforated pipe shall be laid with perforations in the bottom of the pipe.

Multiple installations of corrugated galvanized metal pipe and pipe arches shall be laid with the centerlines of individual barrels parallel. When not otherwise indicated on plans the following clear distances between outer surfaces of adjacent pipes shall be maintained:

Diameter of Pipe	Clear Distance Between Pipes		Pipe Arch Design No.
	Circular	Pipe Arch	
18"	0'-9"	1'-0"	2
24"	0'-11"	1'-0"	3
30"	1'-1"	1'-1"	4
36"	1'-3"	1'-3"	5
42"	1'-5"	1'-5"	6
48"	1'-7"	1'-7"	7
54"	1'-11"	1'-11"	8
60"	2'-0"	2'-0"	9
66"-84"	2'-0"		

(d) Connections. Where new culverts are constructed as extensions to culverts in place or are jointed to existing structures, the construction shall include all work necessary to provide a proper connection between the new structure and the old, as indicated on the plans.

(e) Backfilling. Backfilling shall be in accordance with the provisions of Item S-104, "Structural Excavation."

(f) Minimum and Maximum Fills. Corrugated galvanized metal pipe culverts, constructed in accordance with these specifications shall be laid so that the minimum distance from the finished surface of the roadbed to the top of pipe shall be not less than one-half the diameter of the pipe with a minimum of one foot. The maximum permissible heights of fill shall not exceed those shown in the following table:

PERMISSIBLE HEIGHTS OF FILL OVER
CORRUGATED METAL PIPE CULVERTS OF SPECIFIED GAUGE

Diameter of Pipe Inches	Permissible Fill Feet	Specify on Plans			
		Gauge Number	For Fills Feet	Gauge Number	For Fills Feet
8	40	-	-	-	-
10	40	-	-	-	-
12	40	-	-	-	-
15	40	-	-	-	-
18	40	-	-	-	-
21	35	14	36-40	-	-
24	40	-	-	-	-
30	30	12	36-40	-	-
36	35	10	36-40	-	-
42	25	10	31-35	8	36-40
48	20	10	21-25	8	26-40
54	16	10	17-20	8	21-40
60	16	8	17-40	-	-
66	16	8	17-35	-	-
72	16	8	17-30	-	-
78	25	-	-	-	-
84	25	-	-	-	-

The minimum and maximum fills specified above for full circle pipe culverts shall apply to the corresponding sizes of pipe arch culverts.

S-413.4. METHOD OF MEASUREMENT. Corrugated Galvanized Metal Pipe Culverts shall be measured by the linear foot of complete and accepted pipe in place in accordance with these specifications. Such measurement shall be made between the ends of the pipe barrel along the central axis as installed. Where spurs or branches, or connections to existing pipe lines are involved, measurement of the spur or new connecting pipe shall be made from the intersection of its central axis with the outside surface of the pipe into which it connects. Where inlets, catch basins, manholes, junction chambers or other structures are included in lines of pipe, that length of pipe provided for tie into the structure wall shall be included for measurement but no other portion of the structure length or width shall be so included.

Excavation in natural ground for installing pipe and excavation for installing headwalls will be measured as prescribed in Item S-104, "Structural Excavation."

S-413.5. BASIS OF PAYMENT. Payment for Corrugated Galvanized Metal Pipe Culverts, measured as prescribed above, will be made at the contract unit price bid for the various sizes of the items of "Corrugated Galvanized Metal Pipe", "Perforated Corrugated Galvanized Metal Pipe", and "Corrugated Galvanized Metal Pipe Arch", which payment shall be full compensation for furnishing and transporting the pipe; the excavation, hauling and placing of select material where required for bedding pipe in rock excavation; the preparation and shaping of beds; hauling, placing and joining of pipes; for all connections to existing structures and for all other items of materials, labor, equipment, tools and incidentals necessary to complete the culvert in accordance with the plans and these specifications, except excavation and backfill; which will be paid in for in accordance with Item S-104, "Structural Excavation." Where pipes are laid on a skew, full compensation for cutting the ends parallel with the centerline of the highway shall be considered as included in the price paid per linear foot for the designated item of pipe and no additional allowance will be made therefor.

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ITEM S-414

RELAYING CULVERT PIPE

S-414.1. DESCRIPTION. These specifications shall govern for the removal and reinstallation of existing culvert pipe. Pipe in place and designated for use in new work, shall be removed from the existing locations, transported to the new locations, cleaned, and installed as noted on the plans and in accordance with this specification, in such manner as to prevent damage to the pipe and fittings. Unless otherwise provided on the plans, any culvert pipe or fittings, designated for re-use, damaged by the Contractor shall be replaced by the Contractor at his own expense and without additional compensation.

S-414.2. CONSTRUCTION METHODS. The installation of all pipes shall conform to the requirements of the specification for the type or kind of pipe to be relaid. Connections shall be made to existing structures as called for on the plans, and when the connection is to an existing pipe of the same type as that to be relaid, the connection shall conform to the requirements for jointing sections of pipe as described in the pertinent pipe specification. The connection between reinforced concrete pipe and corrugated metal pipe shall be made with a suitable concrete collar having a minimum thickness of four inches.

The top and bottom of reinforced concrete pipe shall be marked prior to being moved and when relaid shall be placed in the same position with reference to top and bottom as before it was removed.

S-414.3. MEASUREMENT. Relaid pipe shall be measured by the linear foot of pipe complete in place in accordance with this specification.

Excavation for taking up existing pipes for relaying or moving is considered incidental to the pay items involved and will not be measured for payment. Excavation in natural ground for installing culvert pipe to be relaid will be measured as prescribed in Item S-104, "Structural Excavation."

S-414.4. PAYMENT. Payment for relaying culvert pipe measured as prescribed above will be made at the contract unit price bid for "Relaying Culvert Pipe 18 inch diameter and under" or "Relaying Culvert Pipe over 18 inch diameter" as the case may be, which payment shall be full compensation for excavating and removing the pipe from its original location; excavation, hauling and placing of select material where required for bedding pipe in rock excavation; the preparation and shaping of beds; hauling, placing and joining of pipe; for all connections to existing structures and for all other items of materials, labor, equipment, tools and incidentals necessary to complete the work in accordance with the plans and these specifications, except excavation and backfill for relaying which will be paid for in accordance with Item S-104, "Structural Excavation." Where pipes are laid on a skew, full compensation for cutting the ends parallel with the centerline of the highway shall be considered as included in the price paid per linear foot for the designated item of pipe relaid and no additional allowance will be made therefor.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-415

EXTENDING CONCRETE STRUCTURES

S-415.1. DESCRIPTION. This specification shall govern for concrete for extending structures and for preparation of the existing structures for extending or widening, including the materials used; the removal of portions of the existing structure; preparation of exposed surfaces of steel and concrete for bonding new construction to old; and the construction of the proposed extensions, all as indicated on the plans.

S-415.2. MATERIALS. All materials shall conform to the requirements of the specifications pertinent to same. Specific references to governing specifications are as follows:

Material	Item No.
Concrete	S-403
Expansion Joint Material	S-402
Reinforcing Steel	S-405

All concrete shall conform to the requirements of Item S-403 and pertinent special provisions thereto included in the contract.

S-415.3. CONSTRUCTION METHODS. The work shall be performed in accordance with the provisions of Item S-402, "Concrete Structures," and in conformance with the requirements herein.

Portions of the old structure shall be removed to the lines and dimensions shown on the plans, and the materials so removed shall be disposed of as shown on the plans or as directed by the Engineer. Any portion of the existing structure, outside of the limits designated for removal, damaged during the operations of the Contractor shall be restored to its original condition at his entire expense. Explosives shall not be used in the removal of portions of the existing structure.

Except when otherwise provided on the plans new reinforcing bars shall be spliced to exposed reinforcing bars in the old structure either by lapping bars a minimum length of 30 bar diameters or by welded splices conforming with the pertinent requirements of Item S-405. The entire length of exposed bars extending into the new construction shall be cleaned prior to splicing on the new steel.

Dowels, if required by the plans, shall be installed by grouting reinforcing bars to a minimum length of 12 inches into the old structure. Holes for dowel bars shall be cleaned of all loose material, wetted and filled with a 1:3 mix grout immediately prior to placing of dowel bars.

Concrete surfaces which will be in contact with new construction shall be roughened and cleaned prior to placing of forms. These surfaces shall be wetted and painted with a thin coat of neat cement mortar immediately in advance of the placing of concrete.

S-415.4. MEASUREMENT. The quantities of concrete which constitute the completed and accepted work will be measured by the cubic yard in place. Only accepted work will be included and the dimensions used for measurement will be those shown on the plans or ordered in writing by the Engineer.

S-415.5. PAYMENT. The concrete quantities, measured as provided above, will be paid for at the unit price bid per cubic yard for the specified class of "Concrete for Extending Structures," which price shall be full compensation for furnishing, hauling, and mixing all concrete materials;

placing, curing and finishing all concrete; all grouting and painting; furnishing and placing all drains and expansion joint; removing the designated portions of the existing structure; cleaning, bending and cutting of exposed reinforcing steel; welding of new reinforcing steel to old; all drilling and grouting for dowels; cleaning and painting old concrete with neat cement mortar; and all forms and falsework, labor, tools, equipment and incidentals necessary to complete the work, except that payment for excavation and for new reinforcing steel will be made in accordance with the pertinent specifications for these items.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-416

DRILLED SHAFTS AND UNDER-REAMED FOUNDATIONS

S-416.1. DESCRIPTION. This specification shall govern for the construction of foundations construction of foundations consisting of reinforced concrete shafts or columns with or without bell type concrete footings. Concrete shafts shall be placed in drilled excavations when the shafts are without bell type footings and in drilled and under-reamed excavations when shafts are with bell type footings. Such foundations shall be constructed in accordance with this specification and in conformance with the details and governing dimensions shown on the plans.

S-416.2. MATERIALS. All concrete materials and their preparation shall be in accordance with the requirements of Item 403 "Concrete for Structures", and pertinent special provisions. All concrete shall be Class "A", unless otherwise shown on the plans.

Reinforcing Steel shall conform to the requirements of Item 405, "Reinforcing Steel" and pertinent special provisions. The sizes and dimensions shall be as shown on the plans.

S-416.3. CONSTRUCTION METHODS. (a) Excavation: The Contractor shall do all excavation required for the shafts and bell footings, through whatever substances encountered, and to the dimension and grades shown on the plans or required by the site conditions. All shafts shall be bored plumb to within a tolerance of two inches. When bottoms or bells are required, they shall be excavated so as to form a bearing area of the size and shape shown on the plans. Shafts and bells may be excavated either by hand or by mechanical methods.

The plans indicate the expected depths and elevations at which satisfactory bearing soil will be encountered, and this information will be used as a basis for the contract. If satisfactory foundation materials are not encountered at plan elevations, the footings may be raised or lowered as determined by the Engineer, alterations in plan depths being made as judged proper to satisfactorily comply with the design requirements.

Where changes in the lengths of shafts or diameter of footing bells are required, they shall be made as directed by the Engineer. Payment for the altered quantities of the completed work consequent to such changed dimensions shall be made as provided in Section 4.3, of Item 4, "Scope of Work".

Casings will be required for shaft excavations when such provision is necessary to prevent caving of the material above the bell, or when necessary to shut off seepage water. Casings shall be of metal and of ample strength to withstand handling stresses, the pressure of concrete and of the surrounding earth or backfill materials, and shall be watertight. The inside diameter of casing shall be not less than the nominal size of shaft; otherwise, the size of casing and the size of drilled excavation in which the casing is to be placed will be left to the discretion of the Contractor. No extra compensation will be allowed for the concrete required to fill an oversize casing or oversize excavation.

Any excavation for the footing bells or shafts beyond the lines required by the plan dimensions, where casings are not required, shall be backfilled with Class "A" Concrete at the Contractor's expense. Where casings are used, the Contractor will be permitted to backfill around casings with pea gravel or other materials acceptable to the Engineer in order to permit ease of casing removal and at the same time reduce the excess concrete required to fill the shaft due to the size of the casing

If casings are removed they shall be withdrawn as the shaft is filled with concrete, or immediately following the concreting operation. If the casing is removed in sections as the concreting operation progresses, a concrete head of at least two feet shall be maintained above the bottom of casing. Extreme care shall be taken to pull the casings in a truly vertical direction in order to prevent distortion of the shaft.

Material excavation from shafts and bells and not used in the backfill around the completed bents or piers shall be disposed of as directed by the Engineer. The disposal of such material shall be in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure or other parts of the work.

At the time concrete is to be placed the excavation shall be free from accumulated seepage water and all loose material removed from the base area.

The Contractor shall provide suitable access and lighting for the Engineer to inspect the completed foundation excavation and check the dimensions and alignment of drilled shafts and the under-reamed excavation when under-reaming is required.

At any time when a person is in the hole, provision shall be made for pumping fresh air to the workmen, and any required lighting shall be by electric lights. Any mechanical equipment used in the excavations shall be operated by air or electricity. The use of gasoline driven engines placed in the excavation for pumping or drilling will not be permitted.

In order that the Engineer may judge the adequacy of a proposed foundation, the Contractor, if requested, shall make soundings to determine the character of the subgrade materials. The maximum depth of such soundings will not be required to exceed 5 feet below the proposed footing grade. It is the intent of this provision that soundings shall be made at the time the excavation in each foundation is approximately complete.

When the plans require drilled shafts in the end bents, the embankment at the bridge ends shall be made to grade as shown and thoroughly compacted as provided in the governing specifications prior to drilling for end bent shafts.

(b) Reinforcing Steel: The reinforcing steel unit for the shaft consisting of longitudinal bars and spiral hooping or lateral ties shall be completely assembled and placed into position as a unit for shafts of 30" diameter and less. The longitudinal bars shall be tied or tack welded to the spiral hooping at intervals, not to exceed approximate 18" centers, and such tieing shall be staggered on the various bars in order to provide a rigid unit. Bars shall be tied to lateral tie bars at all intersections. The lower end of each vertical bar shall be supported upon a suitable precast concrete spacer block. Side spacer block of concrete shall be used at suitable intervals along the unit to insure accurate spacing for the entire length of the shaft.

Generally, the reinforcing steel unit shall not be placed until immediately before the concreting operations are to be started.

(c) Concrete: The work shall be performed in accordance with the provisions of Item S-402, "Concrete Structures", and pertinent special provisions and in conformance with the requirements herein.

Preferably concrete shall be placed immediately after all excavation is complete and reinforcing steel placed.

Concrete placing shall be as continuous as practicable from the beginning of placing in the shaft or footing bell to the top of shaft or to construction joint as may be indicated on the plans. Time intervals will be allowed for rodding the concrete being placed, for pulling casings, for placing forms and other operations necessarily carried on in sequence with the placing operations.

Concrete shall be placed through a suitable tremie tube to prevent segregation of concrete materials and unnecessary splashing on the reinforcing steel cage. The tremie shall be made in sections to permit the discharge end to be raised as the placement progresses.

Wherever a casing is used, the casing should extend sufficiently above the grade of the finished shaft to provide excess concrete to be placed for the anticipated slump due to the casing removal.

Where a cap block or groundline strut is shown on the plans to be placed at the top of the drilled shaft, and the cap or strut is shown to be placed monolithic with the drilled shaft, a time interval will be allowed for placing the required form and reinforcing after any necessary casing removal.

After a placement is completed, the top surface shall be cured and any construction joint area shall be treated as prescribed in Item S-402, "Concrete Structures".

S-416.4. MEASUREMENT AND PAYMENT. (a) The bent shafts covered by this specification will be paid for at the unit price bid per linear foot of the specified diameter of "Drilled Shafts", measurement being made of the linear foot of acceptable shaft in place, measuring from the bottom of footing to the top of shaft as indicated by the details shown on the plans.

(b) Footing bells will be paid for at the contract unit price bid per cubic yard for "Bell Footings" of the specified diameter measurement being made for the acceptable footings placed. The bell shall be deemed to consist of the footing volume outside the volume of the drilled shaft which, for the purpose of measurement, is considered as extending to the bottom of the bell.

The foregoing unit prices shall be full compensation for making all excavations, doing any necessary pumping, placing and removing any required casings, furnishing and placing all concrete and reinforcing steel, all backfilling, and furnishing all tools, labor, equipment and incidentals necessary to complete the work.

No partial estimates will be allowed for "Bell Footings" or for "Drilled Shafts" until the concrete has been placed, except that partial payments will be made for concrete and reinforcing steel materials delivered on the work in accordance with the provisions of Section 6 of Item 9, "Measurement and Payment".

Texas Highway Department
Construction Specification
March, 1950

ITEM S-417

TIMBER PILING

S-417.1. DESCRIPTION. These specifications shall govern the furnishing and driving of untreated or treated timber piling of the type and in accordance with the lines, spacing, and dimensions shown on the plans.

The lengths of piling to be furnished shall be as shown on the plans or as determined by the Engineer from the results of test pile driving, if test piling are provided in the contract.

S-417.2. MATERIAL.

General Requirements. Untreated piling may be of any species of durable timber which will satisfactorily stand driving. Treated piling shall consist of Southern Yellow Pine or Douglas Fir, impregnated with a preservative of such quantity and process as shown on the plans and/or as specified in the governing specifications. Piling shall be cut from sound, live trees, except that fire-killed, blight-killed or wind-felled timber may be used if not attacked by decay or insects. They shall be free from any defects which may impair utility, strength or durability of piling, such as decay, red heart, ring shakes, large unsound or loose knots, numerous knots or holes, knots in clusters, groups of single knots, twist of grain exceeding 1/2 of the circumference in any 20' length. Piles which have been scored for turpentine may be accepted, provided the scar does not exceed 36", and provided the scoring is of recent date, showing the scar to be entirely sound and free from insect damage. Any defect or combination of defects which would be more injurious than the maximum allowable knot will not be permitted.

Knots. All knots shall be trimmed close to the body of the pile. Sound knots will be permitted, provided they are not in clusters. A knot cluster is the grouping of two or more knots together as a unit with the fibers of the wood deflected around the entire unit. A group of single knots is not a knot cluster. A single knot is one occurring by itself with the fibers of the wood in which it occurs deflected around it. The diameter of a sound knot shall not be greater than 1/3 of the minimum diameter of the pile at the section where it occurs, and shall not exceed 4". The diameter of the knot shall be measured at right angles to the length of the pile. The sum of widths of all knots in any one foot length of piling shall not exceed twice the width of the maximum allowable knot for that section of pile.

Checks, Splits and Shakes. Piling which show excessive checking or splitting before or after treatment and prior to driving shall be rejected. Checked piling, on which the checks are not judged excessive shall have the checks completely filled with hot tar pitch before being driven and after driving if necessary. Excessive splitting or checking shall be gauged as follows:

(1) A large check or split at butt of pile which will permit a number 10 B & S (diameter 0.102") wire to be extended 3' into the body of the pile.

(2) Checking and splitting of such size that at any point along the pile, two checks or splits occur into which a number 10 wire may be inserted for a depth of more than 7/8".

Shakes smaller than 1/3 of the diameter of the pile may be permitted, provided the location and proximity to other defects do not affect the utility of the pile.

Density. Piling shall average not less than 6 annual rings per inch, and in addition, 1/3 or more summer-wood measured over the 3rd, 4th and 5th inches from the center of the pile along a radial line. Where there are less than 6 annual rings per inch, piling may be accepted as dense if averaging 1/2 or more summer-wood. Density shall be determined on butt ends of piling. Untreated piles shall have as little sapwood as possible and, when used in exposed work, the diameter of the heartwood shall be not less than 8/10 of the actual diameter of the pile at the butt. Treated piles shall preferably have as much sapwood as possible. In Southern Pine, the sapwood thickness shall be not less than 1-1/2', and in Douglas Fir, not less than 1" at the butt end. The outer three annual rings of all piling shall be free from compression wood.

Peeling and Trimming. Piles shall be peeled of bark including the inner skin soon after cutting so the piles are smooth and clean. Care shall be taken to remove as little sapwood as possible, and it should not be injured by unnecessary axe cuts. All of the rough bark and at least 80% of the inner-bark shall be removed. In no case shall any piece of inner-bark be over 3/4" in width or 8" in length and there shall be at least 1" of clean cut surface between any two strips of inner-bark. Machine trimming will be permitted, provided the depth of machine cut shall be kept at a practicable minimum of the piling surface, and in no case to be more than 1/4", except at knot whorls. The circumference at any point between the knot whorls shall not be reduced by more than 1".

Soundness. Whenever there is any sign of decay visible in untreated timber, the material shall be rejected. In any case where the condition of timber is doubtful and in all cases of air-seasoned material, the inspector shall require a section 2" thick, or more, to be cut from the butt and tip. Evidence of decay, such as softness of the wood fibers, red heart, sponginess or brownish discoloration, even though there are no definite areas of break down in the wood fibers, shall be sufficient cause for rejection.

Seasoning. When air-seasoning is utilized, great care should be exercised in the examination of the piling during the seasoning to protect them from conditions conducive to deterioration. Piling should preferably be cut during the winter season, and the maximum air-seasoning period shall be limited to 120 days, except by special permission from the engineer. Storage yards should be kept free of vegetation, standing pools of water and debris harbouring fungi. Proper stacking and protection practices shall be followed to reduce possible contamination of the piling while it is seasoning. Necessary records shall be kept by suitably marking the seasoning stacks to facilitate inspection as to time of seasoning.

Pre-treated stock will not be acceptable by the inspector, except in emergencies, and even then, special permission must be obtained from the engineer.

Length. Piles shall be furnished cut to the lengths shown on plans or specified by the Engineer. Variation of 6" from the ordered length shall be allowable, but the average length in any shipment shall be equal to, or greater than, the specified lengths. The supplier shall stencil size and length on the butt end of each piling with numerals at least 1" high. Tips and butts shall be cut at right angles to the axis of piling.

Diameter. The minimum diameter of round piling at a section 4' from the butt, measured under the bark, shall be as follows:

Length of Piling	Minimum Diameter 4' from butt
40' and under	12"
Over 40'	13"

The minimum diameter of the tip shall be as follows:

Length of Piling	Minimum Diameter of Tip
20' and under	9"
21 to 44'	8"
Over 45'	7"

The maximum diameter of the butt shall be 18", unless otherwise specified. When a tree is not exactly round, the diameter shall be determined either by measuring the circumference and dividing by 3.14, or by taking the average of the maximum and minimum diameters at the location specified.

Straightness. Piling shall be butt cut from the main body of the tree and shall be cut above the ground swell with a gradual taper from the point of butt measurement to the tip. Any localized deviation from straightness in a 5' section or less shall be classified as short crook, and the deviation of a line drawn from the center of the pile above the bend to the center of the pile below the bend, shall not exceed 2" in such a section. Piling may have a sweep in one plane in one direction, provided that a straight line from the center of the tip to the center of the butt does not deviate from the centerline of the pile at any point more than 1% of the length, and in no case shall it fall outside from the body of the pile. Piling may have sweeps in two planes (double sweep) or sweeps in two directions in one plane (reverse bend or sweep) provided that the line applied as above does not deviate from the centerline of the pile by more than 1/4 the diameter of the pile at the point of greatest deviation, and provided further, that the reversal or change in direction is within the middle half of the length.

Inspection. All piling shall be subject to inspection before and after treatment by the engineer or an authorized inspection agency. The inspector shall be allowed free access to all points from which materials are being produced or processed and the producer shall render him whatever assistance, in the inspector's judgment, is necessary for the proper inspection of materials In the rejection of materials not found suitable, the judgment of the inspector shall be accepted. The butt and tip of each piece accepted as conforming to the specification will be branded with a marking hammer showing the identity of the inspector who performed the work.

Inspection at all points shall be made with the intention of securing materials complying with these specifications, but in the event any material is found which does not comply in any respect, the Engineer may require corrections or replacement on defective material. The shippers should exercise caution in making final inspection of piling prior to shipment to be sure that conditions subsequent to treatment have not caused excessive splitting, checking, warping or any distortion which may cause the piling to fail specifications. Likewise the Contractor shall store and protect piling at the site in such a way as to eliminate these possible variations from the specifications.

S-417.3. STORING AND HANDLING. The method of storing and handling piling shall be such as to avoid injury. 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 the untreated wood.

S-417.4. PROTECTION OF HEADS. When the nature of the driving is such as to unduly injure the heads, 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 brooming shall be provided where necessary.

S-417.5. DRIVING. Foundation piling shall not be driven until after the excavation is approximately complete. 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 only with the written permission of the Engineer.

The piling for trestles shall be driven to the vertical or batter line indicated, and allowable variations from the true plan alignment shall not exceed the following:

(a) In the direction of the center line of the project, the top of the completed piling shall not be more than two (2) inches from the true position as 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 four (4) inches from the position shown on the plans.

For the purpose of maintaining pile alignment, an alignment hole at least three feet deep and as nearly as practicable equal in size to the size of the pile shall be provided for all piling.

All piling raised during the process of driving adjacent piling shall be driven again. Broken, split, or misplaced piling shall be withdrawn and properly replaced. Piling driven below established cut-off grade, except when so directed by the Engineer as necessary to obtain required bearing capacity, shall be withdrawn and replaced by new, and if necessary, longer piling at the expense of the Contractor.

Unless otherwise indicated on the plans the embankment at bridge ends shall be made to grade as shown and thoroughly compacted as provided in the governing specifications prior to the driving of end bent piling.

S-417.6. HAMMERS. Gravity hammers for driving timber piling shall weigh not less than two thousand (2,000) pounds and not more than three thousand five hundred (3,500) pounds, and the drop shall be so regulated as to avoid injury to the pile and in no case shall exceed fifteen (15) feet. The Contractor shall furnish to the Engineer a certified scale weight of the hammer to be used.

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 seven thousand (7,000) foot pounds for single acting and not less than six thousand (6,000) foot pounds for double acting steam hammers. This requirement may be modified for driving in sandy materials when suitable water jets are used. The maximum size of steam hammers to be used shall be a No. 2 Vulcan (single acting) or equal.

Where test piling are driven and where piles are test loaded, the hammer used in driving all other piling shall be of the same type and size as the hammer used in driving the test piles or the piles which were test loaded.

S-417.7. LEADS. Pile driver leads shall be constructed in such a manner as to afford freedom of movement to the hammer and shall be held in position by guys or stiff braces to insure support to the pile during driving. Except where piling are driven through water, the leads shall be of sufficient length that the use of a follower will not be necessary.

S-417.8. 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 suf-

ficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least one hundred (100) pounds per square inch pressure at two three-fourth (3/4) inch 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.

S-417.9. PENETRATION. The piling shall be driven approximately to the depth shown on plans or as established from the test pile data, and to a greater depth whenever necessary to secure the bearing resistance specified on the plans. The bearing resistance shall be determined by load tests or the specified formulas as directed by the Engineer.

Where the required penetration cannot be obtained without "over driving" of the piling such as would cause brooming, breaking or splitting, either water jets or pilot holes or both shall be used as necessary to obtain the required penetrations without injuring the pile.

The size and depth of pilot holes required or permitted shall be determined by the Engineer from the results of trial operations made on the first few piling driven. In general, the maximum diameter of hole permitted will be approximately one (1) inch less than the diameter of the piling. These size requirements may be varied by the Engineer as may be necessary to obtain penetrations and/or bearing values contemplated by the structure design.

Where pilot holes are required in material which consists of loose sand or gravel overlying a hard material, and which loose materials cannot be sealed off by ordinary "mudding" drilling methods, a casing pipe of sufficient diameter shall be placed around the boring device. The casing shall be of sufficient length to extend down through the upper strata of loose material to the firm material and be held in position until the pilot holes are completed and the driving of the piling is started and has progressed to a sufficient depth through the hard material to prevent sand and other loose material from dropping into the pilot hole.

In all cases, piling shall be driven with the hammer after being placed in the pilot holes. Such driving shall be at least sufficient to seat the pile and obtain the required bearing resistance.

S-417.10. CUT-OFFS AND BUILD-UPS. 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.

Piling which must be driven below established grade in order to attain the required bearing capacity shall be built up to the required grade by splicing on an additional length of piling of the same diameter and quality as the pile to be built up. Splices shall be made in accordance with the details shown on plans after the pile head and the lower end of build-up section have been squared up and treated in accordance with paragraph 11 of this specification. Length of build-up sections used shall be such as to preclude the use of more than one splice in any one pile, and no splices or build-ups will be permitted except under the conditions outlined herein.

S-417.11. TREATMENT OF CUTS, ETC. After the necessary cutting has been done, the heads of treated timber piling shall be given three coats of hot creosote oil and one coat of hot tar pitch. When indicated on the plans, the pile heads shall then be covered with a sheet of roofing felt weighing fifty-five (55) pounds per one hundred (100) square feet or twenty (20) gauge galvanized metal. The cover shall measure at least six (6) inches more in each dimension than the diameter of the piling and it 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 timber piling shall, unless otherwise provided, be thoroughly coated with a thick protective coat of red lead and oil, hot tar, hot asphaltum, or hot tar creosote and, when indicated on the plans, 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 creosoted oil and then with a coating of hot tar pitch. Hot creosote oil shall be injected under pressure 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.

Creosote oil used for treatment of cuts, bolt holes, etc., shall confrom to the requirements of Grade 1 creosote oil as provided in the pertinent specifications for "Timber Preservative and Treatment".

S-417.12. LOAD TESTS. Load tests will be required when called for in plans or special specifications. Also, when the required bearing resistance, as computed by the specified formulae, cannot be attained at or near the depth of penetration indicated on plans, the Engineer may require load tests on one or more piles as necessary to establish the actual resistance developed by the piles.

Load tests shall consist of the application of static loads to the pile by hydraulic jack re-acting against suitable anchorage by loading platform supported by pile, or other similar means, and the measurement of resultant settlements of pile. The superimposed load and the settlement of the pile under each increment of load shall be accurately determined with suitable apparatus. The allowable load shall be fifty per cent of that load, which after a minimum of forty-eight hours of application, the last twenty-four hours of which shall be without increase of settlement, causes a permanent settlement of not more than one-fourth (1/4) inch, measured at the top of the pile.

When load tests are made, the bearing resistance formulae given herein shall be modified to conform to the actual resistances shown by load tests and the modified formulae shall be applied in determining the bearing resistance of all other piles in the structure.

S-417.13. BEARING VALUE FORMULAS. In the absence of loading tests, the bearing values for timber piling shall be determined by the following formulas:

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

$$P = \frac{2WH}{S + 0.2}$$ for single-acting steam hammers.

$$P = \frac{2H\,(W + Ap)}{S + 0.2}$$ for double-acting steam hammers.

Where P = 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 hammers.

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 appreciable bounce after the blow. Twice the height of the bounce shall be deducted from "H" to determine its true value in the formula.

S-417.14. LOAD REQUIREMENTS. All piling shall develop a bearing capacity, as determined either by the specified formula or load tests, of not less than the required capacity as shown on the plans.

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.

S-417.15. 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 the length of piling to be used for the proposed structure. Test piling shall meet the requirements herein specified for untreated timber piling or treated timber piling as the case may be. The test piling shall be of the lengths shown on the plans. The locations for driving and disposal of test piling above the ground line 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 with the same type and size of equipment proposed to be used to drive the piling in the structure.

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 Engineer.

S-417.16. MEASUREMENT. Timber piling, treated or untreated, furnished in lengths specified on the plans or approved by the Engineer from test pile data and driven in accordance with these specifications, in the location specified on the plans or as directed by the Engineer will be measured by the linear foot complete in place after all cut-offs and build ups have been made.

Cut-offs will be measured by the linear foot. The pay length of cut-off for each pile will be determined by deducting the length of accepted pile in place, after cut-off has been made, from the "approved length" of the pile, except that no measurement will be made of cut-offs necessitated by brooming, splitting or other injuries arising from careless or improper driving. Where test piling are not provided, the "approved length" of the pile shall be that shown on the plans. Where test piling are provided, the "approved length" shall be the length shown in the approved schedule of piling as established subsequent to the driving of test piling. No cut-off will be measured on any pile which is spliced and built-up.

Splices for build-ups made in accordance with details shown on the plans will be measured as a unit.

Each test pile will be measured as a unit.

S-417.17. PAYMENT. Timber piling measured as provided above will be paid for at the unit price bid per linear foot for "Treated Timber Piling" or "Untreated Timber Piling", as the case may be.

Cut-offs for Treated or Untreated Timber Piling measured as provided above will be paid for by the linear foot at one-half (1/2) the unit price bid respectively for "Treated Timber Piling" or "Untreated Timber Piling".

Splices for Build-ups for Treated or Untreated Timber Piling measured as provided above will be paid for each at four times the unit price bid respectively for "Treated Timber Piling" or "Untreated Timber Piling". This shall not include any allowance for the length of piling used in the build-up as this is measured and paid for as timber piling as provided elsewhere in this specification.

Test piling will be paid for at the unit price bid for each "Untreated Timber Test Piling" or "Treated Timber Test Piling" as the case may be.

The above provisions for payment shall include full compensation for furnishing and driving all piling; for all preservative and treatment; jetting and pilot holes; and for all materials, equipment, tools, labor, and incidentals necessary to complete the work except that any loading tests called for on the plans or ordered by the Engineer and not otherwise provided for payment in the contract shall be paid for under Supplement Agreement or Extra Work Order. Payment for such extra work will be made on a Force Account basis in accordance with Item 9.5 of the Texas Highway Department Standard Specifications and no additional compensation will be allowed the Contractor because of any delay in the work resulting directly or indirectly from the test loading operation.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-418

PRECAST CONCRETE PILING

S-418.1. DESCRIPTION. Precast Concrete Piling shall consist of piling made of Portland Cement Concrete or High Early Strength Portland Cement Concrete cast and reinforced in accordance with these specifications and in conformity with the pertinent designated plans. Piling shall be driven in accordance with these specifications in the location and to the elevation shown on the plans.

The lengths of piling to be furnished shall be as shown on the plans or as determined by the Engineer from the results of test pile driving, if test piling are provided in the contract.

Test piling, if provided in the contract, shall be furnished and driven at locations as shown on the plans or as directed by the Engineer. Test piling shall conform to the requirements hereinafter provided for precast concrete piling. In general, test piling shall be made a part of the completed work and shall be cut-off or built-up to grade elevation as necessary.

The requirements herein for casting, curing, handling and driving piling shall be considered as minimum requirements. Strict compliance with these minimum requirements will not relieve the Contractor of the responsibility for adopting whatever additional provisions that may be necessary to insure the successful completion of the work.

Unless otherwise shown on the plans, the embankment at bridge ends shall be made to grade as shown in the plans and thoroughly compacted as provided in the governing specifications prior to the driving of end bent piling.

S-418.2. MATERIALS. All concrete shall be Class "A" unless otherwise shown in the plans. Concrete materials and their preparation and placing shall be in accordance with the requirements of Item S-403 and pertinent special provisions.

Reinforcement shall conform to the requirements for Reinforcing Steel, Item S-405. The sizes and dimensions shall be as shown on the plans.

S-418.3. FORMS. In addition to the applicable requirements for forms as provided in Item S-402, the following shall govern for concrete piling.

Piling forms shall be supported on an unyielding foundation. When timber sills are used, the sills shall be of such dimensions as will support the weight of concrete without settlement. The spacing of sills or joists shall be such as to prevent sagging of the bottom forms. Where piling beds are to be located on a subgrade which may be softened and made yielding when wetted, the sills or joists shall be supported on stakes driven into the subgrade. The spacing of such stakes shall be as required to insure continuous uniform support to the piling.

Form lumber for bottom and side forms shall be not less than three-fourths (3/4) inches thick after surfacing. Timber forms for piling shall be face lined with an approved type of form lining material such as masonite, plywood, or equal; except that such lining will not be required on piling which are completely hidden from view in the finished structure, nor will lining be required on any portion of the piling in structures where the governing specifications do not require a similar lining for the forms for the pile caps. If desired by the Contractor, forms for concrete piling may be constructed of plywood not less than one-half (1/2) inch in thickness. The clear

spacing of the supporting studs and joists shall not be more than twenty (20) times the actual thickness of the lumber or plywood. The grain of the face plies on such plywood forms shall be laid parallel to the length of the pile between supporting studs and joists. All forms shall be constructed mortar tight and shall be so maintained as to eliminate the formation of surface marks on the concrete due to the shrinkage of the lumber or plywood.

Unless otherwise provided, all corners of forms for square piling shall be chamfered, using a one inch chamfer strip.

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 reconditioned before re-using.

Forms shall be so constructed as to provide accessibility for placing tamping, and consolidation of the concrete. To permit compliance with the requirements for curing as hereinafter specified, the side forms shall be removed as soon as the concrete has attained its initial set and hardened sufficiently to permit form removal without injury to the concrete. In general, the removal of forms will not be permitted in less than three hours but shall not be later than six hours after the concrete is placed, unless, in cold weather, the Engineer may determine that removal within six (6) hours will be injurious to the concrete. In the process of removing the side forms, the pile shall not be moved on its supports, but shall remain supported throughout the minimum curing period specified.

S-418.4. CASTING. Reinforcement shall be accurately spaced and rigidly supported in accordance with the requirements of the specifications for "Reinforcing Steel". All longitudinal bars shall be uniformly spaced from the top ends of the piling.

Concrete shall be placed continuously in each pile and shall be carefully spaded, puddled, and tamped, and special care shall be exercised to avoid horizontal or diagonal cleavage planes. On completion of the casting, the pile shall be date marked.

In lieu of spading or puddling, mechanical vibrators of an approved type may be used. The operation of such mechanical vibrators shall be to the extent required for thoroughly compacting the concrete but shall be carefully done in order to avoid displacement of the reinforcing steel.

Due to the close spacing of reinforcement in the pile tips, special care shall be taken in placing concrete to avoid the use of large sizes of aggregates in the tips. The concrete shall be deposited and large particles shall be moved as required to insure complete filling of the space between the bars and to avoid honeycomb in the interior of the pile.

S-418.5. CURING. Immediately following the completion of the casting operations, the top surface of the pile shall be struck off and hand floated. As soon as the casting operation is complete for each pile, the pile shall be covered with wet cotton mats. The wet cotton mats shall remain in place until such time as the side forms are removed. When the side forms are stripped, the entire pile or bed of piling, including the ends, shall be covered with wet cotton mats, or with wet earth, or by ponding. The mats or earth shall be maintained in a saturated condition throughout the curing period. If ponding is used, the piling shall be submerged throughout the curing period. In the process of removal of side forms and the placing of curing material, the piling shall be kept covered and wet to the greatest extent practicable, and in no case shall the piling surfaces be permitted to become dry. It is the intent of the curing provision to provide not only for keeping the piling wet, but also to provide for covering the piling for the purpose of maintaining the concrete under uniform curing conditions so that the heat resulting from the concrete setting process will be dispelled gradually and uniformly. Piling shall be cured for a minimum period of ten (10) days and until the concrete has attained a flexural strength of not less than five hundred (500) pounds per square inch or a compressive strength of not less than two thousand (2000) pounds per square inch, as determined by tests of specimens made and tested in accordance with the pro-

visions of S.H.D. Bulletin C-11 and cured in the pile bed under the same conditions as the piling. During this curing period, piling shall remain in their original position on the molding platform and shall not be moved or shifted in any manner. The piling may be removed and driven immediately upon the completion of this curing period. If piling are not driven immediately, curing operation shall be continued until the day piles are driven, except that Contractor shall have the option of suspending curing operations from the end of the above specified curing period until forty-eight (48) hours before piling are to be driven, at which time piling shall be wet down thoroughly and kept wet until driven.

S-418.6. FINISHING. Portions of trestle piling which are exposed to view after the piling are driven shall be given a surface rubbing on completion of the placing of concrete in the structure, except that such rubbing will not be required on piling when the pile caps or the portions of slab units forming the pile caps are not required to be rubbed. The finishing shall be in accordance with the provisions for final rubbing applicable to the finishing of concrete columns in the specifications for "Concrete Structures".

Foundation piling or that portion of trestle piling which will be below the ground surface will not be required to be given a rubbed finish.

The requirements herein for form construction and casting of piling are intended to provide for a completed pile free of porous or honeycombed areas or other surface imperfections which may require pointing or patchwork to be done on the concrete surfaces. In cases where such results are not obtained, it shall be the charge of the Contractor to accomplish the necessary pointing, trimming, and surface repairing by methods that will not defeat the requirements for continuous curing as specified.

S-418.7. HANDLING. The method of storing and handling piling shall be such as to minimize the danger of fracture by impact or undue bending stresses while being handled or driven. Unless otherwise provided, concrete piling shall be handled by means of a suitable bridle or sling attached to the pile at points two-tenths (0.2) the length of the pile from each end. In no case shall the methods of handling be such as to induce stresses in the concrete of more than six hundred and fifty (650) pounds compression per square inch, or in the reinforcing steel a tension in excess of twelve thousand (12,000) pounds per square inch, allowing one hundred (100) per cent of the calculated load for impact and shock effects. The use of chain slings will not be permitted.

Piling cracked in the process of curing, handling, or driving, whether or not the limiting stresses as above specified have been exceeded, shall be subject to the following provisions:

(a) Any piling which is cracked to the extent that the crack shows spalling or is open sufficiently to indicate that the reinforcing has been permanently distorted shall be rejected if the crack occurs in a portion of the pile which will be below ground when the pile is driven.

(b) Piling cracked as described in (a) and on which the crack occurs in a portion of the pile which is not below ground when the pile driving is completed may be used in the structure provided that the Contractor will, at his own expense, cut the concrete of the pile back to the crack, and then treat the pile as a build-up as hereinafter provided in these specifications. The build-up shall be made to grade after the pile is driven, regardless of the amount of cut-off or build-up that would have been required had the pile not been cracked.

(c) Piling which have cracks that do not show spalling, and which cracks are closed sufficiently to indicate that no permanent distortion of the reinforcement has occurred, may be used in the structure, if the Contractor will, at his own expense, waterproof the area over the crack with an approved waterproofing material.

The waterproofing shall be applied over the crack and an area at least one and one-half ($1\frac{1}{2}$) inches each way from the crack. The edge of the waterproofing band shall be straight and shall be

straight and shall be normal to the axis of the pile. If, in the process of pile driving, cracks develop in the portion of the pile which will be below ground, the driving operations shall be stopped for a sufficient length of time to permit the required waterproofing to be done before the crack enters the ground.

(d) Fine hair cracks or checks on the surface of the pile which, as determined by the Engineer, do not extend to the plane of the nearest reinforcing steel, will not be cause for extra treatment or for rejection of piling under these specifications, unless such cracks are numerous and extensive enough that, in the opinion of the Engineer, inadequate curing is apparent, in which case the piling may be rejected for improper curing.

S-418.8. DRIVING EQUIPMENT. Unless otherwise provided, 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 sixty (60) blows per minute of not less than fifteen thousand (15,000) foot pounds per blow and shall be operated at an efficiency of not less than eighty (80) per cent of the manufacturer's rated capacity. If a double-acting steam hammer is used, it shall be capable of striking blows of not less than twelve thousand (12,000) foot pounds per blow when operated at normal rated speed and shall be operated at an efficiency of not less than eighty (80) per cent of the manufacturer's rated capacity. Either steam or compressed air may be used as the operating medium.

Where test piling are driven and where piles are test loaded, the hammer used in driving all other piling shall be of the same type and size as the hammer used in driving the test piles or the piles which were test loaded.

Pile drivers shall be equipped with leads which are constructed in such manner as to afford freedom of movement of the hammer and which are rigidly held in position by stiff braces or guys to insure adequate support to the pile during driving. The vertical axis of the leads and hammer shall coincide with the vertical axis of the pile as nearly as practicable. Except where piling are driven through water, the leads shall be of sufficient length that a follower will not be necessary.

When so specified on plans the use of gravity hammers will be permitted subject to the following requirements. The weight of hammer shall be not less than 3000 pounds nor less than one-half the combined weight of the pile and the driving head. Height of drop shall be so regulated as to avoid injury to the piles and in no case shall exceed eight feet.

The Engineer reserves the right, in all cases, to require heavier driving equipment than that above specified, if satisfactory results are not obtained with the specified equipment.

S-418.9. PENETRATION. The piling shall be driven to approximately the depth shown on the plans, or to a greater depth if same is necessary to secure the bearing power specified on plans. The bearing power shall be determined by tests or formula given herein.

In case the required penetration cannot be obtained by driving with hammers as above specified, then either one or a combination of the following methods shall be resorted to in order to obtain the required penetration.

(a) In localities where water is available and the material is suitable for jetting, 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 hammer, to operate one or more pumps and one or two (depending upon requirements of material) two and one-half ($2\frac{1}{2}$) inch inside diameter jet pipes provided with a three-fourths (3/4) inch diameter nozzle. The plant shall be such that with two jets operating at the same time it shall be capable of delivering a minimum of one hundred and fifty (150) pounds pressure per square inch at the nozzle when flowing freely.

The jetting operations may be done by use of one (1) or two (2) jets as determined by the Engineer from the results of trial jetting operations; the required jetting may be done ahead of the actual pile driving operations or simultaneously with the driving operations as determined by the Engineer from the results of trials.

If jets and hammer are used together for the driving, the jet shall be withdrawn and the final penetration of the pile obtained by driving with the hammer alone. This procedure shall be varied to suit the job conditions and to obtain the desired penetration and load carrying results for the piling.

(b) In localities where water is not available for efficient jetting operations and/or where soil is of such material as will not permit jetting, the Contractor shall provide pilot holes as may be necessary to obtain the required pile penetration. Requirements for pilot holes shall be as follows:

The size and depth of pilot hole required or permitted shall be determined by the Engineer from the results of trial operations made on the first few piling driven. In general, the maximum diameter of hole permitted will be approximately four (4) inches less than the diagonal of square piling, two (2) inches less than the diagonal of octagonal piling, and one (1) inch less than the diameter of round piling. These size requirements may be varied by the Engineer as may be necessary to obtain penetration and/or bearing values contemplated by the structure design.

Where pilot holes are required in material which consists of loose sand or gravel overlying a hard material, and which loose materials cannot be sealed off by ordinary "mudding" drilling methods, a casing pipe of sufficient diameter shall be placed around the boring device. The casing shall be of sufficient length to extend down through the upper strata of loose materials to the firm material and be held in position until the pilot holes are completed and the driving of the concrete piling is started and has progressed to a sufficient dpeth through the hard material to prevent sand and other loose material from dropping into the pilot hole.

In all cases, piling shall be driven with the hammer after being placed in the pilot holes. Such driving shall be at least sufficient to seat the pile and obtain the required bearing resistance. The load carrying capacity for the pile shall be determined from the results of this driving, computed as hereinafter specified.

S-418.10. BEARING RESISTANCE. When loading tests are not required the bearing resistance of all piles shall be determined by the following formulae:

For gravity hammers: $P = \frac{2\ Wh}{S + 1.0}$ (See exception below)

For single-acting steam hammers: $P = \frac{2\ Wh}{S + 0.2}$

For double-acting steam hammers: $P = \frac{2h(W+ap)}{S + 0.2}$, or $P = \frac{2E}{S + 0.2}$

Where:

P = safe bearing in pounds
S = average penetration in inches per blow for the last 5 to 10 blows for gravity hammer; or the last 10 to 20 blows for steam hammer
W = weight, in pounds, of the striking parts of the hammer
a = area of piston in square inches
p = steam pressure in pounds per square inch, at the hammer
h = height of fall in feet
E = rated energy per blow in foot-pounds,

except that when piles are driven with gravity hammer delivering blows of not less than 24,000 ft. lbs. energy (Wxh) to such resistance that the penetration per blow does not exceed 1/4 inch for any of the last 40 blows and does not increase during this period, the bearing resistance may be determined by the formula $P = \frac{2Wh}{3S} \times K$ where S is the average penetration per blow for the final 40 blows, and K is the ratio between the weight of the hammer and the combined weight of the pile and driving head. The value of K shall not be greater than one (1).

Loading tests will be required when called for in plans or special specifications. Also, when the required bearing resistance, as computed by above formulae, cannot be attained at or near the depth of penetration indicated on plans, the Engineer may require loading tests on one or more piles as necessary to establish the actual resistances developed by the piles.

Loading tests shall consist of the application of static loads to pile by hydraulic jack re-acting against suitable anchorage, by loading platform supported by pile, or other similar means, and the measurement of resultant settlements of pile. The superimposed load and the settlement of the pile under each increment of load shall be accurately determined with suitable apparatus. The allowable load shall be fifty per cent of that load, which after a minimum of forty-eight hours of application, the last twenty-four hours of which shall be without increase in settlement, causes a permanent settlement of not more than one-fourth (1/4) inch, measured at the top of the pile.

When loading tests are made, the bearing resistance formulae given herein shall be modified to conform to the actual resistances shown by load tests and the modified formulae shall be applied in determining the bearing resistance of all other piles in the structure.

In cases where bearing values of piling are to be determined by formula, the Contractor shall co-operate with the Engineer and shall so conduct his pile driving operations that the Engineer may obtain the penetration per blow data required. The Contractor shall also furnish the Engineer data on his driving equipment and shall provide and install gauges as required in order to show that the equipment is operating at the efficiency hereinbefore specified.

S-418.11. CUT-OFFS, SPLICES, OR BUILD-UPS. Extensions, splices, or build-ups on concrete piling, when necessary, shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut back leaving the reinforcing steel exposed for a minimum of three inches. Reinforcing of section equivalent to that used in the piling shall be buttwelded to the exposed steel to develop 100% strength in accordance with the Code, Specification and Practice of the American Welding Society for Fusion Welding of Structural Metal as set forth in the latest bulletins of that Society. Any damage to the concrete of the pile shall be remedied by a further cut-back; the final cut of the concrete shall be normal to the axis of the pile. The form work necessary for the build-up shall then be placed, care being taken to prevent leakage along the pile. The concrete used for the build-up shall be of the same quality as that used originally in the pile. Just prior to placing the concrete, the top of the pile shall be thoroughly wetted and covered with a thin coating of retempered mortar, consisting of one part sand and one part Portland Cement. The removal of forms, curing and finishing shall be in accordance with the provisions governing concrete columns in the specifications for "Concrete Structures".

Cut-offs for piling above grade shall be done as specified for the cut-backs above, except that reinforcing steel may be cut off flush with the top of the piling.

S-418.12. ALLOWABLE VARIATION FOR DRIVING. The precast concrete piling for trestles shall be driven to the vertical or batter line indicated, and allowable variations from the true plan alignment shall not exceed the following:

(a) In the direction of the center line of the project, the top of the completed piling shall not be more than two (2) inches from the true position as 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 four (4) inches from the position shown on the plans.

For the purpose of maintaining pile alignment, an alignment hole at least five (5) feet deep and as nearly as practicable equal in size to the size of the pile shall be provided for all piling.

S-418.13. MEASUREMENT AND PAYMENT.

(a) Precast concrete piling will be paid for at the unit price bid per linear foot for the specified size of "Precast Concrete Piling", measurement being made on the linear foot of acceptable piling in place after all cut-offs and build-ups have been made, to which measurement shall be added one foot for each authorized build-up made, other than those made necessary by improper casting, handling or driving of the piling.

(b) Precast Concrete Test Piling will be paid for at the unit price bid per linear foot for the specified size of "Precast Concrete Test Piling", measurement being made on the linear feet of acceptable piling in place after all cut-offs and build-ups have been made to which measurement shall be added one foot for each authorized build-up made, other than those made necessary by improper casting, handling or driving of the piling.

(c) Cut-offs for both Precast Concrete Piling and Precast Concrete Test Piling will be paid for at one-half (1/2) the unit price bid per linear foot for "Precast Concrete Piling", measurement being made on the linear foot of cut-off above grade. Where cut-backs are made below grade for the purpose of making build-ups, payment for same will be included in the allowance for build-ups.

(d) No allowance other than the unit price bid for "Precast Concrete Piling" or "Precast Concrete Test Piling" shall be made for build-ups where same are necessary due to improper casting, handling or driving of the piling.

The foregoing shall be full compensation for furnishing all materials, including reinforcement, tools, labor, equipment, jetting, pilot holes, alignment holes, and incidentals necessary to complete the work; except that any loading tests ordered by the Engineer and not otherwise provided for in the contract shall be paid for under Supplemental Agreement or Extra Work Order. Payment for such Extra Work will be made on a Force Account basis in accordance with Item 9.5 of The Texas Highway Department Standard Specifications and no additional compensation will be allowed the Contractor because of any delay in the work resulting directly or indirectly from the test loading operation.

Where pile shoes are required and shown on the plans, the cost of furnishing and placing shoes shall be included in the unit price bid per linear foot for "Precast Concrete Piling" or "Precast Concrete Test Piling", as the case may be. In case pile shoes are desired to be used by the Contractor but are not required by the plans, the use of pile shoes of an approved design will be permitted, but no additional compensation will be allowed.

Concrete piling ordered cast but not used in the structure will be paid for on the same basis as "Cut-Offs".

No partial estimate allowance will be made for piling cast but not driven during any estimate period except that payment for materials involved may be made in accordance with the provision of Item 9, Section 6.

Texas Highway Department
Construction Specification
March, 1950

(Rev. August, 1950)

ITEM S-419

STEEL H PILING

S-419.1. SCOPE. This specification shall govern for the furnishing and driving of steel piles of H-section. The piling shall be of the type and weight shown on the plans and shall be placed in accordance with the lines, grades and dimensions shown therein.

The lengths of piling to be driven shall be as shown on the plans, or as necessary to obtain the required bearing resistance and required minimum penetration.

S-419.2. MATERIAL. The steel piling shall be manufactured in accordance with Specification Items S-406, "Steel Structures", and S-407, "Metal for Structures", and pertinent special provisions included in the contract.

S-419.3. STORING AND HANDLING. The methods of handling shall be such as not to result in damage to the piling. When steel piling are to be stored, they shall be placed on skids which will raise them above the ground. The stored piling shall be kept clean and fully drained at all times. A sufficient number of skids shall be used to prevent deflection in the stored piling.

S-419.4. DRIVING. Unless otherwise provided on the plans, piling may be driven with either a gravity drop hammer or a steam hammer. Either steam or compressed air may be used as the operating medium for steam hammers. Where test piling are driven, the hammer used in driving all other piling shall be of the same type and size as the hammer used in driving the test piling.

Steam hammers used for driving piles shall develop an energy per blow in foot pounds of not less than 250 x R, where R is the required minimum bearing resistance of the pile in tons. Hammers developing an energy of more than 18000 foot-pounds per blow shall not be used except for the driving of unusually heavy piles and then only with the written permission of the Engineer. Hammers shall be operated at not less than 80% of the manufacturer's rated capacity.

When a gravity drop hammer is used its weight shall not exceed 5,000 pounds and shall be not less than the sum of the weight of the pile and the weight of the driving head nor less than the amount specified in following table:

Required Bearing Resistance of Pile	Minimum Weight of Hammer
Less than 30 tons	2,000 pounds
30 to 37 tons	2,500 pounds
more than 37 tons	3,000 pounds

The fall of the hammer shall be limited to a maximum of 15 feet and shall be so regulated as to avoid injury to the pile. The Contractor shall furnish to the Engineer a certified scale weight of the hammer to be used.

Where test piling are driven, the hammer used in driving all other piling shall be of the same type and size as the hammer used in driving the test piling.

Pile drivers shall be equipped with leads which shall afford free vertical movement for the hammer. The leads shall be stiff enough to resist bending during the driving operation and shall be held rigidly in driving position by stiff braces or guys.

The vertical axis of the leads and hammer shall coincide with the vertical axis of the piling as nearly as practicable. The leads shall be of sufficient length to permit driving to the required penetration without a follower, except where piling are driven through water.

When the plans require piling in the end bents the embankments at the bridge ends shall be made to grade as shown and thoroughly compacted as provided in the governing specifications prior to the driving of the end bent piling.

S-419.5. PROTECTION OF HEADS. A cast or structural steel driving head fitted with wood cushion block shall be used when necessary to prevent damage to the pile. The cushioning provided shall be sufficient to prevent material damage to pile head. Rope mat, belting or similar cushioning material may be used in addition to wood cushion block when necessary.

S-419.6. PENETRATION. The piling shall be driven approximately to the depth shown on the plans, or to a greater depth, if necessary to secure the bearing resistance specified on the plans. The bearing resistance shall be determined by tests or formula given herein.

Piling shall be driven in pile alignment holes when necessary to secure proper alignment. The required depth of alignment holes will not exceed 5 feet. In general, the maximum diameter of the alignment hole will be 4 inches less than the diagonal of the piling. The Engineer may vary the diameter of the alignment hole when necessary.

In case the required penetration cannot be obtained by driving with hammers as specified above, then either one or both of the following methods shall be resorted to in order to obtain the required penetration.

(a) Where the material is suitable for jetting and water is available, the Contractor shall provide jetting equipment as an auxiliary to the hammer as a means of placing the piling. The equipment shall be as follows:

Sufficient power shall be provided, in addition to that used for operating the hammer to operate one or more pumps and one or two (depending upon requirements of the material) two and one-half (2-1/2) inches inside diameter jet pipes provided with a three-fourths (3/4) inch diameter nozzle. The plant shall be such that with two jets operating at the same time it shall be capable of delivering a minimum of one hundred and fifty pounds pressure per square inch at the nozzle when flowing freely.

The jetting operations may be done by one or two jets as determined by the Engineer from the results of trial jetting operations; the required jetting may be done ahead of the actual driving operations or simultaneously with the driving operations as determined by the Engineer from the results of trials.

If the jets and hammer are used together for the driving, the jet shall be withdrawn and the final penetration of the pile obtained by driving with the hammer alone. This procedure shall be varied to suit the job conditions and to obtain the desired penetration and load carrying results for the piling.

(b) In localities where water is not available for efficient jetting operations or where soil is of such material as will not permit jetting, the Contractor shall provide pilot holes as may be necessary to obtain the required pile penetration. Requirements for pilot holes shall be as follows:

The size and depth of pilot hole required or permitted shall be determined by the Engineer from the results of trial operations made on the first few piling driven. In general, the maximum diameter of hole permitted will be approximately four (4) inches less than the diagonal of the piling. The size requirements may be varied by the Engineer as may be necessary to obtain penetration and/or bearing values contemplated by the structure design.

In all cases, piling shall be driven with the hammer after being placed in the pilot holes. Such driving shall be at least sufficient to seat the pile and obtain the required bearing resistance. The load carrying capacity for the pile shall be determined from the results of this driving, computed as hereinafter specified.

S-419.7. CONCRETE COLLARS. When shown on the plans, piling which extend above the permanent ground line shall be provided with concrete collars at the ground line. Concrete for concrete collars shall be mixed and placed in conformance with Specification Items S-403 "Concrete for Structures" and Item S-402 "Concrete Structures", and pertinent special provisions included in the contract.

The surface of the piling to be covered by the concrete collar shall be thoroughly cleaned of loose mill scale, rust, dirt, grease, and all other foreign substances before placing concrete.

The portion of the concrete collar above the ground line shall be formed in a manner that will provide a smooth, uniform appearance for all collars. Where the material on the sides of the hole is sufficiently stable to stand without caving during the concrete placing operation, the forms may be omitted from that portion of the collar below the permanent ground line. Where the sides of the hole are not stable the form shall extend to the bottom of the collar. All concrete in concrete collars shall be cured with wet cotton mats for a minimum of 4 curing days.

S-419.8. CUT-OFFS AND SPLICES. All splices for steel piling shall be made in accordance with the details shown on the plans. If the required penetration or bearing resistance has not been secured, the spliced piling may be driven the additional depth required as soon as the splice is completed.

After the piling has been driven to the approximate penetration and bearing resistance to satisfy the design requirements, the piling shall be cut-off level, with a burning torch, or by other acceptable methods, to the plan grade or the grade established by the Engineer. Where pile-heads are required by the plans, the end surfaces of the piling shall be made as smooth as practicable before the pile-head is welded in place. The pile head shall conform to the plan details.

Where head of piling is appreciably distorted or otherwise damaged below cut-off level, the damaged portion shall be cut off and replaced with an undamaged section spliced in place at Contractor's expense.

S-419.9. PAINTING. Steel piling shall not be painted before driving. After driving, capping, and placing collars all exposed portions of the piling shall be cleaned and painted three coats of paint in accordance with the requirements of the pertinent specification "Paint and Painting" and special provisions thereto.

S-419.10. ALLOWABLE VARIATION FOR DRIVING. Steel piling for trestles shall be driven to the vertical or batter line indicated on the plans. The allowable variation from true plan alignment shall not exceed the following:

(a) The top of the completed piling shall not be more than two (2) inches from the true position in the direction of the center line of the project.

(b) The top of the completed piling shall not be more than four (4) inches from the true position in the direction at right angles to the center line of the project or along the center line of the bent.

S-419.11. BEARING RESISTANCE. When loading tests are not required the bearing resistance of all piles shall be determined by the applicable formula in the following table where:

P = safe bearing in pounds
S = average penetration in inches per blow for the last 5 to 10 blows for gravity hammer; or the last 10 to 20 blows for steam hammer
W = weight, in pounds, of the striking parts of the hammer
a = area of piston in square inches
p = steam pressure in pounds per square inch, at the hammer
h = height of fall in feet
L = total length of pile in feet
E = rated energy per blow in foot-pounds.

	For All Federal Aid Projects	For State Projects
Single-acting Steam Hammers	$P = \frac{2\,Wh}{S + 0.2}$	$P = \frac{2\,Wh}{S + 0.2}$
Double-acting Steam Hammers	$P = \frac{2h(W+ap)}{S + 0.2}$, or $P = \frac{2\,E}{S + 0.2}$	$P = \frac{2h(W+ap)}{S + 0.2}$, or $P = \frac{2\,E}{S + 0.2}$
Gravity Hammers	$P = \frac{2\,Wh}{S + 1.0}$ (Except as noted below)	$P = \frac{2\,Wh}{S + .005L + 0.2}$

Exception:

On Federal Aid Projects when piles are driven with gravity hammer delivering blows of not less than 24,000 ft. lbs. energy (Wxh) to such resistance that the penetration per blow does not exceed 1/2 inch for any of the last 40 blows and does not increase during this period, the bearing resistance shall be determined by the formula $P = \frac{2Wh}{3S}$, where S is the average penetration per blow for the final 40 blows.

Loading tests will be required when called for in plans or special specifications. Also, when the required bearing resistance, as computed by above formulae, cannot be attained at or near the depth of penetration indicated on plans, the Engineer may require loading tests on one or more piles as necessary to establish the actual resistances developed by the piles.

Loading tests shall consist of the application of static loads to pile by hydraulic jack re-acting against suitable anchorage, by loading platform supported by pile, or other similar means, and the measurement of resultant settlements of pile. The superimposed load and the settlement of the pile under each increment of load shall be accurately determined with suitable apparatus. The allowable load shall be fifty per cent of that load, which after a minimum of forty-eight hours of application, the last twenty-four hours of which shall be without increase in settlement, causes a permanent settlement of not more than one-fourth (1/4) inch, measured at the top of the pile.

When loading tests are made, the bearing resistance formulae given herein shall be modified to conform to the actual resistances shown by load tests and the modified formulae shall be applied in determining the bearing resistance of all other piles in the structure.

S-419.12. MEASUREMENT AND PAYMENT.

(a) Steel H Piling will be paid for at the unit price bid per lineal foot for "Steel H Piling", or "Steel H Test Piling", as the case may be, of the specified size and weight. Measurement will be made of the linear feet of acceptable piling complete in place after all cut-offs, splices or build-ups have been made. Measurement will not include thickness of pile-heads.

(b) No direct payment will be made for cut-offs, pile-heads or concrete collars: payment for all work and materials involved in these items shall be included in the unit price bid per lineal foot for "Steel H Piling", or "Steel H Test Piling" as the case may be.

(c) Payment for the work and materials (exclusive of additional length of piling) involved in making each pile splice will be made at a unit price per splice equal to 1-1/2 times the unit price bid for "Steel H Piling" of the size and weight on which the splice is made, except that no payment will be made for any splice on any pile whose actual length left in place, after all cut-offs, splices or build-ups have been made, is not greater than the length shown on plans or specified by the Engineer as a result of test pile investigations, nor will payment be made for more than one splice on any one pile.

(d) The foregoing shall be full compensation for all materials, labor, tools, equipment, and incidentals necessary to complete all the work in accordance with the requirements of this specification except that any loading tests ordered by the Engineer and not otherwise provided for in the contract shall be paid for under Supplemental Agreement or Extra Work Order. Payment for such Extra Work will be made on a Force Account basis in accordance with Item 9.5 of The Texas Highway Department Standard Specifications and no additional compensation will be allowed the Contractor because of any delay in the work resulting directly or indirectly from the test loading operation.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-422

RAILING

S-422.1. DESCRIPTION. This specification shall govern for the construction of concrete, timber, metal, or pipe railing, or railings made up of a combination of these materials, on bridges, walls, or incidental structures as may be designated on the plans.

In general, railing shall include that portion of the structure erected on and above the roadway curb or along the edges of walks for the protection of traffic, and shall include the approach railing, erected on the embankment but connected to the bridge railing, when so indicated on the plans. Unless otherwise provided, metal railings on steel through truss spans and timber railings on timber spans shall be considered as integral portions of the steel or timber units and will not be included for measurement and payment as railing under this specification.

Railings shall be constructed in accordance with the details shown on the plans, and the railing shall be considered as including the construction along the top of curb, walkway, or coping of the structure plus the necessary anchorage details as indicated by the plans.

Throughout this item, where the Standard Specifications of the A.S.T.M. are specified, the latest standard or tentative specification issued by the Society prior to the date of receipt of bids on which the contract is awarded shall govern.

S-422.2. MATERIALS. All materials shall conform to the requirements of the specifications pertinent to same. Specific references to governing specifications are as follows:

Material	Item No.
Concrete	S-403
Expansion Joint Materials	S-402
Reinforcing Steel	S-405
Structural Steel	S-407
Welded and Seamless Steel Pipe	Specifications given Herein
Malleable Castings	S-407
Timber	S-410

Concrete portions of railings shall be constructed of Class A Concrete.

Pipe for railing shall be black or hot dipped galvanized, welded or seamless steel pipe conforming to the requirements of the "Standard Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses," A.S.T.M. Designation A120. Galvanizing shall be applied after the pipe has been shaped to its final cross section. The pipe in the finished railing shall be free from loose mill scale, rust pits, or any defects affecting its strength, durability, or appearance.

All pipe shall be "Standard Weight." The hydrostatic tests prescribed in the A.S.T.M. Specifications will be omitted.

Pipes shall be furnished of the lengths specified on the plan details for railing.

The weight of the "Standard Weight" pipe prescribed for the various sizes of pipe in the A.S.T.M. Specifications is as follows:

Size (Nominal Inside Dia.) Inches	Outside Dia. Inches	Thickness Welded & Seamless Steel Pipe Inches	Weight of Pipe P.L.F. Threaded and With Couplings Pounds
$1\frac{1}{2}$	1.900	0.145	2.73
2	2.375	0.154	3.68
$2\frac{1}{2}$	2.875	0.203	5.82
3	3.500	0.216	7.62
$3\frac{1}{2}$	4.000	0.226	9.20
4	4.500	0.237	10.89
5	5.563	0.258	14.81
6	6.625	0.280	19.19

Where its use is indicated on plans, Guard Fence type railing sections shall be "Flex-beam" as manufactured by Sheffield Steel Company, "Safety Beam" as manufactured by the Bethlehem Steel Company or equivalent. The plates shall be twelve inches wide after bending and, unless otherwise designated on the plans, shall be formed from 10 gauge or heavier metal. Connections shall be as shown on the plans. Plates shall have straight edges and shall be free from warp. When tested with a straight edge or string along either edge of a sectional length of plate, the maximum deviation of the plate's edge from the straight edge shall not exceed one-half inch at any point.

Fittings, bolts, nuts and washers shall conform to the details shown on the plans. All fittings, bolts, etc., shall be made from steel and shall have proper strength for the purpose intended.

The Contractor may submit details of Guard Fence Type rail plates of a different design than specified above and approval will be conditioned upon the alternate design being equal to the specified thickness of "Flex-Beam" or "Safety-Beam" with respect to type of materials, tensile strength of plates and joints, and resistance to bending of plates and joints.

Where their use is indicated on the plans, timber posts, blocks and braces shall conform to the requirements of Specification Item S-410, "Timber for Structure." Posts, blocks and braces shall be of the dimensions shown on the plans and shall be bored, cut and/or framed before treatment. They shall be given an eight pound treatment of creosote oil per cubic foot by the empty cell process. Posts, blocks and braces must be inspected at time of treatment. The quality of oil and manner of treatment shall be as required in the pertinent specifications of the Department.

Rail members (Channel, Pipe or Guard Fence type) may be galvanized or not galvanized. All other metal for Guard Fence type railing except posts and coil springs for take-ups shall be galvanized. The use of chrome nickel bolts at plate connections will be permitted. Galvanizing shall be done by the hot double dip or electro-plate method, and the metal shall have a continuous coating of zinc of a uniform thickness, so applied that it will adhere firmly to the surface, and it shall be capable of withstanding four immersions in a standard testing solution of copper sulphate without showing any trace of metallic copper. The first three immersions shall be for a period of one minute each, and the fourth for a period of one-half minute.

Plates for Guard Fence type railing shall be sampled and tested in accordance with the current requirements of the "Standard Methods of Tension Testing of Metallic Material," A.S.T.M. Designation E 8, if requested. A sample of the spring support and plate may be taken for each project or for each shipment to a project. Samples of bolts and compression springs may also be required. All samples shall be furnished to the Department free of charge. Producers shall furnish certificates as to the copper content of the steel from which the plates are made.

A certificate of analysis executed by the producer shall be furnished the Department setting forth the trade name or brand of paint or primer, except #700 Shop Coat, #701 No. 1 Field Coat, and #703 Aluminum, proposed for use under this item, together with a facsimile copy thereof and a typical analysis showing the percentage of each of the chemical elements in the pigment and vehicle. The producer shall provide that all paint or primer furnished and the trade name or brand given 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. After approval by the Department of a brand for a specific use additional analysis will not be required for that brand unless requested.

S-422.3. CONSTRUCTION. (a) General. Railing shall be constructed of the type specified, in accordance with details shown on the plans, and in conformance with the requirements herein. It shall be constructed to the alignment, grade and camber as designated on plans. Shop fabricated railing shall be of such uniformity as to insure good joints and continuous lines after erection on the structure. Any appreciable amount of cutting, bending or filling required on erection to produce a reasonable fit will be cause for rejection of the rail. Unless otherwise provided, railing shall not be placed until after the falsework for the span has been released. During construction of railing, care shall be exercised to insure proper functioning of expansion joints.

Railing posts shall be erected vertically with the tops on a level line or parallel to the roadway grade as may be indicated on the plans. Backfill around approach rail posts shall be placed in four inch layers and thoroughly tamped.

The fabrication and erection of metal or timber for railing shall conform to the pertinent provisions of the specification items "Steel Structures" and "Timber Structures" respectively, and to the additional requirements of this specification. Splicing of members will be permitted only at points provided by details on the plans.

For railing containing metal requiring fabrication, shop drawings shall be prepared and forwarded for approval in accordance with the requirements of Item S-406, "Steel Structures."

(b) Concrete. For concrete portions of railings, the construction and removal of forms and the placing, curing, and surface finishing shall conform to provisions of Item S-402, "Concrete Structures," and to the requirements herein. Provision shall be made in the construction of railing forms to provide for the checking and correction of the lines and grades of the railing after the concrete has been placed, but before initial set; and the operation required for floating the top of railings shall be conducted in such manner as not to disturb the form alignment after the final check. Particular care shall be exercised in carrying on other construction operations adjacent to railings being placed in order to avoid disturbing or vibrating the span on which the railing is newly placed. Before concrete is placed in rail posts, the area on top of the curbs to be covered by the railing shall be cleaned, wetted, and covered with grout in accordance with the provisions for treatment of construction joints in Item S-402.7. In curing and handling precast members, extreme care shall be taken to preserve true and even edges and corners. Any member which becomes marred or cracked will be rejected and shall be removed from the work.

All storing, splicing, bending, and placing of reinforcing steel for railing shall conform to the pertinent provisions of Item S-405, "Reinforcing Steel."

(c) Oval Pipe. Oval pipe may be rolled to the shape shown on the plans or may be cold pressed from a round pipe of the size and weight shown on the plans. If cold pressed, the design of the press and dies shall be such as to give a pipe uniform in section and free from die marks. After the pipe has been formed to the oval section, it shall be cut to the exact length required. For two pipe railing, the lower pipe shall then be notched to receive the rail post as required by the railing details. Unless otherwise provided on the plans, the end cuts and notches shall be made at such angles with the axis of the pipe as may be required to produce vertical end faces and plumb posts in the finished structure. Cutting and notching of pipe shall be done with a saw or machine guided torch or other means that will insure a neat and workmanlike finish. The rail posts shall be cut to the proper length and fabricated in accordance with the details shown on the plans.

After the railing members have been so prepared, they shall be mounted in a jig so constructed that the posts and pipe will be clamped in their true relative position, accurately spaced with respect to each other. Unless otherwise provided on the plans, the posts and pipe shall be so positioned in the jig that a plane through the major axis of the pipe in the finished structure will be parallel to the roadway grade and at the specified angle thereto. For two pipe railing, in addition to the foregoing requirements, the major axes of the pipes shall lie in planes parallel to each other, the ends of both pipes shall lie in the same vertical plane and the centers of the pipes shall lie along the same vertical line. Thus assembled in the jig, the railing members shall be completely welded together and shall be allowed to cool before dismounting from the jig.

As each rail section is completely assembled and welded, the next succeeding section shall be set in its proper relative position thereto with ends engaged to the completed section and shall remain in this position until completely welded. The two sections shall then be matchmarked so that they may be erected in the same order in which they were fabricated and with the same ends matching.

(d) Painting. Rail members if not galvanized, shall be coated at the factory with one coat of one of the following paints at the option of the Contractor.

1. Primer protective coating.
2. #700 Shop Coat.

Primer protective coating shall be composed of fifty-five percent by weight of pigment and forty-five per cent be weight of vehicle. The pigment composition shall be six per cent lead sulphate, ten per cent zinc oxide, thirty-two per cent basic lead chromate, ten per cent of ninety-five per cent red lead, twenty-one per cent pure iron oxide (Fe_2O_3), and twenty-one per cent silica and silicates. The vehicle shall be of the fast drying, long oil varnish type. The non-volatile portion shall be a minimum of fifty-two per cent by weight of the total vehicle and shall consist of resins combined with drying oils in such manner as to impart a high degree of water resistance, adhesion, elasticity, and durability to the paint. The plates shall be clean at the time the coat is applied.

After erection, all parts of the members on which the first coat or galvanizing has become scratched or chipped shall be thoroughly cleaned and spot painted, using materials of the shop or first field coat.

For all galvanized rail members except pipe sections, painting will be required only on the roadway face and top edge of such rail members. These surfaces and the entire surface of pipe sections, galvanized pipe or black pipe, shall be given two field coats of paint.

If galvanized members are not used, all of the rail shall be given two field coats of paint.

Field paint for "Flex-beam," "Safety-beam" or other Guard Fence type railing shall conform to either of the following two classes at the option of the Contractor. Paint for all other types of railing shall conform to Class B.

CLASS A. The Number One Field Paint shall be composed of seventy-eight to eighty per cent pigment and twenty to twenty-two per cent vehicle. The pigment composition shall be eighty per cent metallic zinc and twenty per cent zinc oxide; the vehicle composition shall be ninety to ninety-five per cent linseed oil and five to ten per cent volatile and drier.

The Number Two Field Coat Paint shall be composed of two pounds of aluminum bronze powder to a gallon of aluminum varnish and must be mixed only on the day the paint is to be applied.

The aluminum bronze powder shall be free from adulterants and shall have suitable leafing property; ninety-eight to one hundred per cent shall pass the one hundred and forty mesh sieve; and fifty to one hundred per cent shall pass the three hundred and twenty-five mesh sieve. Aluminum varnish shall have suitable working and drying characteristics for aluminum paint and shall have fifty to fifty-seven percent non-volatile ingredients and forty-three to fifty per cent volatile ingredients. The non-volatile ingredients shall be composed of only China Wood Oil and Bakelite one hundred per cent phenolic resin with required drier. The ratio of oil to resin shall be forty to forty-five gallons of oil to one hundred pounds of resin.

CLASS B. The Number One Field Coat Paint shall be #701 No. 1 Field Coat. The Number Two Field Coat Paint shall be #703 Aluminum Paint.

Except as hereinabove specified, railing shall be painted in accordance with the requirements of Item S-408 "Paint and Painting."

S-422.4. MEASUREMENT. All railing which is not an integral part of the structure as described in Sec. S-422.1 will be measured by the linear foot complete in place in accordance with the dimensions and details governing quantities as shown on the plans.

S-422.5. PAYMENT. Payment will be made at the contract unit price bid per linear foot for railing of the type indicated on the plans, complete in place, measured as herein provided; which price shall be full compensation for furnishing, preparing and placing of all concrete, expansion joint material, reinforcing steel, structural steel, timber, pipe and all other materials required in the finished railing; and for all labor, tools, hardware, equipment, paint and painting, and incidentals necessary to complete the work in the manner and in accordance with the details specified in the contract.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-423

RIPRAP

S-423.1. DESCRIPTION. These specifications shall govern the furnishing and placing of Riprap of stone, concrete, or concrete in bags, of the kind and type indicated on the plans.

S-423.2. MATERIALS. Stone for Riprap shall consist of field stone or rough unhewn quarry stone as nearly uniform in section as is practicable. The stone shall be dense, resistant to the action of air and water and suitable in all respects for the purpose intended.

The stone used for Common Mortar Riprap may consist of broken up concrete, removed under the contract or obtained from other approved sources. Broken concrete shall be as nearly uniform in section as practicable and of the sizes specified in Section S-423.8, "Common Mortar Riprap."

Materials for concrete, grout and mortar shall conform to the requirements of Item S-403 and pertinent special provisions thereto. Concrete shall be of the class shown on the plans. Mortar and grout required for the several types of riprap shall consist of one part of Portland Cement and three parts of sand, thoroughly mixed with water. Mortar shall have a consistency such that it can be easily handled and spread by trowel. Grout shall have a consistency such that it will flow into and completely fill all joints.

Bar reinforcement shall conform to the requirements of Item S-405, "Reinforcing Steel."

Wire Mesh reinforcement shall consist of a welded fabric meeting the requirements of the A.S.T.M. Specification for Welded Steel Wire Fabric for Concrete Reinforcement (A-185).

Premolded expansion joint material shall conform to the requirements of Item S-402 and pertinent special provisions thereto.

S-423.3. CONSTRUCTION METHODS. The slopes and other areas to be protected shall be dressed to the line and grade shown on the plans prior to the placing of riprap. For Dry Riprap, Type A and B; Grouted Riprap Type A and B; and Mortar Riprap, the stones shall be so placed that the greater portion of their weight is carried by the earth and not by the adjacent stones.

Mortar or Grouted Riprap shall not be placed on embankment slopes until the embankment has been thoroughly compacted.

Spalls and small stones used to fill open joints and voids in stone Riprap shall be driven to a tight fit.

S-423.4. DRY RIPRAP, TYPE A AND TYPE B. Unless otherwise specified, all stones used in these types of Riprap shall weigh between fifty and one hundred and fifty pounds each, and at least sixty per cent of the stones shall weigh more than one hundred pounds each. The stones shall be placed in a single layer with close joints. The upright axes of the stones shall make an angle of approximately ninety degrees with the embankment slope. The courses shall be placed from the bottom of the embankment upward, the larger stones being placed in the lower courses. Open joints shall be filled with spalls. Stone of greater dimension than the required Riprap thickness shall be embedded in the embankment to present a uniform finished top surface such that the variation between tops of adjacent stones shall not exceed three inches. Stones that project more than the allowable amount in the finished work shall be replaced, embedded deeper, or chipped.

Dry Riprap, Type B, differs from Dry Riprap, Type A, only in that a toe wall of concrete, having dimensions and reinforcement as shown on the plans, shall be used.

S-423.5. DRY RIPRAP, TYPE C AND TYPE D. Stones having one broad flat surface shall be used when possible, this surface being placed 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. Fifty per cent of the mass shall be of stones weighing between one hundred and one hundred and fifty pounds each. These stones shall be placed first and roughly arranged in close contact. The spaces between the large 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 practicable.

Dry Riprap, Type D, Differs from Dry Riprap, Type C, only in that a toe wall of concrete, having dimensions and reinforcement as shown on the plans, shall be used.

S-423.6. GROUTED RIPRAP, TYPE A AND TYPE B. Stones used in these types of Riprap shall weigh between forty and one hundred and fifty pounds each. The stones shall be placed in the same manner as specified above for Dry Riprap, Type A and Type B, care being taken to prevent earth or sand from filling the spaces between the stones. After the stones are in place, they shall be thoroughly wetted and the spaces between the stones shall be completely filled with grout. The surface of the Riprap shall be swept with a stiff broom after grouting. No Riprap shall be grouted in freezing weather. The work shall be protected from the sun and kept moist for at least three days after grouting.

Grouted Riprap, Type B, shall have a concrete toe wall as specified for Dry Riprap, Type B.

S-423.7. MORTAR RIPRAP. 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 may be laid with a true and even surface and a minimum of voids. Fifty per cent of the mass shall be broad flat stones, weighing between one hundred and one hundred and fifty pounds each, placed with the flat surface uppermost and parallel to the slope. The largest stones shall be 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 placed with a degree of care that will insure for plane surfaces a maximum variation from the true plane of not more than three inches in four feet. Warped and curved surfaces shall have the same general degree of accuracy as specified for plane surfaces.

Before placing mortar, the stones shall be thoroughly wetted, and 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 embedded laterally. After the work has been completed as described above, 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.

S-423.8. COMMON DRY RIPRAP AND COMMON MORTAR RIPRAP. The stones for this type shall be not less than one-third of a cubic foot in volume and not less than three inches in least dimension. The width of the stone shall not be less than twice the thickness.

Prior to placing the stones, a suitable bed shall be excavated for the base course or layer. The material secured by excavation shall be used in dikes or dams around the end of the walls or uniformly spread on embankment slopes. The base course or layer of stone shall be bedded well into the ground with their edges in contact. Each succeeding course or layer shall be well bedded into and placed on even contact with its preceding course or layer. The finished surface shall present an even, tight surface true to line and grades of typical sections.

Sufficient mortar shall be used in Common Mortar Riprap to completely fill all voids in the layers of stone, and surface shall be swept with a stiff broom. Grout may be used in lieu of mortar. Spalls and small stones used to fill open joints and voids in Common Dry Riprap shall be driven to a tight fit.

S-423.9. CONCRETE RIPRAP. Concrete for Riprap shall be placed in accordance with the details and to the dimensions shown on the plans or as established by the Engineer. Unless otherwise shown on the plans, concrete Riprap shall be reinforced using wire mesh or bar reinforcement.

If wire mesh is used, it shall be a 6"x6" No. 6, or No. 6 plain electric welded reinforcing fabric or its equal. A minimum lap of six inches shall be used at all splices. At the edge of the Riprap, the wire mesh shall not be less than one inch nor more than three inches from the edge of the concrete and shall have no wires projecting beyond the last member parallel to the edge of the concrete.

If bar reinforcement is used, the sectional area of steel in each direction shall not be less than the sectional area of the wire mesh described above. The spacing of bar reinforcement shall not exceed eighteen inches in each direction and the distance from the edge of concrete to the first parallel bar shall not exceed six inches.

Reinforcement shall be properly supported throughout the placement to maintain its position equidistant from the top and bottom surface of the slab.

If the slopes and bottom of the trench for toe walls are dry and not properly consolidated, the Engineer may require the entire area to be sprinkled, or sprinkled and consolidated before the concrete is placed. All surfaces shall be moist when concrete is placed.

After the concrete has been placed, compacted and shaped to conform to the dimensions shown on the plans, and after it has set sufficiently to avoid slumping, the surface shall be finished with a wooden float to secure a reasonably smooth surface.

Immediately after the concrete has attained its final set, it shall be protected from the sun and kept moist for a period of three days.

S-423.10. CONCRETE RIPRAP IN BAGS. Concrete Riprap in bags shall consist of Class "D" Concrete placed in cloth cement bags or suitable burlap bags. The bags shall be filled about two-thirds full with concrete and the mouth of the bag securely wired shut. The bags shall be placed in position immediately after filling. When used for foundation protection, the bags shall be placed as directed by the Engineer.

When used for slope protection, Riprap in Bags shall be placed in conformity with the provisions governing the placement of Dry Riprap, Type C.

S-423.11. STONE RIPRAP FOR FOUNDATION PROTECTION. Stone for foundation protection shall range in weight up to three hundred pounds each, unless otherwise specified or shown on the plans, and shall be graded and so placed as to produce a minimum of voids. The top six inches shall be of graded smaller stones and shall be grouted, the grout and grouting to be in conformity with the requirements and methods outlined for Grouted Riprap, Type A and Type B.

S-423.12. MEASUREMENT. Measurement of acceptable Riprap complete in place will be made on the basis of the area actually covered, and the volume will be computed on the basis of the measured area and the thicknesses specified on the plans.

Concrete in toe walls will be measured as Riprap of the type with which it is placed.

S-423.13. PAYMENT. The Riprap quantities, measured as provided above, will be paid for at the unit prices bid per cubic yard for Riprap of the various classifications shown, which price shall be full compensation for furnishing, hauling and placing all materials including reinforcement and premoulded expansion joint material, and for all labor, tools, equipment and incidental necessary to complete the work.

Payment for all excavation involved in the preparation of slopes and toe wall trenches and for all necessary excavation below natural ground or bottom of excavated channel shall be included in the unit price bid per cubic yard of Riprap.

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Construction Specification
March, 1950

ITEM S-424

PHOTOGRAPHS

S-424.1. DESCRIPTION. This specification shall govern for the furnishing of photographs showing structures in progress of construction and finished structures. The structures to be photographed and the photographic requirements (progress photographs, final photographs or progress and final photographs) will be designated on the plans.

S-424.2. GENERAL. (a) The photographs shall be made by a professional photographer or other person experienced in such work and meeting the approval of the Engineer. Exposures shall be made at a time and from points designated by the Engineer.

(b) Contact prints of each photograph shall be furnished. The prints shall be gloss finish mounted on linen. The picture itself shall be approximately 7-1/2" x 9-1/2" with a 1/4" border on all sides and an additional 1" binder margin on the left end. The overall dimensions shall be exactly 8" x 11". Print enlargements may be substituted for the contact prints specified if the enlargements are made from a sharp, well focused negative which in the opinion of the Engineer will give enlarged prints comparable in quality to full size contact prints. Prints shall be accompanied by the original negatives of the pictures. Film stock negatives shall be furnished. Glass plate negatives are not acceptable.

S-424.3. PROGRESS PHOTOGRAPHS. One photograph shall be taken each month during the progress of the work on any structure for which progress photographs are designated. Unless otherwise provided on the plans or in pertinent special provisions, the Contractor shall furnish the Engineer four prints of each progress photograph for Federal Aid Projects and two prints of each progress photograph for State Projects. These prints shall be furnished as the work progresses.

S-423.4. FINAL PHOTOGRAPHS. A group of three photographs shall be taken of each structure for which final photographs are designated. Each exposure shall show a different view of the entire structure. The pictures shall be made of the completed structure after all equipment, surplus materials and debris have been removed from the site. Unless otherwise provided on the plans or in pertinent special provisions, the Contractor shall furnish the Engineer six prints of each final photograph for Federal Aid Projects and three prints of each final photograph for State Projects. These photographs shall be furnished upon completion of the project.

S-423.5. PAYMENT. No direct compensation will be made to the Contractor for the work and materials involved in furnishing the photographs as such work and materials shall be considered subsidiary to the several items for which unit prices appear in the contract.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-500

REMOVING OLD STRUCTURES

S-500.1. DESCRIPTION. These specifications shall provide for the removal and disposal of old structures or portions of old structures, as noted on the plans, and shall include all excavation and backfilling necessary to complete the removal. The work shall be done in accordance with the provisions of these specifications.

S-500.2. METHOD OF REMOVAL.

Culverts. Pipe culverts shall be removed by excavating all dirt on top and within six (6) inches of the sides 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/or sledging the concrete into sizes not larger than one (1) cubic foot.

Concrete portions of structures 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 dismantled in sections as determined by the Engineer. The sections shall be of such weight and dimensions as will permit convenient handling, hauling and storing. Rivets and bolts connecting steel railing members, steel beams of beam spans and steel stringers of truss spans shall be removed by cutting the heads with a "cold cut" and punching or drilling from the hole, or by such other method as will not injure the members for re-use and will meet the approval of the Engineer. The removal of rivets and bolts from connections of truss members, bracing members and other similar members in the structure will not be required unless specifically called for on the plans or special provisions and the Contractor shall have the option of dismantling these members by flame-cutting the members immediately adjacent to the connections. Flame-cutting will not be permitted, however, when plans or special provisions call for the structure unit to be salvaged in such manner as to permit re-erection. In such case, all members shall be carefully match marked with paint in accordance with diagram furnished by the Engineer prior to dismantling, and all rivets and bolts shall be removed from the connections in the manner specified in the first portion of this paragraph.

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 salvable by the Engineer.

Unless otherwise specified on the plans, timber piles shall be either pulled or cut off at a point not less than two feet below ground line, with the choice between these two methods resting with the Contractor.

Brick or Stone Structures. Brick or stone structures or stone portions of structures shall be removed by blasting and/or sledging the masonry into sizes not larger than one cubic foot.

Portions of such structures 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 (2) feet below the permanent ground line and neatly squared off.

Salvage. All material such as pipe culverts, structural steel, timber, railings, etc., which is deemed salvable 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 which are not deemed salvable by the Engineer shall become the property of the Contractor and shall be removed to suitable disposal sites off of the right-of-way and arranged for by the Contractor or otherwise disposed of in a manner satisfactory to the Engineer.

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 he shall dismantle and stack the material as required above as soon as the new structure is opened for traffic.

The bidder's attention is called to Item 7.9 regarding responsibility in the use of explosives.

Backfill. All excavation made in connection with this item and all openings below the natural ground line caused by the removal of old structures or portions thereof shall be backfilled to the level of the original ground line, unless otherwise provided on the plans.

That portion of the backfill which will support any portion of the roadbed or embankment shall be placed in layers of the same depth as those required for placing embankment. Material in each layer shall be uniformly wetted if required and shall be compacted to the density required in the adjoining embankment. In places inaccessible to blading and rolling equipment, mechanical or hand tamps or rammers shall be used to obtain the required compaction.

That portion of the backfill which will not support any portion of the roadbed or embankment shall be placed as directed by the Engineer in such manner and to such state of compaction as will preclude objectionable amounts of settlement.

S-500.3. MEASUREMENT. The work as provided for by this item shall be measured as each individual structure to be removed.

S-500.4. 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, equipment, excavation, backfilling, materials, and incidentals necessary to complete the work.

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ITEM S-505

PIPE UNDERDRAINS

S-505.1. DESCRIPTION. This item shall consist of pipe underdrains imbedded in filter material, constructed at such places as shown on plans or as designated by the Engineer, in accordance with these specifications and the plans for the work and in accordance with lines and grades established by the Engineer.

S-505.2. MATERIALS.

(1) Pipe

The pipe shall be of the type shown on the plans and the proposal and shall meet the following requirements:

(a) Vitrified Clay or Concrete Pipe.

The pipe may be either thoroughly and perfectly burned, glazed vitrified clay or unreinforced concrete. It shall be of first quality hub and spigot style pipe, sound, without warps or cracks or other imperfections; shall be manufactured in lengths of not less than two (2) feet or more than three (3) feet; and shall be sufficiently tough so that it may be cut with a chisel and hammer.

The diameter of vitrified clay or concrete pipe to be used shall be as indicated on the plans. The diameter shown will refer to inside barrel diameter.

(b) Corrugated Metal Pipe.

Except as herein modified, the pipe shall comply with A.A.S.H.O. Designation M 136-47 and current revisions. The pipe shall be of sixteen gage thickness and shall be of the specified diameter. The diameter shown will, in all cases, refer to manufacturer's nominal diameter.

Perforations shall be of 5/16 inch diameter and shall be placed in two rows on each side of the pipe. The holes shall be spaced on approximately one inch centers. The rows of perforations shall be in the area just above a line 30 degrees down from the horizontal axis, and no perforations shall be placed in the bottom third of the pipe.

Band coupers and branch connections shall have the same surface coating as required for pipe. All bolts on couplers and connections shall be galvanized.

(c) Asphalt Dipped Corrugated Metal Pipe

The pipe shall conform in all particulars to the requirements specified for "Corrugated Metal Pipe", and shall be dipped in asphalt. After fabrication and galvanizing, the pipe shall be submerged in a bath of asphaltic material maintained at a temperature between 400°F. and 425°F., and the pipe shall be kept in such bath until attaining the same temperature. It shall then be drained in a vertical position until cool. The asphalt for coating shall be 99.5% soluble in carbon tetrachloride. The coating on the pipe shall be uniform and shall have a minimum thickness of 0.03 inch.

(2) Filter Materials.

The filter material shall consist of sand conforming to the requirements specified for "Fine Aggregate" in the Item "Concrete for Structures".

S-505.3. CONSTRUCTION METHODS. The excavation of each trench shall begin at its outlet and proceed toward its upper end. The trench must not be excavated below the proposed grade line and shall be of the dimensions shown on plans, located as indicated on plans or where directed by the Engineer, and true to line and grade. The trench shall be dressed with a tile-hoe or shovel, in such manner that a groove will be made that will conform to the shape of the pipe.

When perforated metal pipe is used and the trench is founded in impervious material, a thin layer of tamped impervious material shall be placed on the bottom of the trench on each side of the pipe as indicated on the plans. If the bottom of the trench is founded on pervious material, the tamped layer shall be omitted. The pipe shall be laid with the perforations on the sides and the sections shall be joined with band couplers.

When vitrified clay or concrete pipe is used and the trench is founded in pervious material, a bottom course of the specified filter shall be placed and tamped to a uniform depth of two (2) inches. The pipe shall then be imbedded firmly in the filter material with the hub end upgrade and the spigot end fully entered into the adjacent hub. The open pipe joints shall then be covered with approved two (2) ply tar paper strips, not less than six (6) inches in width and of sufficient length to permit the ends being turned outward and laid flat on the bottom course of filter on each side of the pipe for a distance of three (3) inches. When the trench is founded in impervious material, the two (2) inch bottom course of filter shall be omitted, the pipe placed directly in the trench, and filter material placed in the trench to a depth of two (2) inches on each side of the pipe. The two ply tar paper strips shall then be placed as specified above.

After the pipes have been laid and approved, the remainder of the filter material shall be placed carefully to the depth shown on plans and in such manner as not to displace the pipe or joint covering around and over the pipe. The depth of the filter material shall, in no case, be less than twelve (12) inches above the bottom of the pipe. The remainder of the trench shall be filled with suitable earth, which shall be tamped in layers of four (4) inches.

Approved plugs shall be placed in the upper ends of all pipe and all exposed ends of pipe underdrains shall be covered with 1/2" galvanized hardware cloth as directed by the Engineer.

S-505.4. MEASUREMENT. Work and accepted material will be measured by the linear foot of pipe, complete in place.

S-505.5. PAYMENT. Work performed and materials furnished as prescribed for this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Pipe Underdrains (Vitrified Clay or Concrete)", "Pipe Underdrains (Corrugated Metal)", or "Pipe Underdrains (Asphalt Dipped Corrugated Metal)", as the case may be, of the size specified, which price shall be full compensation for excavating and backfilling the trench; furnishing and placing all pipe, filter material, and other materials; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-508

FINISHING ROADWAY

S-508.1. DESCRIPTION. This item shall consist of shaping, finishing, and cleaning the entire right-of-way as herein specified on such portions of the project as shown on the plans.

S-508.2. CONSTRUCTION METHODS. After the work as contemplated by the contract has been completed except for the exactness of finish as required by this item, the roadway shoulders, slopes, and ditches shall be smoothly trimmed and shaped; all ditches and channels within the right-of-way shall be cleared of all debris and obstructions; any excess earth or other waste material adjacent to structures, poles, trees or other objects shall be leveled down or otherwise disposed of as directed by the Engineer. All loose stones, rocks, and boulders within the right-of-way that would fail to pass a three (3) inch ring shall be removed from the shoulders and neatly piled along the edge of the right-of-way. All roots, trash, and other debris shall be disposed of as directed and the entire right-of-way placed in a neat and presentable condition.

The dragging, pushing, or scraping of material along or across the surface of the completed pavement will not be permitted.

S-508.3. MEASUREMENT. Acceptable work as prescribed for this item will be measured by the one hundred (100) foot station.

S-508.4. PAYMENT. The work performed as required by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Finishing Roadway", which price shall be full compensation for furnishing and operating all equipment, all loading, hauling, unloading, furnishing all labor, fuel, materials, tools, and implements incidental to the satisfactory performance of the work.

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ITEM S-509

GRASS EROSION CONTROL

S-509.1. DESCRIPTION. This item shall consist of providing and planting Bermuda grass or other acceptable sod along or across such areas as are designated on the plans and in accordance with these specifications.

S-509.2. MATERIALS.

(1) Sod. The sod shall consist of live, growing Bermuda grass or other acceptable sod secured from sources where the soil is fertile. The sod shall have a healthy virile root system of dense, thickly matted roots throughout the soil of the sod for a thickness of at least three (3) inches. The Contractor shall not use sod from areas where the grass is thinned out, nor where the grass roots have been dried out by exposure to the air and sun to such an extent to damage its ability to grow when transplanted. The sod shall be free from obnoxious weeds or other grasses and shall not contain any matter deleterious to its growth or which might affect its subsistence or hardiness when transplanted. Unless the area has been closely pastured, it shall be closely mowed and raked to remove all weeds and long standing stems. Sources from which it is to be secured shall be approved by the Engineer.

(2) Fertilizer . Fertilizer shall be that which is commercially termed 5-10-5 or having a different analysis but still meeting the 1-2-1 ratio requirement. The 5-10-5 analysis means that it shall contain not less than five (5) per cent nitrogen, ten (10) per cent of available phosphoric acid, and five (5) per cent of potash as determined by the methods of the Association of Official Agricultural Chemists.

S-509.3. CONSTRUCTION METHODS. After the designated areas have been completed to the lines, grades, and cross-sections shown on the plans and as provided for in other items of this contract, sodding of the type specified shall be performed in accordance with the requirements hereinafter described. Sod blocks, sod in which native soil must be attached to the roots, shall be obtained by excavating to a depth of not less than three (3) inches. Care shall be exercised to retain the soil on the roots of the sod during the process of excavating, hauling, and planting. Mechanical devices for cutting the sod into strips may be used. Sod material shall be planted within three (3) days after it is excavated and shall be kept moist from the time it is dug until planted. After planting, all sodding shall be watered and finished in accordance with the following requirements and as may be hereinafter further specified.

(1) Watering. When so directed by the Engineer, the sod existing at the source shall be watered in the manner and to the extent directed. The sod shall be thoroughly watered immediately after it is planted and shall be subsequently watered at such times and in the manner and quantity directed by the Engineer.

(2) Finishing. Where applicable, the shoulders, slopes, and ditches shall be smoothed after planting has been completed and shaped to conform to the cross-sections previously provided and existing at the time sodding operations were begun. Any excess dirt from the planting operations shall be spread uniformly over adjacent areas or disposed of as directed by the Engineer so that the completed surfaces will present a sightly appearance.

(3) Fertilizer. When an item for fertilizer is included in the plans and proposal, dry fertilizer shall be applied uniformly over the area specified to be fertilized and shall be incorporated into the soil a minimum of two (2) inches away from the root system of the sod. If the sodding is in rows, application of the fertilizer along the rows shall be continuous. In no case shall full strength dry fertilizer be permitted in direct contact with the sod. The fertilizer, dry and in good physical condition, shall be distributed in a manner suitable to the particular method of sodding and shall meet the approval of the Engineer.

Unless otherwise indicated on the plans, fertilizer shall be applied uniformly at the average rate of 600 pounds per acre or approximately 1/8 pound per square yard.

S-509.4. SPOT SODDING. Furrows parallel to the center-line of the road and approximately five (5) inches deep, eighteen (18) inches on centers, or to the dimensions and spacings shown on the plans, shall be opened as indicated on plans or as directed. Sod blocks shall be placed in the furrows as follows:

In the two furrows adjacent to the crown line, the sods shall form a continuous row, not less than three (3) inches wide.

In all other furrows, sods approximately three (3) inches square shall be placed on eighteen (18) inch centers.

Watering and finishing shall be performed as specified under Article 3.

S-509.5. TRENCH SODDING. Trenches parallel to the center-line of the road, or other reference lines, eighteen (18) inch on centers and five (5) inches deep, or to the dimensions and spacings indicated on the plans shall be opened at locations shown on plans or where directed. These prepared trenches shall then be filled with continuous strips or sod blocks and to an elevation which is flush with the adjacent ground surface. After watering and when sufficiently dry, trench sodding shall be rolled with a three hundred (300) pound roller or tamped to form a thoroughly compacted, solid mat.

Watering and finishing shall be performed as specified under Article 3.

S-509.6. BLOCK SODDING. At locations shown on plans or where directed, sod blocks shallbe carefully placed on the prepared area and watered. When sufficiently dry, it shall be rolled with a three hundred (300) pound roller or tamped to form a thoroughly compacted, solid mat. Any voids left in the block sodding shall be filled with additional sod and tamped. Surfaces of block sod, which, in the opinion of the Engineer, may slide due to the height and slope of the surface or nature of the soil, shall, upon direction of the Engineer, be pegged with wooden pegs driven through the sod blocks into firm earth, sufficiently close to hold the block sod firmly in place. Edges along curbs and drives, walkways, etc., shall be carefully trimmed and maintained until accepted.

Watering shall be performed as specified under Article 3.

S-509.7. GRASS RETARDS. Trenches shall be excavated across the side ditches or along the side or back slopes to the lines and dimensions shown on plans. After the trenches have been prepared, they shall be filled to an elevation flush with the adjacent ground surface with sod blocks.

After watering and when sufficiently dry, grass retards shall be rolled with a three hundred (300) pound roller or tamped to form a thoroughly compacted, solid mat.

Watering and finishing shall be performed as specified under Article 3. When directed by the Engineer, water shall be applied to the sod in the trench as the trench is being filled.

S-509.8. MULCH SODDING. The sod source shall be disked in two (2) directions cutting the sod thoroughly to a depth of not less than four (4) inches. Sod material shall be excavated to a depth of not less than four (4) inches or more than ten (10) inches, being careful to avoid having soil containing no grass roots. The disked sod may be windrowed, or otherwise handled in a manner satisfactory to the Engineer. The material shall be rejected if not kept in moist condition.

Prior to placing mulch sod, the cut slopes shall be scarified by plowing furrows four (4) inches to six (6) inches deep along horizontal slope lines at two (2) foot vertical intervals. Excavated material from the furrows shall not protrude more than three (3) inches above the original surface of the cut. The sod shall then be dumped upon the prepared area and spread uniformly to the required approximate thickness shown on the plans.

After the sod material has been spread, it shall be compacted by a roller developing fifteen (15) pounds to twenty-five (25) pounds per square inch. Any section not true to lines and cross-sections shall be remedied by the addition of sod material or by reshaping the material previously placed in order that a section conforming to the cross-sections previously provided will be obtained.

Watering shall be performed as specified under Article 3.

S-509.9. BROADCAST SPRIGGING. Except on areas recently loosened by construction, all ground on which grass or sod is to be placed shall be loosened by disking or other approved methods to a depth of not less than four (4) inches. All large clods shall be pulverized and boulders, rocks, or other debris shall be removed as directed. The Contractor shall take full advantage of weather conditions, but the work may be suspended when, in the judgment of the Engineer, the continuation of the same may result in unfavorable planting conditions.

The sod source shall be disked in two (2) directions, cutting the sod thoroughly to a depth of approximately four (4) inches, which shall be the maximum depth of excavation. The disked sod may be windrowed, or otherwise handled in a manner satisfactory to the Engineer. Sod material shall be loaded in such manner as to avoid taking soil containing no roots. The material shall be rejected if not kept in a moist condition.

The sod material shall be uniformly spread over the prepared area at the rate of approximately one (1) cubic yard per twenty-four (24) square yards of area. The area then shall be disked immediately in order to thoroughly incorporate the grass with the soil. A roller developing fifteen (15) pounds to twenty-five (25) pounds per square inch shall be used to compact the area after disking is completed.

Watering and finishing shall be performed as specified under Article 3.

S-509.10. MEASUREMENT. Work and acceptable material for "Spot Sodding", "Trench Sodding", "Block Sodding" and "Grass Retards" will be measured by the square yard complete in place. Work and acceptable material for "Mulch Sodding" and "Broadcast Sprigging" will be measured by the cubic yard in vehicles as delivered to the place of planting.

Fertilizer will be measured by the ton, as determined by approved scales or by guaranteed weight of sacks shown on the manufacturer's tag.

S-509.11. PAYMENT. The work performed and materials furnished and measured as provided under "Measurement" will be paid for at the unit price bid for "Spot Sodding", "Trench Sodding", "Block Sodding", "Grass Retards", "Broadcast Sprigging" or "Mulch Sodding" as the case may be, which prices shall each be full compensation for all items incident to completion of the work.

All fertilizer furnished, applied, and measured as provided under "Measurement" will be paid for at the unit price bid for "Fertilizer", which price shall be full compensation for all items incident to completion of the work.

All water, except that used for moistening the sod between the operations of digging and planting, will be measured and paid for in accordance with the provisions governing the Item of "Sprinkling".

Water used for keeping the sod damp from the time it is removed from the source until it is planted shall be considered subsidiary to the various pay items involved, and no direct compensation will be made therefor.

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ITEM S-510

ROCK RETARDS

S-510.1. DESCRIPTION. This item shall consist of a course or layer of stones with the spaces between them filled with spalls and selected earth and shall be constructed 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, grades, depth and other details shown on the pertinent typical sections.

S-510.2. MATERIAL. The stones shall be hard and durable, of uniform quality, free from structural defects, not less than one-third (1/3) of a cubic foot in volume and shall have a reasonable uniform thickness of not less than four (4) inches nor more than seven (7) inches. The width of the stones shall not be less than twice their thickness. The spalls shall be of material of similar quality.

Broken concrete pavement or other suitable concrete removed from retards or structures may be used in the construction of retards provided the material so removed meets the requirements specified for stone and provided other provisions are not made in the plans for use of the concrete.

All materials shall be approved by the Engineer prior to use.

S-510.3. CONSTRUCTION METHODS. Prior to placing any material, the excavation for retards shall be made to proper section for the width and depth of the retard. The stones shall be bedded in the trench, one against the other, with the ends in contact. The spaces between the larger pieces shall be filled with spalls of suitable sizes and the smaller interstices then filled with selected earth. All spalls and earth shall be thoroughly rammed into place. The finished surface of the retard shall present an even, tight surface, true to the lines, grades, and sections given.

Material excavated from the trench shall be uniformly spread on adjacent areas or otherwise disposed of as directed by the Engineer.

S-510.4. MEASUREMENT. Rock retards will be measured by the cubic yard, complete in place.

S-510.5. PAYMENT. The work performed and material furnished as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Rock Retards", which price shall be full compensation for all excavation, furnishing, hauling, and placing all material; disposal of excavated material; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-510A

GROUTED ROCK RETARDS

S-510A.1. DESCRIPTION. This item shall consist of approved stones laid in Portland Cement mortar, constructed 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, grades, depth, and other details shown on the pertinent typical sections.

S-510A.2. MATERIALS. The stone shall be clean, hard, and durable. The individual stones shall not be less than three (3) inches in their smallest dimensions, and no stones with a volume of less than one-tenth (1/10) cubic foot shall be used.

Broken concrete pavement or other suitable concrete removed from retards or structures may be used in the construction of retards provided the material so removed meets the requirements specified for stone and provided other provisions are not made in the plans for use of the concrete.

The mortar shall be composed of one (1) part Portland Cement and three (3) parts of clean, hard, durable sand thoroughly mixed with water to a consistency such that it can be easily handled and spread by trowel.

All materials shall be approved by the Engineer prior to use.

S-510A.3. CONSTRUCTION METHODS. Prior to placing the stones and mortar, the excavation for retards shall be made to proper section for the width and depth of retard. All stones shall be thoroughly cleaned, wetted, hand placed, and fully embedded in Portland Cement mortar so that no two will touch but shall be bound firmly together with mortar. The finished surface shall present a neat, smooth, and workmanlike appearance, with no pieces varying more than one (1) inch from the grades or lines of the surface of the retard, as shown on the plans.

No mortar work is to be done when the temperature is below 35°F. and all work shall be protected from freezing. After completion of the retard, all exposed surface shall be covered with burlap or other approved covering and kept wet for a period of three (3) days.

Material excavated from the trench shall be uniformly spread on adjacent areas or otherwise disposed of as directed by the Engineer.

S-510A.4. MEASUREMENT. Grouted Retards will be measured by the cubic yard, complete in place.

S-510A.5. PAYMENT. The work performed and material furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Grouted Rock Retards", which price shall be full compensation for all excavation; furnishing, hauling and placing all materials; disposal of excavated material; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-510B

CONCRETE RETARDS

S-510B.1. DESCRIPTION. This item shall consist of Portland Cement Concrete Retards, constructed at such places as shown on plans or as designated by the Engineer, in accordance with these specifications and in conformity with lines, grades, depth, and other details shown on the pertinent typical sections.

S-510B.2. MATERIALS. All concrete materials used in construction under this item shall conform to the requirements of the Item "Concrete for Structures".

S-510B.3. CONSTRUCTION METHODS. Prior to placing the concrete, the excavation for retards shall be made to proper section, and if considered necessary by the Engineer, the bottom of excavation shall be hand tamped and sprinkled. The excavated area for retards shall be moist when the concrete is placed.

The concrete for this item shall not be classified but shall be mixed in the proportions of one (1) part cement, three (3) parts of fine aggregate, and eight (8) parts of coarse aggregate, mixed in a manner acceptable to the Engineer with sufficient water to give the desired consistency.

After the concrete has been placed, compacted, and shaped to conform to the dimensions and cross-section shown on the plans, and after it has become sufficiently set, it shall be given a moderately rough finish by floating with a wood float.

No concrete work shall be done when the temperature is below 35°F., and all work shall be protected from freezing. After completion of the retard, all exposed surfaces shall be covered with burlap, cotton mats, or other approved covering and kept wet for a period of three (3) days.

Material excavated from the trench shall be uniformly spread on adjacent areas, or otherwise disposed of as directed by the Engineer.

S-510B.4. MEASUREMENT. Concrete Retards will be measured by the cubic yard, complete in place, as indicated on the plans. Measurement will be made in accordance with the neat lines shown on plans.

S-510B.5. PAYMENT. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Retards", which price shall be full compensation for all excavation, furnishing, hauling and placing all materials; disposal of excavated material; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-511

CONCRETE CURB

S-511.1. DESCRIPTION. This item shall consist of Portland Cement Concrete Curb, with or without reinforcing steel as required, constructed on an approved subgrade in accordance with this specification and in conformity with the lines and grades established by the Engineer, and details shown on the plans.

S-511.2. MATERIALS. Materials and proportions for concrete used in construction under this item shall conform to the requirements as specified for Class "A" Concrete under the item "Concrete for Structures", or concrete as specified in the item "Concrete Pavement". Reinforcing steel, if required, shall conform to the requirements as specified in the Item "Reinforcing Steel", or the Item "Concrete Pavement".

S-511.3. CONSTRUCTION METHODS. The subgrade shall be excavated and shaped to line, grade, and cross-section and, if considered necessary in the opinion of the Engineer, hand tamped and sprinkled. If dry, the subgrade shall be sprinkled lightly before concrete is deposited thereon.

Forms shall be of wood or metal, of a section satisfactory to the Engineer, straight, free of warp, and of a depth equal to the depth of the curb. They shall be securely staked to line and grade and maintained in a true position during the depositing of concrete. The inside forms shall be rigidly attached to the outside forms.

The reinforcing steel, if required, shall be placed in position as shown on the typical section. Care shall be exercised to keep all steel in its proper location.

Concrete for the curb shall be mixed in a manner satisfactory to the Engineer. The curb shall be placed in sections of the length indicated on plans, and each section shall be separated by a premoulded or board joint of approved material of cross section specified for the curb, and of the thickness indicated on the plans.

After the concrete has been struck off and after it has become sufficiently set, the exposed surfaces shall be thoroughly worked with a wooden float. The exposed edges shall then be rounded by the use of an edging tool to the radius as indicated on the plans. When the concrete in the curb has become sufficiently set, the inside form shall be carefully removed and all the surface thus exposed shall be pointed up where necessary, then wetted and rubbed with a wood block to remove all form marks and other irregularities, producing a finish similar in appearance to that previously finished.

The completed curb shall be covered with cotton mats, or two thicknesses of ten to twelve ounce burlap, and kept thoroughly wet for a period of four days, at which time the covering may be removed. Other methods of curing as outlined in the items "Concrete Pavement", and "Concrete Structures", will be acceptable.

S-511.4. MEASUREMENT. Concrete curb will be measured by the linear foot, complete in place.

S-511.5. PAYMENT. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Curb", which price shall be full compensation for preparing the subgrade, furnishing and placing all materials, including reinforcing steel and expansion materials; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-512

MONOLITHIC CONCRETE CURB

S-512.1. DESCRIPTION. This item shall consist of a Portland Cement Concrete Curb constructed on and poured monolithically with the pavement in accordance with this specification and in conformity with the lines and grades established by the Engineer, and details shown on plans.

S-512.2. MATERIALS. The materials used and their proportions shall meet the requirements prescribed in the governing item for "Concrete Pavement". Reinforcing Steel, if required, shall conform to the requirements as specified in the Item "Concrete Pavement".

S-512.3. CONSTRUCTION METHODS. All applicable requirements prescribed in the governing item for "Concrete Pavement" shall apply.

Outside forms shall be of wood or metal of a section satisfactory to the Engineer, straight, free of warp, and of a depth equal to the depth of the curb. They shall be securely staked to line and grade and maintained in true position during the placing of concrete. Inside forms if required for the curb shall be of approved material, of such design as to provide the curb required, and shall be rigidly attached to the outside forms.

The upper edges of the pavement shall not be rounded where curbing is to be constructed. The concrete for curb shall be placed in the forms while the concrete pavement is still plastic and shall be spaded with the concrete slab, in order that a thorough bond will be obtained. The top of the curb shall be floated smooth and the edges rounded to the radii shown on the plans while the concrete is still soft.

The curb shall be constructed in lengths equal to the adjoining pavement slab length, and joints shall be provided in the curb opposite each joint in the pavement. Joints shall be of the same type and thickness as required for the adjoining pavement and shall be of the section shown for the curb.

Monolithic curb shall be reinforced, or unreinforced, as indicated on plans.

The reinforcing steel, if required, shall be placed in position as shown on the typical section. Care shall be exercised to keep all steel in its proper location.

The forms shall be removed within twenty-four (24) hours after the concrete has been placed, and the face of the curb shall be rubbed down immediately to a smooth and uniform finish.

Curing shall be as specified in the item "Concrete Pavement".

S-512.4. MEASUREMENT. The curb will be measured by the linear foot complete in place.

S-512.5. PAYMENT. The work performed and materials furnished as prescribed for this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Monolithic Concrete Curb", which price shall be full compensation for furnishing and placing all materials, including reinforcing steel and joint materials; for finishing and curing; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-513

CONCRETE CURB AND GUTTER

S-513.1. DESCRIPTION. This item shall consist of Portland Cement Concrete Curb and Gutter with or without reinforcing steel as required, constructed on an approved subgrade in accordance with these specifications, in conformity with the lines and grades established by the Engineer, and details shown on the plans.

S-513.2. MATERIALS. Materials and proportions for concrete used in construction under this item shall conform to the requirements as specified for Class "A" Concrete under the Item, "Concrete for Structures", or concrete as specified in the Item "Concrete Pavement". Reinforcing Steel, if required, shall conform to the requirements as specified in the Item "Reinforcing Steel" or "Concrete Pavement".

S-513.3. CONSTRUCTION METHODS. The subgrade shall be excavated and shaped to line, grade, and cross-section, and, if considered necessary in the opinion of the Engineer, hand tamped and sprinkled. If dry, the subgrade shall be sprinkled lightly immediately before concrete is deposited thereon.

Outside forms shall be of wood or metal, of a section satisfactory to the Engineer, straight, free of warp and of a depth equal to the depth of the curb. They shall be securely staked to line and grade, and maintained in a true position during the depositing of concrete. Inside forms for the curb shall be of approved material, shall be of such design as to provide the curb required, and shall be rigidly attached to the outside forms.

The reinforcing steel, if required, shall be placed in position as shown on the typical section. Care shall be exercised to keep all steel in its proper location.

Concrete for curb and gutter shall be mixed in a manner satisfactory to the Engineer. The curb and gutter shall be poured in sections of the length indicated on the plans, and each section shall be separated by a premoulded or board joint of approved material of cross-section specified for the curb and gutter, and of the thickness indicated on the plans.

After the concrete has been struck off and after it has become sufficiently set, the exposed surfaces shall be thoroughly worked with a wooden float. The exposed edges shall then be rounded by the use of an edging tool to the radius indicated on the plans. When the concrete in the curb has become sufficiently set, the inside curb form shall be carefully removed and the surface thus exposed shall be pointed up where necessary, then wetted and rubbed with a wood block to remove all form marks and other irregularities, producing a finish similar in appearance to that previously finished.

The completed curb and gutter shall be covered with cotton mats or two (2) thicknesses of ten (10) to twelve (12) ounce burlap, and kept thoroughly wet for a period of four (4) days, at which time the covering may be removed. Other methods of curing as outlined in the Items "Concrete Pavement", and "Concrete Structures" will be acceptable.

The curb and gutter shall be backfilled to the full height of the curb, tamped and sloped as directed.

S-513.4. MEASUREMENT. Concrete curb and gutter will be measured by the linear foot, complete in place.

S-513.5. PAYMENT. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Concrete Curb and Gutter", which price shall be full compensation for preparing the subgrade; furnishing and placing all materials, including reinforcing steel and expansion material; for furnishing, placing, and shaping and tamping back fill behind curbs; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-514

RIGHT-OF-WAY MARKERS

S-514.1. DESCRIPTION. This item shall consist of constructing and/or installing reinforced concrete right-of-way markers on right-of-way lines at points designated on plans or as directed by the Engineer.

S-514.2. MATERIALS. Right-of-way Markers shall be precast of Class "A" Concrete conforming to the requirements of the Item "Concrete for Structures".

Reinforcing steel shall conform to the requirements of the Item "Reinforcing Steel".

S-514.3. CONSTRUCTION METHODS. Right-of-Way Markers shall be cast and finished in accordance with the requirements of the Item "Concrete Structures", except that a surface finish will not be required for the portion of the markers to be placed below the ground line. The shape and dimensions of the markers and the placement of steel shall be in accordance with details shown on the plans.

Markers shall be installed at designated points to the depth, lines, and grades established by the Engineer, and as shown on plans. Backfilling shall be thoroughly tamped in six (6) inch layers.

S-514.4. MEASUREMENT. Right-of-Way Markers will be measured as each marker, complete in place.

S-514.5. PAYMENT. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Right-of-Way Markers", which price shall be full compensation for furnishing all materials, all preparation and erection, all hauling, and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

When bids are requested for "Installing Right-of-Way Markers", satisfactory markers will be furnished the Contractor free of charge at sources indicated on plans for installation at designated points. The work, performed as prescribed by this item, and measured as provided under "Measurement", will be paid for at the unit price bid for "Installing Right-of-Way Markers". which price shall be full compensation for all hauling and erection, and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-515

CONCRETE SIDEWALKS AND DRIVEWAYS

S-515.1. DESCRIPTION. This item shall consist of sidewalks and driveways, with or without reinforcing steel, composed of Portland Cement Concrete, constructed as herein specified on an approved subgrade, in conformity with the lines and grades established by the Engineer, and the details shown on the plans.

S-515.2. MATERIALS. Materials and proportions used in construction under this item shall conform to the requirements as specified for Class "A" Concrete under the Item "Concrete for Structures" or concrete as specified in the Item "Concrete Pavement". Reinforcing Steel, if required, shall conform to the requirements as specified for the Item "Reinforcing Steel" or in the Item "Concrete Pavement".

S-515.3. CONSTRUCTION METHODS. The subgrade shall be excavated and shaped to line, grade, and cross-section and if considered necessary in the opinion of the Engineer, tamped and sprinkled. The subgrade shall be moist at the time the concrete is placed.

Forms shall be of wood or metal, of a section satisfactory to the Engineer, straight, free from warp, and of a depth equal to the thickness of the finished work. They shall be securely staked to line and grade and maintained in a true position during the depositing of concrete.

The reinforcing steel, if required, shall be placed in position as shown on the plans. Care shall be exercised to keep all steel in its proper location.

Sidewalks shall be constructed in sections of the lengths shown on plans. Unless otherwise provided by the plans no section shall be of a length less than eight (8) feet and any section less than eight (8) feet shall be removed by the Contractor at his own expense. The different sections shall be separated by an approved type of premoulded or board joint of the thickness shown on the plans, placed vertically and at right angles to the longitudinal axis of the sidewalk. Where the sidewalk or driveways abut a curb or retaining wall, approved expansion material shall be placed along their entire length. Similar expansion material shall be placed around all obstructions protruding through sidewalks or driveways.

Concrete shall be mixed in a manner satisfactory to the Engineer, placed in the forms to the depth specified, and spaded and tamped until thoroughly compacted and mortar entirely covers the surface. The top surface shall be floated with a wooden float until a slight excess of sand appears. The outer edges and joints shall then be rounded with approved tools to the radii shown on plans.

Sidewalks shall be marked into separate sections, each four (4) feet in length by the use of approved jointing tools.

When completed, the sidewalks and driveways shall be covered with cotton mats or two (2) thicknesses of ten (10) to twelve (12) ounce burlap and kept thoroughly wet for a period of seventy-two (72) hours at which time the covering may be removed. Other methods of curing as outlined in the Items "Concrete Pavement" and "Concrete Structures" will be acceptable.

S-515.4. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the square yard of surface area of completed sidewalks, or sidewalks and driveways, as the case may be.

S-515.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Sidewalks" or "Sidewalks and Driveways" as the case may be, which prices shall each be full compensation for preparing the subgrade; for furnishing and placing all materials, including all reinforcing steel and expansion joint materials; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-516

STEEL PLATE GUARD FENCE

S-516.1. DESCRIPTION. Steel plate guard fence shall consist of one line of steel plate supported on timber or steel posts and constructed of materials and workmanship as prescribed by these specifications, at such places as shown on the plan or as designated by the Engineer, and in conformity with the designated plans and typical details shown.

S-516.2. MATERIALS. The posts may be either timber or steel and shall meet one of the following requirements:

(1) Timber Posts. Timber posts shall be Southern Yellow Pine. All posts shall be round. End posts shall not be less, in any place, than eight (8) inches in diameter, and intermediate posts shall not be less, in any place, than seven (7) inches in diameter. They shall be of a length shown on the plans; the bottom shall be sawed off square, and the top shall be dome shaped. The posts shall be peeled and trimmed of all knots and knobs and shall be straight and smooth. The posts shall be sound and free from defects such as injurious ring shakes, large unsound or loose 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. Any defect or combination of defects which would be more injurious than the maximum allowable knot will not be permitted. A line drawn from the center of each end of the post shall not fall outside the center of the post at any point more than one and one-fourth (1 1/4) inches.

All timber posts shall have a creosote oil or pentechlorphenol treatment of not less than eight (8) pounds per cubic foot, as required in Items S-411 or S-411A. Posts shall be inspected at the time of treatment.

(2) Steel Posts. Steel posts shall be of the section and length shown on the plans. Posts of the rolled I-beam section shall be of structural steel conforming to the requirements of A.S.T.M. specification Designation A7. Posts of the pressed Z-section shall be formed from steel containing a minimum of 0.20% copper and of a tensile strength of not less than 75,000 pounds per square inch. The top of all posts shall be bevelled as required by details, and drilled or punched for bolts for rail attachment.

S-516.3. PLATE AND FITTINGS.

(1) Types 5 and 6. The rail plate shall be formed from copper-bearing steel (minimum 0.20% copper) of not less than No. 12 U.S. Standard Gauge. The depth of the beam formed by the rail plate shall be not less than 3 inches, measured perpendicular to the face of the rail, and the width of the finished rail plate shall be not less than 12 inches. The section modulus of the rail plate about an axis parallel to its face shall be not less than 1.30. The ultimate tensile strength of the plate material shall be not less than seventy-five thousand (75,000) pounds per square inch.

Plates shall be joined end to end by bolts, and where the plates are lapped rather than joined by a flush splice, the lap shall be in the direction of traffic in the lane adjoining the guard fence.

(2) Joints. All joints of connecting rail members shall have a strength in tension of at least sixty thousand (60,000) pounds. Bolts used therein shall be proportioned so that they will not fail under a load less than that specified above.

(3) Fittings. Fittings shall consist of bolts, nuts, and washers, and shall conform to the details given on the designated standard plan.

(4) Bolts. All bolts shall be made from steel and shall have proper strength for the purpose intended.

S-516.4. PRIMER PROTECTIVE COATING. Rail plates may be galvanized or ungalvanized. Rail plates, if not galvanized, and the coil springs for take-up shall be coated at the factory with one coat of a primer composed of fifty-five (55) per cent by weight of pigment and forty-five (45) per cent by weight of vehicle. The pigment composition shall be six (6) per cent lead sulphate, ten (10) per cent zinc oxide, thirty-two (32) per cent basic lead chromate, ten (10) per cent of ninety-five (95) per cent red lead, twenty-one (21) per cent pure iron oxide ($Fe_2 O_3$), and twenty-one (21) per cent silica and silicates. The vehicle shall be of the fast-drying, long oil varnish type. The non-volatile portion shall be a minimum of fifty-two (52) per cent by weight of the total vehicle and shall consist of resins combined with drying oils in such manner as to impart a high degree of water resistance, adhesion, elasticity, and durability to the paint. The plates shall be clean at the time the coat is applied. If galvanized plates are used, the primer protective coating will not be required.

Steel posts shall be coated at the factory with one coat of the specified primer applied on the entire surface while clean and dry. All shop coats shall be applied with a brush.

S-516.5. PAINT. The Number One Field Coat Paint, which is also used for spot painting, shall be composed of seventy-eight (78) to eighty (80) per cent pigment and twenty (20) to twenty-two (22) per cent vehicle. The pigment composition shall be eighty (80) per cent metallic zinc and twenty (20) per cent zinc oxide; the vehicle composition shall be ninety (90) to ninety-five (95) per cent linseed oil and five (5) to ten (10) per cent volatile and drier.

The Number Two Field Coat Paint shall be composed of two (2) pounds of aluminum bronze powder to a gallon of aluminum varnish and must be mixed only on the day the paint is to be applied. The aluminum bronze powder shall be free from adulterants and shall have suitable leafing property; ninety-eight (98) to one hundred (100) per cent shall pass the one hundred and forty (140) mesh sieve; and fifty (50) to one hundred (100) per cent shall pass the three hundred and twenty-five (325) mesh sieve. Aluminum varnish shall have suitable working and drying characteristics for aluminum paint and shall have fifty (50) to fifty-seven (57) per cent non-volatile ingredients and forty-three (43) to fifty (50) per cent volatile ingredients. The non-volatile ingredients shall be composed of only China Wood Oil and Bakelite one hundred (100) per cent phenolic resin with required drier. The ratio of oil to resin shall be forty (40) to forty-five (45) gallons of oil to one hundred (100) pounds of resin.

At the option of the Contractor, paint and painting may conform to the requirements for bridge rail painting as set out in the Item "Paint and Painting". The shop coats shall be applied with a brush. Field coats may be applied either by brushing or spraying.

S-516.6. CERTIFIED ANALYSIS. A certificate of analysis executed by the producer shall be furnished the Department setting forth the trade name or brand of paint or primer proposed for use under this item, together with a facsimile copy thereof and a typical analysis showing the percentage of each of the chemical elements in the pigment and vehicle. The producer shall provide that all paint or primer furnished and the trade name or brand given 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. After approval by the Department of a brand for a specific use, additional analysis will not be required for that brand unless requested.

S-516.7. GALVANIZING. Rail plates may be galvanized or ungalvanized. All other metal except coil springs for take-ups and posts shall be galvanized. Galvanizing shall be done by the hot double dip or electro-plate method, and the metal shall have a continuous coating of zinc of a uniform thickness, so applied that it will adhere firmly to the surface, and it shall be capable of withstanding four (4) immersions in a standard testing solution of copper sulphate without showing any trace of metallic copper. The first three (3) immersions shall be for a period of one (1) minute each, and the fourth (4) for a period of one-half (1/2) minute.

The use of ungalvanized chrome nickel bolts at plate connections will be permitted.

S-516.8. SAMPLING AND TESTING. A sample of the spring support and plate may be taken for each project or for each shipment to a project. Samples of bolts and compression springs may also be required. All samples shall be furnished to the Department free of charge. Producers shall furnish certificates as to the copper content of the steel from which the plates are made.

The plate shall be sampled and tested in accordance with the current requirements of the "Standard Methods of Tension Testing of Metallic Material", A.S.T.M. Designation E 8.

S-516.9. CONSTRUCTION METHODS. The posts shall be set plumb and firm to the line and grade shown on the plans. Backfilling shall be thoroughly tamped in four (4) inch layers. The steel plates and off-sets shall be erected on the posts and the guard fence constructed in accordance with the pertinent standard plans and these specifications.

Steel posts may be driven to the established line and grade where approved caps or driving devices are provided to avoid distortion of the metal. Before driving posts, the ground adjacent to the post shall be excavated to a depth of 6 inches below finished shoulder grade, and after placing, each post shall be painted from 6 inches below the ground surface to 2 inches above, with one brush-coat application of hot asphalt, finished to a neat line at the top.

After erection, all parts of metal posts and the plate on which the primer coat or galvanizing has become scratched or chipped shall be thoroughly cleaned and spot painted with the paint specified for the first field coat. The spot coat shall be allowed to dry for at least twelve (12) hours, after which the plate and metal posts shall be painted with Number One Field Coat. After the Number One Field Coat has dried for at least forty-eight (48) hours, the Number Two Field Coat shall be applied.

If the coil springs for take-ups are not painted with aluminum at the factory, they shall be painted on the job with paint as specified for the plates.

If galvanized plates are used, only the roadway face of rail shall be painted as specified above.

S-516.10. MEASUREMENT. Steel plate guard fence will be measured by the linear foot of fence, complete in place. Measurement shall be made upon the face of the rail in place, from center to center of end posts.

S-516.11. PAYMENT. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Steel Plate Guard Fence", of the types indicated on plans, which price shall be full compensation for furnishing all materials, for all preparation, hauling and erection and painting of same, and for all labor, tools, equipment, and incidentals necessary to complete the work, including excavation, backfilling, and disposal of surplus material.

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ITEM S-516A

TIMBER POST GUARD FENCE

S-516A.1. DESCRIPTION. Timber Post Guard Fence shall consist of posts only. All Guard Fence shall be constructed of materials and workmanship as prescribed by these specifications, at such places as shown on the plans or as designated by the Engineer, and in conformity with the designated plan and typical details shown.

S-516A.2. MATERIALS. The posts shall be Treated Southern Yellow Pine, and shall be not less than six inches (6") in diameter at any point. Posts that are placed in rock or rock embankment shall be not less than four feet (4') in length and posts that are placed in any other material shall be not less than five feet and six inches (5'-6") in length; the bottom shall be sawed off square and the top shall be dome shaped.

Posts shall be round and shall be peeled and trimmed of all knots and knobs and shall be straight and smooth. The posts shall be sound and free from defects such as injurious ring shakes, large unsound or loose 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. Any defect or combination of defects which would be more injurious than the maximum allowable knot will not be permitted. A line drawn from the center of each end of the post shall not fall outside the center of the post at any point more than one and one-fourth (1 1/4) inches. Posts shall be bored and cut to dimensions shown on plans before treatment.

Posts shall be inspected at time of treatment. All posts shall have a creosote oil or pentachlorphenol treatment of not less than eight (8) pounds per cubic foot, as required in Items S-411 and S-411A.

S-516A.3. CONSTRUCTION METHODS. The posts shall be placed as shown on the plans or as directed by the Engineer. Posts that are placed in rock or rock embankments shall be placed one foot and eight inches (1'-8") in the ground and two feet and four inches (2'-4") above the ground. Posts that are placed in any other material shall be placed three feet and two inches (3'-2") in the ground and two feet and four inches (2'-4") above the ground. The posts shall be set plumb and firm to the line and grade shown on the plans. Backfilling shall be thoroughly tamped in four-inch layers.

All timber posts shall be painted with two coats of aluminum paint after erection following which a six inch (6") band of black paint shall be painted eight inches (8") below the top of the post. The material for painting shall be a good quality of paint that will produce a neat and workmanlike job, satisfactory to the Engineer.

S-516A.4. MEASUREMENT. Timber Post Guard Fence will be measured as each post, complete in place.

S-516A.5. PAYMENT. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Timber Post Guard Fence", which price shall be full compensation for furnishing all materials, for all preparation, hauling and installation of same, and for all labor, tools, equipment, and incidentals necessary to complete the work, including furnishing and applying all paint, excavation, backfilling, and disposal of surplus material.

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ITEM S-516B

REMOVING TIMBER POST GUARD FENCE

S-516B.1. DESCRIPTION. This item will consist of the removing of existing guard fence posts that have been placed on the road and the stockpiling of these posts at a designated location within the limits of the project.

S-516B.2. CONSTRUCTION METHODS. Guard fence posts shall be loosened and pulled. The removal of these posts shall be performed in such manner that they will not be marred or damaged. All posts shall be cleaned and neatly stored at designated sites as directed by the Engineer. The storage sites will be within the limits of the project.

S-516B.3. MEASUREMENT. This item shall be measured as each individual post to be removed.

S-516B.4. PAYMENT. The work performed as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Removing Timber Post Guard Fence" which price shall be full compensation for removing and cleaning the existing posts, hauling and stockpiling, and for all labor, tools, equipment and incidentals necessary to complete the work.

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ITEM S-516C

PLACING TIMBER POST GUARD FENCE

S-516C.1. DESCRIPTION. This item shall consist of installing timber post guard fence and painting the posts.

S-516C.2. CONSTRUCTION METHODS. Posts shall be secured from stockpiles along the right-of-way, and shall be placed as shown on the plans or as directed by the Engineer. Posts that are placed in rock or rock embankments shall be placed one foot and eight inches (1'-8") in the ground and two feet and four inches (2'-4") above the ground. Posts that are placed in any other material shall be placed three feet and two inches (3'-2") in the ground and two feet four inches (2'-4") above the ground. The posts shall be set plumb and firm to the line and grade shown on the plans. Backfilling shall be thoroughly tamped in four inch layers. Any posts scarred, battered or broken by the Contractor shall be replaced at his own expense.

All timber posts shall be thoroughly cleaned of all dirt and other foreign matter and after erection, that portion of the post above the ground line shall be painted with one coat of aluminum paint following which a six inch (6") band of black paint shall be painted eight inches (8") below the top of the post. The material for painting shall be a good quality paint that will produce a neat and workmanlike job satisfactory to the Engineer.

S-516C.3. MEASUREMENT. "Placing Timber Post Guard Fence" will be measured as each post, complete in place.

S-516C.4. PAYMENT. Work and accepted materials, performed and measured as provided under "Measurement", will be paid for at the unit price bid for "Placing Timber Post Guard Fence", which price shall be full compensation for setting all posts, cleaning, furnishing and applying all paint, all necessary excavation, backfilling and for all labor, tools, equipment, hauling and incidentals necessary to complete the work.

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ITEM S-516D

REMOVING AND REPLACING TIMBER POST GUARD FENCE

S-516D.1. DESCRIPTION. This work shall consist of the removal of existing timber guard fence posts and replacing same on finished roadway at locations indicated on the plans in accordance with these specifications and the details shown on the plans, or as directed by the Engineer.

S-516D.2. CONSTRUCTION METHODS. Existing posts shall be removed in such a manner that they will not be damaged and shall be carefully placed in neat piles along the right-of-way so as not to interfere with traffic or construction until ready for replacement. Any posts scarred, battered or broken by the Contractor shall be replaced at his own expense.

Posts shall be placed as shown on the plans or as directed by the Engineer. Posts that are placed in rock or rock embankments shall be placed one foot and eight inches (1'-8") in the ground and two feet four inches (2'-4") above the ground. Posts that are placed in any other material shall be placed three feet two inches (3'-2") in the ground and two feet four inches (2'-4") above the ground. The posts shall be set plumb and firm to the line and grade shown on the plans. Back-filling shall be thoroughly tamped in four inch layers.

All timber posts shall be thoroughly cleaned of all dirt and other foreign matter and after erection that portion of the post above the ground line shall be painted with one coat of aluminum paint following which a six inch (6") band of black paint shall be painted eight inches (8") below the top of the post. The material for painting shall be a good quality paint that will produce a neat and workmanlike job satisfactory to the Engineer.

S0516D.3. MEASUREMENT. Removing and replacing Timber Post Guard Fence will be measured as each post, complete in place.

S-516D.4. PAYMENT. The work performed as prescribed by this item, measured as provided "Measurement", will be paid for at the unit price bid for "Removing and Replacing Guard Fence", which price shall be full compensation for furnishing all labor, tools, equipment, and incidentals necessary to complete the work, and for furnishing and applying all paint, all preparation, hauling and installation of same, and for all excavation, backfilling and disposal of surplus material.

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ITEM S-516E

REMOVING WIRE MESH, WIRE CABLE AND STEEL PLATE GUARD FENCE

S-516E.1. DESCRIPTION. This item shall consist of the removal of existing Guard Fence of the type shown on the plans, and its storage at locations shown on plans or as directed by the Engineer.

S-516E.2. CONSTRUCTION METHODS. All cable and wire mesh shall be carefully removed from the posts and rolled into convenient sized rolls and securely tied. All steel plate shall be carefully removed in its original length and neatly stacked. All fittings shall be removed from the posts and the metal rail. The posts shall then be loosened and pulled. Removal of all materials shall be performed in such manner that they will not be marred or damaged.

Posts which are set in concrete may be cut off one (1) foot below new subgrade elevation and the concrete and bottom of post left in place. Any concrete less than one (1) foot below subgrade shall be removed.

Eyebolts anchored to deadmen need not be removed but may be cut off or bent down at an elevation at least one (1) foot below subgrade elevation and left in place along with the deadman.

All materials thus removed and salvaged shall be neatly stored at designated sites or disposed of as directed by the Engineer.

The Contractor will not be required to haul the salvaged material more than one-quarter (1/4) mile.

S-516E.3. MEASUREMENT. "Removing Guard Fence", of the type specified will be measured by the linear foot. Measurement will be made upon the face of the fence in its original position, from center to center of end posts.

S-516E.4. PAYMENT. The work performed as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Removing Guard Fence", of the type specified, which price shall be full compensation for removing all materials, loading, hauling, unloading, and satisfactorily storing; and for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-517

OBLITERATING ABANDONED ROAD

S-517.1. DESCRIPTION. This item shall consist of the obliteration of designated sections of abandoned road by appropriate grading.

S-517.2. CONSTRUCTION METHODS. After the designated sections of an old road, or detours, are no longer needed for traffic, the ditches shall be filled and the roadway graded, either to restore approximately the original contour of the ground or to produce a pleasing appearance by forming natural, rounded slopes. Where shown on plans, borrow required for the new roadway shall be taken from fills on the old road, and surplus or waste material from the new roadway shall be placed in cuts on the old road. Old structures shall be broken down and buried or removed. All material with salvage value shall be carefully removed to avoid damage, and stored at designated sites or used in the construction of the new road where provided. The area of the old road surfacing shall be scarified or plowed to mix it effectively with earth, and the entire area of the old roadway shall be smoothed by blading or other methods.

Where directed, suitable topsoil or humus material shall be conserved and used in covering necessary areas for the purpose of facilitating regrowth of vegetation. No extra payment will be made or allowed for conserving such "Topsoil" material or for such humus material or for the utilization thereof save the payment of any "Overhaul" involved.

S-517.3. MEASUREMENT. Work as prescribed for in this item will be measured by the one hundred (100) foot station.

S-517.4. PAYMENT. The work performed as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Obliterating Abandoned Road", which price shall be full compensation for all manipulation, labor, tools, equipment, and incidentals necessary to complete the work.

Embankment materials removed from the old road for use in the new roadway, and excavated materials from the new roadway wasted on old road areas, and haul on such materials will be measured and paid for in accordance with the provisions governing the Items of "Borrow", "Roadway Excavation", and "Overhaul".

Structures designated on plans for removal will be measured and paid for in accordance with the provisions governing the Item "Removing Old Structures".

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ITEM S-518

REMOVING OLD CONCRETE

S-518.1. DESCRIPTION. This item shall consist of breaking up, removing, and satisfactorily storing or disposing of old concrete existing at locations shown on plans.

S-518.2. CONSTRUCTION METHODS. Existing concrete pavement (with or without bituminous top), sidewalk, driveway, combined curb and gutter, or curb shall be broken up into pieces not greater than eighteen (18) inches in any dimension by air-driven machinery or other suitable means. The use of explosives for breaking up old concrete to be removed will not be permitted except when authorized in writing by the Engineer, and when so authorized, adequate precautions shall be taken to prevent damage to adjacent property.

Where only a portion of the existing concrete is to be removed, special care shall be exercised to avoid damage to that portion of the concrete to remain in place. The existing concrete shall be cut to the neat lines shown on plans or established by the Engineer, and any existing concrete beyond the neat lines so established which is damaged or destroyed by these operations shall be replaced at the Contractor's entire expense.

Old concrete which is removed shall be loaded, hauled, and neatly stored at designated sites, or otherwise disposed of as directed. The Contractor will not be required to haul material over one-quarter (1/4) mile.

Work performed under this item shall be inaugurated at such time, and prosecuted in such manner as to cause a minimum of inconvenience to traffic or to the owners of adjacent property.

S-518.3. MEASUREMENT. Existing concrete pavement, concrete sidewalk, and concrete driveways, removed as prescribed above, will be measured by the square yard in its original position, regardless of its thickness or the depth of covering.

Existing combined concrete curb and gutter and concrete curb, removed as prescribed above, will be measured by the linear foot in its original position, regardless of the dimensions of same.

S-518.4. PAYMENT. The work performed as prescribed by this item, measured as provided "Measurement" will be paid for at the unit price bid for "Removing Old Concrete" (of the type specified), which price shall be full compensation for breaking up the concrete, loading, hauling, unloading, and satisfactorily storing or disposing of the material, and for all labor, tools, equipment, manipulation, and incidentals necessary to complete the work.

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ITEM S-520

ROADSIDE PLANTING

S-520.1. DESCRIPTION. This item shall consist of planting vines, shrubs and trees at point indicated on plans or as directed by the Engineer.

Planting Season. All planting shall be done between December 1st and March 1st, except as otherwise noted on plans or as specifically permitted by written order of the Engineer. Planting of Live Oaks will be permitted only between February 1st and March 1st.

S-520.2. MATERIALS. Plant materials shall be of first class grade, meeting all the requirements of the current standards of the American Association of Nurserymen, the size and height of which will be shown on plans. All plants shall be nursery-grown unless otherwise noted on plans. When the Supervising Landscape Architect is furnished sufficient evidence that suitable nursery-grown plants are not available, collected native material may be used. Plant materials having any of the following unnatural or objectionable features will be rejected.

1. Abrasions of the bark
2. Dried root system
3. Dried top wood or dried foliage of evergreens
4. Plants not true to type or specified size
5. Prematurely opened buds, or with buds stripped off
6. Diseased or insect-infested plants
7. Dry, loose, broken, and/or underweight ball of earth of balled and burlapped plants
8. Showing evidence of heating, molding, or freezing
9. Failure to have a permit tag of the State Department of Agriculture attached to the shipment of nursery grown plants.

(1) Collected Materials. Collected native materials shall have none of the above listed objectionable features and shall be taken from the soils in regions similar to those to which the plants are to be transplanted. At least three (3) days before beginning to dig any collected native plant material the Contractor shall notify the Engineer of the time and place of the proposed digging, and the Engineer shall within such three (3) days, either approve or disapprove the location as a source; however, the inspection of material will be made upon delivery to the project as hereinafter described. No plants shall be collected within view of any State or Federal Highway.

(2) Standard Nomenclature. "Standardized Plant Names", adopted by the American Joint Committee on Horticultural Nomenclature, shall govern.

When sufficient evidence is submitted showing that a specified tree or plant cannot practicably be obtained, substitutions in kind may be made upon written approval by the Engineer.

(3) Delivery. Material shall not be delivered upon the project until ordered in writing by the Engineer, and when so ordered, the Engineer shall be notified of a proposed delivery of plant materials at least twenty-four (24) hours prior to its arrival on the project. Each shipment shall be accompanied by an invoice showing the number, sizes, and varities of the materials included. B & B plants and bare-rooted plants shall be delivered with roots and balls in a moist condition, properly protected from sun and air from the time of digging until delivery on the project. Upon arrival, the Engineer shall make an immediate inspection and shall accept for planting or heeling-in all plants complying with these specifications; and any plants rejected under the same shall be immediately removed from the project.

(4) Receipt of Plants. On delivery of stock to the selected destination point or to the job, the Contractor shall assist the Engineer in the inspection of material. No shipment of plant material shall be accepted or planted by the Contractor until such material shall have been inspected and

accepted by the Engineer. In the measurement of trees, the caliper measurement for diameter shall be taken six (6) inches above the original ground line. In the measurement of shrubs, a plant well grown with single stem, well shaped and bushy, and having sufficiently well spaced side branches to give it weight equal to one grown with numerous canes, shall be an acceptable plant.

(5) Size of Balls for B & B Plants. All B & B stock shall have solid, firm balls which conform to the weights or sizes shown on plans.

Certain small shrubs commercially grown in cans or pots of usual size will be accepted in lieu of balled plants when permitted by the Engineer. Such plants shall be well established in containers before the planting season. At the time of planting potted plants, the root ball and plant shall be removed from the pot, care being taken to prevent the breaking of the ball. The root ball in a can shall not be removed, but the can shall be slit a minimum of four (4) times on the sides and one (1) slit on the bottom.

(6) Mulching. Mulching shall consist of loose, partially decomposed vegetable humus, and shall be free of dry leaves, sticks, excess soil, or other foreign matter. Mulching material shall be moistened to proper consistency before being placed around plants.

S-520.3. CONSTRUCTION METHODS. Immediately following delivery and inspection at the job, all plants with exposed roots and balled plants shall be "heeled in" in a moist material in a manner satisfactory to the Engineer. All plants "heeled in" shall be properly maintained by the Contractor until planted. In handling of plants the utmost care shall be exercised to prevent injuries to the tops or roots of the plants. The solidity of the B & B plants shall be carefully preserved, and such plants shall not be handled by the stems.

The means employed to protect plants with exposed roots from drying out during the time the plants are removed from the "heeling in" bed until actually planted shall be satisfactory to the Engineer. Certain bare-rooted plants such as yuccae, agave, and ocotillo shall have the roots exposed to the air for a period of twenty-four (24) hours prior to planting.

(1) Preparation of Soil. Planting holes shall be excavated to the depths and sizes as listed below:

Plants	Min.Depth of holes	Size of Holes		Approx. Quantity
		Square	Round	
1. Large Trees (1-1/2" Caliper and up to 3")	2.5'	4.0'x4.0'	4.5' Dia.	1.48 C.Y.
2. Small Trees (less than 1-1/2" caliper) Semi-Tree and Large Shrubs (where mature heights exceed 10')	2.0	3.0'x3.0'	3.4' Dia.	.67 C.Y.
3. Medium and Small Shrubs (where mature height is less than 10')	2.0'	2.5'x2.5'	2.9' Dia.	.46 C.Y.
4. Dwarf Shrubs and Vines (Ground Cover and herbaceous perennials)	1.5'	1.5'x1.5'	1.7' Dia.	.13 C.Y.

(Note: 1, 2, 3 and 4 in the first column refer to Key Numbers shown on plans.)

For holes on slopes the above minimum depths apply to the lower side. Size of pits for trees larger than three (3) inches will be noted on plans.

Topsoil from the excavated holes shall be kept separate from the subsoil and before backfilling shall be rendered loose and friable. When soil conditions require the introduction of additional topsoil to improve the soil excavated from the plant holes, it shall be furnished in the amounts directed.

Shape of planting holes will be adjusted to permit use of mechanical hole diggers.

(2) Pruning Roots. Any necessary pruning of the roots of bare-rooted plants shall meet the approval of the Engineer.

(3) Pruning of Tops. Plants shall not be pruned before delivery to the job, except by written permission of the Engineer. The topping of live oaks will not be permitted.

The final pruning of plants, unless otherwise required by the Engineer, shall conform to the best horticultural practice, and shall be appropriate to the various types of plants and the special requirements of each. Deciduous (non-evergreen) shrubs and trees with heavy tops shall have about one-third (1/3) to one-half (1/2) of the top growth removed. Plants otherwise acceptable, but with broken or badly bruised branches, shall have such branches removed with a clean cut. All cut surfaces over one (1) inch in diameter shall be painted with a tree pruning compound of approved manufacture.

(4) Planting and Backfilling.

(a) Depth of Transplanting. The depth to which plants shall be set shall be appropriate to the various types of material and the special requirements of each. In general, plants shall stand, after settlement of the backfill, slightly deeper than they stood in the nursery or collecting field. Roses, budded or grafted plants shall be set at least three (3) inches below previous earth line.

(b) All plants shall be ~~plated~~ planted plumb.

(c) Plants with Exposed Roots. After the soil in the bottom of the hole has been firmed and the plant placed in the proper position, loose, friable topsoil (or loam) shall be worked about the roots and thoroughly settled with water. Care should be taken to avoid bruising or breaking the roots. No sticks, sods, clods, or other material which would tend to form large air pockets in the soil shall be included in the backfill, except that small pieces of sod may be used near the bottom of the pit in limited amounts.

(d) Balled and Burlapped Plants. Plants of this type shall be handled in such manner that the soil of the ball will not be loosened. After the soil in the bottom of the hole has been firmed and the plant placed in the proper position, loose friable soil shall be worked about the ball until the hole is two thirds full. The hole then shall be filled with water and the backfilling completed working the soil and water well to prevent any air pockets. The planting of a hard, dry ball will not be permitted.

(e) Finishing Surface after Backfilling. The ground in planted areas shall be smoothed over as the work progresses and left in a neat and sightly condition. A shallow basin with a diameter equal to the hole or pit and a depth approximately one sixth (1/6) of this diameter shall be constructed around each plant. On Steep slopes, the soil on the lower side of the plant shall be graded in such manner that it will provide a basin as above specified.

Material excavated from the plant holes which is unsuitable for backfilling shall be utilized to form a basin around the plant or be thinly scattered and leveled off with all lumps broken fine so as to leave a neat, smooth appearance. In case the subsoil is of such consistency and lumpy character that it cannot be readily scattered over the surface of the planting areas in an acceptable manner, or in case the scattering of material will interfere with drainage, or otherwise be detrimental, all such material shall be removed and disposed of as directed.

(5) Staking and Bracing Trees and Shrubs. All trees shall be adequately braced diagonally with wires firmly attached to three (3) equally spaced two and one-half (2-1/2) foot stakes. Number 16 galvanized wire shall be used and shall be fastened to the tree using a section of rubber hose or three (3) thicknesses of burlap. All stakes shall be driven two (2) feet into the ground. Stakes may be of durable native wood and one and one-half (1-1/2) inches to three (3) inches in diameter with bark removed or of sawed pipe two (2) inches by two (2) inches. All staking shall be done immediately after the plants have settled. The Contractor shall stake the trees

in an approved manner that will present the most satisfactory appearance from the highway. Retightening of the wires shall be done as many times thereafter as may be required.

(6) Mulching. Mulching shall be placed to a depth of two (2) inches on top of the planted hole and fully intermixed with the upper layer of the soil. All plants shall receive mulching unless otherwise stated on plans.

(7) Watering. Water shall be applied at the time of planting, in quantities sufficient to fill the holes so that all air pockets are replaced with water. Water shall be applied as many times thereafter and in sufficient quantities as the seasonal conditions require to keep the ground moist well below the root system, until acceptance of the work.

(8) Maintenance. The Contractor shall maintain the planted area, keeping such areas within three (3) feet of the planted material clean of weeds until date of acceptance. In cases where insects or diseases affect the plants after planting, the Contractor shall protect or treat the plants in accordance with approved methods of horticultural practice.

S-520.4. MEASUREMENT. Work and accepted materials as prescribed for this item will be measured as each living vine, shrub, or tree in place at the time of the final inspection. After completion of all work provided for in the contract, the Engineer will make an inspection, and those plant materials not in an acceptable living condition shall be replanted prior to the final inspection and acceptance.

S-520.5. PAYMENT. Work and accepted material as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for each living vine, shrub, or tree in place, which price shall be full compensation for all items incident to completion of the work.

Additional Roadside Topsoil, when required for backfilling, will be measured and paid for in accordance with the provisions governing the Item of "Roadside Topsoil".

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ITEM S-521

ROADSIDE TOPSOIL

S-521.1. DESCRIPTION. This item shall consist of the furnishing and proper utilization of approved selected topsoil at the locations shown on plans and in conformity with these specifications.

S-521.2. MATERIAL. Topsoil shall be obtained from approved sources. It shall be fertile loam, easily cultivated, and free from grass, roots, weeds, or other objectionable material.

S-521.3. CONSTRUCTION METHODS. The Engineer shall be notified sufficiently in advance of the opening of any material source to permit inspection and to prepare for necessary checking and measurement.

Excavation for topsoil material shall not exceed eighteen (18) inches in depth except as noted on plans. During the period of removal of the topsoil material from the source, such source shall be kept drained in so far as practicable, and when all material has been removed, the site shall be left in a neat and presentable condition. Selected topsoil material shall be utilized to improve designated areas for planting and/or seed sowing purposes, as directed by the Engineer.

Payment will not be allowed for excavation of any material which is used for purposes other than those designated.

S-521.4. MEASUREMENT. Work and accepted material as prescribed for this item will be measured by the cubic yard of material in vehicles at the point of delivery.

S-521.5. PAYMENT. Work and accepted material as prescribed for this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Roadside Topsoil" which price shall be full compensation for all items incident to completion of the work.

Texas Highway Department
Construction Specification
March, 1950

ITEM S-522

ROADSIDE MASONRY

S-522.1. DESCRIPTION. This item shall consist of approved stone laid up dry or in a lime-cement mortar, as specified, and shall be constructed in accordance with these specifications, in conformity with the form, dimensions, and design shown on the plans, and to the lines and grades established by the Engineer.

S-522.2. MATERIALS.

(1) Stone. The stone shall be sound, durable, free from structural defects, uniform in color, shall have no rounded surfaces, and shall be clean of earth, clay, oil, or other foreign substances. Stratified rock shall be used when readily available on or adjacent to the project.

(2) Cement. Cement shall be a standard normal Portland Cement of an established brand or manufacturer acceptable to the Engineer.

(3) Lime. Hydrated lime shall be of an established brand or manufacturer acceptable to the Engineer.

(4) Sand. Sand shall be composed of clean, hard, durable, uncoated grains, free from lumps, soft or flaky particles, loam, organic matter or other injurious substances, meeting the approval of the Engineer.

(5) Water. Water which is suitable for drinking or for ordinary household use will be accepted for use with cement without being tested.

S-522.3. CONSTRUCTION METHODS. Masonry shall not be placed on fills or embankments until such earthwork has settled and has been thoroughly compacted. The excavation for the foundation trench shall be in accordance with the details shown on plans and the lines and grades established by the Engineer. All masonry shall be laid by experienced workmen in accordance with details shown on plans and these specifications. Methods used shall be such as will produce an attractive stratified-type of masonry of natural appearance. For walls, neither veneered work nor finely dressed stones shall be used. Although minimum sizes of stones are shown on the details, long, flat stones are preferred in all types of masonry. All voids shall be filled with mortar, small stones, or spalls. Exposed faces of stratified, sawed, or field stones used in walls shall be neatly broken with the hammer to produce a natural appearance. Tool marks shall be removed.

For Types I and II, all stones shall be fully embedded in a mortar mixed in the proportions, by volume, of one (1) part cement, one (1) part of lime, and six (6) parts of sand. The sand, cement, and lime shall first be mixed dry in a tight box until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains a consistency such that it can be easily handled and spread with a trowel. Mechanical mixing will be permitted.

Type I. This type masonry shall be hammer-dressed, coursed mortar rubble masonry. All stones shall be laid flat in horizontal courses. A single course shall be of uniform thickness throughout the length of the wall, except as otherwise noted on plans, but the individual courses shall vary in thickness within the limits shown on plans. Overlap between the vertical joints of the stones shall not be less than three (3) inches. Not less than ten (10) per cent of the stones of the body of the wall shall be headers, extending the full width of the wall, and spaced at intervals throughout the full length of the wall. The cap-stones shall be of uniform thickness and shall extend the full width of the wall, or as indicated on plans. The top surface shall be smooth and in accordance with the best practice of stratified flagging or hammer-dressed work.

Type II. This type masonry shall be hammer-dressed, random coursed mortar rubble masonry. All stones shall be laid in horizontal courses or on level beds. Individual courses shall be of

stones of uniform thickness, but the courses may be broken at intervals with larger stones to form a random pattern. The overlap between the vertical joints of the stones shall not be less than three (3) inches. Not less than ten (10) per cent of the stones of the body of the wall shall be headers, extending the full width of the wall, and spaced at intervals throughout the full length of the wall. The cap-stones shall be composed of stones of uniform thickness and shall extend the full width of the wall. The top surface shall be smooth and in accordance with the best practice of stratified flagging or hammer-dressed work.

Type III. This type masonry shall be random coursed dry rubble masonry. All stones shall be roughly dressed and firmly laid with their bedding planes in horizontal courses. The courses may be broken at intervals with larger stones to form a random pattern. The overlap between the vertical joints of the stones shall not be less than four (4) inches. Headers shall be distributed uniformly throughout the wall so as to form not less than one-sixth of the exposed faces, and each shall extend the full thickness of the wall. The cap-stones shall be a minimum of four (4) inches in thickness and shall be laid in mortar in accordance with the details for cap-stones for Roadside Masonry--Type I.

Type IV. This type masonry shall be flagstone work; stones shall be laid without mortar unless otherwise noted on plans. The flagstone floor or walk shall be constructed of stones with an average thickness of four (4) inches, and a minimum thickness of three (3) inches. The subgrade shall be carefully prepared, tamped, and checked prior to the laying of the stones. Filling and removal of material may be made to offset any irregularities in depth of stones. The surface of the flagstones shall not project more than one-half (1/2) inch below or above the grades shown on plans or given by the Engineer. Fifty (50) per cent of the flagstones shall have an area of not less than three (3) square feet. The stones shall be carefully shaped with joints conforming to the details shown on plans. The outer edges of the flagstones shall be carefully shaped to a uniform line.

S-522.4. MEASUREMENT. Roadside Masonry Types I, II and III will be measured by the cubic yard, complete in place.

Roadside Masonry Type IV will be measured by the square yard, complete in place.

S-522.5. PAYMENT. Work and accepted material as prescribed for this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Roadside Masonry", of the type specified, which price shall be full compensation for all items incident to completion of the work.

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ITEM S-523

ROADSIDE PARK FIXTURES

S-523.1. DESCRIPTION. This item shall consist of the construction of tables, benches, and fireplaces at such locations as are shown on the plans or as directed by the Engineer, and in accordance with these specifications and the details shown on plans.

S-523.2. MATERIALS.

(1) Stone. The stone materials for masonry shall be sound, durable, free from structural defects, uniform in color, have no rounded surfaces, and shall be free from earth, clay, oil, or other foreign substances. Stratified rock shall be used when within reasonable hauling distance.

(2) Cement. Cement shall be a standard normal Portland Cement of an established brand or manufacturer acceptable to the Engineer.

(3) Lime. Lime shall be hydrated lime of an established brand or manufacturer acceptable to the Engineer.

(4) Fine Aggregate. Fine Aggregate shall be composed of clean, hard, durable, uncoated grains, free from lumps, soft or flaky particles, loam, organic matter, or other injurious substances and shall be uniformly graded from coarse to fine.

(5) Coarse Aggregate. Coarse Aggregate shall consist of clean, tough, durable particles of gravel or stone (excluding schist, shale, or slate) of uniform quality throughout and shall be free of deleterious substances that might affect the durability. All material shall pass a three-fourths (3/4) inch screen, thirty (30) per cent to seventy (70) per cent shall pass a one-half (1/2) inch screen, and ninety-five (95) per cent to one hundred (100) per cent shall be retained on a one-fourth (1/4) inch screen.

(6) Water. Water that is suitable for drinking or for ordinary household use may be accepted for use with cement without being tested.

(7) Reinforcing Steel. Reinforcing Steel shall be of the sizes, weights, and lengths shown on plans and shall be free from rust and any imperfections and shall meet the approval of the Engineer.

(8) Metal. Metal for grates shall be of wrought iron or mild steel meeting the approval of the Engineer.

(9) Firebrick. Firebrick shall be a standard brand of fire brick, meeting the approval of the Engineer.

S-523.3. CONSTRUCTION METHODS. Masonry for the incinerator, tables, benches, and fireplaces shall be of the type shown on plans, and shall be constructed in accordance with the requirements of Item 522 "Roadside Masonry". The excavation for the foundation shall be in accordance with the details shown on plans. An interval of not less than twenty-four (24) hours shall elapse between the completion of the stone masonry work and the placing of the concrete table top.

Forms for the table top shall be constructed of materials free from knot holes, loose knots, cracks, splits, or any other imperfections that will affect the appearance of the finished concrete surface. The forms shall be painted with a colorless oil, then thoroughly drenched with water before the placing of concrete. No concrete shall be placed until the Engineer has approved the forms and the placing of the steel.

Concrete for the table top shall be mixed in the proportions of one part of cement to two parts of sand to three parts of coarse aggregate, loose measurement. The ingredients shall be mixed dry in a water-tight box until the mixture assumes a uniform color, after which water shall be added and the mixing continued until the concrete is smooth in appearance and of such consistency that it may readily be worked around the reinforcing steel. Mechanical mixing will also be permitted. After the concrete has been allowed to set sufficiently, the side forms shall be removed and all rough places, holes, and porous spots shall be filled with mortar composed of one (1) part Portland Cement to two (2) parts of sand. The sides and upper surfaces of the table top shall be finished with a steel trowel. No concrete shall be placed in freezing weather. All masonry and concrete shall be protected from the sun and kept wet for a period of at least seven (7) days. Bottom forms for the concrete table top shall remain in place until curing is completed.

The fireplace grate shall be constructed of wrought iron or mild steel, in accordance with the details shown on plans. Concrete for fireplace top shall be constructed as specified for table top.

Incinerator shall be constructed in accordance with details as shown on plans.

S-523.4. MEASUREMENT. Roadside Park Fixtures will be measured by the set of one (1) table and two (2) benches; each incinerator; and each fireplace, complete in place.

S-523.5. PAYMENT. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit prices bid for "Table and Benches", "Incinerator", and "Fireplace", which prices shall each be full compensation for all items incident to completion of the work.

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ITEM S-524

ROADSIDE PARK DEVELOPMENT

S-524.1. DESCRIPTION. This item shall consist of the removal and disposal of all objectionable material, and the smoothing and dressing of the entire park area in accordance with these specifications and details shown on the plans and as directed by the Engineer.

S-524.2. CONSTRUCTION METHODS. Trees and brush designated for preservation shall be carefully trimmed and/or pruned and shall be protected from scarring, barking, or other injuries during construction operations.

The park area shall be cleared and grubbed of all undesirable trees, stumps, under-growth, brush, and vines; and all logs, roots, weeds, rocks, debris, and other objectionable material shall be removed from the area as directed by the Engineer.

The entire park area shall be smoothed and dressed by approved methods to section as shown on plans and the lines and grades established by the Engineer.

All cleared and grubbed material shall be disposed of in a manner satisfactory to the Engineer. Unless otherwise provided, all merchantable timber removed as above required shall become the property of the Contractor.

Upon completion of all work, the park area shall be left in a neat and sightly condition.

S-524.3. MEASUREMENT. Work performed as prescribed for this item shall be measured by the acre.

S-524.4. PAYMENT. All work performed and measured as provided under "Measurement", will be paid for at the unit price bid for "Roadside Park Development", which price shall be full compensation for all items incident to completion of the work.

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ITEM S-525

ROADSIDE SURFACE COURSE

S-525.1. DESCRIPTION. This item shall consist of a surface course composed of gravel, caliche, iron ore, or shell materials and shall be constructed on the prepared subgrade for drives, roadways, parking areas, paths in parks, or elsewhere specified on plans in accordance with these specifications and in conformity with the typical cross-sections shown on plans and the lines and grades as established by the Engineer.

S-525.2. MATERIALS. The material shall be obtained from approved sources; shall meet the approval of the Engineer; and shall meet the following requirements for the type or types specified on plans:

(1) Gravel. The material shall consist of hard durable particles of gravel or stone mixed with acceptable binding material. All material shall pass the one and one-half (1 1/2) inch screen.

(2) Caliche. The material shall consist of argillaceous limestone, calcareous or calcareous clay particles, with or without stone, conglomerate gravel, sand, or other granular materials. All material shall pass the one and one-half (1 1/2) inch screen.

(3) Iron Ore. The material shall consist of hematite, hydrated hematite, or limonite ore occurring with or without sand as found at or near the surface, which, when loaded from the material pit, shall not contain an excess of free clay. All material shall pass the two (2) inch screen.

(4) Shell. The material shall consist of durable particles of shell together with approved binding material. All material shall pass a two and one-half (2 1/2) inch screen and not over twenty (20) per cent shall pass a two hundred (200) mesh sieve.

S-525.3. CONSTRUCTION METHODS. The subgrade shall be shaped in conformity with the typical cross-sections shown on plans and the lines and grades established by the Engineer. All holes, ruts, and depressions shall be filled with approved material, and if required, the subgrade shall be sprinkled. Material excavated in the preparation of the subgrade shall be spread on adjacent areas as directed.

The surfacing material shall be delivered in vehicles of uniform capacity and spread upon the prepared subgrade in the amounts required. The material shall be sprinkled, if directed, and bladed, dragged, and shaped to conform to typical sections as shown on plans. All irregularities of surface which cannot be corrected by blading or luting shall be corrected by the addition or removal of material. The edges shall be carefully shaped to conform with the lines shown on plans or established by the Engineer.

When, and as directed by the Engineer, the course or courses shall be sprinkled, and then compacted with an approved roller or with a loaded dual-wheel truck of not less than seven thousand (7,000) pounds weight. Corners inaccessible to the roller or trucks shall be hand tamped. During rolling and compacting operations the course shall be maintained true to grade and section by dragging or other approved methods and the addition of approved material as required. The surface shall be maintained in a satisfactory manner until the work is accepted.

S-525.4. MEASUREMENT. Work and accepted material, as prescribed for this item, shall be measured by the cubic yard of material, in vehicles at the point of delivery on the project.

S-525.5. PAYMENT. The work performed, and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit price bid for "Roadside Surface Course", which price shall be full compensation for all items incident to completion of the work.

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ITEM S-526

ROADSIDE GUARD POSTS

S-526.1. DESCRIPTION. This item shall consist of the furnishing and placing of guard posts along park drives or at other locations indicated on the plans in accordance with these specifications and the details shown on the plans.

S-526.2. MATERIALS. All native or dimensioned material for guard posts shall be of the kind and sizes shown on the plans. Native posts shall be peeled or unpeeled as shown on plans, shall be trimmed of all knots and knobs, and shall be reasonably straight and smooth. If treated posts are specified, the Contractor shall furnish an affidavit executed by the producer showing that the post material, creosote oil, and manner of treatment, comply with the Department's current specifications for treated "Timber Post Guard Fence" except for dimensions.

S-526.3. CONSTRUCTION METHODS. Post holes shall be excavated at the locations shown on the plans or as directed by the Engineer, to such depths that when the posts are set plumb they will project the required distance above the normal ground line and will be true to the required line and grade. Backfilling shall be thoroughly tamped in four (4) inch layers. Posts shall be so selected that those of the largest diameter shall be set adjacent to the highway, the sizes gradually decreasing to the most remote point from the highway.

S-526.4. MEASUREMENT. "Roadside Guard Posts" will be measured as each post, complete in place.

S-526.5. PAYMENT. The work performed and materials furnished and measured as provided under "Measurement" will be paid for at the unit price bid for "Roadside Guard Post" which price shall be full compensation for all items incident to completion of the work.

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March, 1950

ITEM S-527

ROADSIDE ARBORS

S-527.1. DESCRIPTION. This item shall consist of the construction of arbors at points indicated on the plans, in accordance with these specifications and the details shown on the plans.

S-527.2. MATERIALS. All posts, rails, and poles shown to be of native material shall be reasonably straight and shall be trimmed true and flush throughout with the bark remaining or removed as indicated and shall be of the kind and approximate sizes shown on the plans. Dimensioned material shall conform to the kind, commercial sizes, and grades shown on the plans. Hardware shall be of wrought iron or mild steel of the approximate sizes shown on the plans and shall meet the approval of the Engineer. Wire shall be of the size and type shown on plans.

S-527.3. CONSTRUCTION METHODS. Arbors shall be constructed in accordance with the details shown on the plans and as directed by the Engineer. All work shall be performed in a neat and workmanlike manner. Supporting posts shall be set plumb and rigid and cross members securely placed.

When specified in connection with arbors, masonry shall be constructed under Item 522, "Roadside Masonry".

S-527.4. MEASUREMENT. "Roadside Arbors" will be measured by the square yard complete in place. Measurement shall be made from center to center of outside supporting posts.

S-527.5. PAYMENT. The work performed and materials furnished as prescribed by this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Roadside Arbors", which price shall be full compensation for all items incident to completion of the work, except roadside masonry.

All masonry constructed in connection with arbors will be measured and paid for in accordance with the provisions of the Item "Roadside Masonry".

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Construction Specification
March, 1950

ITEM S-528

METAL SERIES RAILROAD CROSSING SIGNS

S-528.1. DESCRIPTION. These specifications shall provide for furnishing and installing two reflectorized railroad crossbuck signs and two reflectorized advance warning signs which together shall comprise the standard "Metal Series Railroad Crossing Signs".

S-528.2. MATERIALS.

(1) Sheet Steel for Signs. Sheet steel shall be corrosion resisting. The total amount of carbon, manganese, phosphorus, sulphur and silicon shall not exceed 0.70 per cent. If the total amount of these 5 elements equals or exceeds 0.20 per cent, the metal shall contain not less than 0.17 per cent copper and not more than 0.06 per cent sulphur. If the total of these 5 elements is less than 0.20 per cent and sulphur is not greater than 0.04 per cent, the presence of copper is optional with the Contractor. The metal shall, after fabrication, be uniformly coated with a good quality of zinc and the surface of the coated metal shall be of such nature that the primer will adhere firmly. Zinc coating shall be applied by the hot dip method and heat treated after coating in such manner as to give a tight dull coat which will not peel or flake on the outside of a flat reverse bend and which shall have the characteristics of a matter and shall be free from bright or flossy spangle, or shall be applied by electro-chemical deposition in a manner which will give equivalent results.

(2) Sheet Steel Crossbuck Signs. Sheet steel crossbuck signs shall conform to these specifications and to the details shown on the plans. The front, back, and intermediate plates shall be No. 16 U.S. Standard Gage (.0625 inches thickness). Reinforcing plates used in the back of signs shall be 1/4" in thickness. The front and back plates of the sign shall be flanged to a depth of not less than 1/2 inch. Flanges shall be welded at the corners. The front plate shall be slightly larger than the back plate so that it will freely telescope over the flanges of the back plate. The front plate shall have the legend of the sign embossed upon it. The embossed legend shall be raised not less than 0.085 inches nor more than 0.125 inches. The dimensions, inside, between the front and back plates shall be such as is necessary to meet the requirements of this specification and the particular reflector units assembled in the sign. The front plate shall be attached to the back plate by bronze screws of special design which can not be removed with an ordinary screw driver. If nuts are used, they shall be of such design that they can not be removed with ordinary pliers, wrench, or screw driver. The opening for reflector buttons in the front plate shall be approximately 3/4 inches in diameter and shall be such that any metal rim of the reflector buttons will not be visible when the buttons are assembled in the sign. The reflector buttons shall be securely held by the intermediate plate with their axes perpendicular to the face of the sign in such manner that the buttons may not be removed except by first dismantling the sign. The intermediate plate shall be readily removable without the use of tools and when removed shall release the reflector buttons. Reflector buttons shall project not more than 1/4 inch outside the aperture in the face of the sign. A durable waterproof gasked of non-corrosive material shall be used between the reflector buttons and the front plate.

(3) Sheet Steel Advance Warning Sign. Sheet steel advance warning signs shall conform to these specifications and the details shown on the plans. The front plate shall be of a minimum thickness of No. 12 U.S. Standard Gage (0.1055 inches thickness) and the intermediate and back plates shall be of a minimum thickness of No. 18 U.S. Standard Gage (0.0475 inches thickness). The dimensions inside between the front and back plates shall be such as is necessary to accommodate the reflector buttons when the units are assembled together. The back plate shall be provided with a flange of such design that when the front, back, and intermediate plates are assembled together with reflector buttons the interior of the housing will be effectively sealed. The three plates shall be securely held together by not less than eight galvanized steel or brass bolts of a minimum size of 3/16 inches equally spaced and located near the outer circumference of the sign face. The openings for reflector buttons in the front plate shall be approximately 3/4 inches

in diameter and shall be such that any metal rim of the reflector buttons will not be visible when the buttons are assembled into the sign. The reflector buttons shall be securely held by the intermediate plate with their axes perpendicular to the face of the sign in such manner that they may be readily replaced and so that the buttons may not be removed except by first dismantling the sign.

(4) Paint and Painting of Metal Signs. The metal shall be thoroughly cleaned before painting. All paint for metal signs shall be of high commercial quality. The prime coat shall consist of red lead chromate or a suitable iron oxide primer of the long oil type applied to all surfaces prior to assembly. The finish coats shall consist of synthetic enamel; the legend of the crossbuck sign being black and all other exterior surfaces being white, eggshell finish; the border, cross and letters of the advance warning sign being black, eggshell finish and all other exterior surfaces being federal yellow, semi-gloss finish. Each color shall consist of three top coats smoothly and evenly applied. Paint shall be applied in accordance with the patterns and dimensions shown on the plans.

(5) Reflector Buttons. Reflector buttons shall be incorporated into the signs in accordance with the details and patterns shown on the plans. The lenses shall be made of clear, practically colorless glass of uniform reflecting power. Each lens shall be accurately formed and free from all defects which adversely affect optical or physical properties. It shall be practically free from chromatic abberation when viewed within an angle of 30 degrees from its axis. The lens shall be so designed that a light at any point within 30 degrees of the axis of the lens will be reflected to a point 40 inches above the source with clear intensity. The source of light shall be an automobile headlight equipped with 32 candle power bulbs and shall be located at 300 feet from the reflector. The reflector button shall be accurately formed and constructed for correct focus. The reflecting surface shall be silvered and shall be hermetically sealed so that the reflector button may be immersed in ice water at 2 degrees centigrade for 30 minutes then transferred to hot water at 90 degrees centigrade for 10 minutes, cooled under tap water, and the operation repeated for three cycles of cooling and heating, and then placed in a damp room with a temperature of 70 degrees Fahrenheit and left for three days without affecting its luminosity or reflecting ability a sufficient amount to be detected when tested buttons are compared with untested buttons. Reflector buttons shall be equipped with bases of suitable design to permit mounting in accordance with the plan details and these specifications.

(6) Masts, Adapter Clamps, Pinnacles, and Split Type Bases for Crossbuck Signs. Four inch standard weight steel pipe masts shall be provided and installed as indicated on the plans. Steel shall be manufactured by the open hearth process. Castings of adapter clamps, pinnacles and split type base shall be in accordance with the details shown on the plans and shall be gray iron conforming to the requirements of the Standard Specifications for Gray Iron Castings, A.S.T.M. Designation A-48, A.S.T.M. Class 20 providing for a minimum ultimate strength of 30,000 pounds per square inch. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. Iron castings shall be true to pattern, 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. Anchor bolts, "U" bolts, and bolts used in attaching the crossbuck to the adapter clamp shall be of steel that has been manufactured by the open hearth process and shall be suitably protected against corrosion. Masts, pinnacles, adapter clamps, split type bases and all of their accessories shall be thoroughly cleaned and then given one prime coat of red lead chromate or a suitable iron oxide primer of the long oil type on all sources, and then shall be painted with two evenly and smoothly applied coats of aluminum paint of high quality acceptable to the Engineer. Stripes on masts shall consist of synthetic enamel being of black, eggshell finish, applied in three top coats, each being smoothly and evenly applied. All paint shall be applied in accordance with the pattern and dimensions shown on the plans.

(7) Concrete Bases for Crossbuck Signs. Concrete for concrete bases of crossbuck signs shall be constructed in accordance with the plans. All concrete shall be Class A. Materials, methods of construction and workmanship shall be in accordance with Items S-402 and S-403. All exposed surfaces shall receive a surface finish. Two and one-half inch conduit shall be installed in bases as indicated on the plans. Each end of the conduit shall be capped to prevent the entrance of foreign materials.

(8) Timber for Advance Warning Sign Posts. Timber for advance warning sign posts shall be Southern Yellow Pine conforming to the requirements of the Standard Specifications for Grade of

Longleaf and Shortleaf Southern Yellow Pine Lumber and Timber of the Southern Pine Association (S.P.A.) for grades, sizes and finish specified herein. Posts for advance warning signs shall be 4" x 4" nominal size, S4S No. 1 Dense Shortleaf Small Timber or No. 1 Longleaf Small Timbers. All timber shall receive an 8 pound minimum retention treatment of creosote oil by the full cell or empty cell process.

(9) Hardware for Mounting Advance Warning Signs. Hardware for mounting advance warning signs shall be galvanized steel and shall be of the sizes, dimensions and character shown on the plans. Hard, weatherproof fibre washers shall be installed on the contact surfaces of the signs as indicated on the plans.

S-528.3. CONSTRUCTION METHODS. Crossbuck signs and advance warning signs shall be assembled and installed complete in place in accordance with these specifications and the plan details, at the locations shown on the plans or as altered by the Engineer. Advance warning signs shall be set in excavated holes with the signs securely mounted after which the posts shall be carefully plumbed and the sign shall be focused as directed by the Engineer. The post holes shall then be backfilled and securely tamped in a manner to prevent swaying or displacement of the signs. Concrete bases for crossbuck signs shall be poured in excavated holes. After the concrete bases are completed the removed material shall be backfilled and securely tamped. Excess material shall be disposed of as directed by the Engineer. Following the installation of the signs, any existing railroad or highway crossing signs in place at or near the crossing prior to installation of the new signs shall then be removed and delivered to the State Highway Department on the adjacent highway right-of-way.

S-528.4. MEASUREMENT. Measurement shall be made of each complete unit of "Metal Series Railroad Crossing Signs", each unit consisting of two crossbuck signs and two advance warning signs, each crossbuck sign complete with pinnacle, adapter clamp, split type base, anchor bolts, conduit, concrete base, reflector buttons, all bolts, nuts, screws, paint and painting and incidentals necessary for the complete sign and each advance warning sign complete with reflector buttons, posts, paint and painting, hardware and incidentals necessary for the complete sign, each sign installed as specified herein and shown on the plans.

S-528.5. PAYMENT. Payment will be made for each complete unit of "Metal Series Railroad Crossing Sign" measured as prescribed under "Measurement", which price will be full compensation for furnishing all materials, equipment, labor, tools, transportation and incidentals necessary to complete the work.

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ITEM S-529

ASPHALT UNDERSEAL FOR CONCRETE PAVEMENT

S-529.1. DESCRIPTION. This item shall consist of pumping an asphaltic material under concrete pavement in accordance with these specifications.

The asphalt shall not be applied when the air temperature is below 50°F. and is falling, and it may be applied when the air temperature is above 40°F. and is rising, the temperature being taken in the shade and away from artificial heat, with the further provision that the asphalt shall be placed only when general weather conditions, in the opinion of the Engineer, are suitable.

S-529.2. MATERIALS.

(1) Asphalt. The asphalt used shall be an oil asphalt of type shown on plans, shall be homogeneous, shall be free from water, shall not foam when heated to 350°F. and shall meet the requirements of the Item "Asphalts, Oils and Emulsions".

(2) Backfill Material. Material of suitable quality for backfilling holes will be furnished the Contractor free of cost in a stockpile within the limits of the work. The material will consist of crushed stone, gravel, or premixed asphaltic concrete.

S-529.3. CONSTRUCTION METHODS. One and one-half (1 1/2) inch diameter holes shall be drilled through the concrete pavement as directed by the Engineer. Asphalt shall then be pumped through the holes and under the pavement by means of an approved type of self-propelled pressure distributor so operated that the pressure shall be from 15 to 45 pounds. The distributor shall be equipped with an accurate pressure gauge. A one (1) inch metallic hose shall connect the asphalt tank through the asphalt pump to a special one (1) inch nozzle, and another one (1) inch metallic hose shall connect the nozzle to the asphalt distributor tank. The nozzle shall be equipped with a three-way valve so designed that the asphaltic material may be circulated back into the asphalt distributor tank when pumping operations are not in progress.

Prior to pumping, the surface of the concrete pavement around the previously drilled 1 1/2 inch holes shall be thoroughly sprinkled with water, or shall be covered with sand, earth, or other suitable material in order to prevent any asphalt that may be spilled on the pavement from adhering to the surface. The nozzle shall then be inserted in the hole, driven to a snug fit, and pumping operations begun. Asphalt shall be pumped through the hole and under the pavement until the voids under the pavement are filled as directed and the pavement shall be raised and levelled by pumping operations only when specifically directed by the Engineer.

The Contractor shall furnish and operate a satisfactory string line during all pumping operations. The holes shall be drilled and asphalt pumped at locations designated by the Engineer.

Pumping operations shall cease, when directed by the Engineer, and the nozzle left in the hole until the asphalt has chilled sufficiently to allow the nozzle to be removed and a wooden plug driven into the hole without an excessive back flow of asphalt through the hole. After the asphalt has hardened, the wooden plug shall be removed and the backfill material shall be thoroughly tamped in the hole, flush with the surface of the concrete pavement. All asphalt spilled on the pavement shall be removed by the Contractor.

All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphalt shall be kept clean and in good operating condition at all times, and they shall be operated in such a manner that there will be no contamination of the asphalt with foreign material. Asphalt shall not be heated above 500°F. at any time, and when pumped under the pavement the temperature shall be not less than 350°F. and not more than 500°F. All asphalt heated above 500°F. will be rejected. The Contractor shall provide all necessary facilities for determining the temperature of the asphalt in all heating equipment and distributors.

S-529.4. MEASUREMENT. "Asphalt" shall be measured in gallons at the applied temperature at the point of application on the road.

"Holes" shall be measured as each hole drilled.

S-529.5. PAYMENT. The work performed and material furnished as prescribed by this item, measured as provided under "Measurement", will be paid for at the unit prices bid for "Asphalt", of the type and grade specified, and "Holes", which prices shall each be full compensation for furnishing all materials; for all freight involved; for drilling and backfilling holes; for furnishing, preparing, heating, hauling and pumping all asphalt; for cleaning surface of concrete pavement; and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-530

ASPHALT SUBGRADE MEMBRANE

S-530.1. DESCRIPTION. This item shall consist of treating, as specified herein, that portion of the prepared subgrade as indicated on plans or directed by the Engineer, for the immediate placement of concrete pavement.

S-530.2. MATERIALS. The materials for treating the subgrade shall consist of an oil asphalt and granular material. The oil asphalt shall be of the grade and type shown on the plans and shall meet the requirements for that type and grade of Asphalt as specified in the Item "Asphalt, Oils, and Emulsions". The granular material shall consist of sand or other suitable granular material, free from lumps of earth, vegetation or other objectionable matter.

S-530.3. CONSTRUCTION METHODS. Subsequent to the preparation of the road to conform to the typical sections shown on plans and the lines and grades established by the Engineer, the subgrade shall be coated with an application of oil asphalt applied with an approved type of pressure distributor so operated as to distribute the material in the quantity specified evenly and smoothly, under a pressure necessary for proper distribution.

The number of applications, the amount of asphalt to be applied and the distance ahead of paving operation that asphalt may be placed shall be as directed by the Engineer. Asphalt shall be heated and applied within application temperature ranges shown in the Item "Asphalts, Oils, and Emulsions".

The Asphalt shall be covered with sand at the rate indicated on the plans or as directed by the Engineer. The sand shall be spread, sprinkled if directed, and lightly rolled with a hand operated roller of sufficient weight to set and compact the sand. Extreme care should be exercised to prevent and avoid damaging the asphalt subgrade membrane in any manner.

S-530.4. MEASUREMENT. Asphalt will be measured in gallons at the applied temperature at the point of application on the road.

Sand will be measured by the cubic yard in vehicles at the point of delivery on the road.

S-530.5. PAYMENT. The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement", will be paid for at the unit price bid for "Asphalt", of the type and grade specified, and for "Sand", which prices shall each be full compensation for furnishing, preparing, hauling and placing all materials; for all freight and royalty involved; for all sprinkling and rolling; and for all manipulations, labor, tools, equipment, and incidentals necessary to complete the work.

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ITEM S-531

MEMBRANE CURING

S-531.1. DESCRIPTION. This item shall consist of the curing of concrete pavement, curbs, gutters, and retards by the impervious membrane method.

This type of curing will be permitted only when specifically indicated in the proposal. This indication will be made on the list of "Governing Specifications and Special Provisions" by including this item number in parenthesis after the item or items on which this type of curing will be permitted. When permitted, membrane curing will be optional to the other types of curing included in the specifications for the item or items of concrete work involved.

S-531.2. MATERIALS. The membrane curing compound shall comply with the following requirements:

It shall be of such consistency that it can be satisfactorily applied as a fine mist through an atomizing nozzle by means of approved pressure spraying equipment at atmospheric temperatures above 35° Fahrenheit.

It shall be of such nature that it will not produce permanent discoloration of concrete surfaces nor react deleteriously with the concrete or its components. It shall contain, to facilitate inspection of application, a fugitive dye that will be distinctly visible not less than four hours nor more than seven days after application.

The compound shall produce a firm, continuous, uniform, moisture impermeable film free from pinholes and shall adhere satisfactorily to surfaces of damp concrete. It shall, when applied to the damp concrete surface, at the rate of coverage specified herein, dry to touch in one hour and dry through in not more than four hours under normal conditions suitable for paving operations and shall adhere in a tenacious film without running off or appreciably sagging. It shall not disintegrate, check, peel or crack during the required curing period.

The compound shall not peel or pick up under traffic and shall disappear from the surface of the concrete by gradual disintegration.

The material shall have a minimum flash point of 80° Fahrenheit when tested by the "Tagliabue Open Cup Method".

The compound shall be delivered to the job only in the manufacturer's original containers, which shall be clearly labeled with the manufacturer's name, the trade name of the material, and a batch number or symbol with which test samples may be correlated.

The compound shall be job sampled and tested by the Engineer and shall not be used before being tested.

The laboratory mortar specimens shall be fabricated and tested in accordance with "Tentative Method of Test for Efficiency of Materials for Curing Concrete" (A.S.T.M. Designation C-156-44T) except that percentage loss shall be defined as the water lost after the application of the curing material divided by the quantity of free water present in the mortar specimen at the time the curing material was applied. The permissible percentage moisture loss (at the rate of coverage specified herein) shall not exceed the following:

24 Hours after application	2 per cent
72 Hours after application	4 per cent

S-531.3. CONSTRUCTION METHODS. After the concrete surface has been finally finished and the surplus water sheen has disappeared it shall be sealed with a single uniform coating of approved curing compound applied at the rate of coverage recommended by the manufacturer and directed by the Engineer, but not less than one (1) gallon per 180 square feet of area. The Contractor shall provide satisfactory means and facilities to properly control and check the rate of applications of the compound.

The compound shall be thoroughly agitated during its use and shall be applied by means of approved mechanical power pressure sprayers, equipped with satisfactory atomizing nozzles, except that for application on small miscellaneous items, hand-powered spray equipment may be used. For all spraying equipment, the Contractor shall provide facilities to prevent the loss of the compound between the nozzle and the concrete surface during the spraying operations.

It shall not be applied to a dry surface and if the surface of the concrete has become dry, it shall be thoroughly moistened immediately previous to application.

At locations where the coating shows discontinuities, pinholes, or other defects; or if rain falls on the newly coated surface before the film has dried sufficiently to resist damage, an additional coat of the compound shall be applied immediately at the same rate of coverage specified herein.

To insure proper coverage, after the compound has dried, the Engineer shall inspect all completed slabs for a period of three (3) days after application of the compound. Dry areas are identifiable because of the lighter color of dry concrete as compared to damp concrete. All suspected areas shall be tested by placing a few drops of water on the suspected areas. If the water stands in rounded beads or small pools which can be blown along the surface of the concrete without wetting the surface, a water-impervious film is present. If the water wets the surface of the concrete as determined by obvious darkening of the surface, or by visible soaking into the surface, no water-impervious film is present. Should the foregoing test indicate that any area is not protected by the required water-impervious film, an additional coat or coats of the compound shall be applied immediately, and the rate of application of the membrane compound shall be increased until all areas, during any of the three (3) days of age, are uniformly covered by the required water-impervious film.

When temperatures are such as to warrant protection against freezing, curing by this method shall be supplemented with an adequate protective blanket of straw or other similar approved insulating material, which shall be maintained in place until the concrete is seven days old.

If this method of curing is used on curbs or exposed surfaces of work not subject to traffic wear, the compound used shall be entirely colorless. This method of curing shall not be permitted on rubbed concrete surfaces or on surfaces in which white cement is used except upon written approval of the Engineer.

If at any time there is reason to believe that this method of curing is unsatisfactory or is detrimental to the work, the Contractor, when notified shall immediately cease the use of this method and shall change to curing by one of the other methods specified under this contract.

S-531.4. MEASUREMENT AND PAYMENT. Work and materials prescribed herein will not be paid for directly but shall be included in the unit price bid for the items of construction in which these materials are used.

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ITEM S-532

CENTRAL MIXING PLANTS AND TRANSIT MIXERS FOR CONCRETE PAVEMENT

S-532.1. DESCRIPTION. This item shall govern when central mixing or transit mixing of concrete pavement materials are permitted. These methods of mixing will be used only when specifically indicated in the proposal. This indication will be made on the list of "Governing Specifications and Special Provisions" by including this item (S-532) in parenthesis after the item or items on which these methods of mixing will be allowed. When permitted, central mixing and transit mixing will be optional to the method of mixing included in the specifications for "Concrete Pavement".

S-532.2. EQUIPMENT.

(1) Central Mixing Plant. The plant shall meet all of the requirements as to mixers, weighing equipment, etc., included in the specifications for the Item "Concrete Pavement".

(2) Truck Mixers. Truck mixers shall have a closed watertight drum suitably mounted and shall be fitted with adequate blades capable of combining aggregate, cement and water into a thoroughly mixed and uniform mass of concrete, and of discharging the mixture without segregation. Either the revolving drum type or the revolving blade type of mixer will be acceptable. The truck mixer shall be equipped with a satisfactory timing device or revolution counter. The batching plant shall meet all of the requirements included in the specifications for the Item "Concrete Pavement".

(3) All equipment shall be approved by the Engineer as to type and condition before use.

S-532.3. MIXING, TRANSPORTATION, AND DELIVERY. Concrete mixed in a central mixing plant or in a truck mixer shall be proportioned and batched as required in the Item "Concrete Pavement", and shall meet the requirements for quality and strength stated therein. The Contractor shall be responsible for producing a concrete that will have the required consistency and slump when delivered to the job. If the concrete, as delivered, is not of the required consistency or workability, the use of additional cement may be required. The use of admixtures will not be permitted. Concrete which is unsuitable as delivered for placement shall be rejected.

Concrete mixed in a central mixing plant shall be transported to the work in watertight agitators in which there shall be no segregation of the aggregates and from which the concrete can be discharged freely at the required consistency. If open top agitators are used, they shall be equipped with tarpaulins for covering the concrete.

When the concrete is to be partially or wholly mixed in transit, the entire amount of mixing water shall be accurately measured either at the batching plant or from a measuring tank mounted on the truck mixer. In either case, means shall be provided for accurate checking of the water used. Mixing speed shall be not less than six (6) nor more than sixteen (16) revolutions per minute of the drum or mixing blades. Each batch of concrete shall be mixed not less than fifty (50) nor more than one hundred fifty (150) revolutions of the drum or mixing blades at mixing speed. Additional mixing after one hundred fifty (150) revolutions shall be done at agitating speed, provided, however, that the Engineer may require that all of the mixing shall be accomplished at agitating speed if the time of haul after mixing begins exceeds ten (10) minutes. Agitating speed shall be not less than two (2) nor greater than six (6) revolutions per minute of the drum or mixing blades.

Concrete, when mixed as prescribed herein, shall be delivered to the site of the work and discharged from the truck mixer or truck agitator not more than forty-five (45) minutes after the addition of the mixing water to the cement and aggregates, or after the addition of cement to the aggregates when the mixer drum contains residual water. Concrete that has developed initial set shall be rejected.

S-532.4. MEASUREMENT AND PAYMENT. Direct payment for the work and materials required herein will not be made. The cost of such work and materials shall be included in the unit price bid for "Concrete Pavement".

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ITEM S-533

CEMENT STABILIZED RIPRAP

S-533.1. DESCRIPTION. This item shall consist of the stabilization of suitable materials for the purpose of protecting portions of the roadway against erosion.

S-533.2. MATERIALS. The materials shall consist of aggregate, normal portland cement, and water. Cement and water shall conform to the requirements of the Item "Concrete for Structures". Aggregate shall consist of suitable materials secured from sources designated on the plans or approved by the Engineer. All materials shall be approved by the Engineer before being incorporated in the work.

S-533.3. CONSTRUCTION METHODS. The Contractor shall excavate the area where the stabilized riprap is to be constructed, to the depth shown on plans. The outline of the area to be riprapped need not be formed but it shall be the Contractor's responsibility that the required depth of stabilized material is placed over the entire area indicated on the plans.

The maximum size aggregate, exclusive of soil, shall not exceed two-thirds (2/3) the depth of course to be placed. Soil shall be pulverized to the extent that no particles greater than one-half (1/2) inch shall remain in the aggregate.

The processed aggregate shall then be mixed with Portland cement at the rate of three sacks of cement per cubic yard of the aggregate. When thoroughly mixed, water shall be added in such quantity that a plastic mass will result. The mixture after addition of water, shall be of such consistency that it will not flow. Handmixing will be permitted.

The mixed material shall be deposited on the prepared subgrade, consolidated and the surface finished by use of trowel, wooden float, or other approved methods, to the required grade and section.

After the finished surface has set sufficiently, it shall be cured for at least four days by using wet cotton mats, burlap, or other approved methods.

S-533.4. MEASUREMENT. Completed and accepted work as prescribed by this item will be measured by the cubic yard of "Cement Stabilized Riprap". The dimensions used in the calculations of quantities will be shown on the plans or shall be as ordered in writing by the Engineer.

S-533.5. PAYMENT. Cement Stabilized Riprap, measured as provided under "Measurement" will be paid for at the unit price bid per cubic yard for "Cement Stabilized Riprap" which price shall be full compensation for excavation necessary in preparation of subgrade, disposal of excavated material, furnishing all materials required in the construction, all processing, mixing, placing, curing, and for all equipment, tools, and incidentals necessary to complete the work.

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ITEM S-540

STRUCTURE FOR FIELD OFFICE AND LABORATORY

S-540.1. DESCRIPTION. These specifications shall govern for the erection of a building to be used by the Engineer during the construction of the project as a Field Office, Field Laboratory or Field Office and Laboratory.

Although other governing specification items on this contract may require a field office and/or laboratory for the use of the Engineer and inspecting force, only one will be required for all work to be performed and it shall conform to the requirements of this specification.

S-540.2. GENERAL REQUIREMENTS. The structure to be furnished by the Contractor shall be one of the types hereinafter described. The type to be furnished will be designated on the List of Governing Specifications included in the proposal and contract.

The building shall be provided immediately after work on the project is begun and shall remain in place until the project is accepted by the State as complete, unless its earlier removal is authorized by the Engineer. It shall be floored and roofed, weather-tight and constructed in a workmanlike manner. All windows shall be screened and a screen door provided in addition to the regular door.

It is contemplated that the building will be constructed of the same kind of material as that used by the Contractor for his office and job buildings. It shall be constructed near the site of the work, at a location acceptable to the Engineer, and shall be an independent unit, detached from any office, storage or warehouse building occupied by the Contractor, and shall be at a minimum clear distance of 50 feet from any such building. The building shall be for the sole use of the Engineer and the inspecting force.

Should the building be destroyed or damaged in any manner, except thru causes due to negligence of the occupying engineering force, the Contractor shall immediately restore it to its original state. Upon the completion of the project the building will become the property of the Contractor and shall be removed from the project site.

The Contractor will not be required to furnish a stove or fuel for the heating of the building.

S-540.3. TYPE OF STRUCTURE.

Type A Structure. Field Office. This building shall not be less than 10' x 16' and 8' high or an approved equivalent, and shall have not less than three glass windows and one door. A table not less than 3' wide and 6' long shall be provided.

Type B Structure. Field Laboratory. This building shall be not less than 8' x 16' and 8' high or an approved equivalent, and shall have not less than two glass windows and one door. A work bench not less than 3' wide and 6' long shall be provided.

Type C Structure. Field Office and Laboratory. This building shall be not less than 16' x 16' and 8' high or an approved equivalent and shall have not less than four glass windows and one door. A work bench and a table, each not less than 3' wide and 6' long, shall be provided.

Type D Structure. Field Office and Laboratory. This building shall be not less than 8' x 16' and 8' high or an approved equivalent and shall have not less than four glass windows and one door. A work bench and a table, each 3' wide and 6' long shall be provided.

Type E Structure. Field Laboratory. This building shall be not less than 8' x 20' and 8' high, containing not less than 2 windows and 2 doors and a work bench 3' wide and 8' long. In addition, the building shall contain a substantial work bench 3' x 4' with supports extending through the floor and firmly fixed in the ground, clear of the building floor, and a small platform not less than 12" square substantially mounted on a post of not less than 6" x 6" lumber extending through the floor and firmly fixed in the ground.

S-540.4. PAYMENT. No direct compensation will be made to the Contractor for the work and materials involved in providing the Field Office, Field Laboratory or Field Office and Laboratory as the case may be. Such work and materials shall be considered subsidiary to the several items of work for which unit prices are requested in the proposal.