DIVISION 800 - BRIDGES AND STRUCTURES

SECTION 801 - EXCAVATION AND FILL

801.01--Description. Foundation excavation shall include the removal of all material, of whatever nature, necessary for the construction of foundations and substructures of bridges in accordance with the plans or as directed by the Engineer. When not shown as a pay item, it shall include the furnishing of all necessary equipment and the construction of all cribs, cofferdams, dewatering, etc. necessary for execution of the work. It shall also include the subsequent removal of cofferdams and cribs and the placement of all necessary backfill as hereinafter specified. It shall also include the disposal of excavated material, which is not required for backfill or other specified usage, in a manner and in locations that will not affect the carrying capacity of the channel or other drainage or be unsightly.

Unless a greater area is necessary for construction, the bridge site shall be the area defined in Subsection 101.02. Clearing and grubbing shall be in accordance with the provisions of Subsection 201.04.

All substructures, where practicable, shall be constructed in open excavation, and where necessary, the excavation shall be shored, braced, or protected by cofferdams in accordance with approved methods. When footings can be placed in the dry without the use of cribs or cofferdams, backforms may be omitted with the approval of the Engineer and the entire excavation filled with concrete to the top of the footing. The additional concrete required shall be placed at the expense of the Contractor.

801.02--Materials. Unless designated otherwise, all material used for backfill shall meet the requirements of Subsection 203.03.8.6.

801.03--Construction Requirements.

801.03.1--Preservation of Channel. Unless otherwise specified, no excavation shall be made outside of cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to the structure shall not be disturbed without permission of the Engineer. If any excavation or dredging is made at the site of the structure before cribs or cofferdams are in place, the Contractor shall, without extra compensation and after the foundation base is in place, backfill all such excavation to the original ground surface or river bed with material satisfactory to the Engineer. Material deposited within the stream area from foundation or other excavation or from the filling of cofferdams shall be removed and the stream area freed from obstruction thereby.

801.03.2--Depth of Footings. The elevations shown on the plans for bottoms of footings shall be considered as approximate, and the Engineer may order in

writing changes in dimensions or elevations necessary for a satisfactory foundation.

801.03.3--Preparation of Foundations for Footings. All rock or other hard foundation material shall be cut to a firm surface, either level, stepped, or roughened as may be directed by the Engineer, and then cleaned of all loose material. All seams shall be cleaned out and filled with concrete, mortar, or grout.

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

Excavation and preparation of foundations for footings for box bridges shall be in accordance with the provisions of Section 206.

801.03.4--Cofferdams and Cribs.

801.03.4.1--General. Cofferdams and cribs shall be safely designed and constructed to adequate depths and heights, and be made as water-tight as is necessary for the proper performance of the work to be done inside them. In general, the interior dimensions of cofferdams and cribs shall be sufficient to permit construction of forms and the inspection of their exteriors and to permit pumping outside of the forms. Cofferdams or cribs which tilt or move laterally during the process of sinking shall be righted, reset, or enlarged so as to provide the necessary clearance. All corrective work shall be at the expense of the Contractor.

When conditions are encountered which, in the opinion of the Engineer, make it impracticable to dewater the foundation, the Engineer may require the construction of a concrete seal of the dimensions necessary. The foundation shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed, and the weight is utilized to partially overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. During the placing of a foundation seal, the water elevation inside the cofferdam shall be controlled to prevent any flow through the seal, and if the cofferdam is to remain in place, it shall be vented or ported at low water level.

801.03.4.2--Protection of Concrete. Cofferdams or cribs shall be constructed so as to protect green concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. Timber or bracing that will extend into the substructure masonry shall not be left in cofferdams without written permission from the Engineer.

801.03.4.3--Drawings Required. The Contractor shall submit to the Engineer four copies of structural design analysis and detail drawings which shows the proposed method of constructing the cofferdam. These drawings shall include the types and sizes of sheeting, wales, bracing, and struts, the connections therefore, and the proposed method of installing, sealing, dewatering, cut-off and/or removal. The cofferdam analysis and details shall be prepared by and bear the seal of a Registered Professional Engineer experienced in cofferdam design.

The Registered Professional Engineer shall certify that the actual material and material fabrication used for cofferdam construction are capable of supporting the loads.

When submitting drawings and design analysis, the Contractor shall list the bent numbers on which the construction of cofferdams is proposed.

801.03.4.4--Removal. Unless otherwise provided, cofferdams or cribs with all sheeting and bracing shall be removed after the completion of the substructure. Care shall be taken not to disturb or otherwise injure the finished masonry.

801.03.5--Pumping. Pumping from the interior of a foundation enclosure shall be done so as to preclude the possibility of movement of water through fresh concrete. There shall be no pumping during the placing of concrete or for a period of at least 24 hours thereafter, unless it can be done from a suitable sump separated from the concrete work by a water-tight wall or other effective means.

Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

801.03.6--Inspection. After each excavation is completed, the Contractor shall notify the Engineer, and no masonry shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material.

801.03.7--Backfill. Backfill of solid structures may commence upon removal of forms. Backfill of wall structures shall be in accordance with Subsection 601.03.6.3.

Adequate provision shall be made for thorough drainage of all backfilling. French drains shall be placed at weep holes as specified.

All excavated space not occupied by the permanent structure shall be backfilled to the surface of the surrounding ground or to the typical section indicated on the plans. All backfill shall be thoroughly compacted and sufficient allowance shall be made for settlement.

Where it provides drainage, bearing strength, or lateral support to the permanent construction, all backfilling shall be performed in accordance with the provisions of Subsection 203.03.8.6. In general, the top surface of backfilled area shall be neatly graded to the section indicated on the plans or established.

801.03.8--Approach Embankment. When approach embankments are required, they shall be constructed and will be paid for in accordance with Section 203.

801.04--Method of Measurement. Foundation excavation, satisfactorily performed, will be measured by the cubic yard in the original position with dimensions determined as follows:

A. Bottom - the elevation of the bottom of the footing, seal, or web wall as applicable.

B. Top - the elevation of the original ground or graded section, whichever is lower.

C. Sides - vertical planes no more than 18 inches outside the outer edges shown on the plans, or directed, for the footing, seal and web wall.

The measurement will not include water or other liquids, but will include mud, muck, and other similar semi-solids.

Extra depth excavation, made necessary by the Engineer establishing the elevation of the footing or seal below the elevation shown on the plans, will be measured in cubic yards in its original position. This volume will be determined by multiplying the area of the excavation, as determined above, by the distance the footing or seal is lowered. This volume will be divided into the applicable increments indicated in Subsection 801.05.

When the material yielded from foundation excavation is insufficient, or is determined to be unsuitable, for backfill material, required backfill material ordered by the Engineer will be included in the measurement for the applicable item of excavation under Section 203. Other materials shown on the plans or ordered and used as backfill materials will be measured in accordance with the provisions governing the material specified.

Unless otherwise specified, haul of foundation excavation and materials for backfill will not be measured for separate payment.

When shown as a pay item, cofferdams will be measured as a lump sum quantity. This lump sum quantity includes all cofferdams necessary for footing construction.

Measurement for progress estimates will be based on the number of cofferdams completed as compared to the total number listed by the Contractor in accordance with Subsection 801.03.4.3.

801.05--Basis of Payment. Foundation excavation, measured to the elevation of the bottom of the footing or seal as shown on the plans, will be paid for at the contract unit price per cubic yard.

Extra depth excavation, required below the footing or seal elevation shown on the plans, will be paid for per cubic yard in accordance with the following schedule:

Established Elevation of the Footing Below the Elevation Shown on the Plans	Payment Percent of Contract Price
0.00 to 1.99 feet	100%
2.00 to 3.99 feet	120%
4.00 to 5.99 feet	150%
6.00 to 7.99 feet	165%
8.00 to 9.99 feet	195%
10.00 feet or more	230%

Selected backfill material, shown on the plans or ordered by the Engineer, to be obtained from sources other than from foundation excavation will be paid for at the contract unit price for the material specified and used.

All necessary cofferdams or cribs will be paid for at the contract lump sum price.

The prices thus paid shall be full compensation for completing the work.

All work required under this section for which no pay items are included in the proposal will not be measured for separate payment, compensation therefore shall be considered as included in the prices and payment for bid items.

Payment will be made under:

801-A: Foundation Excavation for Bridges - per cubic yard

801-B: Cofferdams - lump sum

SECTION 802 - SHEET PILING

802.01--Description. This work consists of furnishing and installing permanent sheet piling as shown on the plan, or ordered by the Engineer to be left in place as part of the finished structure. Except where indicated as a pay item in the plans, no compensation will be allowed for furnishing and installing temporary

sheet piling and appurtenances. Temporary sheet piling will ONLY be paid for when a pay item is included in the plans.

802.02--Materials.

802.02.1--Concrete Sheet Piles. Concrete sheet piles shall be in accordance with the detailed design. The requirements governing their manufacture and installation shall conform, in general, to those governing concrete bearing piles.

802.02.2--Steel Sheet Piles. Steel sheet piles shall conform to the requirements of Subsection 719.05 and shall be of the type and weight designated. The piles, when in place in the completed structure, shall be practically water-tight at the joints. Painting of steel sheet piles shall conform to Section 814.

802.03--Construction Requirements. Construction requirements for sheet piling shall conform to the applicable requirements of Section 803.

Temporary sheet piling shall be a steel sheet pile retaining wall constructed as indicated on the plans. Painting of the sheet piling will not be required. The sheet piling shall be removed upon completion of the work and the area shall be restored as directed by the Engineer.

802.04--Method of Measurement. Permanent sheet piling will be measured by the square foot, on the basis of the piles driven as approved by the Engineer. Cut-offs will be deducted from the measurement. Unless shown as a pay item, no measurement for extra compensation will be made for such temporary sheet piling required for foundations and in conjunction with bridge excavation not designated for payment.

Temporary steel sheet piling will be measured by the square foot, on the basis of the piles driven as approved by the Engineer. Temporary steel sheet piling will only be measured for payment when a pay item is included in the plans.

802.05--Basis of Payment. Permanent and temporary sheet piling, measured as prescribed above, will be paid for by the square foot, which price shall be full compensation for completing the work.

Payment will be made under:

802-A: Permanent Steel Sheet Piling	- per square foot
802-B: Permanent Concrete Sheet Piling	- per square foot
802-C: Temporary Steel Sheet Piling	- per square foot

SECTION 803 - DEEP FOUNDATIONS

803.01--General.

803.01.1--Description. This work consists of furnishing and installing deep foundations in accordance with these specifications and in reasonable conformance with the lines, elevations, and spacings shown on the plans. It shall also consist of furnishing all required labor, tools, and equipment to determine the bearing value of the deep foundation by static load testing, by dynamic load testing, and/or by driving of the specified test piles.

803.01.2--Order Lists for Deep Foundations. Lengths found in the plans are estimated lengths for bid purposes. Unless otherwise specified or authorized in writing by the Bridge Engineer, all permanent deep foundations shall be installed within the prescribed tolerances specified herein and to the depths and/or lengths indicated on the itemized Order List furnished by the Engineer. The Order List shall be furnished after bearing has been verified either through static load testing, dynamic load testing, and/or driving of the specified test piles.

The Contractor shall furnish or install driven piles and/or drilled shafts in accordance with an itemized list furnished by the Engineer. The Order List will show the required length of the piles or drilled shafts for each bridge bent or footing.

803.02--Materials. All materials shall conform to the applicable requirements set forth in Sections 710, 711, 719, 804, and 814.

Driven piles shall conform to all applicable requirements set forth in Section 719 and the plans. Paint for steel piles or steel shells shall conform to the applicable requirements of Sections 710 and 814.

Drilled shaft concrete shall conform to the requirements of Section 804 for Class "DS" concrete. All reinforcing steel shall conform to the requirements of Section 711 of the Specifications.

803.03--Construction Requirement. This work shall consist of furnishing all labor, materials, equipment and services necessary to install driven piles of the prescribed type in accordance with these specifications and in conformance with the lines, elevations, and spacings shown on the plans.

This work shall also consist of furnishing all labor, materials, equipment and services necessary to perform all operations to complete the drilled shaft installations in accordance with these specifications and with the details and dimensions shown on the plans. Drilled shafts shall consist of reinforced or nonreinforced concrete with or without concrete bell footings.

803.03.1--Driven Piles.

803.03.1.1--General. Unless otherwise specified or authorized by the Bridge Engineer, all permanent production piles shall be driven in a continuous operation, to the full lengths indicated on the itemized order list furnished by the Bridge Engineer.

803.03.1.2--Accuracy of Installation. Driven piles in trestle bents shall be driven to within a tolerance of 1/4 inch per foot from the vertical or from the batter shown on the plans. Piles to be incorporated into a cap or footing shall not be out of the position shown on the plans by more than six inches. In all cases, piles shall be driven so that they will not be excessively stressed to place them in the proper location in the cap or footing. Excessive manipulation of the piles will not be permitted, and the Contractor shall redrive or use other satisfactory methods to avoid such manipulations. No shimming on tops of piles will be permitted.

803.03.1.3--Extensions, Build-ups and Splices. If determined by the Engineer to be necessary, production piles that are extended below cut-off shall be extended, built-up, or spliced in accordance with the plans to the extent established by the Bridge Engineer. Extensions or build-ups will not be measured for payment as such, but will be included in the total length of piling in the finished structure.

803.03.1.4--Cut-Offs. If it is determined by the Engineer that the pile has reached practical refusal above pile cut-off elevation but below the prescribed minimum tip elevation shown in the plans then the Contractor will be allowed to cut off the pile at the cut-off elevation.

803.03.1.5--Driven Pile Types. Driven piles shall be of the type listed below unless otherwise specified in the plans.

803.03.1.5.1--Concrete Piles. Concrete piles shall be the size and shape specified. Reinforcement, unless otherwise designated, shall have a clear distance of at least two inches from the face of the pile. When the piles are for use in salt water or alkali soils this clear distance shall be at least three inches.

803.03.1.5.2--Steel Piles. Full-length piles shall be used unless splicing is approved in writing by the Bridge Engineer. When permitted, splicing shall be in accordance with the notes and details shown on the plans.

803.03.1.5.3--Timber Piles. Specified timber piles or timber piles used for temporary construction shall meet the requirements set forth in Section 820.

803.03.1.5.4--Special Piles. Piles not of the type specified above, but called for in the plans or additional specifications shall meet the general requirements contained therein.

803.03.1.6--Preparation for Driving.

803.03.1.6.1--Excavation. When a pile cap is located below the ground line, piles shall not be driven until the required excavation is completed. All material forced up between the piles shall be removed to the correct elevation at the Contractor's expense before concrete for the foundation is placed.

803.03.1.6.2--Pile Cushions. Suitable cushioning material shall be used between the driving helmet and the top of the pile. This is especially critical for concrete piles. The Contractor should submit the type material, cross-sectional area and total thickness of the pile cushion. This information shall be submitted to the Engineer for approval on the completed *Pile Driving Equipment Data Form.* The pile cushion shall be approved with the pile driving system and is subject to satisfactory field performance.

803.03.1.7--Method of Installation and Driving System.

803.03.1.7.1--General. The pile driving system shall be defined as all equipment necessary to install the specified piles to the required minimum tip elevations specified in the plans. The pile driving system shall include the pile hammer, hammer leads, followers, water jets, drilling equipment for pre-formed pile holes, and templates, if necessary.

803.03.1.7.2--Submittal of Pile Driving System Data. The Contractor shall submit to the Engineer all technical specifications and operating instructions relating to the pile driving system that is to be used to drive the piling. The Contractor shall also submit a completed *Pile and Driving Equipment Data Form* to the Engineer at the pre-construction conference or no later than 14 days prior to the anticipated driving date. The Contractor will not be allowed to install any piling until the driving system has been approved in writing by the Engineer. The Department will use the submitted information to perform wave equation analysis and prepare a summary report of the wave equation results. The wave equation analysis and other data shall be used to assess the ability of the proposed systems to install the piles to the desired penetration depth within the AASHTO standards for driving stresses.

The Engineer will notify the Contractor of any additional information required and/or changes that may be necessary to meet the project requirements. Any parts of the driving system that are unacceptable will be rejected and the Contractor will submit changes. Review of these changes will be completed within seven (7) days and the Contractor notified of their acceptance or rejection. Approval of the proposed driving system by the Engineer for driving of test piles

shall be based upon the wave equation analysis indicating that the proposed driving system is acceptable.

All production piles shall be driven with the hammer bearing the same Serial Number submitted on the *Pile and Driving Equipment Data Form* and used to drive the test piles. In the event multiple hammers of differing type are used on the same bridge, the Contractor shall submit to the Engineer for approval a completed *Pile and Driving Equipment Data Form* for each hammer and specify the bridge bents in which each hammer will be used. This will allow the Department the opportunity to develop appropriate driving and acceptance criteria specific to each hammer.

A different pile driving system, modifications to the existing system, or different pile installation procedures shall be proposed by the Contractor if the pile installation stresses predicted by the wave equation analysis or calculated by the PDA are not within the AASHTO values. All approvals are conditional and subject to trial and satisfactory performance in the field. Unless otherwise permitted by the Bridge Engineer in writing, test piles and permanent piles shall be driven with the approved driving system.

803.03.1.7.3--Pile Hammers. Piles may be driven with an approved single-acting or double-acting pile hammer in combination with water jets or pre-formed pile holes. The pile driving system shall be constructed so as to afford freedom of movement of the pile hammer and to drive the piles to the required depth within the tolerances specified without undue injury to the piles.

The pile hammer shall be in good working condition and produce the energy required to install piles to the depth or penetration required in the plans. Single or double-acting Steam/Air, Diesel/Internal Combustion, or Hydraulic hammers may be submitted for review and approval.

In no case shall a gravity or drop hammer be used to drive concrete or steel piles supporting the permanent bridge structure. A drop hammer may be used to install timber or steel piles for temporary construction, but in no case shall a gravity or drop hammer be used to drive concrete piles.

803.03.1.7.4--Driving Appurtenances.

803.03.1.7.4.1--Pile Hammer Leads. Either fixed leads or swinging leads may be used. Swinging leads shall be used in combination with rigid templates approved by the Engineer. Battered piles shall be driven in inclined leads or multiple rigid templates capable of holding the pile in the proper position during driving.

803.03.1.7.4.2--Pile Cushions. Suitable cushioning material shall be used between the driving cap and the top of the pile. The cushion material shall

protect the pile top during driving and shall be constructed such that the hammer energy is uniformly distributed to the pile top. The pile cushion shall be changed prior to driving each pile. In addition, if the cushion material becomes highly compressed, or chars or burns during the driving operations or damage occurs at the pile top, it shall be replaced. The type of material and dimensions of the pile cushion shall be included in the appropriate place on the *Pile and Driving Equipment Data Form.*

803.03.1.7.4.3--Water Jets. Water jets may be used in conjunction with the pile hammer to install piles to the required depth or penetration called for in the plans. The use of water jets, where the stability of embankments or other improvements would be endangered, will not be permitted. When water jets are used, the number of jets and the volume and pressure of water shall be sufficient to adequately facilitate driving without undue damage to the pile or the soil adjacent to or below the pile. Unless otherwise specified, water jets shall not be used within five feet of the final tip elevation of the pile. In addition, it shall be the Contractor's responsibility to withdraw the water jets sufficiently above the five foot requirement to obtain the specified bearing at the required cut off elevation.

In the event a jetted pile fails to obtain the specified bearing at the required penetration and a determination is made by the Engineer that the Contractor has failed to properly control the jetting operation, the Contractor should submit detailed corrective measures for founding the pile to the Engineer for approval. Any required corrective measures to the pile due to the Contractor's operation shall be performed at no additional cost to the State.

803.03.1.7.4.4--Followers. Followers are considered to be part of the Driving System and should be included for approval with the *Pile and Driving Equipment Data Form.* Included with the submittal should be a dimensioned sketch of the follower. Also, the type(s) of materials that the follower is made of and the weight of the follower should be included as well as cushion information.

803.03.1.7.4.5--Pre-formed Pile Holes. The Bridge Engineer will make all determinations as to the necessity for pre-formed pile holes and the size and maximum depth of each hole required or permitted.

If it is determined from the Geotechnical Investigation or from the site survey that pre-formed pile holes are necessary, a pay item and estimated quantities will be included on the plans, and the Bridge Engineer will furnish the Contractor with an itemized list showing the location, size and bottom elevation of each hole.

If the plans do not specify pre-formed pile holes and the Bridge Engineer, with the concurrence of the Construction Engineer, determines during construction that subsurface conditions are encountered that necessitate pre-formed pile holes, at certain locations, an adjustment in the contract unit price for furnishing and

driving piling at these locations may be made under the provisions of Subsection 104.02.

If in the judgment of the Engineer pre-formed pile holes are not required and the Contractor desires to use them, the Contractor may be permitted to do so under conditions prescribed by the Bridge Engineer and at no additional cost to the State.

803.03.1.7.4.6--Additional Equipment. When a minimum penetration is indicated on the plans and is not obtained by the use of an approved hammer, the Contractor shall submit to the Engineer for approval a completed *Pile and Driving Equipment Data* Form for a heavier hammer or resort to jetting at no additional cost to the State.

803.03.1.8--Defective Piles. Prior to driving, piles shall not be subjected to handling that causes damage either through bending, crushing or spalling of concrete, or deformation of the steel. All piles damaged because of internal defects or by improper driving, driven out of the proper location or driven below the specified elevation shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question:

1) The pile shall be withdrawn and replaced by a new and, if necessary, a longer pile.
2) A second pile shall be driven adjacent to the defective or low pile.
3) The pile shall be spliced or built up or a sufficient portion of the footing shall be extended to properly embed the pile. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down to grade.

803.03.1.9--Determination of Bearing Value of Piling.

803.03.1.9.1--General. The ability of the pile to transfer load to the ground will be determined to the satisfaction of the Bridge Engineer. Such determination will be made by the Geotechnical Engineer and Foundation Engineer from a subsurface investigation conducted by the Geotechnical Branch of Materials Division and test piles that are driven out-of-position or driven to be incorporated in the structure as permanent piles.

803.03.1.9.2--Determination of Bearing Value by Pile Hammer Formulas. When load testing, either static or dynamic, is not called for in the plans, the safe bearing values will be determined by the following formulas or as directed by the Engineer.

$$P = \frac{2WH}{S+0.2}$$ for single-acting steam/air hammers and open cylinder diesel hammers

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

Where
- P = safe bearing value 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/air pressure in pounds per square inch at the hammer
- S = the average penetration in 10 blows for gravity hammers and the last 10 to 20 blows for steam/air hammers.

These formulas are applicable for the following conditions only:

- The hammer has a free fall.
- The pile head is not crushed.
- The penetration is reasonably quick and uniform.
- There is no appreciable bounce after the blow.
- A follower is not used.

Where there is appreciable bounce of the hammer, twice the height of the bounce shall be deducted from "H" to determine its value in the formula.

When water jets are used, the bearing value shall be determined by the above formulas from the results of driving after the jets have been withdrawn, or a static or dynamic load test has been conducted.

Formulas for pile hammers not covered herein must be approved by the Bridge Engineer.

803.03.1.9.3--Determination of Bearing Value by PDA Monitoring (Dynamic Load Testing).

803.03.1.9.3.1--Description. This work consists of furnishing all labor, materials, equipment and services necessary to perform all operations to complete the determination of bearing value of piling by Department forces using a Pile Driving Analyzer (PDA) and associated equipment. The dynamic load testing measurements will be performed in accordance with the plans and the guidelines given herein.

803.03.1.9.3.2--Scope and Sequence of Construction. The dynamic measurements will be performed on the piles as detailed below for the purpose of obtaining ultimate pile bearing capacity, pile driving stresses, pile integrity, and the pile driving system efficiency. Unless otherwise directed in the plans, the

sequence of construction outlined below shall not be deviated from unless an alternate sequence of construction is approved in writing by the Engineer.

1) When called for in the plans, Load Testing With Special Instrumentation and/or Conventional Static Load Testing will be performed on piles as detailed. Piles to be load tested shall be driven in the location shown in the plans with PDA monitoring under initial drive and have restrikes performed.
2) When called for in the plans, PDA Test Piles will be driven with PDA monitoring under initial drive and have restrikes performed as detailed below. The test piles will be used as production piles and be incorporated into the bridge structure.
3) Any production piles determined by the Engineer to require PDA monitoring during initial drive or require PDA restrikes.

803.03.1.9.3.3--PDA Monitored Driving and/or Restrike of Piling.

803.03.1.9.3.3.1--General. When called for in the plans or the Engineer, a Pile Driving Analyzer (PDA) and instrumentation will be used to obtain dynamic measurements during pile driving and pile restrikes. The analysis of the monitoring will be the responsibility of the Department. The Contractor shall give notice to the State Geotechnical Engineer at least 14 calendar days before the scheduled date of driving piles to be monitored. The Contractor shall confirm the driving date 3 calendar days prior to the scheduled driving date.

803.03.1.9.3.3.2--Contractor Requirements. The Contractor shall be responsible for furnishing the following:

1) A power supply providing at least 1800 watts of 115-volt AC power with a frequency of 60 Hz at the driving site.
2) Prepare the driving site.
3) Supply the labor necessary for attaching the dynamic monitoring instrumentation to the piles. The Contractor shall make one of their personnel available to place the transducers on the piles after the piles have been placed in the leads.
4) Drive the piles as directed by the Engineer.

The Contractor shall make the piles available prior to driving for drilling and tapping of holes that are necessary for attachment of instrumentation. The expected delay for attaching the instruments to the pile will be approximately one (1) hour. The Contractor shall use reasonable care when working with piles when instruments are installed and shall replace any damaged equipment caused by Contractor error at no additional cost to the State.

803.03.1.9.3.3.3--Driving Requirements. Piles to be used in the determination of pile bearing by PDA monitoring shall be driven with PDA instrumentation attached to the pile and shall have a PDA monitored 1-day and 7-day restrike performed after the initial pile driving. The Engineer may modify the waiting periods that are required before the restrikes are performed. When a static load test is to be performed, the 7-day restrike should be eliminated and a PDA monitored restrike done within 24 hours of completion of the static load test. When deemed necessary by the Engineer, permanent piles may have PDA monitored restrikes performed to confirm or supplement design requirements.

Restrikes shall be performed with a warm hammer operating at normal efficiency. A warm hammer is defined as a hammer that has applied a minimum of 20 blows to another pile or a dummy block immediately before being used in a restrike. The restrike shall consist of striking the pile for 50 blows or until the pile penetrates an additional three inches, whichever occurs first. In the event the pile movement is less than one inch after 15 blows during the restrike, the restrike may be terminated.

803.03.1.9.4--Determination of Bearing Value by Static Load Testing. When called for in the plans or directed by the Engineer, static load testing will be conducted to determine the ultimate bearing capacity of piles. Depending upon the conditions encountered in the field, the Bridge Engineer may increase or decrease the number of static load tests required.

803.03.1.9.4.1--Load Testing of Piling With Special Instrumentation.

803.03.1.9.4.1.1--General. When called for in the plans, out-of-position test piles shall be driven with special instrumentation attached for the purpose of conducting a load test as directed by the plans. A waiting period of seven (7) calendar days shall be observed beginning after the out-of-position test pile is driven. After the waiting period, the pile shall be load tested to failure as directed by the plans. The Contractor will be responsible for furnishing all materials, equipment, labor, and incidentals necessary for conducting the load test. The Contractor shall subcontract and supply all instrumentation, conducting, and reporting of the load test to the company supplying the instrumentation, with the cost included in prices bid for items contained in the contract. Reaction systems and extra pile installations as required in the plans shall be absorbed in the cost for the load test on the pile.

803.03.1.9.4.1.2--Materials. When called for in the plans, instrumentation shall be supplied to meet the requirements set forth in the plans. Instrumentation required in the plans are subject to prior approval by the State Geotechnical Engineer. Additional equipment that may be required are as follows.

1) Materials sufficient to construct a stable reference beam system for monitoring deflection of the pile during testing, supported at a minimum distance of three (3) diameters from the center of the pile to prevent disturbance of the reference system.

2) Materials sufficient to construct a protected work area including provisions such as a tent or shed for protection from inclement weather for the load test equipment. The work area shall be of size and type required by the Engineer.

3) In the case of an out-of-position pile, the pile shall be removed or broken-off such that the remaining pile is at least two (2) feet below the ground or mud line.

Materials supplied, which do not become a part of the finished structure, shall be removed from the job site.

803.03.1.9.4.2--Conventional Static Load Testing of Piling.

803.03.1.9.4.2.1--General. When called for in the plans or directed by the Engineer, the pile to be load tested shall be installed as indicated in the plans to the specified tip elevation or as directed by the Engineer. Once the pile is in place, a static load test will be conducted to determine the ultimate bearing capacity of the pile. A waiting period of seven (7) calendar days shall be observed beginning after all the reaction piles have been driven but prior to static load testing.

803.03.1.9.4.2.2--Contractor Requirements. The Contractor shall be responsible for furnishing the following:

1) A reaction load frame capable of resisting a total load of at least five (5) times the design load called for in the plans. The frame shall consist of a beam or girder that will carry the above load while sustaining only minor deflections in the reaction system. The beam or girder shall be attached to a system of anchor piles. The anchor piles shall not be closer to the test pile than five times the diameter (width) of the pile to be tested. See Figure 1 for additional reaction load frame requirements.

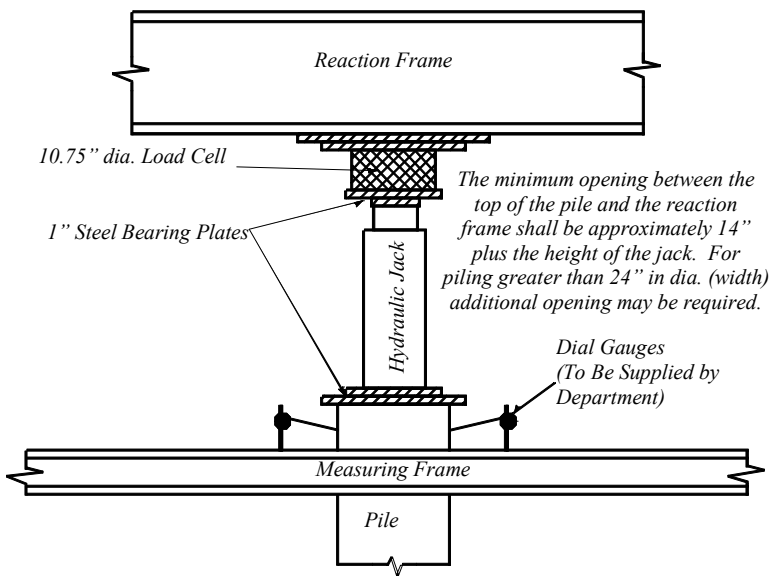
2) A hydraulic jack that has been calibrated for the full range of anticipated loads in accordance with AASHTO Designation: T 67 (ASTM Designation: E 4) at least once. The maximum anticipated load shall be assumed to be five (5) times the design load called for in the plans. The pressure gauge shall be calibrated within one year preceding the time of use and whenever there is a reason to doubt the accuracy of the results. The Contractor shall furnish a certificate of calibration for the hydraulic jack at the time of static load testing.

3) A measuring frame or reference beam for measuring the movement of the pile during testing. Two dial gauges, supplied by the Department, will be attached to the pile as indicated on Figure 1. Each dial gauge shall be actuated by its stem or by a stem attachment resting on the measuring frame. The supports for the measuring frame shall be placed the maximum practical distance from the test pile and the anchor piles for the reaction load frame. In no case should the measuring frame be affected by movement of the test pile or the anchor piles.

4) In the case of an out-of-position pile, the pile shall be removed or broken-off such that the remaining pile is at least two (2) feet below the ground or mud line.

803.03.1.9.4.2.3--Methods and Equipment. Personnel from the Geotechnical Branch of MDOT will assist in the setup and will be responsible for the running of the test. The Department will be responsible for providing the load cell, dial gauges and associated equipment. The static load test will be performed using ASTM Designation: D 1143, quick test methods. A waiting period of seven (7) calendar days shall be observed beginning after all the reaction piles have been driven but prior to static load testing.

Static Load Test



Note: Drawing Not to Scale

Figure 1

803.03.1.10--Pile Acceptance. The safe allowable load for each type, size, and length of pile will be determined by the Bridge Engineer. Acceptance criteria for

permanent production piles will be supplied by the Bridge Engineer with the final order list.

803.03.1.11--Test Piles. When required in the plans, the Contractor shall furnish and install test piles of the sizes, types, and lengths at the locations shown on the plans. The number of test piles may be increased or decreased by the Bridge Engineer as field conditions warrant. If determined by the Engineer to be necessary, test piles shall be extended, built-up, or spliced and in the case of steel piles driven further if deemed necessary, to the depths established by the Bridge Engineer. Similarly, the Contractor may be required to drive test piles below cut-off and extended as necessary.

803.03.2--Drilled Shafts.

803.03.2.1--Submittals.

803.03.2.1.1--Qualification of Contractor. The person(s) or firm directing the work described in this specification shall be knowledgeable of drilled shaft installation procedures and shall have installed drilled shafts of both diameter and length similar to those shown in the plans in accordance with the following minimum experience requirements:

1) A drilled shaft Contractor shall have a minimum of three (3) years of drilled shaft installation experience prior to the bid date for this project; or,
2) A Contractor without prior drilled shaft experience shall employ a superintendent with a minimum of fifteen years of drilled shaft experience prior to the bid date of this project.

A Contractor with limited drilled shaft installation experience may use a combination of their experience and the superintendent's experience, with each five years of experience of the superintendent counting as equivalent to one year's experience of the Contractor. A signed statement listing the applicable work experience of the drilled shaft Contractor shall be submitted to the Engineer at the Preconstruction Conference, or no later than 45 calendar days prior to drilled shaft construction.

At the Preconstruction Conference, or no later than 45 calendar days prior to beginning drilled shaft construction, the Contractor shall furnish the Engineer evidence of the following:

1) A signed statement from the drilled shaft superintendent responsible for the drilled shaft installation that the project site has been visited, and that all the subsurface information has been inspected. This information includes the soil profiles and/or boring logs furnished in the plans, soil

samples and rock cores, and the Geotechnical Investigation. All the above information may be obtained from the Geotechnical Branch of Materials Division.

2) A signed statement from the drilled shaft Contractor detailing their ability to complete a project of this type. This shall be supported by a list containing a detailed description of at least three (3) projects completed in the last three (3) years on which the drilled shaft Contractor and/or superintendent has installed or supervised installation of drilled shafts similar in size to those shown in the plans, and utilized excavation methods similar to those anticipated for this project. This list of projects shall contain names and phone numbers of the project owner's representatives who can verify the drilled shaft Contractor's participation on the project, and the names of the superintendents who were in charge of the drilled shaft operations.

3) Name and experience records of the drilled shaft superintendent and driller who will perform the required work.

The Engineer will evaluate the evidence of qualifications submitted for conformance with these specifications. Should the information submitted be incomplete or not conform to the project specifications, the information will be rejected and the Contractor shall submit changes for reevaluation.

If the Contractor wishes to replace the drilled shaft superintendent or the driller during the life of the project, the name and experience record of their replacement shall be submitted to the Engineer for approval.

803.03.2.1.2--Drilled Shaft Installation Plan. At the Preconstruction Conference, or no later than 45 calendar days before drilled shaft construction begins, the Contractor shall submit to the Engineer an installation plan for review. This plan shall provide information on the following:

1) A copy of the proposed drilled shaft concrete mix design as submitted with the Contractor's Concrete Quality Control Plan. Construction of the trial shaft(s) will not commence until the drilled shaft concrete mix design has been approved in accordance with Section 804, Concrete for Bridges and Structures.

2) List and size of proposed equipment including cranes, drill rigs, augers, bits, bailing buckets, digging buckets, final cleaning equipment, slurry tanks, desanding equipment, slurry pumps, tremies, pump lines, concrete pumps, casings, etc.

3) Details of the method of exploration including the equipment, if required.

4) Details of the sequence of construction operations and sequence of shaft construction within bents or shaft groups.

5) Details of shaft excavation method(s).

6) Details of slurry type and usage, including proposed methods to mix, circulate and desand slurry when slurry is required.

7) Details of proposed methods to clean the drilled shaft excavation upon reaching the minimum required tip elevation.

8) Details of reinforcement placement including the method of support while aligning the cage for placement into the drilled shaft excavation and the centering devices to be used to center the cage and assure minimum outside clear space shown in the plans.

9) Details of concrete placement including proposed operational procedures for concrete tremie or pump, including initial placement, raising during placement, and overfilling of the shaft concrete, and the ability of the concrete supplier to provide a continuous pour for the anticipated volumes.

10) Details of casing installation and removal, when required.

11) Details of any required load tests including equipment and recent calibrations for any jacks supplied by the Contractor.

The Engineer will evaluate the Contractor's *Drilled Shaft Installation Plan* for conformance with the plans and specifications, after which the Engineer will notify the Contractor within 14 calendar days of any additional information and/or changes that may be required. Any part of the plan that is unacceptable will be rejected and the Contractor shall submit changes for reevaluation.

All approvals given by the Engineer shall be subject to trial and satisfactory field performance, and shall not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed on the plans and in the specifications.

803.03.2.2--Trial Shaft Construction. The Contractor shall demonstrate the adequacy of the methods and equipment during construction of an out of position trial shaft. This trial shaft shall be positioned as far as practical from the production shafts, in the position shown on the plans or as directed by the Engineer, and shall be drilled to the minimum tip elevation as required on the plans. When shown on the plans, the reaming of bells at specified trial shafts will be required to establish the feasibility of belling in a specific soil strata. Failure to demonstrate the adequacy of the Contractor's methods and equipment to construct the trial shaft shall be cause for the Engineer to require alterations in equipment and/or method by the Contractor, to eliminate unsatisfactory results. Backfilling of unsuccessful excavations and any additional trial shafts required to demonstrate the adequacy of altered methods of construction or equipment shall be performed by the Contractor at no additional cost to the State. Once the Contractor has completed the excavation for the trial shaft to the satisfaction of the Engineer, the Contractor shall set the reinforcement and pour the concrete to finish construction of the trial shaft. This shall be demonstration that the entire

plan for drilled shaft construction is satisfactory. Failure to successfully construct the trial shaft shall be cause for rejection of the trial shaft, and shall be reason for the Engineer to require alterations necessary to eliminate unsatisfactory results. Additional trial shafts to demonstrate correction of deficiencies shall be at the Contractor's expense.

If differing soil conditions require two (2) or more methods for construction of production shafts, said methods shall be demonstrated by trial shaft prior to construction of any production shaft.

After the successful trial shaft has been completed, the Contractor shall submit in writing for review the successful methods and equipment used. This submittal, once reviewed, will serve as the approved method of construction for all the production shafts covered by that successful trial shaft. Once approval has been given to construct production shafts, no changes will be permitted in the methods, equipment, drilled shaft superintendent, or driller from those used during the construction of the trial shaft without written approval of the Engineer.

Trial shafts shall be cut off two (2) feet below finish grade or two (2) feet below the mudline and left in place. The portions of the shafts cut off and removed shall remain the property of the Contractor. The disturbed areas in the vicinity of the trial shaft shall be restored as nearly as practical to their original condition.

803.03.2.3--Construction Methods and Equipment.

803.03.2.3.1--General.

803.03.2.3.1.1--Protection of Existing Structures. When the plans require drilled shaft excavations within close proximity to existing structures or utilities, the Contractor shall take all reasonable precautions to prevent damage to such structures. This shall include newly constructed shafts. If not otherwise provided for in the plans, the Contractor shall be solely responsible for evaluating the need for, design of, and providing all reasonable precautionary features to prevent damage. These measures shall include, but are not limited to, selecting construction methods and procedures that will prevent caving of the shaft excavation, and monitoring and controlling the vibrations from construction activities, including the driving of casings, driving of sheeting, or from blasting, when permitted. Advancing an uncased drilled shaft excavation or the use of a vibratory hammer to install casings within 30 feet of a newly constructed shaft will not be permitted unless the concrete in that shaft has attained a compressive strength of 2500 p.s.i., as determined by cylinder tests. Based upon observations, the Engineer may adjust this distance accordingly. During shaft construction, the Contractor shall take into account and make provisions for vibrations caused by activities other than the Contractor’s, such as adjacent traffic.

Such structures shall be monitored for settlement in an approved manner, recording elevations to 0.01 foot. The number and location of monitoring points shall be as approved by the Engineer. Elevations shall be taken before construction begins, during the driving of any required casings, and during excavation or blasting as directed by the Engineer.

When shown on the plans, or as directed by the Engineer, the Contractor shall monitor and record vibration levels during the driving of casings, sheeting, or during blasting operations. Vibration monitoring equipment shall be capable of detecting particle velocities of 0.1 inch/second or less.

At any time the Contractor detects settlement of 0.03 foot, vibration levels reaching 1.5 inches per second, or damage to the structure, the Contractor shall immediately stop the source of vibrations, backfill the excavation, and contact the Engineer for instructions.

803.03.2.3.1.2--Construction Sequence for Site Preparation. Excavation to the plan footing elevation, if required, shall be completed before shaft construction begins. Any disturbance to the footing area caused by shaft installation shall be repaired by the Contractor prior to the footing pour.

When drilled shafts are to be installed in conjunction with embankment placement, the Contractor shall construct the drilled shafts after placement of the embankment material.

803.03.2.3.1.3--General Methods and Equipment. The Contractor shall perform the excavations required for the shafts and bell footings, through whatever materials encountered to the dimensions and elevations shown on the plans, or otherwise required by the specifications, at no additional cost to the State. The Contractor's methods and equipment shall be suited for the intended purpose and the materials encountered.

Drilled shafts shall be constructed by either the dry method, wet method, casing method, or permanent casing method, as necessary to produce a sound, durable, concrete foundation free of defects. The permanent casing method shall be used only when required by the plans or authorized by the Engineer. When the plans describe a particular method of construction, this method shall be used unless otherwise permitted by the Engineer. The Engineer may permit an alternate method than designated on the plans, only after successful construction of an out of position trial shaft. When the plans do not describe a particular method, the Contractor shall utilize a method on the basis of its suitability to the site conditions. Blasting shall only be permitted if specifically stated on the plans or approved by the Engineer.

Once approval is given to construct production shafts, no changes will be permitted in the methods or equipment from those used in constructing the accepted trial shaft without written approval of the Engineer.

803.03.2.3.2--Dry Construction Method. The dry construction method shall be used only at sites where the groundwater level and soil conditions are suitable to permit construction of the shaft in a relatively dry excavation, and where the sides and bottom of the shaft may be visually inspected by the Engineer prior to placing the concrete. The dry method consists of drilling the shaft excavation, placing the reinforcing cage, and concreting the shaft in a relatively dry excavation.

The dry construction method shall be used only when the trial shaft excavation demonstrates that: concrete can be placed with less than three (3) inches of accumulated water in the bottom of the shaft; the sides and bottom of the hole remain stable without caving, sloughing, or swelling over a two-hour period immediately following completion of the excavation; and any loose material and excess water can be satisfactorily removed prior to inspection and prior to concrete placement.

803.03.2.3.3--Wet Construction Method. The wet construction method shall be used at all sites where it is impractical to provide a dry excavation for placement of the shaft concrete.

The wet construction method consists of drilling the shaft excavation below the water table, keeping the shaft filled with water or mineral slurry, not a separate pay item, desanding or cleaning the slurry, final cleaning of the excavation by means of a bailing bucket, air lift, submersible pump or other approved devices, and placing the rebar cage and the shaft concrete, with a tremie or concrete pump beginning at the shaft bottom, which displaces the water or slurry as the shaft is concreted. Temporary surface casings shall be provided to aid shaft alignment and position and to prevent sloughing of the top of the shaft, except when the Contractor demonstrates to the satisfaction of the Engineer that the surface casing is not required.

Where drilled shafts are located in open water areas, the shafts shall be constructed by the wet method using casings extending from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. The casing shall be installed in a manner that will produce a positive seal at the bottom of the casing so that there is no intrusion or extrusion of water or other materials into or from the shaft excavation. Casings for this application may include multiple casings, temporary casings, and/or designed permanent casings.

The wet construction method may be used in combination with the dry method and temporary or permanent casing methods.

803.03.2.3.4--Casing Construction Method. The casing construction method may be used at sites when the dry or wet construction methods are inadequate to prevent hole caving or excessive deformation of the hole. In this method, the casing may be either placed in a predrilled hole if no caving, swelling, or yielding occurs, or advanced through the ground by twisting, driving, or vibration before being cleaned out.

When a formation is reached that is nearly impervious, a casing shall be placed in the hole and seated in the nearly impervious formation. Drilling may proceed as with the dry method to the projected depth. If seepage occurs at this point, temporary casing may be advanced further to create the dry condition. In the event seepage conditions prevent use of the dry method, excavation shall be completed using wet methods. The placement of the concrete shall proceed as with the wet or dry method, except that the casing shall be withdrawn after the concrete is placed.

When caving soils occur near the ground surface and/or if the top of the concrete for the drilled shaft is below the ground surface, the Contractor shall set a suitable temporary removable surface casing. The minimum surface casing length shall be the length required to prevent caving of the surface soils and to aid in maintaining shaft position and alignment. Predrilling with slurry and/or overreaming to the outside diameter of the casing may be acceptable if required to install the surface casing at some sites.

Where drilling is through materials having a tendency to cave, the drilling shall be advanced by drilling in a mineral slurry. In the event that a caving layer or layers are encountered that cannot be controlled by slurry, the Contractor shall install temporary removable casing through such caving layer or layers. Overreaming to the outside diameter of the casing may be required. However, the final dimensions of the drilled shaft shall not be altered to accommodate these construction practices unless approved by the Engineer. The Contractor shall take whatever steps are required to prevent caving during shaft excavation including installation of deeper casings. If the Contractor elects to remove a casing and replace it with a longer casing through caving soils, the Contractor shall adequately stabilize the excavation with slurry or backfill the excavation. Other approved methods which will control the size of the excavation and protect the integrity of the foundation soils may be used to excavate through caving layers.

803.03.2.3.5--Permanent Casing Method. The permanent casing method shall be used when required by the plans. In this method, a casing is driven to the prescribed depth before excavation begins. If full penetration cannot be attained, the Contractor may excavate material from inside the casing and the casing may be driven again until reaching the desired penetration. In some cases overreaming to the outside diameter of the casing may be required before driving the casing.

The casing shall be cut off at the prescribed elevation upon reaching the proper construction sequence, and the remainder of the casing is left in place.

803.03.2.3.6--Excavation and Drilling Equipment. The excavation and drilling equipment shall have adequate capacity including power, torque, and down thrust to excavate a hole of both the maximum diameter and to a depth 20 percent greater than the longest shaft shown on the plans.

The excavation and overreaming tools shall be of adequate design, size, and strength to perform the work shown on the plans or described herein. When the material encountered cannot be drilled using conventional earth augers with soil or rock teeth, drill buckets, and/or underreaming tools, the Contractor shall provide special drilling equipment including but not limited to: rock core barrels, rock tools, air tools, blasting materials, and other equipment as necessary to construct the shaft excavation to size and depth required. Approval of the Engineer is required before excavation by blasting is permitted.

Sidewall overreaming shall be required when the sidewall of the hole is determined by the Engineer to have either softened due to excavation methods or delays in excavation completion, swelled due to delays in concreting, or degraded because of slurry cake build-up. Overreaming thickness shall be a minimum of 1/2 inch and a maximum of three inches beyond the shaft radius. Overreaming may be accomplished with a grooving tool, overreaming bucket, or other approved equipment. The thickness and elevation of sidewall overreaming shall be as directed by the Engineer. The Contractor shall bear all costs associated with both sidewall overreaming and additional shaft concrete placement.

803.03.2.3.7--Excavations.

803.03.2.3.7.1--General. Shaft excavations shall be made at locations and to the top of shaft elevations, estimated bottom of shaft elevations, shaft geometry and dimensions shown in the plans. The Contractor shall extend drilled shaft tip elevations when the Geotechnical Engineer determines that the material encountered during excavation is unsuitable and/or differs from that anticipated in the design of the drilled shaft.

The Contractor shall maintain a drilling log during shaft excavation. The log shall contain information such as: the description and approximate top and bottom elevation of each soil or rock strata, seepage or groundwater, and remarks. Three (3) copies of the final Contractor's log shall be furnished to the Engineer with a copy to the Geotechnical Engineer at the time the drilled shaft is completed and accepted.

When shown on the plans, bells shall be excavated to form the height and bearing area of the size and shape shown. The bell shall be excavated by mechanical

methods. Any drilled shaft concrete over the theoretical amount required to fill any excavations for the bells and shafts dimensioned on the plans shall be furnished at no additional cost to the State.

The Contractor shall not permit workmen to enter a shaft excavation for any reason unless: both a suitable size casing has been installed and the water level has been lowered and stabilized below the level to be occupied, and adequate safety equipment and procedures have been provided to workmen entering the excavation. The Contractor is responsible for complying with all State and Federal safety regulations.

803.03.2.3.7.2--Obstructions. Surface and subsurface obstructions at drilled shaft locations shall be removed by the Contractor. Such obstructions may include man-made materials such as old concrete foundations, and natural materials such as boulders. Special procedures and/or tools shall be employed by the Contractor after the hole cannot be advanced using conventional augers fitted with soil or rock teeth, drilling buckets and/or underreaming tools. Such special procedures/tools may include but are not limited to: chisels, boulder breakers, core barrels, air tools, hand excavation, temporary casing, and increasing the hole diameter. Blasting shall not be permitted unless specifically approved in writing by the Engineer.

Drilling tools which are lost in the excavation shall be promptly removed by the Contractor at no cost to the State. All costs due to lost tool removal shall be borne by the Contractor including, but not limited to, costs associated with hole degradation due to removal operations or the time the hole remains open.

803.03.2.3.7.3--Exploration. When directed by the Engineer, the Contractor shall take soil samples or rock cores to determine the character of the material directly below the completed shaft excavation. The soil samples shall be extracted with a standard penetration test split spoon sampler or undisturbed sample (Shelby) tube. Rock cores, if required, shall be cut with an approved double or triple tube core barrel to a minimum of five (5) feet below the bottom of the drilled shaft excavation at the time the shaft excavation is approximately complete. Rock core, undisturbed tube, and/or standard penetration test samples shall be measured, visually identified, and described on the Contractor's log. The samples shall be placed in suitable containers, identified by shaft location, elevation, and project number, and delivered with the Contractor's field log to the Engineer within 24 hours after the exploration is completed. The Engineer will inspect the samples, or cores, and determine the final depth of required excavation based on the evaluation of the material.

803.03.2.3.7.4--Excavation Completion. Concrete placement must begin within two (2) hours of completion of shaft excavation. If the drilled shafts are five (5) feet in diameter or larger and in excess of sixty (60) feet in length, the elapsed time from completion of the drilled shaft excavation until beginning concrete

placement may extend past two hours provided the excavation remains stable and the extended time is demonstrated on the trial shaft. Completion of shaft excavation is defined as the time at which the specified tip elevation is initially achieved. Before concrete placement begins, bottom cleaning operations, any necessary slurry desanding, and placement of the reinforcing steel must be completed. These operations are included in the two hour time limit.

When it becomes apparent, as the excavation of the shaft is nearing completion, that it will not be feasible or possible to place concrete within the specified limit, the Contractor shall halt excavation operations a minimum of five (5) feet above the specified tip elevation. In the event that the wet construction method is being used, the slurry should be desanded at this point so that the remaining excavation will not cause the slurry to be too heavily contaminated and delay concrete placement due to final desanding operations.

In no case shall any excavation within the bearing zone(s) be allowed to remain open and idle for more than 24 hours. The bearing zone(s) are considered as those soil strata below the scour line, in the case of hydraulic structures, or those five feet below the ground line, whichever is greatest in depth. In no instance shall any uncased excavation, except for trial shafts, be allowed to remain open and idle for more than 24 hours. For partially completed excavations which stand idle for more than six (6) hours but less than 24 hours, sidewall overreaming may still be required by the Engineer.

If completion of shaft excavation has been achieved, and concrete placement has not begun within the specified limit, the Contractor shall backfill and/or stabilize the excavation. The Engineer shall then direct the Contractor as to the additional shaft excavation that will be required to produce a sound drilled shaft due to shaft wall and bottom degradation. The cost of the additional excavation, concrete, reinforcing steel, and other incidentals will be borne by the Contractor at no additional cost to the State.

803.03.2.3.7.5--Casings.

803.03.2.3.7.5.1--General. Casings shall be steel, smooth, clean, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of casing shall not be less than the specified size of shaft. No extra compensation will be allowed for concrete required to fill an oversized casing or oversized excavations. All casings, except permanent casing, shall be removed from the shaft excavation. Any length of permanent casing installed below the shaft cutoff elevations shall remain in place.

When the shaft is to extend above the ground or through a body of water, the portion exposed above the ground or through a body of water may be formed with removable casing, except when permanent casing is specified. Removable

casing shall be stripped from the shaft in a manner that will not damage the concrete. Casings can be removed when the concrete is cured for a full 72 hours; the shaft concrete is not exposed to salt water or moving water for seven (7) days; and the concrete reaches a compressive strength of at least 2500 psi as determined from concrete cylinder tests.

803.03.2.3.7.5.2--Temporary Casing. All subsurface casing shall be considered temporary unless specifically shown as permanent in the contract documents. All temporary casing shall be removed. Telescoping, predrilling with slurry, and/or overreaming to beyond the outside diameter of the casing may be required to install the casing. When temporary casing larger than called for on the plans is used for telescoping or overreaming, no additional compensation will be made.

If the Contractor elects to remove a casing and substitute a longer or larger diameter casing through caving soils, the excavation shall be either stabilized with slurry or backfilled before the new casing is installed, as directed in Subsection 803.03.5.4. Other methods, as approved by the Engineer, may be used to control the stability of the excavation and protect the integrity of the foundation soils.

When temporary casings which are to be removed become fouled or bound in the shaft excavation and cannot be practically removed, and concreting has not yet begun, the Engineer may direct that the shaft excavation be drilled deeper to compensate for the loss of capacity due to the presence of the casing. No additional compensation will be paid for the casing left in the excavation. No additional length of shaft will be paid for beyond the current depth of excavation or the plan tip elevation of the production shaft, whichever is lower.

Temporary casings which become bound or fouled during concreting of the shaft, and cannot be practically removed before the concrete begins to set up, shall constitute a defect in the drilled shaft. When the Engineer, in writing, notifies the Contractor of a defective shaft, the Contractor shall be responsible for improving such defective shafts to the satisfaction of the Engineer. Improvements may consist of, but are not limited to, removing the shaft concrete and extending the shaft deeper to compensate for loss of frictional capacity in the cased zone, providing straddle shafts to compensate for capacity loss, proof load testing or providing replacement shafts. All corrective measures, including redesign of footings or drilled shaft caps, shall be performed to the satisfaction of the Engineer by the Contractor without either additional compensation or extension of Contract Time. No compensation will be paid for casing remaining in place. Any redesigns submitted must be approved in writing by the Bridge Engineer.

Temporary casing extraction shall be slow and uniform, pulling along the axis of the shaft. The elevation of the concrete in the casing shall be maintained high enough to displace the drilling slurry between the outside of the casing and the edge of the hole as the casing is removed. Temporary casings shall be removed

while the concrete remains workable. No temporary casings will be removed if the concrete slump is less than four (4) inches. Should this condition occur, the shaft will be designated as defective, and corrections to the situation shall be as described above.

Special casing systems may be used in open water areas, when approved, which are designed to permit removal after the concrete has hardened. Special casings shall be designed so that no damage occurs to the drilled shaft concrete during their removal. Any defects either cosmetic or structural that are apparent after removal of the casing or are due to the removal of the casing shall be repaired to the satisfaction of the Engineer at no additional cost to the State.

In the event that permanent casing is not specified in the plans, and the Contractor elects to use a temporary casing and leave it in place, it shall be cut off at a maximum of 12 inches above the low water elevation as shown on the plans, or painted. Written approval from the Engineer is required in this event, and payment for the temporary casing left in place will be at the contract bid price for temporary casing.

803.03.2.3.7.5.3--Permanent Casings. Permanent casing shall be used when shown on the plans. The casing shall be continuous between top and bottom elevations prescribed on the plans or as directed by the Engineer. Exterior surfaces of permanent casing shall be painted in accordance with the plans unless otherwise noted. After installation is complete, the permanent casing shall be cut off at the prescribed elevation and the shaft completed.

In general, permanent casing shall not be placed in an overreamed shaft hole.

803.03.2.3.8--Slurry. Mineral slurries shall be employed when slurry is used in the drilling process, unless other drilling fluids are approved in writing by the Engineer. The slurry shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. The percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. During construction, the level of the slurry shall be maintained at a height sufficient to prevent caving of the hole. In the event there is a sudden, significant loss of slurry within the drilled shaft excavation, the construction of the drilled shaft shall be stopped until a method to stop slurry loss or an alternate construction procedure has been approved by the Engineer.

Mineral slurry shall be premixed thoroughly with clean, fresh water, and an adequate time (as prescribed by the mineral manufacturer) shall be allotted for hydration, prior to introduction into the shaft excavation. Slurry tanks of adequate capacity will be required for slurry circulation, storage, and treatment. No excavated slurry pits will be allowed in lieu of slurry tanks, without the

written permission of the Engineer. Desanding equipment shall be provided by the Contractor as necessary to control slurry sand content to less than two percent (2%) by volume at any point in the borehole. Desanding will not be required for setting sign post or lighting mast foundations unless shown on the plans. The Contractor shall take all steps necessary to prevent the slurry from "setting up" in the shaft. Such methods may include, but are not limited to: agitation, circulation, and/or adjusting the properties of the slurry. Disposal of all slurry shall be performed offsite in suitable areas by the Contractor, and subject to all environmental regulations pertaining to slurry disposal.

Control tests using suitable apparatus shall be carried out on the mineral slurry mixture by a qualified individual or qualified professional testing laboratory approved by the Engineer. Tests to be conducted will be density, sand content, viscosity, and pH. The acceptable range of values for those physical properties is as shown in the following table:

MINERAL SLURRY
Sodium Montmorillonite (Commercial Bentonite)
Acceptable Range of Values

Property Units	At Time of Slurry Introduction	In Hole at Time of Concreting	Test Method
Density, pcf	64.3** - 69.1**	64.3** - 75.0**	Density Balance
Viscosity, seconds/quart	28 - 45	28 - 45	Marsh Cone
pH	8 - 11	8 - 11	pH paper pH meter

**Increase by 2 pcf in salt water

Notes: a. Tests should be performed when the slurry temperature is above 40 degrees Fahrenheit.

b. If desanding is required, sand content shall not exceed two percent (2%) by volume at any point in the borehole as determined by the American Petroleum Institute sand content test.

The limits in the above table may be adjusted when field conditions warrant, as successfully demonstrated on the trial shaft or as directed by the Engineer. All changes must be approved in writing by the Engineer before continued use.

Tests to determine density, viscosity, and pH value shall be performed during the shaft excavation to establish a consistent working pattern. A minimum of four (4) sets of tests shall be made during the first eight (8) hours of slurry use. When the results show consistent behavior, the testing frequency may be decreased to one set every four (4) hours of slurry use.

The Contractor shall insure that heavily contaminated slurry suspension, which could impair the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the Contractor shall take slurry samples using a sampling tool approved by the Engineer or similar to that shown in Figure 2. Slurry samples shall be extracted from the base of the shaft and at intervals not exceeding 10 feet up the shaft, until two consecutive samples produce acceptable values for density, viscosity, pH, and sand content.

When any slurry samples are found to be unacceptable, the Contractor shall take whatever action is necessary to bring the mineral slurry within specification requirements. Concrete shall not be poured until resampling and testing produce acceptable results.

Reports of all tests required above, signed by an authorized representative of the Contractor, shall be furnished to the Engineer on completion of each drilled shaft. Representatives of the Department may perform comparison tests as determined necessary during mineral slurry operations.

During construction, the level of mineral slurry in the shaft excavation shall be maintained at a level not less than four (4) feet above the highest expected piezometric pressure head along the depth of the shaft. If at any time the slurry construction method fails to produce the desired final results, the Contractor shall discontinue this method and propose an alternate method for approval by the Engineer.

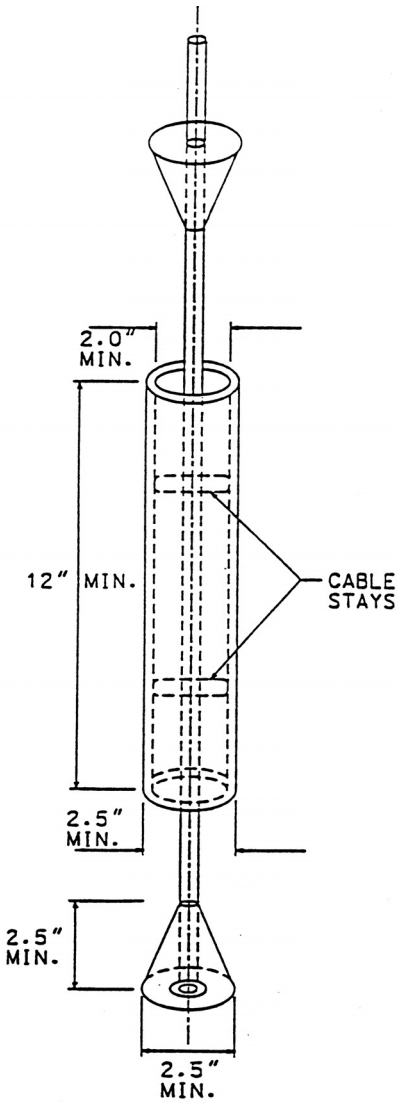
Drilling tools should contain vents to stabilize hydrostatic pressure above and below the tool during extraction. The rate of tool extraction should not cause any noticeable turbulence in the hole.

In locations where saline or chemically contaminated groundwater exists, the slurry should be adjusted with appropriate chemical additives, or developed with a mineral material not affected by such conditions.

803.03.2.4--Excavation Inspection. The Contractor shall provide equipment for checking the dimensions and alignment of each drilled shaft excavation. The dimensions and alignment shall be determined by the Contractor in the presence of the Engineer or the Engineer's inspector. Final shaft depths shall be measured with a weighted tape or other approved methods after final cleaning. Unless otherwise stated on the plans, a minimum of 50 percent of the base of each shaft shall have less than 1/2 inch of sediment at the time of placement of the concrete.

Shaft cleanliness will be determined by the Engineer, by visual inspection for dry shafts, or other methods deemed appropriate to the Engineer for wet shafts. In addition, for dry excavations, the maximum depth of water shall not exceed three (3) inches prior to concrete pour.

SLURRY SAMPLER



The sampler consists of three components:

1. Cable with weighted cone-shaped stopper.
2. Cylindrical sampler center stayed for alignment.
3. Top stopper with hole drilled through the center.

SAMPLING PROCEDURE

1. Lower cable with stopper to desired sampling elevation.
2. Slide cable through aligning guides of sampler.
3. Let sampler drop down the cable and seat onto bottom cone-shaped stopper.
4. Slide cable through hole in top stopper and let drop to seat on top of sampler.
5. Withdraw entire assembly from shaft.
6. Sample may be emptied into separate container and used as necessary to perform required testing.

Figure 2

803.03.2.5--Construction Tolerances. The following construction tolerances apply to drilled shafts unless otherwise stated in the contract documents.

1) The drilled shaft shall be within three (3) inches of plan position in the horizontal plan at the plan elevation for the top of the shaft.

2) The vertical alignment of a vertical shaft excavation shall not vary from the plan alignment by more than 1/4 inch per foot of depth.

3) After all the concrete is placed, the top of the reinforcing steel cage shall be not more than three (3) inches below plan elevation.

4) All casing diameters shown on the plans refer to O.D. (outside diameter) dimensions. The dimensions of casings are subject to American Pipe Institute tolerances applicable to regular steel pipe. When approved, the Contractor may elect to provide a casing larger in diameter than shown on the plans.

5) Bells shall be excavated to the plan bearing area and height shown on the plans as a minimum. The actual diameter of the bells shall not exceed three (3) times the specified shaft diameter. All other plan dimensions shown for the bells may be varied, when approved, to accommodate the Contractor's equipment.

6) Top elevation of the shaft shall have a tolerance of plus one (1) inch or minus three (3) inches from the plan top of shaft elevation.

7) Excavation equipment and methods shall be designed so that the completed shaft excavation will have a planar bottom. The cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of ±3/8 inch per foot of shaft diameter.

Drilled shaft excavations and completed shafts not constructed within the required tolerances are unacceptable. The Contractor shall be responsible for correcting all unacceptable shaft excavations and completed shafts to the satisfaction of the Engineer. Materials and work necessary, including engineering analysis and redesign, to complete corrections for out of tolerance drilled shaft excavations shall be furnished without either cost to the State or an extension of the completion dates of the project. Any redesign shall be performed by a professional engineer, registered in the State of Mississippi and engaged by the Contractor. Redesign drawings and computations prepared by the Contractor's engineer shall be signed and sealed.

Out of tolerance shaft holes shall be backfilled in an approved manner, when directed by the Engineer, until the redesign is complete and approved.

803.03.2.6--Reinforcing Steel Construction and Placement. The reinforcing steel cage, consisting of longitudinal bars, ties, cage stiffener bars, spacers, centralizers, and other necessary appurtenances, shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted, and prior to concrete placement. Details of reinforcing steel will be as shown in the plans.

The reinforcing steel in the shaft shall be double-wire tied at all junctions and supported so that the reinforcing steel will remain within allowable tolerances given in Subsection 803.03.7. Stiff tie wire may be required for long reinforcing steel cages. Free-rolling concrete centralizers or other approved noncorrosive rolling centralizer devices shall be used at sufficient intervals. The centralizers shall be attached to the reinforcing steel cage near the bottom, and at intervals not exceeding 10 feet up the shaft for shaft lengths less than 60 feet, and intervals not exceeding seven (7) feet for shaft lengths greater than 60 feet, to insure concentric spacing for the entire cage length. Centralizers shall be constructed of approved material equal in quality and durability to the concrete specified for the shaft. The centralizers shall be of adequate dimension to insure a minimum five (5) inch annular space between the outside of the reinforcing cage and the side of the excavated hole. Approved cylindrical feet (bottom supports) shall be provided to insure that the bottom of the cage is maintained the proper distance above the base.

The elevation of the top of the steel cage shall be checked before and after the concrete is placed. If the rebar cage is not maintained within the specified tolerances, corrections shall be made by the Contractor to the satisfaction of the Engineer. No additional shafts shall be constructed until the Contractor has modified the rebar cage support in a manner satisfactory to the Engineer.

If the bottom of the excavated shaft elevation is lower than the bottom of the shaft elevation shown on the plans, all reinforcement required in the upper portion of the shaft shall be achieved by splicing the additional length at the bottom of the cage, to avoid congestion in the upper portion of the shaft.

803.03.2.7--Concrete Placement.

803.03.2.7.1--General. Drilled Shaft concrete shall meet the requirements in Section 804.

Concrete placement during cold weather shall be allowed when ambient air conditions are at or expected to drop below 40°F, but protection of the fresh concrete shall be in accordance with the provisions stated in Sections 804 and 501. The Contractor shall assume all responsibility for protection of fresh concrete in cold weather.

Concrete shall be placed as soon as possible after reinforcing steel placement. Concrete placement shall be continuous from the bottom to the top elevation of the shaft. Concrete placement shall continue after the shaft excavation is full until good quality concrete is evident at the top of the shaft. Concrete shall be placed either through a tremie, concrete pump or free fall. Free fall placement shall require prior written approval of the Engineer and shall be restricted for use in dry excavations only.

For tremied or pumped concrete, the elapsed time from the beginning of concrete placement in the shaft to the completion of the placement shall not exceed four (4) hours, except as noted below. Retarders and/or water reducers in the concrete mix shall be adjusted as approved for the conditions encountered on the job, so that the concrete remains in a workable plastic state throughout the four hour placement limit. This is defined as a minimum slump of four (4) inches existing everywhere within the concrete shaft after placement has been completed. Prior to concrete placement, the Contractor shall provide test results of a trial mix, set time test per AASHTO Designation: T 197, and a slump loss test using approved methods, to demonstrate that the concrete meets this four hour requirement. These tests shall be conducted by an approved testing laboratory at least 30 days prior to initial concrete placement, with the Department's Central Laboratory personnel present, at temperatures and conditions similar to those at the job site at the time of the shaft pour. However, the Contractor may request a longer placement time, provided a concrete mix is supplied that will maintain a slump of four (4) inches or greater over the longer placement time, as demonstrated by trial mix, set time, and slump loss tests. A slump loss test shall be conducted from the concrete at the site for verification of slump loss requirements, using a sample from a minimum batch size of four cubic yards of concrete.

In the event that free-fall concrete placement is approved and used, the four inch slump in four hours requirement will be waived. However, a different trial mix must be approved with its corresponding set time and slump loss tests.

The Contractor shall place the concrete within the approved time and temperature limitations determined by the trial mix demonstration.

Before the casing is withdrawn, the level of fresh concrete shall be at such a level that the fluid trapped behind the casing is displaced upward. As the casing is withdrawn, care shall be exercised to maintain the level of concrete within the casing so that the fluid trapped behind the casing is displaced upward out of the shaft excavation without mixing with or displacing the shaft concrete.

803.03.2.7.2--Tremies. Tremies used for concrete placement in either wet or dry excavations shall consist of a tube of sufficient length, weight, and diameter to discharge concrete at the shaft base elevation. The tremie shall not contain aluminum parts which will have contact with the concrete. The tremie inside diameter shall be at least six (6) times the maximum size of aggregate used in the concrete mix but shall not be less than 10 inches. The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concreting. The wall thickness of the tremie shall be adequate to prevent crimping or sharp bends which restrict concrete placement.

The tremie used for wet excavation concrete placement shall be watertight. Underwater placement shall not begin until the tremie is placed at the bottom of

the excavation. Valves, bottom plates, or plugs may be used only if concrete discharge can begin within one tremie diameter of the base. Plugs and plates shall either be removed from the excavation or be of a material, approved by the Engineer, which will not cause a defect in the shaft if not removed. The discharge end of the tremie shall be constructed to permit the free radial flow of concrete during placement operations. The tremie discharge end shall remain at the excavation bottom as long as possible, and thereafter be immersed at least two shaft diameters but not less than 10 feet in concrete at all times after starting the flow of concrete. The flow of concrete shall be continuous. The concrete in the tremie shall be maintained at a positive pressure differential at all times to prevent water or slurry intrusion into the shaft concrete.

If, at any time during the concrete pour in a wet excavation, the tremie line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete all necessary sidewall removal directed by the Engineer and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.

803.03.2.7.3--Pumping Concrete. Concrete pumps and lines may be used for concrete placement in either wet or dry excavations. All pump lines shall have a minimum five (5) inch diameter and be constructed with watertight joints. The use of aluminum pipe as a conveyance for the concrete will not be permitted. Concrete placement shall not begin until the pump line discharge orifice is at the bottom of the excavation.

For wet excavations, a plug or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. The plug shall either be removed from the excavation or be of a material, approved by the Engineer, which will not cause a defect in the shaft if not removed.

The discharge orifice shall remain at least two shaft diameters but not less than 10 feet below the surface of the fluid concrete at all times after starting the flow of concrete. When lifting the pump line during concreting, the Contractor shall temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation.

If, at any time during the concrete pour, the pump line orifice is removed from the fluid concrete column and discharges concrete above the rising level, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete all necessary sidewall removal directed by the Engineer and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.

803.03.2.7.4--Free Fall Method. Placement of concrete by the free fall method

will be permitted only when approved in writing by the Engineer. Approval of concrete placement by the free fall method shall be contingent upon the following conditions:

1) The clear opening inside the reinforcing cage is not less than 24 inches in diameter.

2) The dry construction method is used in constructing the drilled shafts.

3) The height of free fall placement shall not exceed 75 feet.

4) Concrete shall fall directly to the placement location without contacting either the reinforcing cage or shaft walls.

5) A hopper shall be used at the top of the shaft to center and direct free fall placement.

6) The Engineer will observe the falling of the concrete within the shaft. The Contractor shall reduce the rate of concrete placement or reduce the height of free fall as directed by the Engineer when the concrete strikes the reinforcing cage or shaft sidewalls, when there is excessive spatter from the impact of the falling concrete, or when concrete placement causes the shaft excavation to cave or slough.

7) When in the opinion of the Engineer, placement cannot be satisfactorily accomplished by the free fall method, the Contractor shall change to either the tremie or pumping method to accomplish the pour.

803.03.2.8--Drilled Shaft Load Tests. The methods required for the load testing of drilled shafts shall be Static and/or Static with Special Instrumentation. Load testing of drilled shafts shall be completed before construction of any production drilled shafts, and the results used by the Bridge Engineer to determine the drilled shaft lengths given on the order list. The method, number, and locations of load tests shall be as shown on the plans or as designated by the Engineer.

After completion of any load test, the order list providing the final production lengths will be provided within two weeks of receiving the load test results. The production shaft lengths provided by the Bridge Engineer may differ from the individual shaft lengths shown on the plans. Requests for adjustment to the contract due to changes in shaft lengths shall be subject to the provisions of Subsection 104.02.1. Before any consideration will be given for an adjustment to the contract, it must be determined that a significant change in the character of the work has occurred.

803.03.2.8.1--Static Load Tests. Static load testing shall not begin until the concrete has attained a compressive strength of 3000 psi as determined from

cylinder tests. During the curing time, no other construction or operations which will induce excessive vibration levels, as previously discussed, shall be performed.

Static axial load tests shall be performed by personnel of the Geotechnical Branch of MDOT assisted by the Contractor's personnel using the procedures as described in ASTM Designation: D 1143, quick test method. No weighted platforms to totally supply the axial load are allowed.

The Contractor shall be responsible for furnishing the following:

1) A reaction frame capable of resisting a total load of at least four (4) times the design load of the test shaft shall be provided. The frame shall consist of a beam(s) or girder(s) that will carry the required load while sustaining only minor deflections in the reaction system. The beam or girder shall be attached to a system of anchor shafts or piles. The anchor piles shall not be closer than three (3) diameters measured from the center of the test shaft.

2) A hydraulic jack that has been calibrated for the full range of anticipated loads in accordance with AASHTO Designation: T 67 (ASTM Designation: E 4) at least once. The maximum anticipated load shall be assumed to be four (4) times the design load for the test shaft. The pressure gauge shall be calibrated within one year preceding time of use. The Contractor shall furnish a certificate of calibration for the hydraulic jack at the time of load testing.

3) A measuring frame or reference beam for measuring the movement of the test shaft during testing. Two dial gauges, supplied by the Department, will be attached to the test shaft during testing to monitor downward movement. Each dial gauge will be actuated by its stem or by a stem attachment resting on the measuring frame. The supports for the measuring frame shall be placed the maximum practical distance from the test pile and the anchor shafts or piles. In no case shall the measuring frame be affected by movement of the test shaft or the anchor shafts or piles.

The Geotechnical Branch will furnish the load cell, gages, any needed details of the shaft gauge locations and personnel to run the test. The Geotechnical Branch shall also be responsible for reviewing and submitting the results to the Bridge Engineer. The Contractor shall submit a detailed plan for any jacks and load frame to the Engineer for evaluation. This plan should include the following:

1) Size and type of the reaction beam or beams.

2) Size, type, number, and length of reaction piles or shafts.

3) Type and capacity of any jacks and their most recent calibration documents.

4) A plan sheet shop drawing showing plan and profile of load frame details. Details should be shown for of how the reaction beam will be connected to the reaction piles or shafts. A detail showing how the jack, load cell (6" height, 11" diameter, supplied by MDOT), and bearing plates are to be arranged between the shaft top and the bottom of the reaction beam.

5) Details of a protected work area, including provisions such as a tent or shed for protection from inclement weather for the testing equipment, of a size and type required by the Engineer.

After testing is completed, the test shafts and any anchor shafts shall be cut off at an elevation two (2) feet below the finished ground surface. The portion of the shafts cut off and removed shall remain the property of the Contractor.

803.03.2.8.2--Load Testing of Drilled Shafts With Special Instrumentation.

803.03.2.8.2.1--General. When designated on the plans, a dedicated test shaft shall be constructed as detailed in the plans with instrumentation and hydraulic jack(s) cast in the concrete of the drilled shaft. The Contractor will be required to furnish all materials, equipment, labor, and incidentals necessary for conducting the load test and reporting the results. The Contractor shall subcontract the instrumenting, conducting, and reporting of the load test to the company supplying the instrumentation with the cost included in prices bid for test shaft.

No reaction systems and extra drilled shaft installations such as anchor shafts are required for conducting the load test. The load test is a non-destructive test, and if the test shaft designated on the plans is a production shaft, it shall be left in a condition suitable for use as a production shaft in the finished structure.

803.03.2.8.2.2--Materials. When called for in the plans, instrumentation shall be supplied to meet the requirements set forth in the plans. Instrumentation required in the plans are subject to prior approval by the State Geotechnical Engineer. Additional equipment that may be required is as follows.

1) Materials sufficient to construct a stable reference beam system for monitoring deflection of the shaft during testing, supported at a minimum distance of three (3) diameters from the center of the shaft to prevent disturbance of the reference system.

2) Materials sufficient to construct a protected work area, including provisions such as a tent or shed for protection from inclement weather for the load test equipment, of size and type required by the Engineer.

Materials supplied which do not become a part of a finished structure shall be removed from the job site at the conclusion of the load test.

803.03.2.8.2.3--Equipment. The Contractor shall supply any additional equipment required to install the testing instrumentation and conduct the load test, remove the load test apparatus, and, if the test shaft is to become a production shaft at the conclusion of the test, restore the shaft to a condition suitable for use in the finished structure. This equipment includes, but is not limited to:

1) Electric power and welding equipment, as required, to assemble the test equipment, instrumentation, and prepare the work area.

2) A suitable pressurized gas source consisting either of an approved air compressor or of compressed nitrogen, i.e. four 230 cubic-foot cylinders of nitrogen per load test.

3) Equipment and operators for handling the instrumentation and reinforcing cage, if required, during the installation of the test shaft and during the test. This shall include, but is not limited to, a crane or other lifting device, manual labor, and hand tools.

4) Equipment and labor sufficient to erect the protected work area and monitoring reference beam system, to be constructed to the requirements of the Engineer and instrumentation supplier.

5) Approved small piston type power grout pump with experienced operator, for grouting the cell upon completion of the test if required. Successful demonstration that the grout pumping system works as intended will be required before placing the instrumentation in the test shaft hole.

6) Approved small power mortar mixer with suitable mortar box to discharge grout, if required, with an experienced operator.

7) Screen with an approximately 1/4-inch mesh to screen grout prior to placement in the grout pump to prevent clogging of the grout pump or the piping.

8) Suitable operating and reference level platforms, as required by the Engineer and/or instrumentation supplier, for testing over water or in otherwise unstable foundation conditions.

803.03.2.8.2.4--Procedure. The test shaft shall be constructed by the shaft construction technique approved by the Engineer after trial shaft construction. The test shaft shall then be constructed in accordance with the plans and at the direction of the Engineer.

The instrumentation shall be assembled and made ready for installation under the direction of the instrumentation supplier, in a suitable area, adjacent to the test shaft, to be provided by the Contractor. When a reinforcing cage is required for the test shaft, the instrumentation shall be placed as directed in the plans.

When the test shaft excavation has been completed and accepted by the Engineer, the Contractor shall then install the instrumentation and, if required, the reinforcing cage assembly in the test shaft under the direction of the Engineer. The Contractor shall use the utmost care in handling the reinforcing cage and test equipment assembly so as not to damage the instrumentation during installation.

After the installation of the instrumentation, the test shaft shall be concreted in the manner approved from the trial shaft construction. Load testing shall not begin until the concrete has attained a compressive strength of 3000 psi as determined from cylinder tests. During the curing period, no other construction or operations which will induce excessive vibration levels shall be performed.

After completion of the load test, and at the direction of the Engineer, the Contractor shall remove any equipment, material, etc. which are not to be a part of the finished structure.

The Contractor shall supply the Engineer with six (6) copies of the final load test report.

803.04--Method of Measurement.

803.04.1--Test Piles. Test piles will be measured per each complete-in-place. Piles measured as test piles will not be included in the measurement of pay footage for permanent piles.

Test piles constructed in accordance with the lengths indicated on the plans and which are required to be extended or built up will be measured as a percentage, calculated by dividing the sum of the plan length plus the length of the ordered extension or build-up, by the plan length. Splices required for the extension(s) will not be measured for payment.

No measurement for payment will be made for cut-off of a test pile.

803.04.2--Conventional Static Pile Load Tests. Conventional static pile load tests will be measured by the actual number of static load tests conducted on either a test pile or permanent production pile in accordance with these specifications.

In the event a pile is reloaded in accordance with these specifications, the reloading will be measured for payment as 50 percent of a separate conventional static pile load test.

803.04.3--Pile Shoes. Pile shoes of approved design, ordered and used, will be measured and paid as set out in Subsection 803.05.3.

803.04.4--Piling. Piling, exclusive of those measured as test piles, will be measured by the linear foot for each class and size of piling furnished and installed in accordance with lengths shown on the plans or approved by the Bridge Engineer. Cut-offs for each individual pile will be measured and deducted as set forth in Subsection 803.04.5.

Pile lengths in excess of those shown on the plans or approved by the Bridge Engineer will not be measured for payment unless such additional lengths below cut-off are approved in writing by the Bridge Engineer for incorporation in the structure.

803.04.5--Cut-Off. The summation of all cut-offs shall be deducted at 40 percent to determine the length for payment of in-place permanent piling.

The summation of all cut-offs for pile lengths in excess of those shown on the plans or approved by the Bridge Engineer will be deducted at 100 percent to determine the length for payment of in-place permanent piling.

An allowance will be made for prestressed concrete piling cut-offs in accordance with the provisions of Subsection 803.05.5. Cut-offs shall be measured for payment per each for each pile requiring cut-off.
All piling cut-offs shall become the property of and shall be disposed of by the Contractor.

803.04.6--Extensions or Build-Ups. Extensions or build-ups will not be measured for payment as such, but will be included in the length of piling remaining in the finished structure. In determining the amount to be included in piling footage, no allowance will be made for cut-offs necessary to accomplish the extensions or build-ups.

803.04.7--Falsework and Defective Piles. No allowance will be made for furnishing or driving of falsework piles, for piles driven out of place, for defective piles, or for piles which are damaged by handling or driving.

803.04.8--Splices. Splices necessary for extensions or build-ups on bearing piles will be measured by the linear foot. For prestressed concrete piles, the number of linear feet will be determined by allowing seven linear feet of piling for each splice. For other piles, the number of linear feet will be determined by allowing four linear feet of piling for each splice. The total number of linear feet of piling to be paid for shall be determined by adding seven feet or four feet, as applicable, to the net length of piling for each splice in place in the finished structure.

No measurement or payment will be made for splices except those made at the direction and under the supervision of the Engineer.

803.04.9--Pre-formed Pile Holes. Pre-formed pile holes, when included as a pay item on the plans, will be measured by the linear foot. For trestle type bents, the footage for each hole will be determined by subtracting the elevation of the bottom of the hole shown on the itemized list from the elevation of the natural ground at the pile site or from the elevation of the excavated section, whichever is lower. For foundations and end bents, the footage will be determined by subtracting the elevation of the bottom of the hole as shown on the itemized list from the elevation of the bottom of the footing or the bottom of the end bent caps, as applicable.

803.04.10--PDA Test Piles, Special Instrumentation Load Test. PDA test piles, special instrumentation load test will be measured per each, which shall include a static load test with special instrumentation. Piles paid for as PDA test piles, special instrumentation load test, will not be included in the measurement of pay lengths for permanent piles.

Completion of this pay item shall include the 1-day restrike after the initial pile driving, the special instrumentation load test, and the restrike within 24 hours after the static load test and the individual components will not be considered separately. Any additional restrike required by the Engineer on this type test pile will be paid for as a PDA Restrike.

803.04.11--PDA Test Piles, Conventional Load Test. PDA test piles, conventional load test, will be measured per each, which shall include a static load test. Piles paid for as PDA test piles, conventional load test will not be included in the measurement of pay lengths for permanent piles.

Completion of this pay item shall include the 1-day restrike after the initial pile driving, the conventional static load test, and the restrike within 24 hours after the static load test and the individual components will not be considered separately. Any additional restrike required by the Engineer on this type test pile will be paid for as a PDA Restrike.

803.04.12--PDA Test Pile. PDA test pile will be measured per each. Piles paid for as PDA test piles will not be included in the measurement of pay lengths for permanent piles.

Completion of this pay item shall include the 1-day and 7-day restrike after initial driving and individual components will not be considered separately. Any additional restrike required by the Engineer on this type test pile will be paid for as a PDA restrike.

803.04.13--Pile Restrike. Pile restrike will be measured per each actually performed on permanent piles or test piles as directed by the Engineer. The pile restrike will be conducted as directed by the Engineer for bearing determination and may be conducted either with or without PDA monitoring.

803.04.14--Drilled Shaft. Drill shaft will be measured per linear foot. Measurement shall be the authorized length in feet of the completed concrete drilled shaft, including bells, of the diameter and containing the reinforcement shown on the plans. The length shall be determined as the difference between the plan top of shaft elevation and the final bottom of shaft elevation.

803.04.15--Test Shaft. Test shaft of the specified diameter will be measured per each. Such measurement shall be full compensation for excavating the test shaft through whatever materials are encountered to the bottom of the shaft elevation shown on the plans or as authorized by the Engineer, concrete, reinforcement, required casings, special instrumentation load cell when required, conducting and reporting load test results, restoring the site as required, and all other expenses to complete the work.

803.04.16--Trial Shaft. Trial shaft of the specified diameter will be measured per linear foot. Such measurement shall be full compensation for excavating the trial shaft hole through whatever materials are encountered to the bottom of shaft elevation shown on the plans or as authorized by the Engineer, using mineral slurry as necessary, utilizing temporary casing as necessary which is not a separate pay item, providing inspection facilities, backfilling the holes, setting reinforcement and placing concrete as required, restoring the site, and all other expenses necessary to complete the work.

803.04.17--Exploration. Exploration will be measured per linear foot of soil samples and/or rock cores of the diameter and length required and authorized by the Engineer. Such measurement shall be full compensation for drilling, extracting, packaging and classifying the samples or cores, delivering them to the Department, furnishing concrete to fill the core hole, and all other expenses necessary to complete the work.

803.04.18--Casing. Casing shall be measured per linear foot. Such measurement shall be full compensation for furnishing, placing, and removing when required, the casing in the shaft excavation.

803.05--Basis of Payment.

803.05.1--Test Piles. Test piles, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.2--Conventional Static Pile Load Tests. Conventional static pile load tests, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.3--Pile Shoes. If not covered by a contract item or otherwise required by the plans, metal shoes ordered by the Engineer will be paid for at double the invoice cost of the shoe. The cost of placing the pile shoes and driving piling with these additional requirements will not be paid for directly, and the cost thereof shall be considered incidental to the respective pile driving pay item.

803.05.4--Piling. Piling of the type specified will be paid for at the contract unit price per linear foot.

803.05.5--Cut-Offs. For permanent prestressed concrete piles required to be cut off and the cut-offs are not necessitated by damage to the pile or as a result of a pile furnished in a length greater than that established by the pile list on the plans or furnished by the Bridge Engineer, the Contractor will be paid $60.00 per each pile cut-off for sizes smaller than 20 inches and $80.00 per each pile cut-off for sizes 20 inches and larger.

803.05.6--Extensions or Build-Ups. Extensions or Build-ups will not be paid for directly, but will be included in payment for piling. No payment will be made for extensions or build-ups for test piles.

803.05.7--Blank.

803.05.8--Splices. Splices, measured as prescribed above, will be paid for at the contract unit price per linear foot for the particular type pile splices.

803.05.9--Pre-formed Pile Holes. Pre-formed pile holes of the sizes specified will be paid for at the contract unit price per linear foot.

803.05.10--PDA Test Piles, Special Instrumentation Load Test. PDA test piles, special instrumentation load test, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.11--PDA Test Piles, Conventional Load Test. PDA test piles, conventional load test, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.12--PDA Test Piles. PDA test piles, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.13--Pile Restrike. Pile restrikes, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.14--Drilled Shafts. Drilled shafts of the type specified, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall include the cost of concrete, reinforcing steel, and all labor, materials including mineral slurry, equipment, and incidentals necessary to complete the drilled shaft.

803.05.15--Test Shafts. Test shafts of the type specified, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for excavating the test shaft through whatever materials are encountered to the bottom of the shaft elevation shown on the plans or as authorized by the Engineer, concrete, reinforcement, required casings, special instrumentation load cell if required, conducting and reporting load test results, restoring the site as required, and all other expenses to complete the work.

803.05.16--Trial Shaft. Trial shafts of the type specified, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for excavating the trial shaft through whatever materials are encountered to the bottom of the shaft elevation shown on the plans or as authorized by the Engineer, concrete, reinforcement, required casings, special instrumentation if required, conducting and reporting load test results, restoring the site as required, and all other expenses to complete the work.

803.05.17--Exploration. Exploration, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for drilling, extracting, packaging and classifying the samples or cores, delivering them to the Department, furnishing concrete to fill the core hole, and all other expenses necessary to complete the work.

803.05.18--Casings. Casings, measured as prescribed above, will be paid for at the contract price per linear foot, which price shall be full compensation for furnishing, placing, and removing (when required) the casing in the shaft excavation.

The prices thus paid shall be full compensation for all materials, tools, equipment, labor, and incidentals required to complete work.

Payment will be made under:

803-A: Test Pile	- per each
803-B: Conventional Static Pile Load Test	- per each
803-C: ___" Prestressed Concrete Piling	- per linear foot
803-D: ___ Steel Piling	-per linear foot

803-E: Concrete Piling Cut-off, Size - per each

803-F: ___" Pre-formed Pile Hole - per linear foot

803-G: PDA Test Pile, Special Instrumentation Load Test - per each

803-H: PDA Test Pile, Conventional Load Test - per each

803-I: PDA Test Pile - per each

803-J: Pile Restrike - per each

803-K: Drilled Shaft, ___" Diameter - per linear foot

803-L: Test Shaft, ___" Diameter - per each

803-M: Trial Shaft, ___" Diameter - per linear foot

803-N: Exploration - per linear foot

803-O __*__ Casing, ___" Diameter - per linear foot
* Temporary or Permanent

SECTION 804--CONCRETE BRIDGES AND STRUCTURES

804.01--Description. This work consists of constructing concrete bridges and structures in accordance with these specifications and in reasonably close conformity with the dimensions, designs, lines, and grades indicated on the plans or established.

Construction of box bridges shall be in accordance with Sections 601 and 602.

804.02--Materials.

804.02.1--General. Concrete produced and controlled from this specification shall be accepted upon proper certification of concrete production through an approved quality control program and verification by job site acceptance criteria. The Contractor shall develop and implement a quality control program that will be used to maintain the required properties of concrete. For large volume projects, 2000 cubic yards and more, quality control and acceptance shall be achieved through statistical evaluation of test results. For small volume projects of more than 200 but less than 2000 cubic yards, quality control and acceptance shall be achieved by individual test results. For projects less than or equal to 200 cubic yards, refer to the requirements of TMD-20-05-00-000 "Sampling and Testing of Small Quantities of Miscellaneous Materials".

The materials for concrete bridges and structures, when sampled and tested in accordance with Subsection 700.03, shall meet the requirements of the following Subsections:

Portland Cement	701.01 and 701.02
Admixtures	713.02
Fly Ash	714.05
Water	714.01.1 and 714.01.2
Fine Aggregate	703.02
Coarse Aggregate	703.03
Curing Materials	713.01
Joint Materials	707.01, 707.02, and 707.07
Structural Steel Joints and Bearing Devices	717.01
Sheet Copper	716.07.2
Bronze Bearing Devices	716.06
Copper-Alloy Bearing Devices	716.07.1
Self-Lubricating Bearing Plates	716.08
Bearing Pads	714.10
Wire Rope or Wire Cable for Prestressed Concrete	700.01 and 711.03
Sprayed Finish for Concrete Surface	714.12
Reinforcing Steel	711.02

804.02.2--Use, Care and Handling. The use, care and handling of materials shall conform to the applicable requirements of Subsection 501.03.10 and the specific requirements of Subsections 804.02.4 and 804.02.5. Unless otherwise authorized, only fine aggregate or coarse aggregate of one type and from the same source shall be used in the construction of any one unit of a structure. Should the Contractor, with written permission of the Engineer, elect to substitute high early strength cement for cement of the type specified, the Contractor will not receive additional compensation for the substitution.

804.02.3--Sampling & Testing. Sampling and testing shall meet the requirements of these specifications.

804.02.4--Care and Storage of Concrete Aggregates. The handling and storage of aggregates shall be such as to prevent segregation or contamination with foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

When specified, coarse aggregates shall be separated into two or more sizes in order to secure greater uniformity of the concrete mixture. Different sizes of aggregate shall be stored in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from becoming intermixed.

804.02.5--Storage of Cement. All cement shall be stored in suitable weather-proof buildings or bins. These buildings or bins shall be placed in locations

approved by the Engineer. Provision for storage shall be ample, and the shipments of cement as received shall be stored separately or other provisions made to the satisfaction of the Engineer for easy access for the identification, inspection, and sampling of each shipment as deemed desirable. Stored cement shall meet the test requirements at any time after storage when a retest is ordered by the Engineer.

On small jobs, open storage consisting of a raised platform and ample waterproof covering may be permitted by written authorization from the Engineer.

When specified, the Contractor shall keep accurate records of deliveries of cement and of its use in the work. Copies of these records shall be supplied in the form required by the Engineer.

804.02.6--Classification and Uses of Concrete. When a specific class of concrete is not specified on the plans or in the contract documents, the structure or parts thereof shall be constructed with the class of concrete as directed by the Engineer.

The classes and their uses are as follows:

(1) Class AA - Concrete for bridge construction and concrete exposed to seawater.
(2) Class A - Concrete for use where indicated.
(3) Class B - General use, heavily reinforced sections, cast-in-place concrete piles, and conventional concrete piles.
(4) Class C - Massive sections or lightly reinforced sections.
(5) Class D - Massive unreinforced sections and riprap.
(6) Class F - Concrete for prestressed members.
(7) Class FX - Extra strength concrete for prestressed members, as shown on plans.
(8) Class S - For all seal concrete deposited under water.
(9) Class DS - Drilled Shaft Concrete

804.02.7--Composition of Concrete. The composition of concrete mixtures shall meet the requirements of these specifications.

804.02.8--Laboratory Accreditation. The Contractor shall be responsible for furnishing the laboratory used to perform concrete quality control tests. The laboratory may be the Contractor's facility, the concrete producer's facility, or a certified independent testing laboratory.

Only laboratories certified by the Mississippi Department of Transportation are qualified to perform material testing. Certification by AASHTO Accreditation Program (AAP) will be acceptable if the laboratory is listed in the latest AASHTO Accreditation Program publication and maintains accreditation to completion of concrete work.

The Contractor's laboratory designated for quality control testing shall have equipment necessary to test aggregates and concrete for the test methods listed in Table 1.

Table 1

AASHTO: T 2	Sampling Aggregates
AASHTO: T 19	Bulk Density ("Unit Weight") and Voids in Aggregates
AASHTO: T 22	Compressive Strength of Cylindrical Concrete Specimens
AASHTO: T 23	Making and Curing Concrete Test Specimens in the Field
AASHTO: T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO: T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO: T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO: T 119	Slump of Hydraulic Cement Concrete
AASHTO: T 121	Mass per Cubic Meter (Cubic Foot), Yield, and Air Content (Gravimetric) of Concrete
AASHTO: T 126	Making and Curing Concrete Test Specimens in the Laboratory
AASHTO: T 141	Sampling Freshly Mixed Concrete
AASHTO: T 152	Air Content of Freshly Mixed Concrete by Pressure Method *
AASHTO: T 196	Air Content of Freshly Mixed Concrete by the Volumetric Method *
AASHTO: T 231	Capping Cylindrical Concrete Specimens
AASHTO: T 248	Reducing Field Samples of Aggregate to Testing Size
AASHTO: T 255	Total Evaporable Moisture Content of Aggregate by Drying
ASTM: C 1064	Temperature of Freshly Mixed Portland Cement Concrete

* Equipment necessary for either pressure or volumetric air content.

Testing equipment shall have been inspected by the Department or through AAP. Testing equipment calibration files shall be made available upon request by the Department.

804.02.9--Testing Personnel. Technicians testing Portland cement concrete, for either acceptance or production control purposes, shall be certified by an accepted certification program. Recertification is required for each Class after five years. Certification requirements are listed in Table 2.

Table 2

Required Certification	Concrete Technician's Tasks
MDOT Class I or ACI Grade I	Field Testing of Plastic Concrete, AASHTO Designation: T 23, T 119, T 121, T 141, T 152, T 196, and ASTM Designation: C 1064
MDOT Class II	Aggregate Sampling, Total Moisture, and Sieve Analysis, AASHTO Designation: T 2, T 27, T 248, T 255

MDOT Class III	Unit Weight and Voids of Aggregates, Specific Gravity*, Concrete Mix Design, Capping and Compressive Strength of Cylindrical Concrete Specimens*, AASHTO Designation: T 19, T 22, T 84, T 85, T 126, T 231

* Technicians performing specific gravity or compressive strength tests shall be either Certified Class III or may be supervised by a Certified Class III Technician. Also, technicians performing these tests are required to demonstrate the specific gravity and compressive strength tests during the inspection of laboratory equipment by the Central Laboratory.

804.02.10--Portland Cement Concrete Mix Design. At least 30 days prior to production of concrete, the Contractor shall submit to the Engineer proposed concrete mix designs complying with TMD 21-12-00-000. Materials shall be from approved sources meeting the requirements of the Standard Specifications. Proportions for the mix designs shall be for the class concrete required by the contract plans and shall meet the requirements of the "Master Proportion Table for Structural Concrete Design" listed in Table 3. The concrete producer shall assign a permanent unique mix number to each mix design. Each mix design shall be field verified as required in Subsection 804.02.10.3. Acceptable field verification data shall be required for final approval of a mix design. All concrete mix designs will be reviewed by the Central Laboratory prior to use. Concrete mix designs disapproved will be returned to the Contractor with a statement explaining the disapproval.

Table 3
MASTER PROPORTION TABLE FOR STRUCTURAL CONCRETE DESIGN

CLASS	COARSE AGGREGATE SIZE NO. *	MAXIMUM WATER/ CEMENTITIOUS ** RATIO	SPECIFIED COMPRESSIVE STRENGTH (f'_c) psi	MAXIMUM SLUMP *** inches	TOTAL AIR CONTENT %
AA	57 or 67	0.45	4000	3	3.0 to 6.0
A	57 or 67	0.45	4000	3	3.0 to 6.0
B	57 or 67	0.50	3500	4	3.0 to 6.0
C	57 or 67	0.55	3000	4	3.0 to 6.0
D	57 or 67	0.70	2000	4	3.0 to 6.0
F	67	0.40	5000	3	****
FX	67	(As required by special provisions)		3	****
S	57 or 67	0.45	3000	8	3.0 to 6.0
DS	67	0.45	4000	*****	****

* Maximum size aggregate shall conform to the concrete mix design for the specified aggregate.

** Maximum replacement of Portland cement by weight is 25% for fly ash or 50% for ground granulated blast furnace slag. The addition of fly ash as a replacement for cement will not be permitted in Type IP blended hydraulic cement, portland cement combined with ground granulated blast furnace slag or Type III portland cement when specified in the contract.

*** The slump may be increased up to 6 inches with an approved mid-range water reducer or up to 8 inches with an approved type F or G high range water reducer. A mid-range water reducer is classified as a water reducer that reduces the mix water a minimum of 8% when compared to a control mix with no admixtures. Minus slump requirements shall meet those set forth in Table 3 of AASHTO M157 specifications.

**** No entrained air except for pilings exposed to seawater.

***** Class DS Concrete for drilled shafts shall have an 8 ±1-inch slump. In the event the free fall method of concrete placement is used, the slump shall be 6 ±1-inch. No fly ash, ground granulated blast furnace slag, or F or G high range water reducers allowed in drilled shaft concrete. A slump retention admixture is required.

Either Type A, D, F, G, or mid-range chemical admixture, shall be used in all classes of concrete, except as noted above for drilled shaft concrete. Any combinations of water reducing admixtures shall be approved by the Engineer before their use.

804.02.10.1--Proportioning of Portland Cement Concrete Mix Design. Proportioning of Portland cement concrete shall be based on an existing mix of which the producer has field experience and documentation or based on a recently batched laboratory mix tested according to the required specifications.

804.02.10.1.1--Proportioning on the Basis of Previous Field Experience of Trial Mixtures. Where a concrete production facility has a record, based on at least 10 consecutive strength tests within the past 12 months from a mixture not previously used on Department projects, the standard deviation shall be calculated. The record of tests from which the standard deviation is calculated shall:

a) Represent similar materials and conditions to those expected. Changes in materials and proportions within the test record shall not have been more closely restricted than those for the proposed work.

b) Represent concrete produced to meet a specified strength.

c) Consist of 10 consecutive tests, average of two cylinders per test, tested at 28 days.

The standard deviation, s , shall be calculated as:

$$s = \left[\sum \left(X_i - \overline{X}\right)^2 \div (N-1)\right]^{1/2}$$

where:

X_i = the strength result of an individual test

$\overline{X}$ = the average of individual tests in the series
N = number of tests in the series

When the concrete production facility does not have a record of tests for calculation of standard deviation, as required in the above formula, the requirements of Subsection 804.02.10.1.2 shall govern.

The required average compressive strength (f'_{cr}) used as the basis for selection of concrete proportions shall conform to the inequality listed below, while using a standard deviation, s, calculated as shown above.

$$\overline{X} \geq f'_{cr}$$

where:

$$f'_{cr} = f'_c + 1.43s$$

where:

f'_c = specified compressive strength of concrete, psi
f'_{cr} = required average compressive strength of concrete, psi
s = standard deviation, psi

1.43 represents the Lower Quality Index necessary to assure that 93% of compressive strength tests are above f'_c.

804.02.10.1.2--Proportioning on the Basis of Laboratory Trial Mixtures. When an acceptable record of field test results is not available, concrete proportions shall be established based on laboratory trial mixtures meeting the following restrictions:

a) The combination of materials shall be those intended for use in the proposed work.

b) Trial mixtures having proportions and consistencies suitable for the proposed work shall be made using the ACI 211.1 as a guide to proportion the mix design.

c) Trial mixtures shall be designed to produce a slump within ±3/4 in. of the maximum permitted, and for air-entrained concrete, 6.0 ±0.5 percent total air content. The temperature of freshly mixed concrete in trial mixtures shall be reported.

d) For each proposed mixture, at least three compressive test cylinders shall be made and cured in accordance with AASHTO Designation: T 126.

Each change of water-cement ratio shall be considered a new mixture. The cylinders shall be tested for strength in accordance with AASHTO Designation: T 22 and shall meet the required 28 day strength.

e) The required average strength of laboratory trial mixes shall exceed f'_c by 1200 psi for concrete mix designs less than 5000 psi and by 1400 psi for concrete mix designs of 5000 psi or more.

f) The laboratory trial batch mixtures shall have been made within the previous 12 months before being submitted for approval and shall not have been previously used on Department projects.

804.02.10.2--Documentation of Average Strength. Documentation that the proposed concrete proportions will produce an average strength equal to or greater than the required average shall consist of the strength test records from field tests or results from laboratory trial mixtures.

804.02.10.3--Field Verification of Concrete Mix Design. Concrete mix designs will only be tentatively approved pending field verification. Mix designs may be transferred to other projects without additional field verification testing, once the mix design has passed the field verification process.

The Contractor's Certified Quality Control Technicians shall test each concrete mix design upon the first placement of the mix. Aggregates and concrete tests during the first placement shall be as follows:

Aggregates	Concrete
Bulk Specific Gravity	Water Content
Moisture	Slump
Gradation	Air Content
	Unit Weight
	Yield

The mix shall be verified to yield within 2.0% of the correct volume when all the mix water is added to the batch, producing a slump within a minus 1½ inches tolerance, or minus 2½ inches with Type F or G chemical admixture, of the maximum permitted and total air content within a minus 1½ percent tolerance of the maximum allowable air content listed in Table 3 . The mix shall be adjusted and retested, if necessary, on subsequent placements until the above mentioned properties are met. If the requirements of yield, slump, or air are not met after three attempts, subsequent field verification testing shall not be permitted on Department projects, and the mix design shall not be used until the requirements listed above are met. Any mix design adjustments, changes in the mix proportions, are to be made by a Class III Certified Technician representing the Contractor. After the mix design has been verified and adjustments made, verification test results will be reviewed by the Engineer.

804.02.10.4--Adjustments of Mixtures Proportions. After ten compressive tests have been performed for which a standard deviation is calculated, the mix design may be adjusted provided the average strength ($\overline{X}$) complies with the inequality in Subsection 804.02.10.1.1 and the adjusted mix design satisfies the water/cementitious ratio requirement listed in Table 3. Any adjustments of the concrete mix design shall necessitate repeat of field verification procedure as described in Subsection 804.02.10.3 and approval by the Engineer.

804.02.11--Concrete Batch Plants. The concrete batch plant and assigned mixer trucks shall be on the list of approved concrete batch plants and mixer trucks. For large quantity projects the plant shall meet the requirements for an automatic system capable of recording batch weights. It shall also have automatically moisture compensation for the fine aggregate.

For small volume projects, the plant can be equipped for manual batching with a fine aggregate moisture meter visible to the plant operator.

The concrete batch plant shall have available adequate facilities to cool concrete during hot weather.

804.02.12--Contractor's Quality Control. The Contractor shall provide and maintain a quality control program that will provide reasonable assurance that all materials and products submitted to the Department for acceptance will conform to the contract requirements, whether manufactured or processed by the Contractor or procured from suppliers, subcontractors, or vendors.

The Contractor's Quality Control program shall implement the minimum quality control requirements shown in Table 4, "CONTRACTOR'S MINIMUM REQUIREMENTS FOR QUALITY CONTROL". The quality control activities shown in the table are considered to be normal activities necessary to control the production and placing of a given product or material at an acceptable quality level. To facilitate the Department's activities, all completed gradation samples shall be retained for a maximum of sixty (60) days by the Contractor until further disposition is designated by the Department.

The Contractor shall perform, or have performed, the inspections and tests required to substantiate product conformance to contract document requirements and shall also perform, or have performed, all inspections and tests otherwise required.

The Contractor's Quality Control program shall encompass the requirements of AASHTO Designation: M 157 into concrete production and control, equipment requirements, testing, and batch ticket information. The requirement of AASHTO Designation: M 157, Section 11.7 shall be followed except, on arrival to the job site, a maximum of 1½ gallons per cubic yard shall be allowed to be

added to bring the slump within the required limits. Water shall not be added at a later time.

The Contractor's quality control inspections and tests shall be documented and shall be available for review by the Engineer throughout the life of the contract.

As set out in these specifications, quality control sampling and testing performed by the Contractor will be used by the Department for determination of acceptability of the concrete.

The Contractor shall maintain standard equipment and qualified personnel as required to assure conformance to contract requirements.

804.02.12.1--Quality Control Plan. The Contractor shall prepare a Quality Control Plan which shall identify the personnel responsible for the Contractor's quality control including the company official who will act as liaison with Department personnel. The Quality Control Plan shall be submitted in writing to the Engineer for approval 30 days prior to the production of concrete.

The class(es) of concrete involved will be listed separately. If an existing mix design(s) is to be used, the mix design number(s) as previously approved shall be listed.

It is intended that sampling and testing be in accordance with standard methods and procedures, and that measuring and testing equipment be standard and properly calibrated. If alternative sampling methods and procedures, and inspection equipment are to be used, they shall be detailed in the Quality Control Plan.

804.02.12.1.1--Elements of Plan. The Plan shall address all elements that affect the quality of the structural concrete including, but not limited to, the following:

1) Stockpile Management
2) Procedures for Corrective Actions for Non Compliance of Specifications
3) Procedure for Controlling Concrete Temperatures

804.02.12.2--Personnel Requirements. The Contractor's Designated Certified Technician shall perform and use quality control tests and other quality control practices to assure that delivered materials and proportioning meet the requirements of the mix design including temperature, slump, air content, and strength and shall periodically inspect all equipment used in transporting, proportioning, and mixing.

The Contractor's Designated Technician shall periodically inspect all equipment used placing, consolidating, finishing, and curing to assure it is operating

properly and that placement, consolidation, finishing, and curing conform to the mix design and other contract requirements.

804.02.12.3--Documentation. The Contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, date and time of samples taken, the quantities approved and rejected, and the nature of corrective action taken as appropriate. The Contractor's documentation procedures will be subject to approval of the Department prior to the start of the work and to compliance checks during the progress of the work.

All conforming and non-conforming inspections and test results shall be kept complete and shall be available at all times to the Department during the performance of the work. Forms shall be on a computer-acceptable medium. Batch tickets and gradation data shall be documented in accordance with Department requirements. Copies shall be submitted to the Department as the work progresses.

Test data for Portland cement concrete, including gradation, shall be charted in accordance with the applicable requirements.

The Contractor may use additional control charts as deemed appropriate. It is normally expected that testing and charting will be completed within 24 hours after sampling.

All charts and records documenting the Contractor's quality control inspections and tests shall become the property of the Department upon completion of the work.

804.02.12.4--Corrective Action. The Contractor shall take prompt action to correct conditions that have resulted, or could result, in the submission to the Department of materials and products that do not conform to the requirements of the contract documents. All corrective actions shall be documented.

804.02.12.5--Non-Conforming Materials. The Contractor shall establish and maintain an effective and positive system for controlling non-conforming material, including procedures for its identification, isolation and disposition. Reclaiming or reworking of non-conforming materials shall be in accordance with procedures acceptable to the Department.

All non-conforming materials and products shall be positively identified to prevent use, shipment, and intermingling with conforming materials and products. Holding areas, mutually agreeable to the Department and the Contractor, shall be provided by the Contractor.

TABLE 4
CONTRACTOR'S MINIMUM REQUIREMENTS FOR QUALITY CONTROL

Portland Cement Concrete		
Control Requirement	**Frequency**	**AASHTO/ASTM Designation**
A. PLANT AND TRUCKS		
1. Mixer Blades	Monthly	
2. Scales		
a. Tared	Daily	
b. Calibrate	Every 6 months	
c. Check Calibration	Weekly	
3. Gauges & Meters - Plant & Truck		
a. Calibrate	Every 6 months	
b. Check Calibration	Weekly	
4. Admixture Dispenser		
a. Calibrate	Every 6 months	
b. Check Operation & Calibration	Daily	
B. AGGREGATES		
1. Sampling		T 2
2. Fine Aggregate		
a. Gradation / FM	250 yd³ Concrete	T 27
b. Moisture	Check Meter Against Test Results Weekly	T 255
c. Specific Gravity / Absorption	2500 yd³ Concrete	T 84
3. Coarse Aggregates		
a. Gradation / FM	250 yd³ Concrete	T 27
b. Moisture	Minimum of once daily or more as needed to control production	T 255
c. Specific Gravity / Absorption	2500 yd³ Concrete	T 85
C. PLASTIC CONCRETE		
1. Sampling		T 141
2. Air Content	First load then one per 50 yd³	T 152 or T 196
3. Slump	First load then one per 50 yd³	T 119
4. Compressive Strength	One set (two cylinders) for 0-100 yd³ inclusive and one set for each additional 100 yd³ or fraction thereof for each class concrete delivered and placed on a calendar day from a single supplier. A test shall be the average of two cylinders.	T 22, T 23, T 231
5. Yield	Each 400 yd³	T 121
6. Temperature	With each sample	C 1064

804.02.13--Quality Assurance Sampling and Testing. Quality Assurance (QA) inspection and testing will be provided by the Department to assure that the Contractor's Quality Control (QC) testing meets the requirements of these specifications.

Acceptance of the material is based on the inspection of the construction, monitoring of the Contractor's quality control program, QC test results, and the comparison of the QA test results with the QC test results. The Department may use the results of the Contractor's QC tests as a part of the acceptance procedures instead of the results of QA tests, provided:

a) The Department's inspection and monitoring activities indicate that the Contractor is following the approved Quality Control program and, respectively,
b) For aggregates, the results from the Contractor's QC and the Department's QA testing of aggregate gradations compare by both meeting the aggregate type's gradation requirements;
c) For concrete, the Contractor's QC and Department's QA testing of concrete compressive strengths compare when using the data comparison computer program with an alpha value of 0.01 for large volume projects; or, strength comparisons are within 990 psi for small volume projects.

The minimum frequency for QA testing of aggregate and plastic concrete by the Department will follow the frequencies listed in Table 5, **"**DEPARTMENT'S MINIMUM REQUIREMENTS FOR QUALITY ASSURANCE".

TABLE 5
DEPARTMENT'S MINIMUM REQUIREMENTS FOR QUALITY ASSURANCE

Quality Assurance Tests	Frequency	AASHTO/ASTM Designation
A. AGGREGATES		
1. Sampling		T 2
2. Fine Aggregate Gradation and FM	250 yd³ Concrete	T 27
3. Coarse Aggregates Gradation and FM	250 yd³ Concrete	T 27
B. PLASTIC CONCRETE		
1. Sampling		T 141
2. Air Content	Every 100 yd³	T 152 or T 196
3. Slump	Every 100 yd³	T 119
4. Compressive Strength	One set (two cylinders) for every 100 yd³ inclusive. A test shall be the average of two cylinders.	T 22, T 23, T 231
5. Temperature	With each sample	C 1064

Periodic inspection by the Department of the Contractor's QC testing and production will continue through the duration of the project. Weekly reviews will be made of the Contractor's QC records and charts.

For aggregates, comparison of data of the Contractor's QC aggregate gradation test results to those of the Department's QA aggregate gradation test results will be made monthly during concrete production periods according to Department Standard Operating Procedures. When it is determined that the Contractor's QC test results of aggregate gradations are comparative to that of the Department's QA test results, then the Department will use the Contractor's QC results as a basis for acceptance of the aggregates and the Department's QA testing frequency of aggregates may be reduced to a frequency of no less than three QA tests to every 10 QC tests. If the Contractor's QC aggregate gradation test

results fail to compare to those of the Department's QA aggregate gradation test results, Department testing for aggregate gradations will revert to the frequency shown in Table 5 for aggregates until the Contractor's and Department's aggregate gradation test data compare.

For concrete compressive strength, comparison of data of the Contractor's QC compressive strength test results to those of the Department's QA compressive strength test results will be made monthly during concrete production periods according to Department Standard Operating Procedures. When it is determined that the Contractor's QC test results of concrete compressive strengths are comparative to that of the Department's QA test results, then the Department will use the Contractor's QC results as a basis for acceptance of the concrete and the Department's QA testing frequency of concrete compressive strengths may be reduced to a frequency of no less than three QA tests to every 10 QC tests. If the Contractor's QC compressive strength test results fail to compare to those of the Department's QA compressive strength test results, Department testing will revert to the frequency shown in Table 5 for plastic concrete until the Contractor's and Department's compressive strength test data compare.

804.02.13.1--Basis of Acceptance.

804.02.13.1.1--Slump. Slump of plastic concrete shall meet the requirements of Table 3: MASTER PROPORTION TABLE FOR STRUCTURAL CONCRETE DESIGN. A check test shall be made on another portion of the sample before rejection of any load.

804.02.13.1.2--Air. Total air content of concrete shall be within the specified range for the class of concrete listed in Table 3: MASTER PROPORTION TABLE FOR STRUCTURAL CONCRETE DESIGN. A check test shall be made on another portion of the sample before rejection of any load.

804.02.13.1.3--Yield. If the yield of the concrete mix design is more than plus or minus 3% of the designed volume, the mix shall be adjusted by a Class III Certified Technician representing the Contractor to yield the correct volume plus or minus three percent (±3%). If batching of the proportions of the mix design varies outside the batching tolerance range of the originally approved proportions by more than the tolerances allowed in Subsection 804.02.12.1, the new proportions shall be field verified per Subsection 804.02.10.3.

804.02.13.1.4--Temperature. Cold weather concreting shall follow the requirements of Subsection 804.03.16.1. Hot weather concreting shall follow the requirements of Subsection 804.03.16.2 with a maximum temperature of 95°F for Class DS concrete containing a slump retention admixture and for concrete mixes containing pozzolanic materials as a replacement of Portland cement. For other classes of concrete without pozzolanic materials, the maximum concrete

temperature shall be 90°F. Concrete with a temperature more than the maximum allowable temperature shall be rejected and not used in Department work.

804.02.13.1.5--Compressive Strength. Laboratory cured concrete compressive strength tests shall conform to the specified strength (f'_c) listed in the specifications. Concrete represented by compressive strength test below the specified strength (f'_c) may be removed and replaced by the Contractor. If the Contractor elects not to remove the material, it will be evaluated by the Department as to the adequacy for the use intended. All concrete evaluated as unsatisfactory for the intended use shall be removed and replaced by the Contractor at no additional cost to the Department. For concrete allowed to remain in place, reduction in payment will be as follows:

Large Volume Projects. When the evaluation indicates that the work may remain in place, a statistical analysis will be made of the QC and QA concrete test results. If this statistical analysis indicates at least 93% of the material would be expected to have a compressive strength equal to or greater than the specified strength (f'_c) and 99.87% of the material would be expected to have a compressive strength at least one standard deviation above the allowable design stress (f_c), the work will be accepted. If the statistical analysis indicates that either of the two criteria are not met, the Engineer will provide for an adjustment in pay as follows for the material represented by the test result.

Total Pay on Material in Question = Unit Price - (Unit Price x % Reduction)

$$\% \text{ Reduction} = \frac{(f'_c - X)}{f'_c - (f_c + s)} \times 100$$

where:

f'_c = Specified 28-day compressive strength, psi
X = Individual compressive strength below f'_c, psi
s = standard deviation, psi*
f_c = allowable design stress, psi

* Standard deviation used in the above reduction of pay formula shall be calculated from the applicable preceding compressive strengths test results plus the individual compressive strength below f'_c. If below f'_c strengths occur during the project's first ten compressive strength tests, the standard deviation shall be calculated from the first ten compressive strength tests results.

Small Volume Projects. When the evaluation indicates that the work may remain in place, a percent reduction in pay will be assessed based on a comparison of the deficient 28-day test result to the specified strength. The

Engineer will provide for an adjustment in pay as follows for the material represented by the test result.

Total Pay on Material in Question = Unit Price - (Unit Price x % Reduction)

$$\% \text{ Reduction} = \frac{(f'_c - X)}{f'_c} \times 100$$

where:

f'_c = Specified 28-day compressive strength, psi
X = Individual compressive strength below f'_c, psi

804.02.14--Dispute Resolution. Disputes over variations between Contractor's QC test results and the Department's QA test results shall be resolved at the lowest possible level. When there are significant discrepancies between the QC test results and the QA test results, the Contractor's Quality Control Manager, the Project Engineer, and/or the District Materials Engineer shall look for differences in the procedures, and correct the inappropriate procedure before requesting a third party resolution.

If the dispute cannot be resolved at the project or District level, the Department's Central Laboratory will serve as a third party to resolve the dispute. The Central Laboratory's decision shall be binding.

The Contractor shall be responsible for the cost associated with the third party resolution if the final decision is such that the Department's QA test results were correct. Likewise, the Department will be responsible for the cost when the final decision is such that the Contractor's QC test results were correct.

804.03--Construction Requirements.

804.03.1--Measurement of Materials.

804.03.1.1--General. The accuracy for measuring materials shall be in accordance with AASHTO Designation: M 157.

804.03.1.2--Measurement by Weighing. Except when otherwise specified or authorized, materials shall be measured by weighing. The apparatus provided for weighing materials shall be suitably designed and constructed for this purpose. Cement and aggregates shall be weighed separately. Cement in standard bags need not be weighed, but bulk cement shall be weighed. The mixing water shall be measured by volume or by weight. All measuring devices shall be subject to approval.

804.03.2--Blank.

804.03.3--Blank.

804.03.4--Hand Mixing. Hand mixing of concrete will not be allowed.

804.03.5--Delivery. The plant supplying concrete shall have sufficient capacity and transporting apparatus to insure continuous delivery at the rate required. The rate of delivery shall be such as to provide for the proper continuity in handling, placing, and furnishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of delivering and handling the concrete shall be that which will facilitate placing with minimum rehandling and without damage to the structure or the concrete.

804.03.6--Handling and Placing Concrete.

804.03.6.1--General. Prior to placing concrete, all reinforcement shall have been accurately placed in the position shown on the plans and fastened as set out in Section 805. All sawdust, chips, and other construction debris and extraneous matter shall have been removed from the interior of the forms. Temporary struts, braces, and stays holding the forms in correct shape and alignment shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and shall not be buried in the concrete.

No concrete shall be placed until the forms and reinforcement have been inspected.

Except as provided for truck mixers and truck agitators, concrete shall be placed in the forms within 30 minutes after the time that the cement is first added to the mix.

Concrete shall be placed so as to avoid segregation of materials and displacement of reinforcement. The use of troughs, chutes, and pipes over 25 feet in length for gravity conveyance of concrete to the forms, will not be permitted except when authorized by the Engineer and subject to the production of quality concrete.

Only approved mechanical conveyors will be permitted.

Open troughs and chutes shall be metal or metal lined. The use of aluminum pipes, chutes, or other devices made of aluminum that come into direct contact with the concrete shall not be used. Where steep slopes are required, the chutes shall be equipped with baffles or be in short sections that change the direction of movement.

All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure.

When placing operations involve dropping the concrete more than five feet, it shall be deposited through sheet metal or other approved pipes to prevent segregation and unnecessary splashing. The pipes shall be made in sections to permit discharging and raising as the placement progresses. A non-jointed pipe may be used if sufficient openings of the proper size are provided to allow for the flow of the concrete into the shaft. As far as practicable, the pipes shall be kept full of concrete during placing, and their ends shall be kept buried in the newly placed concrete.

Except as hereinafter provided, concrete shall be placed in horizontal layers not more than 12 inches thick. When, with the Engineer's approval, less than the complete length of a layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken its initial set and shall be compacted so as to avoid the formation of a construction joint with the preceding layer.

804.03.6.2--Consolidation. Concrete, during and immediately after depositing, shall be thoroughly consolidated by the use of approved mechanical vibrators and suitable spading tools. Hand spading alone will be permitted on small structural members such as railing and small culvert headwalls. Mechanical vibration of concrete shall be subject to the following:

A. The vibration shall be internal unless special authorization of other methods is given by the Engineer or as provided herein.

B. In general, vibrators shall be a type and design approved by the Engineer. They shall be capable of vibration frequencies of at least 4500 impulses per minute.

C. The intensity of vibration shall be such as to visibly affect a mass of concrete of one inch slump over a radius of at least 18 inches.

D. The Contractor shall provide sufficient vibrators to properly compact each batch immediately after it is placed in the forms.

E. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms.

   Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted into and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed.

Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

F. Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have taken initial set. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.

G. Vibration shall be supplemented by spading as necessary to insure smooth surfaces and dense concrete along form surfaces, in corners, and in locations impossible to reach with vibrators.

H. These provisions shall apply to the filler concrete for steel grid floors except that the vibrator shall be applied to the steel.

I. These provisions shall apply to precast piling, concrete cribbing, and other precast members except that, if approved by the Engineer, the manufacturer's methods of vibrations may be used.

When hand spading is used for consolidation, a sufficient number of workmen with spading tools shall be provided. They will be required to flush a thin layer of mortar to all the surfaces and thoroughly and satisfactorily consolidate the concrete.

The entire operation of depositing and consolidating the concrete shall be conducted so that the concrete shall be smooth and dense and free from honeycomb or pockets of segregated aggregate.

804.03.6.3--Discontinuance of Placing. When placing is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible joints insofar as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint, such as in the sloped top surface of a wing wall, an inset form work shall be used in the preceding layer to produce a blocked out portion that will provide an edge thickness of at least six inches in the succeeding layer. Work shall not be discontinued within 18 inches of the top of any face unless provision has been made for a coping less than 18 inches thick. In this case and if permitted by the Engineer, the construction joint may be made at the under side of the coping.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed on the reinforcement and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset

concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to break or injure the concrete-steel bond at and near the surface of the concrete while cleaning the reinforcement. After initial set the forms shall not be jarred, and no strain shall be placed on the ends of projecting reinforcement until the concrete has sufficiently set to insure against any damage by such jarring or strain.

804.03.6.4--Placing Bridge Concrete. The method and sequence of placing concrete shall conform to the provisions and requirements set forth for the particular type of construction.

804.03.6.4.1--Foundations and Substructures. Concrete seals shall be placed in accordance with Subsection 804.03.9. All other concrete for foundations shall be poured in the dry unless otherwise stipulated or authorization is given in writing by the Engineer to do otherwise. Concrete shall not be placed in foundations until the foundation area has been inspected and approved.

Unless otherwise specified, the placement of concrete in the substructure shall be in accordance with the general requirements of Subsection 804.03.6.

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

804.03.6.4.2--Superstructure. For simple spans, concrete shall preferably be deposited by beginning at the center of the span and working toward the ends. For continuous spans, concrete shall be deposited as shown on the plans. Concrete in girders shall be uniformly deposited for the full length of the girder and brought up evenly in horizontal layers.

Unless otherwise permitted by the Engineer, concrete shall not be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. Unless otherwise permitted by the Engineer, the load of the superstructure shall not be placed on pile bents until the caps have been in place at least seven days and shall not be placed on other types of bents until the bents have been in place at least 14 days.

In placing concrete around steel shapes, it shall be placed on one side of the shape until it flushes up over the bottom flange of the shape on the opposite side, after which it shall be placed on both sides to completion.

Concrete in girder haunches less than three feet in height shall be placed at the same time as that in the girder stem. Whenever a haunch or fillet has a height of three feet or more at the abutment or columns, the haunch and the girder shall be poured in three successive stages: first, up to the lower side of the haunch; second, to the lower side of the girder; and third, to completion.

Except when intermediate construction joints are specified, concrete in slab, T-beam, or deck-girder spans shall be placed in one continuous operation for each span.

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

Concrete in box girders shall be placed as shown on the plans.

Concrete shall not be chuted directly into the forms of the span and shall be placed continuously with sufficient speed to be monolithic and to allow for finishing before initial set.

804.03.7--Pneumatic Placing. Pneumatic placing of concrete will be permitted only if specified in the contract or if authorized by the Engineer. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 10 feet from the point of deposit. The discharge lines shall be horizontal or inclined upwards from the machine. At the conclusion of placement the entire equipment shall be thoroughly cleaned.

804.03.8--Pumping Concrete. Placement of concrete by pumping will be permitted only if specified in the contract or if authorized in writing by the Engineer. If used, the equipment shall be arranged so that no vibrations result which might damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipe line, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

The use of aluminum pipe as a conveyance for the concrete will not be permitted.

804.03.9--Depositing Concrete Under Water. Concrete shall not be deposited in water except with the approval of the Engineer.

Concrete deposited under water shall be Class S.

Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie, a bottom dump bucket, or other approved method and shall not be disturbed after being deposited. Special care shall be exercised to maintain still water at the point of deposit. No concrete shall be placed in running water and all form work designed to retain concrete under water shall be water-tight. The consistency of the concrete shall be carefully regulated, and special care shall be exercised to prevent segregation of materials.

Concrete seals shall be placed continuously from start to finish, and the surface of the concrete shall be kept as nearly horizontal as practicable at all times. To insure thorough bonding, each succeeding layer of a seal shall be placed before the preceding layer has taken initial set.

When a tremie is used, it shall consist of a tube having a diameter of at least 10 inches and constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit the free movement of the discharge over the entire top surface of the work and to permit it to be lowered rapidly when necessary to choke off or retard the flow of concrete. The discharge end shall be closed at the start of the work so as to prevent water entering the tube and shall be entirely sealed. The tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow is then stopped by lowering the tremie. The flow shall be continuous until the work is completed.

Depositing of concrete by the drop bottom bucket method shall conform to the following: The top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

Dewatering may proceed when the concrete seal is sufficiently hard and strong. As a general rule, this time will be 48 hours for concrete made with high-early-strength cement and three days for concrete made with other types of cement. All laitance and other unsatisfactory material shall be removed from the exposed surface by scraping, chipping, or other means which will not injure the surface of the concrete.

804.03.10--Construction Joints.

804.03.10.1--General. Unless otherwise approved by the Engineer, construction joints shall be made only where located on the plans or shown in the pouring schedule. If not detailed on the plans, or in the case of emergency, construction joints shall be placed as directed by the Engineer. Shear keys or inclined

reinforcement shall be used where necessary to transmit shear or to bond the two sections together.

For continuous spans, bridge deck concrete shall be deposited as shown on the plans. Deviation from the pouring schedule shown in the plans is not permitted.

804.03.10.2--Bonding. Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened. The surface of the hardened concrete shall be roughened as required by the Engineer and in a manner that will not leave loosened particles of aggregate or damaged concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance and saturated with water. When directed by the Engineer, the cleaned and saturated surfaces, including vertical and inclined surfaces, shall first be thoroughly covered with a coating of mortar or neat cement grout against which the new concrete shall be placed before the grout has attained its initial set.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints which are exposed to view shall be carefully finished, true to line and elevation.

In order to bond successive courses suitable depressed or raised keys of the designated size shall be constructed. Raised keys shall be monolithic with the concrete of the lower course.

804.03.11--Concrete Exposed to Seawater. Unless otherwise specifically provided, concrete for structures exposed to seawater shall be Class AA concrete as referenced in Subsection 804.02.10. The clear distance from the face of the concrete to the nearest face of reinforcing steel shall be at least four inches. The mixing time and the water content shall be carefully controlled and regulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughly compacted, and stone pockets shall be avoided. No construction joints shall be formed between the levels of extreme low water and extreme high water as determined by the Engineer. Between these levels, seawater shall not come in direct contact with the new concrete until at least 30 days have elapsed. The surface concrete as left by the forms shall be left undisturbed.

804.03.12--Blank.

804.03.13--Falsework. The Contractor shall submit to the Engineer four copies of structural design analysis and detail drawings, which show the method of falsework or centering. These designs and detail plans shall be prepared and bear the seal of a Registered Professional Engineer with experience in falsework design.

Falsework plans shall include falsework elevations together with all other dimensions and details which is considered necessary for the construction.

Other pertinent data needed is size and spacing of all falsework members and minimum bearing requirements for false piles.

Upon completion of falsework erection, the Registered Professional Engineer shall certify that the erected falsework is capable of supporting the load for construction.

Falsework piling shall be spaced and driven so that the bearing value of each pile is sufficient to support the load that will be imposed upon it. The bearing value of the piles should be calculated according to the appropriate formula given in Section 803.

For designing falsework and centering, a weight of 150 pounds per cubic foot shall be assumed for green concrete. All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. The Contractor may be required to employ screw jacks or hardwood wedges to take up slight settlement in the falsework either before or during the placing of concrete. An allowance shall be made for anticipated compressibility of falsework and for the placement of shims, wedges, or jacks to produce the permanent structural camber shown on the plans. If during construction, any weakness develops and the falsework shows any undue settlement or distortion, the work shall be stopped, the part of the structure affected removed, and the falsework strengthened before work is resumed. Falsework which cannot be founded on a satisfactory footing shall be supported on piling, which shall be spaced, driven, and removed, as referenced in Subsection 804.03.15, in a manner approved by the Engineer.

All structures built across a public street or highway on which maintenance of traffic is required, shall have falsework so arranged that a vertical clearance of at least 12' 6" is provided. Unless otherwise specified, a horizontal clearance of at least the width of the traveled way shall be provided at all times. If the vertical clearance is less than 13' 6" or the horizontal clearance is less than the full crown width of the roadway, the Contractor shall install and maintain appropriate safety devices, clearance signs and warning lights, and shall notify the Engineer sufficiently in advance of restricting the clearance for the Engineer to advise both the Traffic Engineering and the Maintenance Divisions. All traffic control and safety devices shall be in accordance with the Manual on Uniform Traffic Control Devices (MUTCD).

804.03.14--Forms.

804.03.14.1--General. Forms shall be wood, metal, or other material approved by the Engineer. All forms shall be built mortar-tight and sufficiently rigid to prevent distortion due to pressure of the concrete and other loads incident to the construction operations. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage. The forms shall be

substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The design of the forms shall take into account the effect of vibration of concrete as it is placed.

Minimum requirements for slab overhang forms shall be 3/4-inch plywood supported on 2-inch x 6-inch S4S wood timbers placed flatwise on 16-inch centers.

Adjustable brackets for support of slab overhang forms shall be spaced at a maximum distance of 3' 0" center to center unless specifically approved otherwise. Grade points for forms shall coincide with the location of the adjustable form brackets.

Forms for surfaces exposed to view shall be of uniform thickness with a smooth inside surface of an approved type. Joints in forms for exposed surfaces shall be closely fitted to eliminate fins, stone pockets, or other variations in the surface of the concrete which would mar a smooth and uniform texture.

Forms shall be filleted at all sharp corners and shall be given a bevel or draft in the case of all projections, such as girders and copings, to insure easy removal.

Metal ties or anchorages within the forms shall be so constructed as to permit their removal, without injury to the concrete, to a depth of at least the reinforcing steel clearance shown on the plans. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 1/4 inch from the face of the concrete with chisels or nippers. Nippers shall be used for green concrete. All fittings for metal ties shall be designed so that upon their removal the cavities which are left will be the smallest practicable size. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color.

Forms shall be set and maintained to the lines designated until the concrete is sufficiently cured for form removal. Forms shall remain in place for periods which shall be determined as hereinafter specified. If forms are deemed to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.

The shape, strength, rigidity, water-tightness, and surface smoothness of reused forms shall be maintained at all times. Warped or bulged lumber shall be resized before being reused. Forms which are unsatisfactory in any respect shall not be reused.

Access to the lower portions of forms for narrow walls and columns shall be provided for cleaning out extraneous material immediately before placing the concrete.

All forms shall be treated with an approved oil or saturated with water immediately before placing the concrete. For rail members or other members with exposed faces, the forms shall be treated only with an approved oil to prevent the adherence of concrete. Any material which will adhere to or discolor the concrete shall not be used.

When metal forms are used they shall be kept free from rust, grease, or other foreign matter which will discolor the concrete. They shall be of sufficient thickness and so connected that they will remain true to shape and line, and shall conform in all respects as herein prescribed for mortar tightness, filleted corners, beveled projections, etc. They shall be constructed so as to insure easy removal without injury to concrete. All inside bolt and rivet heads shall be countersunk.

All chamfer strips shall be dressed, straight, and of uniform width and shall be maintained as such at all times.

804.03.14.2--Stay-In-Place Metal Forms. The use of stay-in-place metal forms will not be allowed.

804.03.15--Removal of Falsework, Forms, and Housing. In the determination of the time for the removal of falsework, forms, and housing and the discontinuance of heating, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the setting of the concrete, and the materials used in the mix. No forms or supports shall be removed prior to approval by the Engineer. During cold weather, removal of housing and the discontinuance of heating shall be in accordance with Subsection 804.03.16.1.

Concrete in the last pour of a continuous superstructure shall have attained a compressive strength of 2,400 psi, as determined by cylinder tests, prior to striking any falsework. It is important that falsework be removed as evenly as possible to prevent excessive deflection stresses in the spans.

At the Contractor's option and with the approval of the Engineer, the time for removal of forms may be determined by cylinder tests, in which case the Contractor shall furnish facilities for testing the cylinders. The facilities shall include an approved concrete testing machine of sufficient capacity and calibrated by an acceptable commercial laboratory. Tests shall be conducted in the presence of a Department representative to witness and record strengths obtained on each break or performed by a Department certified technician in an approved testing laboratory.

When form removal or placing of beams is not controlled by cylinder tests, Column A, exclusive of the days when the ambient temperature is below 40°F, herein shall apply as a guide for removal of forms and falsework. When cylinder tests are used, Column B shall be used. The cylinders shall be cured under

conditions which are not more favorable than those existing for the portions of the structure which they represent.

If Type IP cement or Type I or II Portland cement plus fly ash is used, only Column B will be applicable.

	Column A Minimum Cure	Column B Minimum PSI
Forms:		
Columns	24 Hours	1000
Side of Beams	24 Hours	1000
Walls not under pressure	24 Hours	1000
Floor Slabs, overhead	7 Days	2000
Floor Slabs, between beams	7 Days	2000
Slab Spans	14 Days	2400
Other Parts	24 Hours	1000
Centering:		
Under Beams	14 Days	2400
Under Bent Caps	7 Days	2000
Limitation for Placing Beams on:		
Pile Bents, pile under beam	3 Days	2000
Frame Bents, two or more columns	7 Days	2200
Frame Bents, single column	14 Days	2400

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and supports shall be removed in a manner that will permit the concrete to uniformly and gradually take the stresses due to its own weight. Centers shall be gradually and uniformly lowered in a manner that will avoid injurious stresses in any part of the structure.

As soon as concrete for railings, ornamental work, parapets and vertical faces which require a rubbed finish has attained a safe strength, the forms shall be carefully removed without marring the surfaces and corners, the required finishing performed, and the required curing continued.

Prior to final inspection of the work, the Contractor shall remove all falsework, forms, excavated material or other material placed in the stream channel during construction. Falsework piles may be cut or broken off at least one foot below the mudline or ground line unless the plans specifically indicate that they are to be pulled and completely removed from the channel.

804.03.16--Cold or Hot Weather Concreting.

804.03.16.1--Cold Weather Concreting. In cold weather, the temperature of the concrete when delivered to the job site shall conform to the temperature limitations of "Temperature Limitations on Concrete when Delivered to Job Site" listed in Table 6 below.

When the Contractor proposes to place concrete during seasons when there is a probability of ambient temperatures lower than 40°F, the Contractor shall have available on the project the approved facilities necessary to enclose uncured concrete and to keep the temperature of the air inside the enclosure within the ranges and for the minimum periods specified herein.

When there are indications of temperatures of less than 40°F during the first four days after placement of the concrete, the concrete shall be protected from cold temperatures by maintaining a temperature between 50°F and 100°F for at least four days after placement and between 40°F and 100°F for at least three additional days. The Contractor shall use such heating equipment such as stoves, salamanders, or steam equipment as deemed necessary to protect the concrete. When dry heat is used, means of maintaining atmospheric moisture shall be provided.

One or more of the aggregates and/or mixing water may be heated. The aggregates may be heated by steam, dry heat, or by placing in the mixing water which has been heated. Frozen aggregates shall not be used. When either aggregates or water are heated above 100°F, the aggregates and water shall be combined first in the mixer before the cement is added to avoid flash set. Cement shall not be mixed with water or with a mixture of water and aggregate having a temperature greater than 100°F.

The use of salt or other chemical admixtures in lieu of heating will not be permitted.

Before placing concrete, all ice or frost shall be removed from the forms and reinforcement.

In the case of concrete placed directly on or in the ground, such as for footings or bottom slabs, protection and curing during cold weather may be provided as set for concrete pavement under Subsection 501.03.20.3.

The Contractor shall assume all risk and added cost connected with the placing and protecting of concrete during cold weather. Permission given by the Engineer to place concrete during such time will in no way relieve the Contractor of responsibility for satisfactory results. Should it be determined at any time that the concrete placed under such conditions is unsatisfactory, it shall be removed and replaced with satisfactory concrete by the Contractor without extra compensation.

TABLE 6
COLD WEATHER TEMPERATURE LIMITATIONS ON CONCRETE WHEN DELIVERED TO JOB SITE

Ambient Temperature °F	Minimum Concrete Temperature °F	
	For sections with least dimension less than 12 inches	For sections with least dimensions 12 inches or greater
30 to 45	60	50
0 to 30	65	55
Below 0	70	60

804.03.16.2--Hot Weather Concreting. The manufacture, placement, and protection of concrete during hot weather requires special attention to insure that uniform slump ranges and satisfactory placement qualities are maintained, that surface cracking is held to a minimum, and that design strengths are produced.

804.03.17--Curing Concrete. Concrete surfaces shall be protected from premature drying by covering as soon as possible with a satisfactory curing material. When wetted burlap is used, it shall be not less than two thicknesses of Class 3 burlap or its equivalent, and the burlap shall be kept continuously and thoroughly wet. Careful attention shall be given to the proper curing and protection of concrete, and curing by the wetting method shall continue for a period of at least seven days after placing the concrete. If high-early-strength cement is used, this period may be reduced to four days.

Surfaces to have a Class 2 rubbed or sprayed finish and bridge deck surfaces when the atmospheric temperature is 90°F or above shall be cured only by wetting methods. The curing of concrete bridges with membrane curing will be permitted only under the conditions specified herein.

Surfaces on which curing is to be by liquid membrane shall be given the required surface finish prior to the application of curing compound. During the finishing period the concrete shall be protected by the water method of curing. Concrete surfaces cured by the liquid membrane method shall receive two applications of curing compound. The first application shall be applied immediately after the finishing is completed and accepted. Prior to applying the first application, the concrete shall be thoroughly wetted with water and the liquid membrane applied just as the surface film of water disappears. The second application shall be applied immediately after the first application has set. The rate of application of curing compound will be as prescribed by the Engineer with a minimum spreading rate per application of one gallon per 200 square feet of concrete surface. The coating shall be protected against marring for at least 10 days after the application of the curing compound. The coating on bridge decks shall

receive extra attention and may require additional protection as required by the Engineer. All membrane marred or otherwise disturbed shall be given an additional coating. Should the surface coating be subjected repeatedly to injury, the Engineer may require that the water curing method be applied at once.

When using curing compound, the compound should be thoroughly mixed within an hour before use. If the use of curing compound results in a streaked or blotched appearance, the method shall be stopped and water curing applied until the cause of defective appearance is corrected.

Other precautions to insure the development of strength shall be taken as directed.

Adequate tarpaulins of ample size shall be on the project and used as necessary to protect the work in case of rain or other emergencies.

Conditions governing the placement of concrete and the requirements for the placement, protection, and curing of concrete during cold or hot weather shall conform to the limitations, conditions, and requirements stipulated in Subsection 804.03.16 as applicable.

804.03.18--Expansion and Fixed Joints, Bearings, Anchor Bolts, Plates, Castings, Pipes, Drains, Conduits, Etc. All joints shall be constructed according to details shown on the plans. The edges of the concrete at open or filled joints shall be chamfered or edged as indicated on the plans.

804.03.18.1--Open Joints. Open joints shall be placed in the locations shown on the plans and shall be constructed by the insertion and subsequent removal of a wood strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the plans.

804.03.18.2--Filled Joints. Poured expansion joints and joints to be sealed with premolded materials shall be constructed similar to open joints. When premolded types are specified, the filler shall be placed in correct position as the concrete on one side of the joint is placed. When the form is removed, the concrete on the other side shall be placed. Adequate water stops of metal, rubber, or plastic shall be carefully placed as shown on the plans.

804.03.18.3--Premolded and Preformed Joint Seals. When preformed elastomeric compressive joint seals are specified, the previously formed and cured open joint shall be thoroughly cleaned of all foreign matter, the required adhesive uniformly applied, and the seal installed in accordance with the recommendations of the manufacturer of the seal.

When premolded filler is used for the joints in the roadway slab, the tops shall be adequately sealed with poured joint filler in accordance with details on the plans. Premolded filler shall be permanently fastened to an adjacent concrete surface by appropriate use of copper wire, copper nails, or galvanized nails.

804.03.18.4--Steel Joints. The plates, angles, or other structural shapes shall be accurately shaped at the shop to conform to the section of the concrete floor. Fabrication and painting shall conform to the specifications covering those items. When called for on the plans or in the special provisions, the material shall be galvanized in lieu of painting. Care shall be taken to insure that the surface in the finished plane is true and free of warping. Positive methods shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be that designated on the plans at normal temperature, and care shall be taken to avoid impairment of the clearance in any manner.

804.03.18.5--Water Stops. Adequate water stops of metal, rubber, or plastic shall be placed as shown on the plans. Where movement at the joint is provided for, the water stops shall be of a type permitting movement without injury. They shall be spliced, welded, or soldered to form continuous watertight joints.

804.03.18.6--Bearing Devices. Bearing plates, rockers, and other bearing devices shall be constructed according to details shown on the plans. Unless otherwise specified or set in plastic concrete, they shall be set in grout to insure uniform bearing. Structural steel and painting shall conform to the requirements of Sections 810 and 814. When specified, the material shall be galvanized in lieu of painting. The rockers or other expansion bearing devices shall be set, considering the temperature at the time of erection, so that the required position of the device is provided.

At all points of bearing contact, concrete members shall be separated from underlying members by dimensioned bearing pads or by methods and/or materials specified on the plans.

When not otherwise specifically provided, contact areas between concrete superstructures and substructures shall be separated by three layers of No. 15, Type I, roofing felt.

804.03.18.7--Friction Joints. Metal friction joints shall consist of plates as indicated on the plans and shall be securely anchored in correct position. All sliding surfaces shall be thoroughly coated with an approved graphite grease. Movement shall not be impeded by the concrete in which the plates are embedded.

804.03.18.8--Placing Anchor Bolts, Plates, Castings, Grillage, Conduits, Etc. All anchor bolts, plates, castings, grillage, conduits, etc. indicated on the plans to

be placed in or on the concrete shall be placed, set, or embedded as indicated or as directed. These items of the construction shall be set in portland cement mortar as referenced in Subsection 714.11.5, except that anchor bolts may, as permitted by the Engineer, be built into the masonry, set in drilled holes, or placed as the concrete is being constructed by inserting encasing pipe or oiled wooden forms of sufficient size to allow for adjustment of the bolts. After removal of the pipe or forms, the space around the bolts shall be filled with portland cement mortar completely filling the holes. The bolt shall be set accurately and perpendicular to the plane of the seat.

Anchor bolts which are to be set in the masonry prior to the erection of the superstructure shall be carefully set to proper location and elevation with a template or by other suitable means.

When bed plates are set in mortar, no superstructure or other load shall be placed thereon until this mortar has been allowed to set for a period of at least 96 hours, subject to the restrictions for cold weather concreting in Subsection 804.03.16.1. The mortar shall be kept well moistened during this period.

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.

Where backfill is to be made at weep holes or openings in the structure, sand or stone chimneys or French drains shall be constructed as specified and shall extend through the portion of the backfill to be drained. Except as otherwise provided, the sand, stone, or slag used in this construction shall meet the requirements of Subsection 704.04.

804.03.19--Finishing Concrete Surfaces.

804.03.19.1--Classes of Finishes. Surface finishes of exposed concrete surfaces shall be classified as follows:

Class 1 - Ordinary Surface Finish
Class 2 - Rubbed or spray Finish
Class 3 - Tooled Finish
Class 4 - Sand-Blast Finish
Class 5 - Wirebrush or Scrubbed Finish
Class 6 - Floated Surface Finish

804.03.19.2--Class 1, Ordinary Surface Finish. Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other defects shall be

thoroughly cleaned, and after having been kept saturated with water for at least three hours shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the class of the concrete being finished. Mortar used in pointing shall be not more than one hour old. The mortar patches shall be cured as specified under Subsection 804.03.17. All construction and expansion joints shall be left carefully tooled and free of mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

The resulting surfaces shall be true and uniform. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be given a Class 2 rubbed finish.

804.03.19.3--Class 2, Rubbed or Spray Finish.

804.03.19.3.1--Rubbed Finish. After removal of forms, the Class 1 finish shall be completed and the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for at least three hours. Surfaces shall be rubbed with a medium course Carborundum stone using a small amount of mortar on its face. The mortar shall be composed of cement and sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids are filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time.

After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine Carborundum stone and water. This rubbing shall continue until the entire surface is of a smooth texture and uniform color.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and objectionable marks.

804.03.19.3.2--Spray Finish. Prior to the spray finish, the concrete shall be given a Class 1 finish in accordance with Subsection 804.03.19.2, supplemented if necessary with a grout meeting the requirements of Subsection 714.11 with fine aggregate modified to require 100 percent passing the No. 16 Sieve.

Grout shall be applied with burlap pads or float sponges, and as soon as the grout has dried the surface shall be brushed to remove all loose grout and the surface left smooth and free of air holes. Surfaces to be sprayed shall be free of efflorescence, flaking coatings, dirt, oil, and other foreign substances. Prior to application of the spray finish, the surfaces shall be free of moisture, as determined by sight and touch, and in a condition consistent with the manufacturer's published recommendations.

The spray finish material shall meet the requirements of Subsection 714.12 and shall be listed on of Approved Sources of Materials. The spray finish shall be applied with heavy duty spray equipment capable of maintaining a constant pressure as necessary for proper application. The material shall be applied as recommended by the manufacturer except the rate of application shall not be less than one gallon per 50 square feet of surface area without prior written approval of the Engineer.

The completed finish shall be tightly bonded to the structure and present a uniform appearance and texture equal to or better than a rubbed finish. If necessary, additional coats shall be sprayed to produce the desired surface texture and uniformity. Upon failure to adhere positively to the structure without chipping or cracking or to attain the desired surface appearance, the coatings shall be completely removed and the surface given a rubbed finish in accordance with 804.03.19.3.1, or other approved methods shall be used to obtain the desired surface finish to the satisfaction of the Engineer without additional cost to the State.

804.03.19.4--Classes 3, 4, and 5 Finishes. If required, specifications for these finishes will be contained in the special provisions.

804.03.19.5--Class 6, Floated Surface Finish. After the concrete has been deposited in place, it shall be consolidated and the surface shall be struck off by means of a strike board and floated with a wooden or cork float. An edging tool shall be used on edges and expansion joints. The surface shall not vary more than 1/8 inch under a 10-foot straightedge. The surface shall have a granular or matte texture which will not be slick when wet.

804.03.19.6--Required Finishes for Various Surfaces.

804.03.19.6.1--General. Unless otherwise specified, the top surface of sidewalks, the top horizontal surfaces of footings, and top slabs of box bridges, box culverts, or other structures shall be given a Class 6 finish. All formed concrete surfaces shall be given a Class 1 finish, except on surfaces which are completely enclosed, such as the inside surfaces of cells of box girders, the removal of fins and form marks and the rubbing of mortared surfaces to a uniform color will not be required.

In reference to finishing, exposed surfaces are surfaces or faces which may be seen after all backfill has been placed. Exposed surfaces requiring a Class 2 finish shall be finished at least one foot below the ground line or the low water elevation, whichever is higher.

The Class 2 finish shall be made upon a Class 1 finish. After the removal of forms the Class 1 finish shall be completed and the rubbing of concrete shall be started as soon as the condition of the concrete will permit.

Bridge floors shall be finished in accordance with Subsection 804.03.19.7.

804.03.19.6.2--Finishing Formed Concrete Surfaces of Box Bridges, Box Culverts, Pipe Headwalls, and Minor Structures. The exposed surfaces of wing walls and parapets of box bridges and box culverts to be used as vehicular or pedestrian underpasses shall be given a Class 2 finish. Exposed surfaces of other box culverts or box bridges, pipe culvert headwalls, and other minor structures shall be given a Class 1 finish unless otherwise indicated on the plans.

The exposed surfaces of retaining walls including copings and parapets shall receive a Class 2 finish.

804.03.19.6.3--Finishing Formed Concrete Surface of Bridges. All formed concrete bridge surfaces which are exposed shall have a Class 1 or 2 finish as set forth herein unless designated otherwise on the plans.

Bridges with designated surfaces for Class 2 finish are classified as follows:

Group A - Bridges over highways, roads and streets.
Group B - Bridges over waterways and railroads.
Group BB - Twin or adjacent bridges of Group B category.

When a Group B or BB bridge also spans a highway, road or street, exposed concrete surfaces shall be finished in accordance with Group A requirements.

(A) Superstructures. Concrete surfaces to be given a Class 2 finish shall be the exposed surfaces of wings and rails and other exposed surfaces indicated by a double line in Figures 804-1, 804-2, and 804-3.

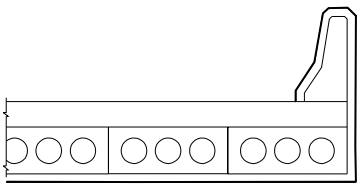
When a Group B or BB also spans a highway, road or street, the superstructure of spans over and extending one span in each direction beyond the lower level highway, road or street shall be given a Class 2 finish as shown for Group A.

(B) Substructures. Concrete surfaces to be given a Class 2 finish are as follows:

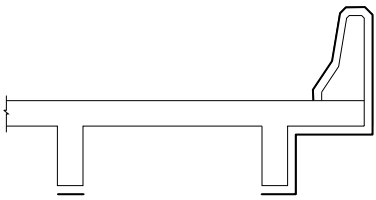
Group A. Exposed surfaces of abutments, end bents, end bent posts, wing walls, railing, retaining walls, parapets, copings, piers, columns, piles, caps, struts or walls between columns or piles, encasement of steel piles, arch rings and spandrel walls.

Group B and BB. Exposed surfaces of abutments, wing walls, end bent posts, railing, retaining walls, parapets and copings.

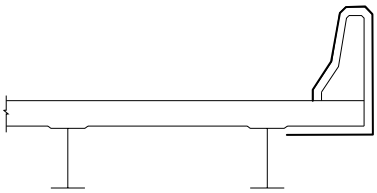
CONCRETE SLAB SPAN & HOLLOW SLAB SPAN



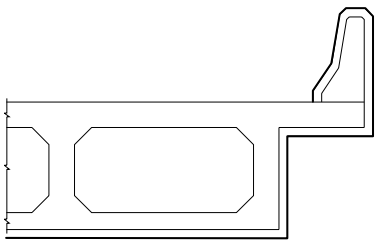
PRECAST HOLLOW SLAB SPAN



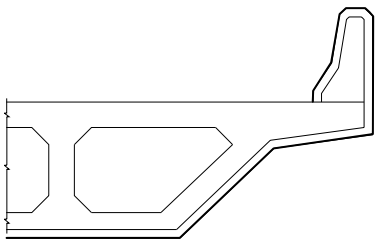
CONCRETE GIRDER SPAN



STEEL BEAM SPAN

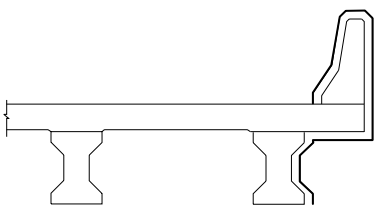


Vertical Face

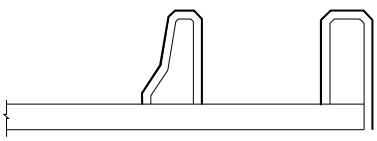


Slope Face

CONCRETE BOX GIRDER SPAN



PRESTRESSED CONCRETE BEAM SPANS



For Finishing On The Remainder Of Superstructure,
See The Appropriate Section On This Page.

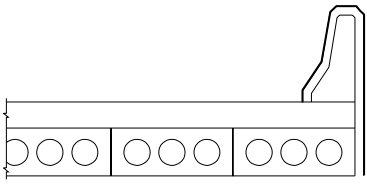
TYPICAL SIDEWALK SECTION

GROUP "A"

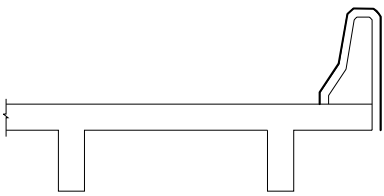
BRIDGES OVER HIGHWAYS, ROADS & STREETS

CLASS 2 FINISH - BRIDGE SUPERSTRUCTURES - FIG. 804-1

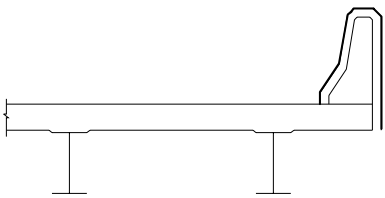
CONCRETE SLAB SPAN & HOLLOW SLAB SPAN



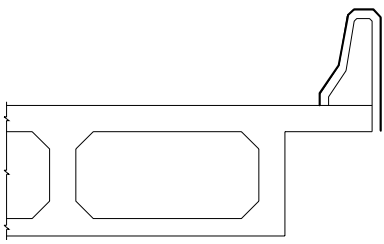
PRECAST HOLLOW SLAB SPAN



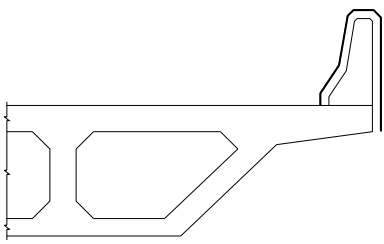
CONCRETE GIRDER SPAN



STEEL BEAM SPAN

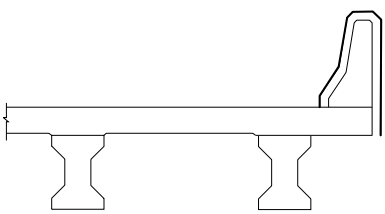


Vertical Face

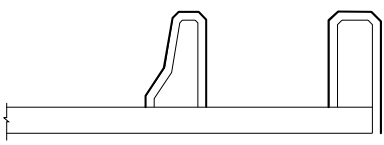


Slope Face

CONCRETE BOX GIRDER SPAN



PRESTRESSED CONCRETE BEAM SPANS



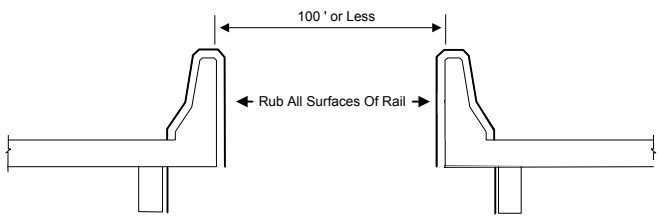
For Finishing On The Remainder Of Superstructure,
See The Appropriate Section On This Page.

TYPICAL SIDEWALK SECTION

GROUP "B"

BRIDGES OVER WATERWAYS AND BRIDGES OVER RAILROAD TRACKS

CLASS 2 FINISH - BRIDGE SUPERSTRUCTURES - FIG. 804-2



GROUP "B B" - ADJACENT BRIDGES

GROUP "B B"

TWIN or DUAL BRIDGES

CLASS 2 FINISH - BRIDGE SUPERSTRUCTURES - FIG. 804-3

804.03.19.7--Finishing Bridge Floors.

804.03.19.7.1--General. Concrete bridge decks shall be struck off and finished by the method(s) designated on the plans.

In the event a method is not designated, the Contractor may use either the longitudinal or transverse method subject to the requirements contained in these specifications.

Except when indicated otherwise on the plans, the final surface texture of the bridge floor shall be either a drag, belt, or broom finish. The surface texture specified and surface requirements shall be in accordance with the applicable requirements of Subsections 501.03.17 and 501.03.18 modified only as the Engineer deems necessary for bridge deck construction operations.

804.03.19.7.2--Longitudinal Method. The longitudinal method requires that the strike-off screed be supported on accurately graded and supported bulkheads or templates placed across the full width at the end(s) of the pour. Before the concrete is placed, approved fixed templates or wooden bulkheads of not less than 1¼-inch lumber shall be placed perpendicular to the centerline of the roadway, or in the case of skew bridges at the angle of skew. The upper surface of the template or bulkheads shall be accurately set to conform to the required grade and crown.

Special attention shall be given to the gutter lines where the strike-off screed cannot reach. The gutters shall be finished by hand and tested with the straight edge. Floor drains shall be set lower than the finished gutter line and finished over. After initial set, the concrete shall be dished out and finished around the drains to form an outlet.

After the concrete has been deposited and rough graded, it shall be struck off by means of a strike-off screed resting on the bulkheads or fixed templates. The strike-off screed shall be of a type satisfactory to the Engineer and shall have sufficient strength to retain its shape under all working conditions. The final surface shall comply with the applicable requirements of Subsections 501.03.17.6 and 501.03.18, and unless otherwise specified in the contract, the final finish under this method shall be the belt finish.

In general, the overall strike-off screed should be trussed, with bracing heavy enough to support the weight of a man without deflecting, and should be adjustable for camber and correction of sag.

The strike-off screed will ride on the bulkheads or fixed templates at the ends of the section being finished. Care shall be taken to see that the bulkhead or fixed template elevations are accurately set since the entire span surface will be

controlled by them. The manipulation of the screed shall be such that neither end is raised from the bulkheads or templates during the process.

The concrete shall be struck off by beginning at one curb and proceeding entirely across the span. A slight excess of concrete shall be kept in front of the cutting edge at all times. This operation shall be repeated at least three times. In each case, the strike-off screed shall be picked up and carried back to the point of beginning. No backward strokes will be allowed. The strike-off screed shall be moved along the bulkheads or fixed templates with a combined longitudinal and transverse motion. This operation may be manual or mechanical. Standing or walking in the fresh concrete ahead of the strike- off screed will not be permitted.

804.03.19.7.3--Transverse Method. The transverse method requires that the screeding equipment be supported on accurately graded and supported rails placed beyond the gutter lines and parallel with the centerline of the bridge.

The machine shall be so constructed and operated as to produce a bridge floor of uniform density with minimum manipulation of the fresh concrete and achieved in the shortest possible time. Manual transverse methods of screeding will not be permitted.

The finishing machine shall be supported on vertically adjustable rails set a sufficient distance from the gutter line to allow free movement of the screed from gutter line to gutter line. Satisfactory means of load distribution with minimum rail deflection shall be provided. The screed rails for a deck pour shall be completely in place for the full length of the pour and shall be firmly secured prior to placing concrete. The screed rails shall be adjusted as necessary to compensate for settlement and deflection occurring during the screeding operations. Supports for the screed rail shall be located directly over slab overhang support brackets as referenced in Subsection 804.03.14.1.

At least one dry run shall be made the length of each pour with a "tell-tail" device attached to the screed carriage to assure the specified clearance to the reinforcing steel.

The screed shall be equipped with a metal cutting edge or other approved mechanical means for accurately fine grading the plastic concrete to the required grade and surface smoothness and shall be supported by a bridging structure sufficiently rigid and heavy to perform operations satisfactorily on concrete of minimum slump without vibration, distortion, and wrecking of forms. The screed shall be mechanically actuated to deliver the screeding action and for travel in a longitudinal direction at a uniform rate along the bridge floor.

The screed shall complete sufficient passes to strike off all of the excess concrete with ample mortar along the entire leading edge to assure filling of low spots.

Care shall be taken to remove all objectionable material from the gutters where final hand finishing will be required.

The selection of the transverse method may require the Contractor to furnish bridge deck concrete which contains an approved water-reducing set retarding admixture in the quantities approved by the Engineer at no additional cost to the State. See Subsection 713.02 for more information.

Other finishing requirements shall be in accordance with the general requirements in Subsection 804.03.19.7.1 and as specified on the plans.

804.03.19.7.4--Acceptance Procedure for Bridge Deck Smoothness. After the bridge decks and bridge end slabs are completed and preferably before the construction of the bridge railing, they shall be tested for ride quality using a Contractor furnished profilograph. Profile Index Values shall be determined in accordance with Department SOPs and these specifications. The profilograph shall meet the requirements of Subsection 401.02.6.5. Profiles will be obtained in the wheel paths of the main thru lanes and, where conditions allow, in the wheel paths of any auxiliary lanes or tapers. Profile Index Values for bridge decks and bridge end slabs shall be obtained for all state roads with four lanes or more, on state roads three lanes or less where the current traffic count is 2,000 ADT or higher, or as designated on the plans. Ride quality tests will begin at a point where the rearmost wheel of the profilograph is as close to the beginning of the bridge end slab as possible and shall proceed forward across the remainder of the bridge end slab, across the bridge deck and continue across the next bridge end slab to a point where the front-most wheel of the profilograph reaches the far-most edge of the bridge end slab. Bridges and bridge end slabs not requiring a ride quality test must meet a 1/8 inch in 10-foot straightedge requirement in longitudinal and transverse directions. Bridges in horizontal curves having a radius of less than 1,000 feet at the centerline and bridges within the superelevation transition of such curves are excluded from a test with the profilograph.

The Profile Index Value for bridge decks including the bridge end slabs shall be averaged for the left and right wheel path for each lane and where applicable, each auxiliary lane and taper, and shall not exceed 65 inches per mile for each lane. In addition, individual bumps or depressions exceeding 0.3 of an inch, when measured from a chord length of 25 feet, shall be corrected and the surface shall meet a 1/8 inch in 10-foot straightedge check made transversely across the deck or slab.

Bridge decks and bridge end slabs not meeting the preceding requirements shall be corrected. Corrective work shall be done at no additional cost to the Department. Corrective work shall consist of grinding the bridge deck in accordance with this specification. All corrective work shall precede final surface texturing. After completion of final surface texturing, all surface areas

corrected by grinding shall be sealed with a nonstaining 40% minimum alkylalkoxysilane penetrating sealant applied per the manufacturer's directions.

In case the bridge end slabs are to be constructed on a future project, the bridge deck(s) alone shall be tested for ride quality using the acceptance procedure outlined above, except that the ride quality test will begin at a point where the rearmost wheel of the profilograph is as close to the beginning of the bridge as possible and shall proceed forward across the bridge deck to a point where the front-most wheel of the profilograph reaches the far-most edge of the bridge.

Expansion joint installation shall be delayed and the joint temporarily bridged to facilitate operation of the profilograph and grinding equipment across the joint wherever feasible.

It shall be the Contractor's responsibility to schedule profilograph testing. The Contractor shall notify the Department at least five (5) days in advance of profilograph testing. The Contractor shall ensure that the area to be tested has been cleaned and cleared of all obstructions. Profilograph testing of bridge decks and bridge end slabs shall be performed by the Contractor under supervision of the Engineer. All profilograph testing shall be performed at no additional cost to the Department. The Contractor will be responsible for traffic control associated with this testing operation.

804.03.19.7.4.1--Grinding Bridge Decks.

804.03.19.7.4.1.1--Equipment. The grinding equipment shall be a power driven, self-propelled machine that is specifically designed to smooth and texture Portland cement concrete pavement with diamond blades. The effective wheel base of the machine shall not be less than 12.0 feet. It shall have a set of pivoting tandem bogey wheels at the front of the machine and the rear wheels shall be arranged to travel in the track of the fresh cut pavement. The center of the grinding head shall be no further than 3.0 feet forward from the center of the back wheels.

The equipment shall be of a size that will cut or plane at least 3.0 feet wide. It shall also be of a shape and dimension that does not encroach on traffic movement outside of the work area. The equipment shall be capable of grinding the surface without causing spalls at cracks, joints, or other locations.

804.03.19.7.4.1.2--Grinding. The grinding areas will be determined by the Contractor and approved by the Engineer. The Contractor shall develop and submit to the Engineer for approval a Grinding Plan. The Contractor shall allow up to 45 days for the Department to review the Plan prior to starting any grinding operations. This plan shall include as a minimum:

1) Name of the project superintendent in responsible charge of the grinding operation.
2) List and description of all equipment to be used.
3) Maximum depth of each pass allowed by the grinding equipment.
4) Maximum width of each pass allowed by the grinding equipment.
5) Details of a sequence of the grinding operation.
6) Complete data from Profilograph runs, based on a 0.3 inch bump height, for each wheel path over the entire bridge including bridge end slabs, which shall include profile index, bump locations (in stations), bump heights and proposed final cross-slopes. When a computerized profilograph is used, a complete printout of the profile including the header information for each wheel path will be required.
7) Data showing reinforcing steel clearance in all areas to be ground.
8) A detailed drawing of the deck showing areas to be ground with station numbers and grinding depths clearly indicated.
9) A description of grinding in areas where drains are in conflict with grind areas.
10) Details of any changes in deck drainage, anticipated ponding, etc.

The Engineer will evaluate the grinding plan for conformance with the plans and specifications, after which the Engineer will notify the Contractor of any additional information required and/or changes that may be needed. Any part of the plan that is unacceptable will be rejected and the Contractor shall submit changes for reevaluation. All approvals given by the Engineer shall be subject to trial and satisfactory performance in the field, and shall not relieve the Contractor of the responsibility to satisfactorily complete the work.

The construction operation shall be scheduled and proceed in a manner that produces a uniform finished surface. Grinding will be accomplished in a manner that eliminates joint or crack faults while providing positive lateral drainage by maintaining a constant cross-slope between grinding extremities in each lane. Auxiliary or ramp lane grinding shall transition as required from the mainline edge to provide positive drainage and acceptable riding surface.

The operation shall result in a finished surface that conforms as close as possible to the typical cross-section and the requirements specified in Subsection 804.03.19.7.4.1.3.

The Contractor shall establish positive means for removal of grinding residue. Residue shall not be permitted to flow across lanes used by public traffic or into gutters or drainage facilities.

804.03.19.7.4.1.3--Final Surface Finish. The grinding process shall produce a finish surface that is as close as possible to grade and uniform in appearance with a longitudinal line type texture. The line type texture shall contain parallel longitudinal corrugations that present a narrow ridge corduroy type appearance.

The peaks of the ridges shall be approximately 1/16 inch higher than the bottoms of the grooves with approximately 53 to 57 evenly spaced grooves per foot. Grinding chip thickness shall be a minimum of 0.080 inches thick.

The finished bridge decks and bridge end slabs shall be retested for riding quality using a Contractor furnished profilograph meeting the requirements of 401.02.6.5. The finished results shall meet the following conditions:

(a) Individual bumps or depressions shall not exceed 0.3 inches when measured from a chord length of 25 feet.
(b) The final index value for the bridge deck and bridge end slabs shall be an average of both the right and left wheel paths of each lane and shall not exceed 65 inches per mile.

The final profilogram will be furnished to the Engineer for informational purposes.

804.03.19.8--Finishing Horizontal Surfaces of Footings or Top Slabs of Box Bridges, Culverts, or Other Structures. The finishing of horizontal surfaces of footing or top slabs of box bridges, culverts, or other structures shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. After the concrete has been struck off the surface shall be given a Class 6 finish.

804.03.19.9--Finishing Exposed Surfaces of Sidewalks. After the concrete has been deposited in place it shall be consolidated and the exposed surface shall be given a Class 6 finish. An edging tool of the required radius shall be used on all edges and at all expansion joints. The surface shall have a granular texture which will not be slick when wet.

Sidewalk surfaces shall be laid out in blocks with an approved grooving tool as shown on the plans or as directed.

804.03.20--Opening Bridges.

804.03.20.1--Public Traffic. Unless otherwise specified, concrete bridge floors shall be closed to public highway traffic for a period of at least 21 days after placing concrete.

804.03.20.2--Construction Traffic. Unless otherwise specified, concrete bridge floors shall be closed to construction traffic for a period of seven days after placing concrete and the minimum required compressive strength for the concrete placed is obtained.

804.03.21--Final Cleanup. Upon completion of the work all equipment, surplus materials, forms, and waste material shall be removed, the bridge cleaned, and the site of the work given a final cleanup.

804.03.22--Precast-Prestressed Concrete Bridge Members.

804.03.22.1--General. All installations and plants for the manufacture of precast-prestressed bridge members shall be PCI (Prestressed Concrete Institute) Certified. Bridge members manufactured in plants or installations not so approved will not be accepted for use in the work. The Contractor or other manufacturer shall employ a technician skilled in the adopted system of prestressing to supervise the manufacturing operations. This technician shall be certified according to the guidelines of this specification. The Contractor shall develop and implement a Quality Control Program as per Division I of PCI Quality Control Manual, 4th Edition. The Quality Control Program shall be submitted to the District Materials Engineer for approval.

804.03.22.2--Stressing Requirements. The jacks for stressing shall be equipped with accurate calibrated gauges for registering the jacking pressure. Means shall be provided for measuring elongation of strands to at least the nearest 1/16 inch.

Prior to beginning work, the Contractor or manufacturer shall have all jacks to be used, together with their gauges, calibrated by an approved laboratory. All jacks and gauges shall have an accuracy of reading within two percent. The testing agency shall furnish the Engineer a statement certifying that the jacks and gauges meet this requirement. During the progress of the work, if a gauge appears to be giving erratic results or if the gauge pressure and elongations indicate materially differing stresses, recalibration will be required.

Calibration of jacks and gauges shall be repeated at intervals deemed necessary by the Engineer. These intervals for calibration shall not exceed one year.

Shop drawings of prestressed beams, including an erection plan, shall be submitted in duplicate to the Bridge Engineer for approval prior to manufacture of members.

804.03.22.2.1--Methods. Plans for the particular bridge members will show prestressing by one of the following methods:

(A) Pretensioning. The prestressing strands are stressed initially. After the concrete is placed, cured, and has attained the compressive strength shown on the plans, the stress is transferred to the member. The method used for pretensions shall be in accordance to Division V of PCI Quality Control Manual, 4th Edition.

(B) Posttensioning. The posttensioning tendons are installed in voids or ducts and are stressed and anchored after development of the compressive strength specified on the plans. The voids or ducts are then pressure grouted.

(C) Combined Method. Part of the reinforcing is pretensioned and part posttensioned. Under this method all applicable requirements for the two methods specified shall apply to the respective stressing elements being used.

804.03.22.2.2--Alternate Details for Prestressed Members. In the event that the Contractor / Manufacturer desires to use materials or methods that differ in any respect from those shown on the plans or described in these specifications, the Contractor shall submit for approval full plan details on acceptable tracings suitable for reproduction and specifications which shall become the property of the Department. In order for alternate materials and/or methods to be considered, they will be required to comply fully with the following:

A. Provisions equal to those stipulated in these specifications.
B. Current AASHTO Specifications.
C. Recommendations of materials manufacturer.
D. Camber tolerance of beams and spans shown on plans.

Note: Alternate materials and methods will not be authorized on Federal-Aid Projects.

The Engineer shall be the sole judge as to the adequacy and propriety of any variation of materials or methods.

804.03.22.2.3--Stressing Procedure.

(A) General. Stressing shall be performed by suitable jacks working against unyielding anchorages and capable of maintaining the required stress for an indefinite period without movement or yielding. Strands may be stressed singularly or in a group.

The tension to be applied to each strand shall be as shown on the plans. The tension shall be measured by both jacking gauges and elongations in the strands and the result shall check within close limits.

It is anticipated that there will possibly be a difference in indicated tension between jack pressure and elongation of about five (5) percent. In this event, the discrepancy shall be placed on the side of slight overstress rather than understress.

In the event of an apparent discrepancy between gauge pressure and elongation of as much as five (5) percent, the entire operation shall be carefully checked, and the source of error determined before proceeding further.

Elongation is to be measured after the strands have been suitably anchored, and all possible slippage at the anchorages has been eliminated.

In all stressing operations, the stressing force shall be kept as nearly symmetrical about the vertical axis of the member as practicable.

(B) Pretensioning. All strands to be prestressed shall be brought to a uniform initial tension prior to being given their full pretensioning. This uniform initial tension of approximately 1000 to 2000 pounds shall be measured by suitable means such as a dynamometer so that its value can be used as a check against elongation computed and measured.

After the initial tensioning, the strand or group shall be stressed until the required elongation and jacking pressure is within the limits specified.

When the strands are stressed in accordance with the plan requirements and these specifications and all other reinforcing is in place, the concrete shall be placed in the prepared forms.

Strand stress shall be maintained until the concrete between anchorages has attained the required compressive strength as determined by cylinder tests, after which the strands shall be cut off flush with the ends of column members, and cut as shown on the plans for beams, girders, etc. Strands shall be cut or released in such a manner that eccentricity of prestress will be kept to a minimum and no damage to the member will result. The strand cutting pattern shall be as shown on the plans or as approved by the Bridge Engineer.

(C) Posttensioning. For all posttensioning tendons/bars the anchor plates shall set exactly normal in all directions to the axis of the tendon/bar. Parallel wire anchorage cones shall be recessed within the beams. Tensioning shall not take place until the concrete has reached the compressive strength shown on the plans.

Elongation and jacking pressures shall make appropriate allowance for all possible slippage or relaxation of the anchorage. Posttensioning tendons/bars shall be stressed in the order and manner shown on the plans.
The units shall be tensioned until the required elongations and jacking pressures are attained and reconciled within the limits specified in Subsection 804.03.22.2.3(A) with such overstresses as approved by the Engineer for anchorage relaxation.

Independent references shall be established adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the strands.

Straight tendons/bars may be tensioned from one end. Unless otherwise specified, curved tendons shall be stressed by jacking from both ends of the tendons.

(D) Combined Method. In the event that girders are manufactured with part of the reinforcement pretensioned and part posttensioned, the applicable portions of the requirements listed herein shall apply to each type.

804.03.22.3--Manufacture.

804.03.22.3.1--Forms. The forms used for precast-prestressed bridge members shall meet the requirements of Division II of the PCI Quality Control Manual, 4th Edition.

804.03.22.3.2--Placing and Fastening Steel. Placing and fastening of all steel used for precast-prestressed bridge members shall meet the requirements of Division V of the PCI Quality Control Manual, 4th Edition.

804.03.22.3.3--Holes for Prestressing Tendons/Bars. Holes provided in girders for prestressing tendons/bars shall be formed by means of inflatable rubber tubing, flexible metal conduit, metal tubing, or other approved means.

804.03.22.4--Placing and Curing Concrete.

804.03.22.4.1--Placing. The placing of concrete shall meet the applicable requirements of Division III of PCI Quality Control Manual, 4th Edition.

804.03.22.4.2--Curing. Initial and accelerated curing of all members shall meet the applicable requirements of Division IV of PCI Quality Control Manual, 4th Edition except for the following listed requirements.

The source of heat for accelerated cure shall be steam. Calibrated thermocouples shall be implanted into the concrete members to monitor areas expected to have maximum and minimum heat. Curing methods and procedures listed in the prestress producer’s PCI Quality System Manual shall be approved by the Department before their implementation.

804.03.22.4.3--Removal of Side Forms. Side forms may be removed after the concrete has attained sufficient strength to maintain a true section. In order to obtain "sufficient strength", it may be necessary to cure members for 12 hours or more as prescribed in Subsection 804.03.22.4.2, or to attain a minimum compressive strength of 1,000 psi.

If high-early-strength concrete is obtained by use of low slump (0 to 1.5-inch) concrete, vacuum process, or other approved methods, side forms may be removed earlier; however, approval of the methods and revision from normal

schedules will be made only after inspections by the District and Jackson Laboratories have determined that satisfactory results will be attained by the methods and schedules proposed.

804.03.22.4.4--Grouting. The holes through posttensioned members in which the tendons are installed shall be equipped with approved grouting vents. All prestressing tendons to be bonded shall be free of dirt, loose rust, grease, or other deleterious substances. Before grouting, the ducts shall be free of water, dirt, and other foreign substances. The ducts shall be blown out with compressed air until no water comes through the ducts. For long members with draped tendons an open tap at low points may be necessary. After completion of stressing, the annular space between sides of tendon and sides of hole shall be grouted as set in the following paragraphs.

With the grouting vent open at one end of the core hole, grout shall be applied continuously under moderate pressure at the other end until all entrapped air is forced out through the open grout vent, as evidenced by a steady stream of grout at the vent. Whereupon, the open vent shall be closed under pressure. The grouting pressure shall be gradually increased to a refusal of at least 75 psi and held at this pressure for approximately 10 seconds, and the vent shall then be closed under this pressure.

Portland cement grout shall consist of a mixture of:

1	part Type 1 Portland cement
1/4	part fly ash
3/4	part washed sand *
4 to 6	gallons of water per bag of cement.

* all passing No. 16 sieve and not more than 5% retained on No. 30

A plasticizing admixture, subject to approval by the Engineer, shall be used in accordance with the manufacturer's recommendations.

The grout shall be mixed in a mechanical mixer, shall have the consistency of heavy paint, and shall be kept agitated until placed.
Members shall not be moved before the grout has set, ordinarily at least 24 hours at 80°F or higher.

804.03.22.5--Finishing and Marking. Units shall be given a Class 1 finish at the plant and shall be given a Class 2 finish after erection when required.

Recesses in girders at end of diaphragm bars, holes left by form ties, and other surface irregularities shall be carefully cleaned and patched with an approved non-shrink commercial grout or a non-shrinkage mortar of the following composition:

1 part Type 1 cement
1 1/2 to 2 parts fine sand
1/2 to 3/4 ounces aluminum powder per bag of cement
Approved admixture per Subsection 713.02.
Sufficient water to produce a workable but rather stiff mix.

The units shall be clearly marked in accordance with Department SOP.

804.03.22.6--Handling, Storage, and Installation. Posttensioned members may be handled immediately after completion of stressing and grout has set. Pretensioned members may be handled immediately after release of tensioning. In either case, the members shall have developed a minimum compressive strength of 4000 psi prior to handling. In the event stressing is not done in a continuous operation, members shall not be handled before they are sufficiently stressed, as determined by the Engineer, to sustain all forces and bending moments due to handling. In the handling, storage, and transporting of beams or girders, they shall be maintained in an upright position (position as cast) at all times and shall be picked up from points within distance from beam ends equal to beam depth or at pick-up points designated on the plans. Disregard of this requirement and dropping of units may be cause for rejection, whether or not injury to the unit is apparent. Piles shall be picked up and loaded for shipment at points shown by the suspension diagram on the plans. Extreme care shall be used in handling and storing piles to prevent damage. The dropping of a pile may be cause for rejection of same, whether or not there is apparent injury to the member.

Care shall be exercised during the storage, hoisting, and handling of precast units to prevent damage. Damaged units shall be replaced by the Contractor at no additional costs to the State.

When members are stacked for storage, each layer shall be supported at or near the pick-up points. Supports shall be carefully placed in a vertical line in order that the weight of any member will not stress an underlying member. To prevent damage in moving members it is suggested that rigid supports be covered with a cushion of wood or other resilient material.

Members shall not be transported until at least one day after the concrete has reached a compressive strength of 5,000 psi or greater strength when shown on the plans.

Piles used in salt water shall not be driven until concrete is seven days old, and air-entrained concrete shall be used in such piles.

After prestressed concrete voided slab units are set, doweled and bolted in their final position the keyways and dowel holes shall be filled with an approved non-

shrink grout. Traffic shall not be permitted on the spans for 24 hours after grouting, and heavy construction equipment exceeding 15 tons will not be permitted on the spans for a period of 72 hours after grouting.

Adjacent slab units that mismatch more than one-fourth inch shall be adjusted prior to grouting of the shear keys. The maximum deviation from cross-section and grade (exclusive of camber) at any point shall not exceed one-fourth inch; and when the surface is checked with a ten-foot straightedge applied both parallel and perpendicular to the centerline, the variance shall not exceed one-fourth inch.

In addition to the requirements set out in this section, the applicable requirements of Section 803 shall apply.

804.03.22.7--Tolerances for Accepting Precast Prestressed Concrete. Member shall meet the dimension tolerances set by Division VII of PCI Quality Control Manual, 4th Edition.

804.03.22.8--Testing of Materials. Concrete and aggregate testing shall meet the requirements of Division VI of PCI Quality Control Manual, 4th Edition, except that the concrete mix design shall meet the requirements of Subsection 804.02.10 "Portland Cement Concrete Mix Design". Also, in addition to concrete compressive tests samples made for detensioning and 28-day strength, test samples shall be made and tested in order to prove compliance to the requirements of Subsection 804.03.22.6 for handling and shipping prestressed members. Compressive strength test cylinders for detensioning, handling and shipping shall receive the same type curing as the prestressed members for which they represent. Compressive strength samples shall be made each day for each prestress casting bed.

804.03.22.9--Testing Personnel. Technicians testing Portland cement concrete used in the production of precast-prestressed members shall be PCI Quality Control Technician/Inspector Certified. Each producer of precast-prestressed members shall have at least one PCI Level II certified technician on site during production for Department projects.

804.03.22.10--Documentation. The Precast-Prestressed Producer for each Precast-Prestressed concrete bridge member shall maintain documentation as set forth in Department SOPs. Testing and inspection record forms shall be approved by the Central Laboratory and as a minimum contain information listed in Division VI of PCI Quality Control Manual, 4th Edition.

804.03.22.11--Use in the Work. Before any Precast-Prestressed member is incorporated into the work, documentation as described in Subsection 804.03.22.10 is required along with visual inspection of the member at the bridge construction site. Project Office personnel as per Department SOP will make visual inspection of the prestressed member at the bridge construction site.

804.04--Method of Measurement. Concrete, complete and accepted, will be measured in cubic yards. The concrete volume will be computed from the neat dimensions shown on the plans, except for such variations as may be ordered in writing by the Engineer. The quantity of concrete involved in fillets, scorings, and chamfers one square inch or less in cross-sectional area will be neglected. Deductions shall be made for the following:

(1) The volume of structural steel, including steel piling encased in concrete.
(2) The volume of timber piles encased in concrete, assuming the volume to be 0.80 cubic foot per linear foot of pile.
(3) The volume of concrete piles encased in concrete.

No deduction will be made for the volume of concrete displaced by steel reinforcement, floor drains, or expansion joint material that is one inch or less in width normal to the centerline of the joint. Where railing is bid as a separate item, that portion of the railing above the top of the curb, above the surface of the sidewalk, or above the bridge roadway, as the case may be, will not be included in the measurement of concrete, but will be measured as railing. Massive pylons or posts which are to be excepted from payment for railing and are intended to be measured for as concrete will be so noted on the plans.

When shown on the plans or directed by the Engineer, concrete placed as a seal for cofferdams will be measured by the cubic yard actually in place, except that no measurement will be made of seal concrete placed outside of an area bounded by vertical planes 18 inches outside the neat lines of the footing as shown on the plans or as directed and parallel thereto.

Reinforcing steel will be measured and paid for in pounds as set out in Section 805.

Unless otherwise specified, structural steel will be measured and paid for as set out in Section 810.

Excavation for bridges will be measured and paid for as in Section 801.

Piling will be measured and paid for as set out in Sections 802 and 803.

Railing will be measured and paid for as set out in Section 813.

Prestressed concrete beams and plank will be measured by the linear foot.

Prestressed concrete voided slab units, interior and exterior with railing, and precast concrete caps, intermediate and end cap with winged abutment wall, of the size and type specified will be measured by the unit complete in place and accepted. Railing, winged abutment walls, grout, tie rods, nuts, washers, bearing pads and other appurtenances will not be measured for separate payment.

804.05--Basis of Payment. Concrete will be paid for at the contract unit price per cubic yard for the class or classes specified, complete in place. Prestressed concrete beams and plank will be paid for at the contract unit per linear foot of specified size and type.

Prestressed concrete voided slab units and precast caps will be paid for at the contract unit price per each for the specified types and sizes, complete in place and accepted; which price shall be full compensation for furnishing, hauling and erecting the members; including all prestressing reinforcement and other reinforcement in the members. Payment at the contract unit prices bid shall be full compensation for furnishing all materials, equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

804-A: Bridge Concrete, Class ____	- per cubic yard
804-B: Box Bridge Concrete, Class ___	- per cubic yard
804-C: Length Prestressed Concrete Beam, Type ___	- per linear foot
804-D: Length Prestressed Concrete Plank	- per linear foot
804-E: Length Prestressed Concrete Voided Slab, Size Interior	- per each
804-F: Length Prestressed Concrete Voided Slab, Size Exterior	- per each
804-G: Length Precast Concrete Caps, End Unit with Wall	- per each
804-H: Length Precast Concrete Caps, Intermediate Unit	- per each

SECTION 805 - REINFORCEMENT

805.01--Description. This work consists of furnishing and placing steel reinforcement for bridges in accordance with these specifications and in reasonably close conformity with the dimensions, bending, spacing, and other requirements shown on the plans.

805.02--Materials. Materials used shall conform to the requirements of Section 711.

Supports for bar reinforcement shall meet the requirements of Subsection 711.02.7.

805.02.1--Order Lists. Before ordering reinforcement, all order lists and bending diagrams shall be furnished by the Contractor for the approval of the Engineer, and no materials shall be ordered until the lists and bending diagrams have been approved. All expense incident to the revision of material furnished in accordance with such lists and diagrams to make it comply with the design drawings shall be borne by the Contractor.

805.03--Construction Requirements.

805.03.1--Protection of Material. Steel reinforcement shall be protected at all times from damage. Damaged material will not be approved for use in the work. When placed in the work and immediately prior to placing the concrete, the reinforcement shall be free from dirt, oil, paint, grease, and other foreign substances and shall be free of loose or thick rust or millscale which could impair bond of the steel with the concrete.

805.03.2--Fabrication. Bent bar reinforcement shall be cold bent to the shapes shown on the plans, and unless otherwise provided on the plans or by authorization, bends shall be made in accordance with Subsection 711.02. Bars partially embedded in concrete shall not be field bent except as shown on the plans or permitted.

Bar reinforcement shall be bundled, tagged and marked in accordance with Code of Standard Practice of the Concrete Reinforcing Steel Institute.

805.03.3--Placing and Fastening. Reinforcement shall be accurately placed in the positions shown on the plans and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections; except where spacing is less than one foot in each direction, alternate intersections shall be tied.

Distances from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shape and dimensions or metal chairs, reference Subsection 711.02.7. Layers of bars shall be separated by precast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe, and wooden blocks will not be permitted. The clear distance between parallel bars, except in columns and between multiple layers of bars in beams, shall not be less than the nominal diameter of the bars, 1 1/3 times the maximum size of the coarse aggregate, nor one inch.

Where reinforcement in beams or girders is placed in two or more layers, the clear distance between layers shall not be less than one inch, and the bars in the upper layers shall be placed directly above those in the bottom layer.

In spirally reinforced and in tied columns, the clear distance between longitudinal bars shall not be less than 1½ times the bar diameter, 1½ times the maximum size of the coarse aggregate, nor 1½ inches.

The clear distance between bars shall also apply to the clear distance between a contact splice and adjacent splices or bars.

Reinforcement in any member shall be inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and removal and replacement of concrete and reinforcement required.

If fabric reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

805.03.4--Splicing of Bars. All reinforcement shall be furnished in the full lengths indicated on the plans. Splicing of bars, except when shown on the plans, will not be permitted without the written approval of the Engineer. Splices shall be staggered insofar as possible.

The minimum distance to the surface of the concrete shall be as specified on the plans. Reinforcement shall not be welded except if detailed on the plans or if authorized by the Engineer in writing. Welding shall conform to the current AWS specifications for Recommended Practices for Welding Reinforcement Steel, Metal Inserts, and Connections in Reinforced Concrete Construction.

805.03.5--Lapping of Mesh or Mats. Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh in width.

805.03.6--Substitutions. Substitutions of different size bars will be permitted only with specific authorization by the Engineer. If steel is substituted, it shall have an area equivalent to the design area or larger.

805.03.7--Epoxy Coated Bars.

805.03.7.1--Repair of Damaged Epoxy Coating. When required, damaged epoxy coating shall be repaired with patching material conforming to ASTM Designation: A 775. Repair shall be done in accordance with the patching material manufacturer's recommendations.

805.03.7.2--Handling of Epoxy Coated Bars. The Contractor shall use padded or non-metallic slings and padded straps to protect the coated reinforcement from damage. The bundled bars shall not be dropped or dragged and must be stored on wooded cribbing. If, in the opinion of the Engineer, the coated bars or plates have been damaged as a result of the Contractor's negligence, the material will be rejected. The Contractor may propose, for the approval of the Engineer, alternate precautionary measures.

805.03.7.3--Placing of Epoxy Coated Bars. Epoxy-coated reinforcing bars supported from formwork shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable materials. Wire bar supports shall be coated with dielectric material for a minimum distance of two inches from the point of contact with the epoxy-coated reinforcing bars. In walls having reinforcing bars, spreader bars where specified by the Engineer shall be epoxy coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcing bars shall be made of corrosion resistant material. Epoxy-coated reinforcing bars shall be fastened with nylon-, epoxy-, or plastic-coated tie wire or other acceptable materials.

805.04--Method of Measurement. Steel reinforcement incorporated in bridge concrete and accepted will be measured in pounds based on the total computed weight for the sizes and lengths of bars, mesh or mats shown on the plans or authorized. Reinforcement for box bridge concrete will be measured and paid for in accordance with Section 602.

Epoxy coated reinforcement bars, not included in other pay items, will be measured in pounds based on the computed weight from the theoretical weight of plain round bars of the same nominal size as shown in the table of areas and masses in Section 711.
The weight of mesh will be computed from the theoretical weight of plain wire. If the weight per square foot is given on the plan, that weight will be used.

The weight of plain or deformed bars, or bar mat, will be computed from the theoretical weight of plain round bars of the same nominal size as shown in the table of area and weights in Section 711.

The weight for payment of structural steel reinforcement, incorporated in the work and accepted, will be the theoretical weight of the material used.

The weight of reinforcement used in railings measured on a linear foot basis will not be measured. The weight of reinforcement in precast piles and other items where the reinforcement is included in the contract price for the item will not be measured.

No allowance will be made for clips, wire, separators, wire chairs, and other material used in fastening the reinforcement in place. If bars are substituted upon

the Contractor's request and as a result more steel is used than specified, only the bars specified will be measured.

When splices, other than those shown on the plans, are made for the convenience of the Contractor, the extra steel will not be measured.

805.05--Basis of Payment. Reinforcement will be paid for at the contract unit price per pound, which shall be full compensation for completing the work.

Payment will be made under:

805-A: Reinforcement	- per pound
805-B Reinforcement, Epoxy Coated	- per pound

SECTION 806 - PRECAST CONCRETE BRIDGE CAPS, SPANS AND WINGS

806.01--Description. This work consists of furnishing and installing precast concrete caps, precast concrete spans complete with post, bridge railing or concrete barrier rail and precast wings for bridges in accordance with these specifications and all in reasonably close conformity with the dimensions and design indicated on the plans and placed on a prepared substructure to the lines and grades established by the Engineer.

806.02--Materials. The materials used in this construction, in addition to the general requirements of these specifications, shall conform, unless otherwise stipulated, to the requirements prescribed in Division 700, Material and Tests, for the particular kind and type of material specified.

806.02.1--Sampling and Testing. As referenced in Subsection 106.03, approval of the source of supply of cement, fine and coarse aggregate, water, reinforcement and other materials used in the construction of the caps, slabs and wings and the results of tests showing their suitability for use shall be obtained prior to their use in any construction. Samples shall be submitted as directed.

The Contractor/Manufacturer without extra compensation, shall supply the Engineer's representative, plant inspector, with the necessary materials and representative concrete mix for making a minimum of one test cylinder of concrete for each seven caps, slabs, or wings or a minimum of one test cylinder per day if less than seven caps, slabs, or wings are constructed. Other test cylinders may be required by the Engineer to establish strength for handling slabs or caps. Cylinders are to be cured with the same method used in curing the caps, slabs, or wings, as the case may be. Only those caps, slabs, or wings bearing identification marks of acceptance by the Department or approved laboratories

will be permitted for use in the construction. The acceptance of any precast concrete member at the production plant shall in no way be final and further inspection will be made at the structure site before and after the member has been placed in its final position.

806.03--Construction Requirements.

806.03.1--General. The methods of construction shall conform, unless otherwise stipulated, to the provisions and requirements prescribed in these specifications and indicated on the plans for the several items which constitute the complete structure.

806.03.2--Substructure. The substructure shall be constructed in conformity with Section 803 and as indicated on the plans. Payment for same will be made under Section 803, unless otherwise indicated.

The piles shall be so driven that the cap may be placed in its proper location without excessive manipulation of the piles.

806.03.3--Precast Caps, Slabs, and Wings.

806.03.3.1--Proportioning and Mixing Concrete. The composition, proportioning and mixing of the concrete used in this construction shall be as specified in Section 804, Concrete Bridges and Structures, and shall be the class concrete specified on the plans.

806.03.3.2--Reinforcing Steel. Reinforcing steel shall be of the quality, type, and size specified on the plans and placed as indicated. It shall meet the requirements set out in Subsection 711.02, as applicable.

Separate payment will not be made for reinforcing steel.

806.03.3.3--Forms. All forms shall be of metal or wood. They shall be built mortar-tight and of sufficient rigidity to prevent any distortion due to pressure of the concrete and other loads incident to the construction operations. The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The design of the forms shall take into account the effect of vibration of concrete as it is placed.

Forms shall be filleted at all sharp corners and shall be given a bevel or draft in the case of all projections to ensure easy removal.

All forms shall be set and maintained true to the lines designated until the concrete is sufficiently hardened or for periods as hereinafter specified.

Forms shall be treated with oil immediately before placing concrete in them. Any material which will adhere to, or discolor, the concrete shall not be used. Extreme care shall be exercised to make sure that no oil gets on the reinforcing steel.

806.03.3.4--Handling and Placing Concrete. Prior to the placing of any concrete, the forms shall be thoroughly cleaned of any construction debris and extraneous matter and the reinforcing bars of the size and type indicated placed and secured in the forms as indicated on the plans. Concrete shall not be deposited in the forms until the inspector has checked the placing of the reinforcement and has given approval to proceed.

Ready mix concrete transported in a truck mixer or truck agitator shall be discharged at the site of the work and placed in its final position in the forms within one hour after the introduction of the mixing water to the cement and aggregate or the cement to the aggregate whichever occurs first; except that in abnormal weather, or under other conditions contributing to the quick stiffening of the concrete, the Engineer may make a determination of a lesser time for placement considering all factors affecting initial set of the concrete. When mixed concrete is transported in approved non-agitating trucks, the concrete shall be discharged at the work site within thirty minutes after the introduction of the mixing water to the cement and aggregate.

The concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. Open troughs and chutes used shall be of metal or metal lined and shall be kept clean and free from coating of hardened concrete by flushing with water after each pour. Water used for flushing shall be discharged clear of the cap, slab, or wing forms.

806.03.3.5--Compaction. Concrete for the caps, slabs, and wings during and immediately after depositing shall be thoroughly compacted by the use of vibrators and suitable spading tools. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibration shall be internal and shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed.

The entire operation of depositing and consolidating the concrete shall be so conducted that the concrete shall be smooth, dense and free from any honeycomb or pockets of segregated aggregates. The roadway surface of slabs and tops of caps and wings shall be finished with a wood float.

Concrete in the precast caps, slabs and wings shall be placed in one continuous operation for each cap, slab, and wing.

806.03.3.6--Placing Bolts, Drains, Bolt Holes, etc. All bolts, drains, bolt holes, etc., indicated on the plans as necessary or desirable shall be placed in the concrete at the locations indicated on the plans. They shall be formed by approved methods and operations and shall be such as to ensure proper connections.

806.03.3.7--Removal of Forms and Curing. Side forms for precast concrete bridge caps, slabs and wings may be removed after the concrete has attained sufficient strength to maintain a true section. The minimum time for removal, using alternate types of curing, is considered to be as follows:

With a minimum of three thicknesses of wetted burlap, cotton mats, or constant fogging with temperatures of more than 40°F and less than 80°F -- 24 hours; with temperatures 80°F and higher -- 20 hours.

Steaming in enclosures at temperatures of not less than 80°F and not more than 150°F -- 12 hours.

When Type III Cement is permitted, side forms may be removed after 12 hours using all types of curing.

Bottom forms shall remain in place until the concrete has obtained a minimum compressive strength of 2,500 psi as determined by cylinder tests. When the caps, slabs, or wings are moved, they shall be deposited directly on a level hard-surfaced true-plane area without stacking and shall remain undisturbed for seven days beyond the period of initial handling while the curing continues.

Caps, slabs and wings shall be covered with wetted burlap immediately after the finishing operations.

Liquid membrane curing may be used, but shall be white pigmented and applied at the rate of not less than one gallon per 150 square feet of surface. The entire surface and exposed edges shall be sprayed with the membrane as soon as practicable after finishing is complete and as side forms are removed. The seal shall be applied to the surface as a fine mist which shall provide a continuous, uniform, water impermeable film. The bottom of the caps, slabs, or wings shall be sealed with the membrane when they are removed from the bottom supporting forms.

The Contractor may use steam curing provided the Engineer has given written approval prior to casting operations. Steam curing shall be according to stipulations set out in Subsection 804.03.22.4.2.

The cap, slab, wing and rail units shall not be shipped until the concrete has obtained the specified minimum compressive strength as determined by cylinder

tests and shall be cured for a minimum of 14 or 21 days as indicated in the table below:

	Requirements Prior to Shipment	
Compressive Strength Specified PSI	Minimum Curing Days	Minimum Compressive Strength PSI
3000	14	3000
4000	21	4000
5000	21	5000

806.03.4--Tolerance of Dimensions.

806.03.4.1--Caps. The width and length of the caps shall not vary more than one-quarter inch from the plan dimensions. The bottom of the cap shall be smooth and shall not vary more than one-eighth of an inch when tested with a straightedge in a horizontal direction for any ten-foot length. The top of the caps shall not vary more than one-sixteenth inch from the slope shown on the plans.

806.03.4.2--Slabs. The four sides of the slab shall not vary more than one-eighth inch for the full depth of the slab when tested with a straightedge in a vertical direction, nor more than one-quarter inch in the full length of the slab when tested with a straightedge in a horizontal direction, nor shall the top of the slab vary more than one-eighth inch in any ten-foot length.

806.03.4.3--Wings. The width and length of the wings shall not vary more than one-quarter inch from the plan dimensions.

806.03.4.4--Concrete Barrier Rail. The width of the rail shall not vary more than one-eighth inch and the length shall not vary more than one-quarter inch. The sides shall be smooth with no discolorations. In the event patching is required, the entire rail shall be given a Class 2 finish.

806.03.5--Handling and Placing Precast Caps, Slabs, Barrier Rail and Wings. The precast caps, slabs, barrier rail, and wings shall be handled in such a manner that they will not be subjected to excessive and undue abuse producing crushing, spalling, or undue marring of the concrete. Injury to units may be cause for rejection whether the injury to the unit is apparent or not. Damaged units shall be replaced by the Contractor at no additional costs to the State.

Where the caps, slabs, barrier rail, and wings are to be loaded or stored in tiers, the blocking between the tier should be in a vertical plane so that the weight of the upper caps, slabs or wings cannot produce bending in those of a lower tier.

After the caps are set and doweled, welded, or grouted to the piling, the dowel holes shall be filled with grout or AC-13 before the slabs are set.

Each section or unit shall be placed as closely as possible to its final position in the structure so that the use of bars or other tools which might mar the concrete will be eliminated. The abutting edges of each slab unit shall be carefully cleaned of any concrete or extraneous matter in order that the longitudinal joints may be bolted tightly together.

After the slab units are set, doweled and bolted in their final position the keyways and dowel holes shall be filled with an approved non-shrink grout. Traffic shall not be permitted on the spans for 24 hours and heavy construction type traffic, or other loads exceeding 15 tons, will not be allowed on the spans for a period of 72 hours after grouting. When epoxy grout is allowed, these time requirements may be reduced to 12 hours. When a non-shrink commercial grout is used the 72 hours time requirement may be reduced to 24 hours.

Expansion material shall be placed between all bearing points of the slabs and surfaces of the caps. When not otherwise specifically provided, three layers of No. 15, Type I, roofing felt shall be used.

806.03.5.1--Transverse Joints. When a bridge consists of more than one span, bituminous premolded joint filler, one-quarter inch in thickness, shall be placed in the joint between spans. This joint filler shall be for the full thickness of the concrete, less one inch at the top of the slab, and for the full width of the structure, including curb. When the spans are completely in place and bolted the transverse joints shall be sealed with AC-13 or other joint sealer approved by the Engineer.

806.03.5.2--Railing. The bridge railing shall be installed after all other work on the bridge has been completed.

The material used shall meet the dimensions and requirements specified on the plans and the railing shall be constructed in conformity with the details indicated and to the lines and grades established.

806.04--Method of Measurement. Precast concrete slab units either interior or curb units, precast barrier rail units and precast concrete caps either intermediate or end bent with winged abutment wall of the size and type specified will be measured by the unit per each.

Winged abutment walls, grout, tie rods, nuts, washers, bearing pads and other appurtenances will not be measured for separate payment.

806.05--Basis of Payment. Precast concrete slab units, precast barrier rail units and precast concrete caps will be paid for at the contract unit price per each for

the specified types and sizes. This price shall be full compensation for furnishing all materials, hauling and erecting, equipment, tools, labor and incidentals necessary to complete the work.
Payment will be made under:

806-A: ___' Precast Concrete Slab Units, ___' Interior	- per each
806-B: ___' Precast Concrete Slab Units, Curb	- per each
806-C: ___' Precast Barrier Rail Units	- per each
806-D: ___' Precast Concrete Caps, Intermediate Unit	- per each
806-E: ___' Precast Concrete Caps, End Unit with Wall	- per each

SECTION 808 - JOINT REPAIR

808.01--Description. All joints requiring repair shall be reconstructed with specified materials according to details shown on the plans and instructions contained herein. All other requirements shall be in accordance with the applicable provisions of Sections 501 and 804 of the Standard Specifications.

808.02--Materials.

808.02.1--General. When materials from the Department's current list of approved materials are to be used, the Contractor shall submit documentation to the Engineer that the epoxy and all components meet the requirements of the contract.

If the materials proposed for use are not from the Department's current list of approved materials, a sample of the epoxy and all components required for the epoxy mortar mix shall be submitted to the Engineer for evaluation and approval at least 30 calendar days prior to placement.

Subsequent approval of each new lot may be by certification. The manufacturer must certify that the new lot of material is the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

A representative of the epoxy manufacturer must be present for sufficient time to assure that the Contractor is properly schooled in the use of the epoxy materials.

808.02.2--Epoxy Resin. The material shall meet the requirements of ASTM Designation: C 881, Type I, Grade 2, Class C.

808.02.3--Silica Sand. The material shall be bagged general purpose blast cleaning sand.

808.02.4--Epoxy Mortar Mix. The mortar mix shall consist of one part liquid epoxy to 3.5 parts clean dry sand by volume.

808.02.5--Mixing and Curing. Mixing of all epoxy materials shall be accomplished with a mechanical mixer.

A trial batch of mortar, approximately one cubic foot, will be mixed and used for joint repair. From this batch, the pot life and subsequent amount of material to be mixed will be determined.

Workers should wear rubber gloves and any other protective measures necessary to minimize contact with skin, eyes, etc.

The curing time shall be regulated so the repaired area may be open to traffic in four hours from time of placement.

To meet the above requirement, it may be necessary to store materials in heated enclosures and provide temporary cover and heat to the repaired area.

808.03--Construction Details. All repair areas are to be thoroughly cleaned by chipping and sandblasting to sound concrete.

To form joints, insert styrofoam or other approved forming materials to desired grade. Forms are to be greased lightly to assist in removal.

The mortar mix shall be prepared and placed during periods of warm weather if at all possible.

The prepared surface shall be lightly primed with neat epoxy prior to placement of the mortar mix.

Placement of the mortar mix shall start at the earliest practical time and may continue until approximately four and one-half hours prior to opening the section of roadway or bridge to traffic.

The mortar mix shall be finished to the line of the existing joint and to the grade of the adjacent pavement or bridge deck.

After final finish of the mortar mix, the surface shall be sprinkled with sand to provide texture. Excess sand to be hand broomed from surface after mortar has set.

Acetone alcohol may be used to clean and lubricate trowels to assist with the surface finishing.

808.04--Method of Measurement. When specified for payment, joint repair will be measured by the linear foot for joint preparation and by the gallon for the mortar mix. When the mortar mix consist of epoxy and sand, the volume of measurement for the mortar mix will be determined from the summation of the volumes of the epoxy components; and the volume of sand will not be measured for payment.

808.05--Basis of Payment. The accepted quantities of joint repair will be paid for at the contract unit price per linear foot for joint preparation and per gallon for the mortar mix, which price shall be full compensation for furnishing and placing all materials including sand and forming materials and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. No payment will be made for the sand used in the epoxy mortar mix. The price bid for each item of work shall include the cost of continuous maintenance of traffic and protective services as required by the Department's Traffic Control Plan. This shall include all required individual traffic control devices.
Payment will be made under:

808-A: Joint Preparation - per linear foot

808-B: Kind Mortar Mix - per gallon

SECTION 809 - RETAINING WALL SYSTEMS

809.01--Description. This work shall consist of designing and installing one of the retaining wall systems described herein in accordance with the lines, grades and dimensions shown in the plans and specifications.

809.01.1--General. Retaining wall systems shall comply with all material, fabrication and construction requirements found in the Standard Specifications and the construction plans. The submitted retaining wall system shall be as shown in the plans or consist of one of the following three types: Conventional Cantilevered Gravity Wall, Mechanically Stabilized Earth Wall (MSEW), or Precast Gravity Wall. All costs associated with the design and construction of the wall system selected by the Contractor shall be included in the bid price for the wall. The Contractor may select different wall types for different sites, as provided for on the plans.

In the event a MSEW System is chosen, the wall system supplier shall have submitted their system to the Highway Innovative Technology Evaluation Center (HITEC) for review and shall have had a formal evaluation completed for all components of the wall system. The wall system is considered to be the wall

facing and the associated geosynthetic or steel soil reinforcement. Three copies of HITEC's final evaluation report for the chosen MSEW System shall be included with the initial design submittal.

The time required for preparation and review of wall shop drawings shall be charged to the allowable contract time. No additional compensation will be made for any additional material, equipment, or other items found necessary to comply with the project specifications as a result of review by the Department. All submittals shall be submitted to the Bridge Engineer for approval prior to construction.

The retaining wall system shall follow the lines, grades, and location as shown in the plans. In the event that plan dimensions are revised due to field conditions or other reasons, the Contractor shall be responsible for revising the wall plans, design calculations, and summary of quantities.

809.01.2--Submittals.

809.01.2.1--Initial Design Submittal. The initial design submittal shall include three sets of wall plans and three sets of design calculations and notes. The wall plans and design calculations and notes shall clearly state the wall type chosen. The wall plans and design calculations will be returned to the Contractor within thirty (30) calendar days of receipt. All final design calculations and plans shall be prepared, stamped and signed by a Professional Engineer licensed to practice in the State of Mississippi. The calculations shall include, but not be limited to, those items listed below. The designer/supplier furnishing the plans and calculations for the wall system proposed shall be responsible for the internal and external stability of the wall system.

The drawings shall include all details, dimensions, quantities and cross-sections necessary to construct the wall. Prints of the original cross sections will be available to purchase with plans. The wall system plans shall include, but not be limited to, the following items:

1. A plan and elevation sheet or sheets for each wall shall contain the following:

    a) The elevation view of the wall which shall indicate the elevation at the top of the wall, at all horizontal and vertical break points, and at least every 50 feet along the wall, elevations at the top of leveling pads and footings, and the original and final ground line.
    b) The plan view of the wall shall show the offset from the construction centerline to the face of the wall at all changes in horizontal alignment. Also included should be the limits of the soil reinforcement, if required, and any drainage structures or pipes lying behind or extending through or under the wall.

c) General notes required for construction of the wall.
d) All horizontal and vertical curve data affecting the wall shall be included.
e) A list of all required materials and the required quantity of each shall be provided on the elevation sheet of each wall.

2. All bar bending details shall be included.

3. All details for foundations and leveling pads shall be shown including steps in the footings or leveling pads. Foundations and leveling pads shall have a minimum cover of two feet.

4. All panels, modular blocks, coping, and lagging shall be detailed. The details shall include all dimensions necessary to construct the element.

5. Details should be included for the walls around any existing drainage facilities.

6. All details concerning the appearance of the wall face shall be included.

Three sets of wall plans shall be submitted with the initial submittal. The plans that are submitted with the initial design submittal shall be prepared on standard 24-inch by 36-inch sheets. Each sheet shall have a title block in the lower right hand corner. The title block shall include the sheet number of the drawing, type of wall designated, the project number, and the Contractor.

The initial design submittal shall include a set of design calculations and notes for the wall(s). Three sets of design calculations and notes shall be submitted. The design calculations and notes shall contain the project number, type of wall designated, date of preparation, and the name of the designer. The package shall have a clear index outlining the design notes and shall include an explanation of the design procedure, explanation of any symbols, and technical documentation of any computer programs used. The design calculations shall clearly state the factors of safety for sliding, pullout, and overturning. In addition, the bearing pressures beneath the wall footing used in the calculations shall be noted.

809.01.2.2--Final Plan Submittal. All final construction plans shall be submitted on 24-inch by 36-inch reproducible mylar sheets. In addition the plans shall be accompanied by either 3½-inch HD floppies or Compact Disks containing the plans in Tagged Image File Format (TIFF) for archive purposes. The final construction plans shall reflect all changes made on the plans submitted for the design submittal.

809.01.3--Design Criteria. The design for any proposed wall shall consider the internal and external stability of the wall including the bearing pressure, overturning and sliding. The design shall consider lateral earth pressures,

including any applicable surcharge loads. In addition, the following general guidelines shall be followed.

1. The chosen wall system shall be designed in accordance with the current version of the *AASHTO Standard Specifications for Highway Bridges*.

2. Prior to the design of the wall system, the designer/supplier shall be required to perform an in-house geotechnical review of the available geotechnical information with the Geotechnical Branch of Materials Division. The purpose of the geotechnical review will be to obtain the pertinent design information relating to global stability as well as answer questions concerning any of the geotechnical information provided in the plans. The final design shall take into account any global stability issues that are brought forth by the geotechnical review. A generic analysis for global stability will be conducted by the Department and the results provided to the Retaining Wall System Designer at the geotechnical review. Any allowed changes to the wall lines and grades or stabilized soil mass that affect the global stability calculations will require the wall supplier to include a global stability analysis with the final design. The Geotechnical Engineer may be contacted to schedule an appointment.

3. The minimum factors of safety to be used in design are as listed below.

   a. External Stability

Sliding	1.5
Overturning	2.0
Eccentricity, e, at Base	$\leq$L/6 for MSEW, where L is the length of the reinforced soil mass
Bearing Capacity	2.5
Temporary Slopes	1.2
Global Stability	1.4, as noted above

   b. Internal Stability

Pullout Resistance for MSEW	1.5

4. The wall design shall take into account all appurtenances behind, in front of, under, mounted upon, or passing through the wall and supply the appropriate construction details. These items should be accounted for in the internal and external stability calculations.

5. Leveling pads, foundations, or footings shall have a minimum cover of two feet. For design purposes, passive pressure in front of the wall shall be assumed to be zero.

6. The front face of the wall may be battered into the slope to improve stability as long as this does not interfere with other project appurtenances such as drainage features or right-of-way.

7. The wall design shall provide positive drainage behind the wall to assure that the backfill material remains in a drained condition.

8. Where geogrid is to be used for MSEW structures as the soil reinforcement, the following design criteria should be followed.

   a) The allowable tensile load (T_A) shall be calculated using the following equation and be based on a 100 year design life. The variables used in the equation shall be as allowed by AASHTO or as demonstrated with supporting data in the HITEC evaluation.

Allowable Design Strength of Geogrid:

$$T_A = \frac{T_{CR}}{FS_{ID} \times FS_D \times FS_{UN}}$$

Where:

T_A = Maximum Design Strength
T_{CR} = Creep Limited Strength
FS_{ID} = Factor of Safety For Installation Damage
FS_D = Factor of Safety For Durability
FS_{UN} = Factor of Safety For Uncertainties

   b) The maximum design tensile load of the geogrid shall not exceed the laboratory tested ultimate strength of the geogrid/facing unit connection divided by a factor of safety of 1.5. The connection strength testing and computation procedures shall be in accordance with AASHTO and demonstrated in the HITEC evaluation.

809.02--Materials. Material requirements will vary depending on the type of wall system chosen. Specific material requirements for each wall type are given below.

809.02.1--Conventional Cantilevered Gravity Wall. Concrete for conventional cantilevered gravity walls shall meet the requirements for Class "AA" concrete as set forth in Section 804 of the Standard Specifications. Reinforcing steel shall conform to the requirements set forth in Subsection 711.02 of the Standard Specifications. Driven Piles shall meet the requirements set forth in Sections 803 and 804.

Unless otherwise indicated on the plans, the exposed concrete surfaces of the wall shall have a Class "2" finish as defined in Section 804.

809.02.2--Mechanically Stabilized Earth Walls (MSEW). Materials for Mechanically Stabilized Earth Walls shall meet the following minimum standards.

809.02.2.1--Precast Concrete Facing Panels. Precast concrete facing panels shall be fabricated in accordance with Section 804 with the following exceptions and additions.

1. Concrete for the precast concrete facing panels shall conform to Class "AA" concrete.

2. Section 804 is supplemented by the following: The units shall be fully supported until the concrete reaches a minimum compressive strength of 1,000 psi. The units can be shipped after reaching a minimum compressive strength of 3,000 psi. At the option of the Contractor, the units may be installed after the concrete reaches a minimum compressive strength of 3,400 psi.

3. Unless otherwise indicated on the plans, the concrete surface for the front face shall have a Class "1" finish as defined in Section 804 of the Specifications and the rear face a uniformed surface finish. The rear face of the panel shall be screeded to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch. The panels shall be cast on a flat area. The soil reinforcing strips or other galvanized attachment devices used to attach the precast concrete facing panel to the soil reinforcement shall not contact or be attached to the face panel reinforcement steel.

4. The date of manufacture, the production lot number, and the piece mark shall be clearly scribed on an unexposed face of each panel.

5. All units shall be handled, stored, and shipped in such a manner as to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Panels in storage shall be supported on firm blocking to protect the panel connection devices and the exposed exterior finish.

6. All units shall be manufactured within the following tolerances:

    a) Panel Dimensions – Position of the panel connection devices shall be within one inch. All other dimensions shall be within 3/16 inches.

b) Panel Squareness – Squareness shall be determined by the difference between the two diagonals and shall not exceed 1/2 inches.

c) Panel Surface Finish – Surface defects on smooth formed surfaces measured over a length of five feet shall not exceed 1/8 inch. Surface defects on the textured-finish surfaces measured over a length of five feet shall not exceed 5/16 inch.

7. Section 804 of the Specifications will be modified as follows.

Acceptance of concrete panels with respect to compressive strength will be determined on the basis of production lots. A production lot is defined as a group of panels that will be represented by a single compressive strength sample and will consist of either 40 panels or a single day's production, whichever is less.

During the production of the concrete panels, the manufacturer will randomly sample the concrete in accordance with AASHTO Designation: T 141. A single compressive strength sample, consisting of a minimum of four cylinders, will be randomly selected for every production lot.

Compression tests shall be made on standard 6-inch by 12-inch test specimen prepared in accordance with AASHTO Designation: T 23. Compressive strength testing shall be conducted in accordance with AASHTO Designation: T 22.

Air content will be performed in accordance with AASHTO Designation: T 152 or AASHTO Designation: T 196. Air content samples will be taken at the beginning of each day's production and at the same time as compressive samples are taken to insure compliance with the specifications. The slump will be determined at the beginning of each day's production and at the same time as the compressive samples are taken.

For every compressive strength sample, a minimum of two cylinders shall be cured in accordance with AASHTO Designation: T 23 and tested at 28 days. The average compressive strength of these cylinders, when tested in accordance with AASHTO Designation: T 22, will provide a compressive strength test result which will determine the compressive strength of the production lot.

If the Contractor wishes to remove forms or ship the panels prior to 28 days, a minimum of two additional cylinders shall be cured in the same manner as the panels. The average compressive strength of these

cylinders when tested in accordance with AASHTO Designation: T 22 will determine whether the forms can be removed or the panels shipped.

Acceptance of a production lot will be made if the compressive strength test result is greater than or equal to 4,000 psi. If the compressive strength test result is less than 4,000 psi, then the acceptance of the production lot will be based on its meeting the following acceptance criteria in its entirety:

a) 90% of the compressive strength test results for the overall production exceeds 4,150 psi
b) The average of any six consecutive compressive strength test results exceeds 4,250 psi
c) No individual compressive strength test result falls below 3,600 psi

Units shall be rejected because of failure to meet any or all of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection.

a) Defects that indicate imperfect molding
b) Defects indicating honeycombed or open texture concrete
c) Cracked or severely chipped panels
d) Color variation on from face of panel due to excess form oil or other reasons

809.02.2.2--Modular Block.

809.02.2.2.1--General and Architectural Requirements for Modular Block Units. Unless otherwise specified in the project plans, general and architectural requirements of modular block units shall be as follows:

Face Color – Gray
Face Finish – sculptured rock face in angular multiplaner configuration
Bond Configuration – running with bonds nominally located at the midpoint of vertically adjacent units, in both straight and curved alignments

Exposed surfaces of units shall be free of chips, cracks or other imperfections when viewed from a distance of 10 feet under diffused lighting.

Modular block units shall be manufactured in accordance with ASTM Designations: C 90 and C 140.

809.02.2.2.2--Material Requirements for Modular Block Units. Material requirements shall be as follows:

1. Cement: Materials shall conform to the following applicable specifications and requirements:

   a. Portland Cement: AASHTO Designation: M 85
   b. Modified Portland Cement: Portland cement conforming to AASHTO Designation: M 85, modified as follows.

      Limestone: calcium carbonate, with a minimum 85% content, may be added to the cement, provided these requirements of AASHTO Designation: M 85 as modified are met:
      i) Limitation on insoluble residue, percent 1.5
      ii) Limitation on air content of mortar, maximum volume percent 22
      iii) Limitations of loss of ignition, percent 7

   c. Blended Cements: AASHTO Designation: M 295
   d. Pozzolans: AASHTO Designation: M 295
   e. Blast Furnace Slag Cement: AASHTO Designation: M 302

2. Aggregates**:** Aggregates shall conform to the following specifications, as applicable.

   a. Normal Mass Aggregates: ASTM Designation: C 33
   b. Lightweight Aggregates: ASTM Designation: C 331

3. Other Constituents**:** Air entraining agents, coloring pigments, integral water repellents, finely ground silica, and other constituents shall be previously established as suitable for use in modular block retaining wall units and shall conform to applicable AASHTO or ASTM standards or, shall be shown by test or experience to be not detrimental to the durability of the modular block units or any material customarily used in retaining wall construction.

809.02.2.2.3--Structural Requirements for Modular Block Units. Structural requirements for modular block units shall be as follows:

1. 28-day Compressive Strength: ..... 4,000 psi, minimum
2. Absorption: ..... 6% maximum by weight
3. Maximum horizontal gap between erected units: ..... 0.5 inch

809.02.2.2.4--Base Leveling Pad Material. Base leveling pad material shall be constructed using non-reinforced concrete and be a minimum of six inches thick by 12 inches wide. Class C concrete shall be used for the base leveling pad material unless otherwise noted in the plans.

809.02.2.2.5--Unit Infill or Drainage Fill. Unit Infill or Drainage Fill shall consist of clean, free draining crushed stone or gravel with a one inch maximum particle size and shall meet the gradation listed below.

Sieve Size	Percent Passing
1”	100
3/4”	75 – 100
# 4	0 – 10
# 40	0 – 5

The Engineer shall approve the gradation of the Unit Infill or Drainage Fill. Pea gravel shall not be used. A minimum of 1.5 cubic foot of drainage fill shall be used for each square foot of wall face. Drainage fill may be placed between, behind, and within the cores of units to meet this requirement. In no case will a geotextile or geocomposite be used as a substitute for the drainage fill.

809.02.2.3--Reinforced Backfill for Mechanically Stabilized Earth Walls. Reinforced backfill shall be free of debris and meet the following gradation requirements:

Sieve Size	Percent Passing
3/4”	75 – 100
# 4	20 – 100
# 40	0 – 60
# 200	0 – 15

The maximum aggregate size shall be limited to ¾-inch unless field tests have been performed to evaluate potential strength reductions to the geogrid design due to damage during construction.

The plasticity index (P.I.) as determined by AASHTO Designation: T 90 shall not exceed 6.

The backfill material, when compacted to 95% of Standard Proctor, AASHTO Designation: T 99, at optimum moisture content, shall exhibit an angle of internal friction of not less than 34° as determined by a standard direct shear test, AASHTO Designation: T 236, or triaxial test, AASHTO Designation: T 296. In addition, the in-place density shall be within 5% of the assumed density used in wall design calculations.

When metallic reinforcing strips are used, all backfill material shall conform to the following electrochemical requirements:

Electrochemical Properties	Requirements	Test Method, AASHTO Designation
pH	5 – 10	T-289
Resistivity	>3,000 ohms/cm minimum	T-288
Chlorides	<100 ppm maximum	T-291
Sulfates	<200 ppm maximum	T-290
Organic Content	<1%	T-267

Contractor shall submit reinforced backfill sample and laboratory test results to the Engineer for approval prior to the use of any of the proposed reinforced backfill material.

809.02.2.3.1--Metallic Reinforcing and Attachment Devices. All reinforcing and attachment devices shall be inspected to insure they are true to size and free from defects that may impair their strength and durability, and shall meet the following conditions.

1. Reinforcing Strips – Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Their physical and mechanical properties shall conform to ASTM Designation: A 36 or A 572, Grade 65 or equal. Galvanization shall conform to the minimum requirements set forth in AASHTO Designation: M 111.

2. Reinforcing Mesh – Reinforcing mesh shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO Designation: M 32M/M and shall be welded into the finish mesh fabric in accordance with AASHTO Designation: M 55M/M. Galvanization shall be applied after the mesh is fabricated and conform to the minimum requirements of AASHTO Designation: M 111.

3. Tie Strips – The tie strips shall be shop fabricated of a hot rolled steel conforming to the minimum requirements of ASTM Designation: A 572, Grade 50 or equivalent. Galvanization shall conform to AASHTO Designation: M 111.

4. Fasteners – Fasteners shall consist of 1/2-inch diameter, hexagonal cap screw bolts and nuts, which are galvanized and conform to the requirements of AASHTO Designation: M 164 or equivalent.

5. Connector Pins – Connector pins and mat bars for the MSEW system shall be fabricated from A36 steel and welded to the soil reinforcement mats as shown on the plans. Galvanization shall conform to AASHTO Designation: M 111.

809.02.2.4--Geogrid Reinforcement for Mechanically Stabilized Earth Walls.

809.02.2.4.1--General. A geogrid is defined as a geosynthetic formed by a regular network of integrally connected elements with apertures greater than 0.25 inch to allow interlocking with surrounding soil, rock, earth and other surrounding materials to function primarily as reinforcement.

The geogrid(s) to be utilized in the Modular Block Retaining Wall System shall be creep tested in accordance with ASTM Designation: D 5262. The long term design strength (T_{CR} – Creep Limited Strength) shall be obtained from tests run on representative samples for no less than 10,000 hours. The long term design strength shall be defined as the load at which no more than 10% strain occurs over a 100-year design life.

The geogrid shall be mildew resistant and inert to biological degradation and naturally encountered chemicals, alkalis and acids. The geogrid shall contain stabilizers and/or inhibitors, or a resistance finish or covering to make it resistant to deterioration from direct sunlight, ultraviolet rays, and heat.

809.02.2.4.2--Marking, Shipment and Storage. Each roll or container of geogrid shall be visibly labeled with the name of the manufacturer, trade name of the product, lot number, and quantity of material. In addition, each roll or container shall be clearly tagged to show the type designation that corresponds to that required by the plans. During shipment and storage the geogrid shall be protected from direct sunlight, and temperatures above 120°F or below 0°F. The geogrid shall either be wrapped and maintained in a heavy duty protective covering or stored in a safe enclosed area to protect from damage during prolonged storage.

809.02.2.4.3--Manufacturer's Certification. The Contractor shall furnish the Engineer three copies of the manufacturer's certified test reports indicating that the geogrid furnished conforms to the requirements of the specifications and is of the same composition as that originally approved by the Department.

809.02.2.4.4--Acceptance Sampling and Testing. Final acceptance of each shipment will be based upon results of tests performed by the Department on verification samples submitted from the project, as compared to the manufacturer's certified test reports. The Engineer will select one roll or container at random from each shipment for sampling. A sample extending full width of the randomly selected roll or container and being at least five (5) square yards in area will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

809.02.3--Precast Gravity Walls. Materials for precast gravity walls shall meet the following minimum requirements.

809.02.3.1--Foundation Preparation and Base Leveling Pad. The foundation bed for the structure shall be graded as required before erection is started. Prior

to wall construction the foundation shall be compacted as specified in Section 203 of the Standard Specifications.

The base leveling pad may be either precast or cast-in-place, as directed by the wall supplier. The base leveling pad shall be constructed of Class "C" concrete unless otherwise specified and shall be cured until a compressive strength of 2,000 psi is attained before placement of wall modules. The completed surface shall be constructed in accordance with the lines and grades shown on the final wall plans. The base leveling pad shall be plane to within 1/8 inch in 10 feet.

809.02.3.2--Prefabricated Modular Units. Prefabricated modular units shall be designed for developed earth pressures behind the wall and from pressures developed inside the modules. Prefabricated modular units shall be constructed in accordance with *AASHTO Standard Specifications for Highway Bridges, Section 5.*

Concrete for prefabricated modular units shall have a minimum 28-day compressive strength of 5,000 psi. The prefabricated modular units shall not be shipped before attaining the required 5,000 psi compressive strength. Unless otherwise indicated on the plans, the concrete surface for the front face shall have a Class "1" finish as defined in Subsection 804 of the Specifications.

The manufacturing process shall be such that it produces uniform modular units and shall be subject to inspection by the Engineer prior to shipment. Precast units will be subject to rejection if they fail to conform to any of the specification requirements or fail to meet the following tolerances.

1. Dimensions not conforming to the following tolerances:

   Face of Panes, length or width ..... ±3/16 inch
   Deviation From Square, diagonals across front face ..... 5/16 inch

2. Honeycombed or open texture

3. Any damage which would prevent making a satisfactory joint.

4. The date of manufacture, lot number, and type of unit in accordance with the approved erection drawings shall be clearly marked on the inside face of each unit.

809.02.3.3--Backfill Material for Modular Units. Backfill material and the embankment behind the wall shall be placed and compacted in accordance with Section 203 of the Standard Specifications. In the event the select backfill recommended by the wall supplier consists of open-graded rock with insufficient fines for conventional compaction controls, the material shall be compacted to a maximum practical density as determined by the Engineer. Otherwise, the select

backfill material shall be placed and compacted to at least 95% density as determined by AASHTO Designation: T 99.

When the modular backfill material consists of open-graded rock containing insufficient fines to fill the voids between particles in a compacted state, any exposed modular backfill material shall be covered by a layer of Type V nonwoven geotextile to prevent migration of fines into the modular backfill material. The geotextile shall overlap the module a minimum of six inches, except for the front cell.

809.03--Construction Requirements.

809.03.1--General Construction Requirements for All Wall Types.

809.03.1.1--Excavation. The Contractor shall excavate to the lines and grades shown on the final wall plans. The Contractor shall be careful not to disturb the embankment and foundation materials beyond the lines shown. The Engineer will inspect the excavation and give approval prior to placement of the base leveling pad. Soils that the Engineer deems to be unstable or unsuitable shall be excavated and replaced with select borrow material.

Excavation for the wall system shall be as directed by the plans or as directed by the Engineer. Where excavation is required in the immediate vicinity of adjacent structures and/or properties, extreme caution should exercised. It shall be the Contractor's responsibility to place what bracing, shoring, or ground support system deemed necessary to prevent a failure and protect the persons working near the excavation. The soil supporting the wall system shall be inspected and approved by the Engineer to confirm that the actual foundation soil conditions meet or exceed the assumed design conditions. Over-excavated areas shall be backfilled with select borrow material.

809.03.1.2--Backfill Material. All backfill material shall be compacted in accordance with Section 203 of the Standard Specifications unless otherwise noted on the wall plans. Unless otherwise noted all backfill material shall be placed in non-compacted lifts not to exceed eight inches and be compacted to at least 95% density as determined by AASHTO Designation: T 99. Compaction of the backfill within three feet of the back face of the wall shall be accomplished by making at least three passes with a lightweight mechanical tamper, roller, or vibratory system.

At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing to rapidly direct runoff away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

809.03.2--Conventional Cantilevered Gravity Wall. The Contractor shall be responsible for all temporary shoring required to construct the conventional cantilevered gravity wall in accordance with the wall design.

809.03.3--Mechanically Stabilized Earth Walls. All components of the MSEW wall system shall be installed in strict accordance with the plans and the manufacturer's recommendations. A representative of the wall manufacturer shall be present at the start of construction of the wall to train the Contractor in the proper installation procedures for the chosen wall system.

809.03.3.1--Foundation Preparation. The foundation for the structure shall be graded level for a width equal to the length of the reinforcement elements plus one foot or as directed by the wall plans. Prior to wall construction, the foundation shall be compacted with a smooth wheel vibratory roller. Any foundation soils found to be unsuitable shall be removed and replaced as outlined in Subsection 809.03.1.1.

809.03.3.2--Wall Erection.

809.03.3.2.1--Precast Concrete Facings. Precast concrete panels shall be placed so that their final position is vertical or battered as shown on the wall plans. For erection, panels shall be handled by means of lifting devices connected to the upper edge of the panel. Panels should be placed in successive horizontal lifts in the sequence shown on the wall plans as backfill placement proceeds. As backfill material is placed behind the panels, the panels shall be maintained in position by means of temporary wedges or bracing according to the wall supplier's recommendations. Concrete facing vertical tolerances and horizontal alignment tolerances shall not exceed 3/4 inch when measured with a 10-foot straightedge. During construction, the maximum allowable offset in any panel joint shall be 3/4 inch. The overall vertical tolerance of the wall from top to bottom shall not exceed 1/2 inch per 10 feet of wall height. Reinforcement elements shall be placed normal to the face of the wall, unless otherwise shown on the plans.

809.03.3.2.2--Modular Block Facings. The first course of modular block units shall be carefully placed on the base leveling pad and each unit checked for level and alignment.

Then, the following sequence of operations shall be followed.

1. The modular block units shall be placed so that they are in full contact at the base and properly seated. The modular block units are to be placed side by side for full length of wall alignment. Alignment may be done by means of a string line or offset from a base line.

2. The voids in and around the modular block units shall be filled with unit drainage fill material. Tamp or rod unit drainage fill to insure that all voids are completely filled.

3. The maximum stacked vertical height of wall units, prior to wall drain fill and backfill placement, shall not exceed two courses.

4. Excess material shall be swept from the top of the modular blocks prior to installation of the next course. Ensure that each course of modular block units is completely filled with unit drainage fill before proceeding to next course.
5. Position vertically adjacent units as recommended by the wall manufacturer.

6. Whole or cut units on curves and corners shall be erected with running bond approximately centered on units above and below.

7. Reinforcing shall be laid at the proper elevations and oriented such that the strong direction is normal to the wall alignment. Correct orientation of the reinforcing shall be verified by the Engineer.

8. Splicing of geogrid pieces shall not be allowed unless approved by the Engineer.

809.03.3.2.3--Precast Gravity Walls. At each foundation level, the base leveling pad shall be given a wood float finish and shall be cured a minimum of 72 hours or reach a compressive strength of 2,000 psi before placement of any modular units. The completed surface of the base leveling pad shall not vary more than 1/8 inch in 10 feet.

All precast modular units above the first course shall interlock with lower courses. Vertical joints shall be staggered with each successive course. The vertical joint opening on the front face of the wall shall not exceed ¾ inch. Joint filler and neoprene pads shall be installed in the horizontal joints of both faces.

All vertical joints between modules shall be covered on the back side of the front face of the wall by a Type V nonwoven geotextile that is a minimum of 18 inches wide. Joints at the corners or angle points shall be closed in accordance with the recommendations of the wall manufacturer.

When the modular backfill material is a rock backfill containing insufficient fines to fill the voids between particles in a compacted state, any exposed modular backfill material shall be covered by a layer of Type V nonwoven geotextile to prevent migration of soil fines into the modular backfill material.

The overall vertical tolerance of the wall, plumbness from top to bottom, shall not exceed 1/2 inch per 10 feet of wall height.

809.04--Method of Measurement. The retaining wall system will be measured by the square foot of accepted vertical face area of the completed structure, constructed as directed by these specifications. The area measured for payment will be computed from the horizontal length of the wall segments and the average wall height between the bottom of the wall or top of the base leveling pad and the top of the wall. In the case of a battered wall, either specified in the plans or battered at the Contractor's option, the vertical distance will be used in the area calculation and not the slope distance along the face of the wall.

809.05--Basis of Payment. The retaining wall system shall be paid for at the contract unit price per square foot, which price shall be full compensation for the design and construction of the retaining wall system, all excavation, select backfill material, leveling pads, undercut, all the materials for the wall drainage system, facing materials, soil reinforcement, equipment, labor, and incidentals necessary to complete the work as directed by the Engineer.

Payment will be made under:

809-A: Retaining Wall System - per square foot

SECTION 810 - STEEL STRUCTURES

810.01--Description. This work consists of furnishing, fabricating, preparing, assembling, erecting, and painting structural steel and all accessories and other metal parts required in steel spans. This work shall be constructed as indicated on the plans, in reasonably close conformity with the lines, grades, dimensions, and design shown, and in accordance with the applicable provisions and requirements in other sections of these specifications for the different items which constitute the complete structure.

These specifications apply to bolted and welded construction when indicated in the contract.

810.02--Materials.

810.02.1--General. Unless otherwise specified, structural steel, miscellaneous metals, and paints shall conform to the applicable requirements of this section and Sections 710, 716, 717, and 814. Unless otherwise specified, structural carbon steel, ASTM Designation: A 36, shall be furnished.

810.02.2--Drawings. The Contractor shall prepare shop drawings for all materials to be fabricated. The size of the sheets on which the drawings are

prepared shall conform to the standard bridge sheet of the Department. Two complete sets of prints shall be submitted to the Bridge Engineer for approval prior to ordering any materials for fabrication.

For all fabrication to be done by welding, two copies of welding procedures in accordance with the provisions of ANSI/ASSHTO/AWS D1.5 Bridge Welding Code, hereinafter referred to as the Welding Code, shall also be submitted to the Bridge Engineer for approval. After final approval of the shop drawings and welding procedures, if applicable, six complete sets of prints shall be submitted to the Bridge Engineer. As required by special conditions, the Bridge Engineer shall be furnished with as many additional sets of prints as may be necessary. Shop drawings for railroad bridges shall be prepared with ink on linen tracing cloth or other approved equal, which shall be delivered to the Bridge Engineer prior to final acceptance of the project. No changes shall be made in a shop drawing after it has been approved, nor shall steel sections different from those shown on the plans be substituted except with the written consent or direction of the Engineer.

Prior to the fabrication of any part of a structure, shop drawings and welding procedures for that part of the structure shall have been given final, unconditional, approval by the Bridge Engineer. Work performed prior to approval of drawing and procedures may be rejected.

810.02.3--Shop Painting. Shop painting, unless otherwise designated or permitted, shall consist of inorganic zinc primer, Section 710, applied as specified in Section 814. Machine-finished surfaces of pins, pin rollers and bores shall be coated as soon as practicable after acceptance with a heavy coat of Petrolatum meeting the requirements of ASTM Designation: D 217, NLGI Consistency Grade 2 or 3, or other approved coating prior to removal from the shop.

810.02.4--Storage of Materials. Structural material, either plain or fabricated, shall be stored at the bridge shop above ground on 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.

810.02.5--Straightening Material. Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Heat straightening of ASTM Designation: A514/A517 steel shall be done only under rigidly controlled procedures and each application subject to the approval of the Engineer. In no case shall the maximum temperature of the steel exceed 1125°F. Sharp kinks and bends will be cause for rejection of the material.

810.02.6--Curving Rolled Beams and Welded Girders. Steels that are manufactured to a yield point greater than 50,000 psi shall not be heat curved.

810.02.6.1--Type of Heating. Beams and girders may be curved by either continuous or V-type heating as approved by the Engineer. For the continuous method, a strip along the edge of the top and bottom flange shall be heated simultaneously; the strip shall be of sufficient width and temperature to obtain the required curvature. For the V-type heating, the top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their bases along the flange edge and spaced at regular intervals along each flange; the spacing and temperature shall be as required to obtain the required curvature, and heating shall progress along the top and bottom flange at approximately the same rate.

For the V-type heating, the apex of the truncated triangular area applied to the inside flange surface shall terminate just before the juncture of the web and the flange is reached. To avoid unnecessary web distortion, special care shall be taken

when heating the inside flange surface so the heat is not applied directly to the web. When the radius of curvature is 1000 feet or more, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend to the juncture of the flange and web. When the radius of curvature is less than 1000 feet, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend past the web for a distance equal to 1/8 of the flange or 3 inches, whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees, but the base of the triangle shall not exceed 10 inches. Variations in the patterns prescribed above may be made with the approval of the Engineer.

For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is only mandatory when the flange thickness is 1¼ inches or greater; in which case, the two surfaces shall be heated concurrently. The maximum temperatures shall be as prescribed below.

810.02.6.2--Temperature. The heat-curving operation shall be conducted in such a manner that the temperature of the steel does not exceed 1150°F as measured by temperature indicating crayons or other suitable means. The girder shall not be artificially cooled until after naturally cooling to 600°F. The method of artificial cooling is subject to the approval of the Engineer.

810.02.6.3--Position for Heating. The girder may be heat- curved with the web in either a vertical or a horizontal position. When curved in the vertical position, the girder shall be braced or supported in such a manner that the tendency of the girder to deflect laterally during the heat- curving process will not cause the girder to overturn.

When curved in the horizontal position, the girder must be supported near its ends and at intermediate points, if required, to obtain a uniform curvature; the

bending stress in the flanges due to the dead weight of the girder must not exceed the usual allowable design stress. When the girder is positioned horizontally for heating, intermediate safety catch blocks must be maintained at the midlength of the girder within two inches of the flanges at all times during the heating process to guard against a sudden sag due to plastic flange buckling.

810.02.6.4--Sequence of Operations. The girder shall be heat curved in the fabrication shop before it is painted. The heat curving operation may be conducted either before or after all the required welding of transverse intermediate stiffeners is completed. However, unless provisions are made for girder shrinkage, connection plates and bearing stiffeners shall be located and attached after heat curving. If longitudinal stiffeners are required, they shall be heat curved or oxygen cut separately and then welded to the curved girder. When cover plates are to be attached to rolled beams, they may be attached before heat curving if the total thickness of one flange and cover plate is less than 2½ inches and the radius of curvature is greater than 1000 feet. For other rolled beams with cover plates, the beams must be heat-curved before the cover plates are attached; cover plates must be either heat curved or oxygen cut separately and then welded to the curved beam.

810.02.6.5--Camber. Girders shall be cambered before heat curving. Camber for rolled beams may be obtained by heat- cambering methods approved by the Engineer. For plate girders, the web shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving. The heat-curving process may tend to change the vertical camber present before heating. This effect will be most pronounced when the top and bottom flanges are of unequal widths on a given transverse cross section. However, subject to the approval of the Engineer, moderate deviations from specified camber may be corrected by a carefully supervised application of heat.

810.02.6.6--Measurement of Curvature and Camber. Horizontal curvature and vertical camber shall not be measured for final acceptance before all welding and heating operations are completed, and the flanges have cooled to a uniform temperature. Horizontal curvature shall be checked with the girder in the vertical position by measuring off-sets from a string line or wire attached to both flanges or by using other suitable means. Camber shall be checked by adequate means.

810.02.7--Finish. Portions of work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

810.02.8--Bolt Holes. All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than 3/4 inch for structural steel, 5/8 inch for high strength steel, or 1/2 inch for quenched and tempered

alloy steel, unless subpunching and reaming is required under Subsection 810.02.11.1.

When there are more than five thicknesses or when any of the main material is thicker than 3/4 inch for structural steel, 5/8 inch for high strength steel, or 1/2 inch for quenched and tempered alloy steel, all holes shall either be subdrilled or drilled full size.

When required under Subsection 810.02.11, all holes shall be either subpunched or subdrilled 3/16 inch smaller and after assembling, reamed 1/16 inch larger or drilled full size to 1/16 inch larger than the nominal diameter of bolts. Hole shall be subdrilled if thickness limitation governs.

810.02.9--Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

810.02.10--Reamed or Drilled Holes. Reamed or drilled holes shall be cylindrical, perpendicular to the member, and shall comply with the requirements of Subsection 810.02.8 as to size. Where practicable, reamers shall be directed by mechanical means. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required by the Engineer, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match marked before disassembling.

810.02.11--Preparation of Field Connections.

810.02.11.1--Subpunching and Reaming of Field Connections. Unless otherwise specified, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, each face of towers, plate girders, and rigid frames shall be subpunched or subdrilled if subdrilling is required by Subsection 810.02.8, and subsequently reamed while assembled or to a steel template, as required by Subsection 810.02.16.

All holes for floorbeam and stringer field end connections shall be subpunched and reamed to a steel template or reamed while assembled.

Reaming or drilling full size of field connection holes through a steel template shall be done after the template has been located with utmost care as to position and angle and firmly bolted in place. Templates used for reaming matching members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts or members shall be accurately

located so that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, the fabricator shall have the option of drilling holes full size with all thicknesses of material assembled in proper position.

If additional subpunching and reaming is required, it shall be as specified on the plans.

810.02.11.2--Numerically-Controlled Drilled Field Connections. Alternately, for any connection or splice designated in Subsection 810.02.11.1 in lieu of sub-sized holes and reaming while assembled, or drilling holes full-size while assembled, the Contractor shall have the option to drill bolt holes full-size in unassembled pieces and/or connections including templates for use with matching sub-sized and reamed holes by means of suitable numerically-controlled (N/C) drilling equipment subject to the specific provisions contained in this article.

If N/C drilling equipment is used, the Engineer, unless otherwise stated in the special provisions or on the plans, may require the Contractor, by means of check assemblies, to demonstrate that this drilling procedure consistently produces holes and connections meeting the requirements of Subsections 810.02.13 and 810.02.16.

The Contractor shall submit to the Engineer for approval a detailed outline of the procedures proposed to be followed in accomplishing the work from initial drilling through check assembly, if required, to include the specific members of the structure that may be N/C drilled, the sizes of the holes, the location of common index and other reference points, composition of check assemblies, and all other pertinent information.

Holes drilled by N/C drilling equipment shall be drilled to appropriate size either through individual pieces or any combination of pieces held tightly together.

810.02.12--Accuracy of Punched and Drilled Holes. All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling, before any reaming is done, a cylindrical pin ⅛-inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If this requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin 3/16 inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

810.02.13--Accuracy of Reamed and Drilled Holes. When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thicknesses of metal.
All steel templates shall have hardened steel bushings in holes accurately dimensioned from the center lines of the connection as inscribed on the template. The center lines shall be used in accurately locating the template from the milled or scribed ends of the members.

810.02.14--Fitting for Bolting. 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 is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformation.

Preparatory to the shop riveting of full-sized punched material, the rivet holes, if necessary, shall be spear-reamed for the admission of the rivets. The reamed holes shall not be more than 1/16 inch larger than the nominal diameter of the rivets.

End connection angles, stiffener angles, and similar parts shall be carefully adjusted to correct position and bolted, clamped, or otherwise firmly held in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts, insofar as practicable, to prevent damage in shipment and handling.

810.02.15--Blank.

810.02.16--Shop Assembling.

810.02.16.1--General. The field connections of main members of trusses, arches, continuous beam spans, bents, each face of towers, plate girders, and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing, and then shall have their subsize holes reamed to specified size while the connections are assembled. Assembly shall be Full Truss or Girder Assembly unless Progressive Truss or Girder Assembly, Full Chord Assembly, Progressive Chord Assembly, or Special Complete Structure Assembly is specified in the special provisions or on the plans. Modifications to these assemblies may be allowed when approved in writing by the Bridge Engineer.

When required on the plans, check assemblies and N/C drilled field connections shall be in accordance with the provisions of Subsection 810.02.16.7.

Each assembly, including camber, alignment, accuracy of holes, and fit of milled joints, shall be approved by the Engineer before reaming is commenced or before an N/C drilled check assembly is dismantled.

A camber diagram shall be furnished the Engineer by the Fabricator showing the camber at each panel point in the cases of trusses or arch ribs, and at the location of field splices and fractions of span length in case of continuous beam and girders or rigid frames. Fraction points of span lengths shall be 1/4 points minimum, 1/10 points maximum. When the shop assembly is full truss or girder assembly or special complete structure assembly, the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly is used, the camber diagram shall show calculated camber.

810.02.16.2--Full Truss or Girder Assembly. Full truss or girder assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at one time.

810.02.16.3--Progressive Truss or Girder Assembly. Progressive truss or girder assembly shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at least three contiguous shop sections or all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths, i.e. length between field splices, and not less than 150 feet in the case of structures longer than 150 feet. At least one shop section or panel or as many panels as are associated with a chord length shall be added at the advancing end of the assembly before any member is removed from the rearward end, so that the assembled portion of the structure is never less than that specified above.

810.02.16.4--Full Chord Assembly. Full chord assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connection to steel templates set at geometric not cambered angular relation to the chord lines.

Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member and the templates at both ends of the member shall be accurately located from one of the milled ends or scribed lines.

810.02.16.5--Progressive Chord Assembly. Progressive chord assembly shall consist of assembling contiguous chord members in the manner specified for full chord assembly and in the number and length specified for progressive truss or girder assembly.

810.02.16.6--Special Complete Structure Assembly. Special complete structure assembly shall consist of assembling the entire structure, including the floor system. This procedure is ordinarily needed only for complicated structures such as those having curved girders, or extreme skew in combination with severe grade or camber, and will be required only when so indicated on the plans.

810.02.16.7--Check Assemblies with Numerically Controlled Drilled Field Connections. Unless otherwise indicated, a check assembly shall be fabricated for each major structural type and shall consist of at least three contiguous shop sections or, in a truss, all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths; i.e., length between field splices. Check assemblies should be based on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Such special points could be the portals of skewed trusses, etc.
Use of either geometric angles, giving theoretically zero secondary stresses under dead-load conditions after erection, or cambered angles, giving theoretically zero secondary stresses under no-load conditions, should be designated on the plans or in the special provisions.

The check assemblies shall preferably be the first such section of each major structural type to be fabricated.

No match-marking and no shop assemblies other than the check assemblies will be required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required by the Engineer for which there shall be no additional cost to the State.

810.02.17--Drifting of Holes. The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

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

810.02.19--Blank.

810.02.20--Bolts and Bolted Connections. Bolted connections fabricated using high strength bolts shall conform to Subsection 810.02.21.

810.02.20.1--General. Bolts shall be unfinished, turned, or ribbed bolts conforming to the requirements for Grade A Bolts of Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners, ASTM

Designation: A 307. Bolted connections shall be used only as indicated by the plans or special provisions. Bolts shall have single self-locking nuts or double nuts unless otherwise shown on the plans or in the special provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

810.02.20.2--Unfinished Bolts. Unfinished bolts shall be furnished unless other types are specified.

810.02.20.3--Turned Bolts. The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed with bolts furnished to provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

810.02.20.4--Ribbed Bolts. The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads conforming to ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement.

810.02.21--Connections Using High Strength Bolts. This subsection covers the assembly of structural joints using ASTM Designation: A 325 high strength bolts for structural steel joints or ASTM A 490 quenched and tempered alloy bolts for structural steel joints, or equivalent fasteners, tightened to a high tension. The bolts are used in holes conforming to the requirements of Subsections 810.02.8, 810.02.9 and 810.02.10.

810.02.21.1--Bolts, Nuts, Washers and Direct Tension Indicators (DTI). All bolts, nuts, washers and DTI shall conform to the requirements of Section 717 for such items.

Unless otherwise shown on the plans, all threaded bolts shall be of sufficient length to provide at least full-thread engagement, as defined in Subsection 810.04.4, immediately prior to final tensioning.

All markings on bolts, nuts, washers and direct tension indicators must include the symbol of the manufacturer and not the distributor or any other trading entity. This is spelled out in all ASTM specifications covering these product categories. A325 bolts shall be marked "A325" and A490 bolts marked "A490". Type 1 A325 bolts shall be marked with three radial lines 120° apart. Type 3 A325 bolts shall have A325 underlined plus other distinguishing marks indicating that the bolt is atmospheric corrosion resistant and of a weathering type. Type 2 A325 bolts shall be marked with three radial lines 60° apart. Direct tension indicators shall also be marked "325" in the case of Type "325" or "490".

810.02.21.2--Bolted Parts. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of dirt, loose scale, burrs, other foreign material, and other defects that would prevent solid seating of the parts. Paint is permitted in bearing-type connections.

Contact surfaces within friction-type joints shall be free of oil, paint, lacquer or other coatings, except as listed below:

A. Hot dip galvanizing, if contact surfaces are scored by wire brushing or blasting after galvanizing and prior to assembly. The wire brushing treatment shall be a light application of manual brushing, not power wire brushing, that marks or scores the surface but removes relatively little of the zinc coating. The blasting treatment shall be a light "brush-off" treatment which will produce a dull gray appearance. However, neither treatment should be severe enough to produce any break or discontinuity in the zinc surface.

B. Inorganic zinc rich paints as specified in Subsection 710.03.

ASTM A 325 Type 2 and ASTM A 490 bolts shall not be galvanized nor shall they be used to connect galvanized material.

810.03--Construction Requirements.

810.03.1--Installation.

810.03.1.1--Bolt Tension. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension for the size and grade of fastener used, as shown in the following table:

BOLT TENSION

Bolt Size, inches	Minimum Bolt Tension, pounds ASTM A 325 Bolts	ASTM A 490 Bolts
1/2	12,050	14,900
5/8	19,200	23,700
3/4	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1 1/8	56,450	80,100
1 1/4	71,700	101,800
1 3/8	85,450	121,300
1 1/2	104,000	147,500

The rotational-capacity test described in Subsection 717.02.3.4 shall be performed on each rotational-capacity lot prior to the start of bolt installation. Hardened steel washers are required as part of the test although they may not be required in the actual installation procedure.

A Skidmore-Wilhelm Calibrator or an equivalent tension measuring device shall be required at each job site during erection. Periodic testing, at least one each working day when the calibrated wrench method is used, shall be performed to assure compliance with the installation requirements for calibrated wrench tightening, turn-of nut tightening or direct tension indicators (DTI) tightening.

The Contractor shall provide all wrenches necessary for obtaining the specified bolt tension, and shall also provide, at no additional costs to the State, the necessary inspection wrenches and provisions for calibration of such wrenches as specified in this subsection and in Subsection 810.03.2.

Threaded bolts shall be checked for tension with properly calibrated wrenches, by the turn-of-nut method, or by the use of Direct Tension Indicators. When required because of bolt entering and wrench operating clearances, tightening may be accomplished by turning the bolt while the nut is prevented from rotating, provided the requirements of Subsections 810.03.1.2 and 810.03.1.5 are met.

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

ASTM A490 and galvanized ASTM A325 bolts shall not be reused. Other ASTM A325 bolts may be reused, but not more than once, if approved by the Engineer. Retightening previously tightened bolts which may have been loosened by the tightening of adjacent bolts shall not be considered as a reuse.

Galvanized nuts shall be checked to verify that a visible lubricant is on the threads. Black bolts shall "oily" to the touch when delivered and installed. Weathered or rusted bolts and nuts shall be cleaned and relubricated prior to installation. Bolt, nut and washer, when required, combinations as installed shall be from the same rotational-capacity lot, reference Subsection 717.02.

810.03.1.2--Washers. All fasteners shall have a hardened washer under the element (nut or bolt head) turned in tightening except that ASTM A325 bolts installed by the turn of the nut method in holes which are not oversize or slotted may have the washer omitted. Hardened washers shall be used under both the head and nut regardless of the element turned in the case of ASTM A490 bolts if the material against which it bears has a specified yield strength less than 40 ksi. When ASTM A 490 bolts over one inch in diameter are used in conjunction with short slotted or oversized holes, the hardened washers shall be at least 5/16 inch thick.

Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

810.03.1.3--Calibrated Wrench Tightening. When calibrated wrenches are used to provide the bolt tension specified in Subsection 810.03.1.1, their setting shall be such as to induce a bolt tension five percent to ten percent in excess of this value. These wrenches shall be calibrated at least once each working day by tightening, in a device capable of indicating actual bolt tension, not less than three typical bolts of each diameter to be installed. Power wrenches shall be adjusted to stall or cut-out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the calibrating tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in the tightening direction when torque is measured. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the specified tension.

The required torque for calibrated wrenches may be approximated by the following formula:

T(inch-pounds) = 0.2 x Bolt Diameter (inches) x Bolt Tension (pounds)

810.03.1.4--Turn-of-Nut Tightening. When the turn-of-nut method is used to provide the bolt tension specified in Subsection 810.03.1.1, there shall first be enough bolts brought to a "snug tight" condition to insure that the parts of the joint are brought into full contact with each other. "Snug tight" is defined as the initial tightening of the nut such that a load in the bolt of not less than 10% of the specified proof load for each type and size bolt used is produced. Following this initial operation, bolts shall be placed in the remaining holes in the connection

and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable nut rotation specified in the following table with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

NUT ROTATION(1) FROM SNUG-TIGHT CONDITION

For coarse thread heavy hexagon structural bolts of all sizes and lengths and heavy hexagon semi-finished nuts

	Disposition of Outer Faces of Bolted Parts		
Bolt Length, as measured from underside of head to extreme end of point	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20. Bevel washer not used.	Bolt faces sloped not more than 1:20 from normal to bolt axis. Bevel washers not used.
Up to and including 4 diameters	1/3 turn*	1/2 turn*	2/3 turn**
Over 4 diameters but not exceeding 8 diameters	1/2 turn*	2/3 turn**	5/6 turn**
Over 8 diameters but not exceeding 12 diameters	2/3 turn**	5/6 turn**	1 turn**

(1) Nut rotation is rotation relative to bolt regardless of the element, nut or bolt, being turned.

* Rotation Tolerance: Plus or minus 30 degrees
** Rotation Tolerance: Plus or minus 45 degrees

810.03.1.5--Direct Tension Indicators (DTI) Tightening. When DTI are required on the plans, the Contractor shall furnish a copy of the manufacturer's written installation instructions to the Bridge Engineer for approval prior to beginning work.

It shall be the Contractor's responsibility to have a manufacturer's representative on the job site during initial installation of bolted connections to instruct personnel on the correct method of installation and inspection of the DTI.
The DTI shall be installed and the bolts tightened in strict accordance with the manufacturer's written instruction. The DTI are in addition to washers required by the plans and Standard Specifications.

DTI protrusions for all installations shall bear against a hardened unturned surface, normally either the underside of the bolt head or a hardened washer, and never directly against the turned element.

Prior to the final tightening of all high strength bolts, all the plies of steel shall be drawn together by partially compressing DTI protrusions to ensure "snug tight" conditions. The final tightening shall progress systematically from the most rigid part of the joint to its free edges until the DTI on all bolts are closed to 0.005 inch.

DTI shall not be reused. If it becomes necessary to loosen a bolt previously tensioned, the DTI shall be discarded and replaced.

Bolts shall be of sufficient length to accommodate an indicator and washers made necessary by its use.

The Contractor shall furnish a Skidmore-Wilhelm device or approved equal capable of measuring actual bolt tension. At least three typical bolts and direct tension indicators shall be tightened in a device capable of determining their performance characteristics prior to the start of bolt placement. The device shall be made available thereafter during bolt placement for similar checks not to exceed intervals of one week unless directed otherwise by the Bridge Engineer.

High strength bolts, nuts, washers, and direct tension indicators shall be shipped to the project site in sealed metal containers or an approved equal. They shall be stored out of the weather in a location approved by the Engineer. The containers shall remain unopened until the contents are needed for erection. Bolts which, before use, have been exposed and become dried out or rusty will be rejected and will not be used until they are cleaned and lubricated.

810.03.1.6--Lock-Pin and Collar Fasteners. The installation of lock-pin and collar fasteners shall be by methods and procedures approved by the Engineer.

810.03.2--Inspection. The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are tightened. When the calibrated wrench method of tightening is used, the Engineer will have full opportunity to witness the calibration tests prescribed in Subsection 810.03.1.3.

The following inspection shall be used unless a more extensive or different inspection procedure is specified.

810.03.2.1. Either the Engineer, or the Contractor in the presence of the Engineer, shall use an inspecting wrench which may be either a torque wrench or a power wrench that can be accurately adjusted in accordance with the requirements of Subsection 810.03.1.3.

810.03.2.2. Three bolts of the same grade, size and conditions as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. The length of the bolt may be any length representative

of bolts used in the structure. There shall be a washer under the part turned in tightening each bolt.

810.03.2.3. When the inspecting wrench is a torque wrench, each bolt specified in Subsection 810.03.2.2 shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in Subsection 810.03.1.1. The inspecting wrench then shall be applied to the tightened bolt and the torque necessary to turn the nut or head five degrees, approximately one inch at 12-inch radius, in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspecting torque to be used in the manner specified in Subsection 810.03.2.5.

810.03.2.4. When the inspecting wrench is a power wrench it shall be adjusted so that it will tighten each bolt specified in Subsection 810.03.2.2 to a tension at least five but not more than ten percent greater than the minimum tension specified for its size in Subsection 810.03.1.1. This setting of wrench shall be taken as the job inspecting torque to be used in the manner specified in the following paragraph.

810.03.2.5. Bolts represented by the sample prescribed in Subsection 810.03.2.2 which have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to ten percent of the bolts, but not less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection shall be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job inspecting torque shall be tightened and reinspected, or alternatively, the fabricator or erector, at no additional costs to the State, may re-tighten all of the bolts in the connection in the manner required and subject to the limitations imposed for the initial tightening and then resubmit the connection for the specified inspection.

810.03.2.6. When direct tension indicators are used, the Department's inspector will check for correct tensioning by inserting a correct-thickness pointed feeler gage into the opening between adjacent flattened protrusions in accordance with the manufacturer's instructions and Subsection 810.03.1.5. At least ten percent, but no less than two, of the bolts in each connection will be examined.

A nil gap on ASTM A325 bolts is not cause for rejection. A nil gap for ASTM A490 bolts is not allowed.

810.03.2.7. The procedures for inspecting and testing the lock-pin and collar fasteners and their installation to insure that the required pre-load tension is provided shall be as approved by the Engineer.

810.03.3--Blank.

810.03.4--Plate Cut Edges.

810.03.4.1--Edge Planing. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stress shall be planed to a depth of 1/4 inch. Re-entrant cuts shall be filleted to a minimum radius of 3/4 inch before cutting.

810.03.4.2--Visual Inspection and Repair of Plate Cut Edges. Visual inspection and repair of plate cut edges shall be in accordance with the Welding Code.

810.03.5--Welds. Welding of steel structures, when authorized on the plans or on approved working drawings, and pre-qualification of welding operators shall conform to the Welding Code.

Welding shall be tested by non-destructive methods as prescribed in the Welding Code and as indicated on the plans. Edge blocks shall be used when radiographing butt welds greater than 1/2 inch thickness. The edge blocks shall have a length sufficient to extend beyond each side of the weld centerline for a minimum distance equal to the weld thickness, but no less than two inches, and shall have a thickness equal to or greater than the thickness of the weld. The minimum width of the edge blocks shall be equal to half the weld thickness, but not less than 1 inch. The edge blocks shall be centered on the weld with a snug fit against the plate being radiographed, allowing no more than 1/16 inch gap. Edge blocks shall be made of radiographically clean steel and the surface shall have a finish of ANSI 125 μinch, or smoother. Non-destructive testing shall be performed at the expense of the Contractor.

810.03.6--Oxygen Cutting. All oxygen cutting shall conform to the Welding Code.

810.03.7--Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the ANSI surface roughness requirements as defined in ANSI B 46.1, Surface Roughness, Waviness, and Lay, Part 1:

Steel Slabs	ANSI 2,000
Heavy plates in contact in shoes to be welded	ANSI 1,000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

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

810.03.9--End Connection Angles. Floorbeams, stringers and girders having end connection angles shall be built to the exact length shown on the plans measured between the heels of the connection angles, with a permissible tolerance of zero inch to minus 1/16 inch. Where continuity is to be required, end connections shall be faced. The thickness of the connection angles shall not be less than 3/8 inch or that shown on the detail drawings.

810.03.10--Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

810.03.11--Fabrication of Members. Unless otherwise shown on the plans, steel plates for main members and splice plates for flanges and main tension members, not secondary members, shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile and/or compressive stresses.

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

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

Splices in webs of girders without cover plates shall be sealed on the top with red lead paste prior to painting.

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

810.03.13--Bent Plates. Unwelded, cold-bent, load-carrying, rolled-steel plates shall conform to the following:

A. They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic decks bridges may be bent in the direction of rolling if permitted by the Engineer.

B. Bending shall be such that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in the following table:

THICKNESS IN INCHES

	Up to 1/2	Over 1/2 to 1	Over 1 to 1½	Over 1½ to 2½	Over 2½ to 4
All grades of steel	2t	2½t	3t	3½t	4t

Note: Low alloy steel in thicknesses over 1/2 inch may quire hot bending for small radii.

Allowance for springback of ASTM A514 and A517 steels should be about three times that for structural carbon steel. For break press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1200^{o} F, except for ASTM A514/A517 steel. If ASTM A514/A517 steel plates to be bent are heated to a temperature greater than 1125°F, they must be requenched and tempered in accordance with the producing mill's practice. Hot bent plates shall conform to requirement A.

C. Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout the portion of the plate at which the bending is to occur.

810.03.14--Fit of Stiffeners. End stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing, either milled, ground or on weldable steel in compression areas of flanges, welded as shown on the plans or specified, on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless shown or specified otherwise, fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

810.03.15--Eyebars. Pin holes may be flame cut at least two inches smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together in the order that they will be placed on the pin and bored at both ends while so clamped. Eyebars shall be packed and match marked for shipment and erection. All identifying marks shall be stamped with steel stencils on the edge of one head of each member after fabrication is completed so as to be visible when the bars are nested in place on

the structure. The eyebars shall be straight and free from twists and the pin holes shall be accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/16 inch to a foot.

The edges of eyebars that lie between the transverse centerline of their pin holes shall be cut simultaneously with two mechanically operated torches abreast of each other, guided by a substantial template, in such a manner as to prevent distortion of the plates.

810.03.16--Annealing and Stress Relieving. Structural members which are indicated to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and annealing, full annealing, shall be as specified in ASTM Designation: E 44. The temperatures shall be maintained uniformly throughout the furnace during the heating and cooling so that the temperature at no two points on the member will differ by more than 100°F at any one time.

Members of ASTM A514/A517 steels shall not be annealed or normalized and shall be stress relieved only with the approval of the Engineer.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used.

Proper instruments, including recording pyrometers, shall be provided for determining at any time the temperatures of members in the furnace. The records of the treatment operation shall be available to and meet the approval of the Engineer. The holding temperature for stress relieving ASTM A514/A517 steel shall not exceed 1125°F.

Members, such as bridge shoes, pedestals, or other parts which are built up by welding sections of plate together shall be stress relieved in accordance with the Welding Code.

810.03.17--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. Pins and rollers more than nine inches in diameter shall be forged and annealed. Pins and rollers nine inches or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than nine inches in diameter, a hole not less than two inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling and before being annealed.

810.03.18--Boring Pin Holes. 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 end holes in tension members and inside to inside of end holes in compression members shall not vary from that specified by more than 1/32 inch. Boring of holes in built-up members shall be done after the riveting is complete.

810.03.19--Pin Clearances. The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins five inches or less in diameter or 1/32 inch for larger pins.

810.03.20--Threads for Bolts and Pins. Threads for all bolts and pins for structural steel construction shall conform to the Unified Standard Series UNC-ANSI B1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 1 3/8 inches or more shall be threaded six threads to the inch.

810.03.21--Pilot and Driving Nuts. Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

810.03.22--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 been so notified.

Prior to any fabrication, the fabricator shall have on hand Shop Drawings, Weld Procedures and a procedure for storage and handling of welding electrodes, wire and flux which have been approved by the Bridge Engineer. No fabrication shall begin until a prefabrication conference has been held and the facilities have been inspected and approved by the Bridge Engineer.

When ordering structural steel, the fabricator shall specify the current ASTM designation for the material based on the date of advertisement for bids.

810.03.23--Facilities for Inspection. The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and the inspectors shall be allowed free access to the necessary parts of the works.

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

810.03.24--Inspector's Authority. Inspectors shall have the authority to reject any material or work which does not meet the requirements of the specifications. In case of dispute, the Contractor may appeal to the Engineer, whose decision shall be final.

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

Material and workmanship not previously inspected will be inspected after its delivery to the site of the work.

810.03.25--Working Drawings and Identification of Steel During Fabrication.

810.03.25.1--Working Drawings. Shop drawings and other required drawings shall be submitted to the Engineer in accordance with and subject to the provisions of Subsection 810.02.2.

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

The Contractor shall expressly understand that the Engineer's approval of the working drawings cover the requirements for "strength and detail," and the Engineer assumes no responsibility for errors in dimensions.

810.03.25.2--Identification of Steels During Fabrication.

810.03.25.2.1--Identification by Contractor. The Engineer shall be furnished with four complete copies of certified mill test reports showing chemical analysis and physical tests for each heat of steel for all members unless excepted by the Engineer. Each piece of steel to be fabricated shall be properly identified for the Engineer.

Shop drawings shall specifically identify each piece that is to be made of steel other than ASTM A36. Pieces made of different grades of steel shall not be given the same assembling or erecting mark, even though they are of identical dimensions and detail.

The Contractor's system of assembly-marking individual pieces, required to be made of steel other than ASTM A36, and the issuance of cutting instructions to the shop, generally by cross-referencing of the assembly-marks shown on the shop drawings with the corresponding item covered on the mill purchase order, shall be such as to maintain identity of the mill test report number.

Material the Contractor can identify by heat number and mill test report may be furnished from stock.

All excess material placed in stock for later use shall be marked with the mill test report number and shall be marked with its ASTM A6 specification identification color code, see table below, when separated from the full-size pieces furnished by the supplier.

810.03.25.2.2--Identification of Steels During Fabrication. During fabrication, up to the point of assembling members, each piece of steel, other than ASTM A36, shall show clearly and legibly its specification identification color code shown in the table below.

Individually marked pieces of steel which are used in furnished size, or reduced from furnished size only by end or edge trim, that does not disturb the heat number or color code or leave any usable piece may be used without further color coding provided that the heat number or color code remains legible.

Pieces of steel, other than ASTM A36, which are to be cut to smaller size pieces shall, before cutting, be legibly marked with the ASTM A6 specification identification color code.

Individual pieces of steel, other than ASTM A36, which are furnished in tagged lifts or bundles shall be marked with the ASTM A6 specification identification color code immediately upon being removed from the bundle or lift.

Pieces of steel, other than ASTM A36, which, prior to assembling into members, will be subject to fabricating operations such as blast cleaning, galvanizing, heating for forming, or painting which might obliterate paint color code marking shall be marked for grade by steel die stamping or by a substantial tag firmly attached.

The following identification color code shall be used to identify material required to meet the individual specifications listed.

IDENTIFICATION COLOR CODES

ASTM A 36	White
ASTM A 514	Red
ASTM A 517	Red and Blue
ASTM A 572, Grade 50	Green and Yellow
ASTM A 588	Blue and Yellow
ASTM A 852	Blue and Orange

Other steels, except ASTM A36, not covered above, nor included in the ASTM A6 Specification, shall have an individual color code which shall be established and on record for the Engineer.

810.03.25.2.3--Certification of Identification. Upon request, the Contractor shall furnish an affidavit certifying that throughout the fabrication operation, the identification of steel has been maintained in accordance with this specification.

810.03.26--Full Size Tests. When full size tests of fabricated structural members or eyebars are required, the plans or specifications will state the number and the nature of the tests, the results to be attained, and the measurements of strength, deformation, or other performance that are to be made. The Contractor shall provide suitable facilities, material, supervision, and labor necessary for making and recording the tests. The members tested in accordance with the contract will be measured for payment in accordance with Subsection 810.04. The cost of testing including equipment, handling, supervision, labor, and incidentals for making the tests shall be included in the contract price for the fabrication or fabrication and erection of structural steel, whichever is the applicable item in the contract, unless otherwise specified.

810.03.27--Marking and Shipping. Each member shall be painted or marked with an erection mark for identification, and an erection diagram shall be furnished with erection marks shown thereon.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements, and erection diagrams as the Engineer may direct. The weights of the individual members shall be shown on the statements. Members weighing more than three tons shall have the weights marked thereon. Structural members shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

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

When Direct Tension Indicators are required on plans, the bolts, nuts, washers and DTI shall be shipped and stored in accordance with Subsection 810.03.1.5.

810.03.28--Erection of Structure. If the substructure and superstructure are built under separate contracts, the Department will provide the masonry, constructed to correct lines and elevations and properly finished.

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

810.03.28.1--Plans. If the fabrication and erection of the superstructure are done under separate contracts, the Department will furnish detail plans for the bridge or bridges to be erected, including shop details, camber diagrams, erection diagrams, list of field rivets and bolts, and copy of shipping statements showing a list of parts and their weights.

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

810.03.28.3--Delivery of Material. If the contract is for erection only, the Contractor shall receive the materials entering into the finished structure, free of charge at the place designated and loaded or unloaded as specified.

810.03.28.4--Handling and Storing Materials. Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, the Contractor shall check the material supplied against the shipping lists and report promptly in writing all shortages or injuries discovered. After receiving the material, the Contractor shall be responsible for the loss of any material and for all damage caused to it.

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

810.03.28.6--Methods and Equipment. Before starting erection, the Contractor shall inform the Engineer fully as to the proposed method of erection and the amount and character of equipment proposed for use, all 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 of the method or equipment used or from carrying out the work in full accordance with the plans and specifications. No work shall be done until the approval of the Engineer has been obtained.

810.03.28.7--Bearings and Anchorages. Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed, or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry. Unless otherwise directed by the Engineer, they shall be placed on a layer of sheet lead one-eighth inch in thickness.

Elastomeric bearing pads, if used, shall be set directly on the masonry.

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

Location of anchors and setting of rockers or rollers shall take into account the variation from mean temperature at time of setting and anticipated lengthening of bottom chord or bottom flange due to dead load after setting, the intention being that, as near as practicable, at mean temperature and under dead load the rockers and rollers shall set vertical and anchor bolts at expansion bearings will center their slots. Care shall be taken that full and free movement of the superstructure at the movable bearings is not restricted by improper setting or adjustment of bearings or anchor bolt and nuts.

810.03.28.8--Straightening Bent Material. The straightening of plates, angles, other shapes, and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and supervised application of limited localized heat, except that heat straightening of ASTM A514/A517 steel members shall be done only under rigidly controlled procedures, each application subject to the approval of the Engineer. In no case shall the maximum temperature of ASTM A514/A517 steel exceed 1125°F, nor shall the temperature exceed 950°F at the weld metal or within six inches of weld metal. Heat shall not be applied directly on weld metal. In all other steels, the temperature of the heated area shall not exceed 1200°F, a dull red, as controlled by temperature indicating crayons, liquids, or bimetal thermometers.

Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

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

810.03.28.9--Cambering. Correction of errors in camber in welded beams and girders of ASTM A514/A517 material shall be done only under rigidly controlled procedures, each application subject to approval of the Engineer.

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

810.03.28.11--Blank.

810.03.28.12--Pin Connections. Pilot and driving nuts shall be used in driving pins. They shall be furnished by the Contractor without charge. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

810.03.28.13--Misfits. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the inspector . The method of correction shall require approval by the inspector in whose presence the correction will be made. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for all misfits, errors, and injury and shall make the necessary corrections and replacements. If the contract is for erection only, the inspector, with the cooperation of the Contractor, will keep a correct record of labor and materials used, and the Contractor shall render within 30 days an itemized bill for the approval of the Engineer.

810.03.29--Removal of Old Structures and Falsework. Unless the contract indicates that an old structure is to remain in place, the Contractor shall dismantle and dispose of such structure in accordance with the methods and requirements set out in Section 202.

Upon completion of the erection and before final acceptance, the Contractor shall remove all falsework, excess excavation and useless materials.

All excavated material or falsework placed in the stream channel during construction shall be removed by the Contractor before final acceptance.

810.04--Method of Measurement.

810.04.1--General. The steel superstructure will be measured as a lump sum quantity, complete in place. Structural steel will be measured for payment by the pound based on the weight of metal in the fabricated structure as provided in the contract.

Miscellaneous material items such as castings, bearing plates, lead sheets, anchor bolts, and all other metal for which no direct payment is specified and the contract proposal does not include a bid item for miscellaneous bridge appurtenances will be included in the measurement for structural steel except when the plans and specifications provide that payment will not be allowed for certain materials. When direct tension indicators are not required by the contract and the Contractor elects to use such indicators, no measure for payment will be allowed.

810.04.2--Miscellaneous Bridge Appurtenances. When the bid schedule of the contract contains a pay item for Miscellaneous Bridge Appurtenances, measurement will not be made of individual miscellaneous items, but all will be included in a single lump sum quantity, including all miscellaneous metals and other miscellaneous materials and work not specified to be measured for payment under or to be included in other items of work.

810.04.3--Payment of Weights.

Weights of metals to be paid for shall be based on computed weights.

The weights of erection bolts, extra field rivets or high strength bolts, paint, and all boxes, crates, or other containers used for packing, together with sills, struts, and rods used for supporting members during transportation will be excluded. All metals not to remain in the completed structure will not be computed for payment.

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 indicated on the plans.

Full size members which are tested as required under Subsection 810.03.26 and meet the requirements of these specifications will be measured for payment at the same rate as for the structure.

810.04.4--Computation of Weights.

The weights of metals specified to be paid for by weight will be computed for payment from the following table:

Metal	Weight in Pounds Per Cubic Foot of Material
Aluminum, cast or wrought	173.0
Bronze, cast	536.0
Copper-alloy	536.0
Copper sheet	558.0
Iron, cast	445.0
Iron, malleable	470.0
Iron, wrought	487.0
Lead, sheet	707.0
Steel, rolled, cast, copper bearing, silicon, nickel and stainless	490.0
Zinc	450.0

The weight of rolled shapes and of plates shall be computed on the basis of their nominal weights and dimensions, as shown on the approved plans and shop drawings, deducting for copes, cuts and open holes.

The weight of castings may be computed from the dimensions shown on the plans, with an addition of five percent for fillets and over-runs, or weighed on approved scales.

No allowance will be made for the weight of paint.

The weight of heads, nuts, single washers, DTIs when required, and threaded stick-through of all high tensile strength shop bolts will be included on the basis of the following weights:

Diameter of Bolt, Inches	**Weight per 100 Bolts, Pounds**
1/2	19.7
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1 1/8	165.1
1 1/4	212.0
1 3/8	280.0
1 1/2	340.0

It shall be understood that the weight of the "threaded stick-through" of the bolts will be on the basis of the full-thread engagement. Full-thread engagement is

defined as being accomplished when the end of the bolt is flush with the outer face of the nut. At the discretion of the Contractor, the next longer standard length of bolt than that necessary to accomplish full-threaded engagement may be furnished and used, at no additional cost to the State.

The weight of weld metal will be computed on the basis of the theoretical volume from dimensions of the welds.

810.04.5--Deduction for Fabrication Inspection Cost Overruns. Under separate agreement, the Department will contract with a private company to provide inspection services for structural steel fabrication on this project. By this agreement a maximum amount payable, including a fixed fee will be established beyond which no funds will be authorized for payment without a Supplemental Agreement to this agreement.

The Department will be responsible for structural steel fabrication inspection costs not to exceed the established maximum amount payable including the fixed fee and any additional amount authorized for payment by Supplemental Agreement.

Structural steel fabrication inspection costs exceeding the above described amount will be deducted from monies due the Contractor under pay items 810-A, Structural Steel; 810-B, Steel Superstructure, and/or 810-C, Miscellaneous Bridge Appurtenances, as the case may be.

Ninety percent (90%) of the amount bid for structural steel items listed above will be the maximum amount paid the Contractor until such time final fabrication inspection costs have been determined and the Bridge Engineer notifies the Project Engineer to release full payment to the Contractor; otherwise, the Bridge Engineer will advise the Project Engineer of the amount to withhold from the Contractor's estimate to cover structural steel fabrication inspection costs that exceed the amount approved for payment by the Department.

810.05--Basis of Payment. Structural steel, subject to the deductions set out in Subsection 810.04.5, will be paid for at the contract unit price per pound. Steel superstructure and miscellaneous bridge appurtenances when shown as a pay item will be paid for at the contract lump sum price. The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

810-A: Structural Steel *	-per pound
810-B: Steel Superstructure	- lump sum
810-C: Miscellaneous Bridge Appurtenances	- per pound or lump sum

* Specify the type if other than A 36

SECTION 811 - BRONZE OR COPPER-ALLOY BEARING AND EXPANSION PLATES

811.01--Description. This work consists of furnishing and installing metal plates of the kind and type specified and in the manner shown on the plans.

811.02--Materials. Bearing and expansion plates, of the type and kind specified shall meet the requirements of Subsections 716.06 or 716.07 or 716.08, as applicable.

811.02.1--Bronze Plates. Plates shall be cast according to details shown on the plans. Sliding surfaces shall be planed parallel to the movement of the spans and polished unless detailed otherwise.

811.02.2--Copper-Alloy Plates. Plates shall be furnished according to details shown on the plans. Finishing of the rolled plates will not be required provided they have a plane, true, and smooth surface.

811.03--Construction Requirements. Bearing plates shall be accurately set in correct position as shown on the plans and shall have a uniform bearing over the whole area. Provision shall be made to keep the plates in correct position as the concrete is being placed.

811.04--Method of Measurement. Accepted bearing and expansion plates of the type specified will be measured by the pound. Unless otherwise provided, the measurements will be the Inspector's certified shop scale weight of plates placed in the structure. If specified in the contract, measurement will be computed weights, obtained by methods shown on the plans.

Lubricants will not be measured for separate payment.

811.05--Basis of Payment. Bearing and expansion plates will be paid for at the contract unit price per pound which price shall be full compensation for completing the work.

Payment will be made under:

811-A: Bronze Plates	- per pound
811-B: Copper-Alloy Plates	- per pound
811-C: Self-Lubricating Type Plates	- per pound

SECTION 812 - STEEL GRID FLOORING

812.01--Description. This work consists of constructing steel grid flooring, open or concrete-filled type as specified, in accordance with these specifications and in reasonably close conformity to the lines and grades shown on the plans or established.

812.02--Materials. Materials shall conform to the provisions of Subsection 717.05.

812.02.1--Arrangement of Sections. Where the main elements are normal to centerline of roadway, the units generally shall be of such length as to extend over the full width of the roadways up to 40 feet, but in every case the units shall extend over at least three panels. Where joints are required, the ends of the main floor members shall be welded at the joints over their full cross-sectional area or otherwise connected to provide full continuity.

Where the main elements are parallel to centerline of roadway, the sections shall extend over at least three panels, and the ends of abutting units shall be welded over their full cross-sectional area or otherwise connected to provide full continuity in accordance with the design.

812.02.2--Provisions for Camber. Unless otherwise provided on the plans, provision for camber shall be made as follows:

Steel units so rigid that they will not readily follow the camber required shall be cambered in the shop. To provide a bearing surface parallel to the crown of the roadway the stringers shall be canted or provided with shop-welded beveled bearing bars. If beveled bars are used, they shall be placed along the centerline of the stringer flange, in which case the design span length shall be governed by the width of the bearing bar instead of by the width of the stringer flange.

Longitudinal stringers shall be mill cambered or provided with bearing strips so that the completed floor after dead-load deflection will conform to the longitudinal camber shown on the plans.

812.02.3--Welding. All shop and field welding shall be in accordance with Subsection 810.03.5.

812.02.4--Repairing Damaged Galvanized Coatings. All galvanizing that has been chipped off or damaged in handling or transporting or in welding or riveting shall be repaired by field galvanizing by the application of a paste composed of approved zinc powder and flux with a minimum amount of water. The places to be coated shall be thoroughly cleaned, including removal of slag on welds, before the paste is applied. The surface to be coated shall first be heated with a torch to a sufficient temperature so that all metallics in the paste are melted when

applied to the heated surface. Extreme care shall be taken to see that the galvanized surfaces are not damaged by the torch. The flux in the paste will cause a black substance to appear on the surface of the coated parts, and this black substance shall be removed by wiping off with waste or by the quick application of cold water.

812.03--Construction Requirements.

812.03.1--Field Assembly. Areas of considerable size shall be assembled before the floor is welded to its supports. The main elements shall be made continuous, and sections shall be connected together along their edges by welding of bars or by riveting them. The connections shall meet with the approval of the Engineer. The rivets may be cold driven.

812.03.2--Connection to Supports. The floor shall be connected to its steel supports by welding. Before any welding is done the floor shall either be loaded to make a tight joint with full bearing, or it shall be clamped down. The location, length, and size of the welds shall be subject to the approval of the Engineer, but in no case shall they be less than the manufacturer's standards.

The ends of all the main steel members of the slab shall be securely fastened together at the sides of the roadway for the full length of the span by means of steel plates or angles welded to the ends of the main members, or by thoroughly encasing the ends with concrete.

812.03.3--Concrete Filler. Floor types with bottom flanges not in contact shall be provided with bottom forms of metal or wood to retain the concrete filler without excessive leakage.

Metal form strips, when used, shall fit tightly on the bottom flanges of the floor members and be placed in short lengths so as to extend only about one inch onto the edge of each support, but in all cases the forms shall be such as will result in adequate bearing of slab on the support.

The concrete shall be mixed, placed, and cured in accordance with Section 804. The concrete shall be thoroughly compacted by vibrating the steel grid floor. The vibrating device and the manner of operating it shall be subject to the approval of the Engineer.

812.03.4--Painting. Flooring furnished without galvanizing but with a shop coat of paint shall be given field coats of paint in accordance with Section 814.

When a structural steel plate is used on the bottom of a filled type floor, the bottom surface of the plate shall be given one shop coat, one field intermediate coat, and one field top coat of paint in accordance with Section 814.

812.04--Method of Measurement. Steel grid floor of the type specified will be measured by the square foot complete in place. No separate measurement will be made for galvanizing or painting and concrete filling when required.

812.05--Basis of Payment. Steel grid floor of the type specified, measured as prescribed above, will be paid for at the contract unit price per square foot, which price shall be full compensation for completing the work.

Payment will be made under:

812-A: Steel Grid Floor, Open Type	- per square foot
812-B: Steel Grid Floor, Concrete Filled	- per square foot

SECTION 813 - RAILING

813.01--General. This work consists of constructing bridge railing of the type specified in accordance with these specifications. Railing for bridges shall include all work constructed above the top of the bridge deck, curb, or sidewalk surface, as applicable.

813.02--Materials. All materials shall conform to the requirements of Division 700 or as specified on the plans. Unless otherwise specified, concrete shall be Class "AA" meeting the requirements of Section 804.

813.03--Construction Requirements.

813.03.1--Line and Grade. Lines and grades of railing shall be in reasonably close conformity to that shown on the plans and shall not follow any unevenness in the superstructure. Unless otherwise specified or shown on the plans, the railing, posts, and curbs on bridges, whether on horizontal grade, superelevated, or not shall be vertical.

813.03.2--Concrete Railing.

813.03.2.1--General. In no case shall concrete railings be placed until the centering or falsework for the span has been released and the span is self-supporting.

813.03.2.2--Railings Cast-In-Place. The portion of the railing or parapet which is to be cast in place shall be constructed in accordance with the requirements of Section 804. Special care shall be exercised to secure smooth and tight-fitting forms which can be rigidly held to line and grade and removed without injury to the concrete.

Forms shall either be of single width boards or other approved material or shall be lined with suitable material which has the approval of the Engineer. Form joints in plane surfaces will not be permitted.

All moldings, panel work, and bevel strips shall be constructed according to the detail plans with neatly mitered joints, and all corners in the finished work shall be true, sharp, and clean-cut and shall be free from cracks, spall, or other defects.

When railing is constructed by the slipform method, placement shall be as specified in Subsection 615.03.2.

813.03.2.3--Surface Finish. The surfaces of concrete railings shall conform to the requirements of Section 804.

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

813.03.3--Metal Railing.

813.03.3.1--Construction. Fabrication and erection of ferrous metal shall be in accordance with the requirements of Section 810. In the case of welded railings, all exposed joints shall be finished by grinding or filling to give a neat appearance.

Fabrication and erection of non-ferrous material shall be in general conformity with applicable requirements of Section 810 and the specific requirements shown on the plans.

Metal railings shall be carefully adjusted prior to fixing in place to insure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at the correct grade and alignment. Welding may be substituted for rivets in field connections with the approval of the Engineer.

Where galvanized ferrous metal railing is designated by the plans, the components shall be hot dip galvanized after fabrication in accordance with the requirements of the plans.

813.03.3.2--Painting. Painting shall conform to the requirements of Sections 710 and 814.

813.03.4--Wood Railings. Wood railings will be constructed and paid for under the provisions of Section 820.

813.04--Method of Measurement. Railing of the type specified will be measured by the linear foot within the nominal measuring points of spans at bridge ends. When the contract includes rails of various heights, the appropriate pay item decryption listed below will contain the rail height

813.05--Basis of Payment. Railing of the type specified, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for completing the work.
Payment will be made under:

813-A: Concrete Railing	- per linear foot
813-B: Concrete-Steel Railing	- per linear foot
813-C: Concrete-Aluminum Railing	- per linear foot
813-D: Concrete Median Barrier Railing	- per linear foot
813-E: Type Railing	- per linear foot

SECTION 814 - PAINTING METAL STRUCTURES

814.01--Description. This work consists of furnishing all materials and painting of metal structures. It shall include, unless otherwise provided in the contract, the preparation of metal surfaces, application, protection and drying of the paint coatings, supplying of all tackle, scaffolding and other essentials necessary to complete the work in reasonably close conformity with the specifications and as indicated on the plans.

The Coating System will consist of one shop coat of inorganic zinc, one field intermediate coat of acrylic latex and one field top coat of acrylic latex. The shop coat, field intermediate coat and top coat shall each have a dry film thickness of not less than 3 mils nor more than 5 mils.

Touch-up paint for field repair of damaged areas in the inorganic zinc shop coat shall consist of epoxy mastic applied to a uniform dry film thickness of not less than 4 mils nor more than 6 mils.

814.02--Materials.

814.02.1--Shop Coat. Paint for the shop or prime coat shall be an inorganic zinc primer and meet the requirements of Subsection 710.03.

814.02.2--Acrylic Latex Intermediate Coat. Paint for the acrylic latex intermediate field coat shall meet the requirements of Subsection 710.03.

814.02.3--Acrylic Latex Top Coat. Paint for the acrylic latex top field coat shall meet the requirements of 710.03.

814.02.4--Epoxy Mastic Touch-Up Paint. Field touch-up paint for repair of damaged inorganic zinc shop coat shall meet the requirements of Subsection 710.03.

814.03--Construction Requirements.

814.03.1--Mixing of Paint. All paint shall be mixed in accordance with the manufacturer's printed instructions.

814.03.2--Weather Conditions. Solvent base paint shall not be applied when the surrounding air temperature is below 40°F. Waterborne paint shall not be applied when the surrounding air temperature is below 50°F. Paint shall not be applied when the surrounding air temperature is expected to drop to 32°F prior to drying of the paint. Paint shall not be applied when the metal is hot enough to cause blistering or produce a porous film. Paint shall not be applied when the steel surface is less than 5°F above the dew point nor shall it be applied in rain, snow, wind, fog, mist or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work.

814.03.3--Application.

814.03.3.1--Shop Coat. The coating shall be capable of being applied in accordance with specification requirements and shall be applied in accordance with the manufacturer's printed instructions.

After initial mixing, the paint shall be strained through a metal 30-60 mesh screen.

Stirring paddles on the mechanical mixing equipment shall reach to within one inch of the bottom of the paint container.

Airless spray equipment for application of inorganic zinc silicate paint shall provide pressure of not less than 2200 psi at the nozzle. The fluid hose between the pot and nozzle shall not be less than 3/8-inch inside diameter. Pressure may vary depending on tip size and pump.

Conventional spray equipment for application of inorganic zinc silicate paint shall provide pressure of not less than 10 psi at the pot and 30 psi at the nozzle.

814.03.3.2--Acrylic Latex Intermediate and Top Coats. All applications of the acrylic latex intermediate and top coats shall be in accordance with the manufacturer's printed instructions. The primer coat and the intermediate coat shall have dried a minimum of eight hours under normal conditions prior to

application of the intermediate and top coats, respectively. All surfaces shall be free of any soluble residue and surfaces on which the primer coat has been applied shall be free of excessive amounts of loose zinc before a subsequent coat is applied. Dust and dirt which may have accumulated on the surface shall be removed from the dried film with a soft brush or rag before application of a subsequent coat.

When applied by brushing or spraying, the coating shall deposit a uniform dry film thickness without running or sagging.

814.03.4--Removal of Paint. If any painting is unsatisfactory, it shall be removed and the metal thoroughly cleaned and repainted.

814.03.5--Thinning Paint. Paint shall be thinned only in strict accordance with the manufacturer's recommendations.

814.03.6--Painting Galvanized Surfaces. Prior to application of the acrylic latex field coats, galvanized surfaces shall be primed with Epoxy Mastic Touch-Up Paint as specified in Subsection 814.02.

814.03.7--Cleaning of Surfaces. Surfaces to be painted shall be thoroughly cleaned, removing rust, loose mill scale, dirt, oil or grease and other foreign substances.

All exposed and accessible surfaces of the metal shall be cleaned by sandblasting in accordance with the requirements of Steel Structures Painting Council SSPC-SP-10, Near White Blast Cleaning. The surface, regardless of starting condition, shall in the opinion of the Engineer or the Engineer’s designated representative be at least equal to the appearance of Pictorial Swedish Standard Sa 2 1/2 of SIS 05 59 00, SSPC-VIS 1.

All rust blooms shall be removed by reblasting before coating. The surface shall be constantly and diligently examined ahead of the coating operations for any traces of rust, oil, grease or blemishes not permitted by the blast cleaning specifications.

814.03.8--Shop Painting. Unless otherwise specified, the shop coat shall be applied immediately after the steel work has been accepted by the inspector.

Shop contact surfaces shall not be painted. Field contact surfaces except for machine finished pins and holes shall receive a shop coat with a minimum dry film thickness of 1½ mils. All other surfaces which will be inaccessible after assembly or erection shall be given all required coats.

Surfaces which will be embedded or in contact with concrete shall not require painting unless otherwise noted on the plans. They may be painted in whole or

partially due to overspray provided the paint thickness does not exceed the requirements specified for adjacent areas.

Structural steel which is to be field welded shall not be shop painted within two inches of the field welds.

All surfaces of iron and steel castings except for machine finished pins and holes shall be given two shop coats of paint.

Erection marks for field identification of members and weight marks shall be painted on areas previously painted with the shop coat. Material shall not be loaded for shipment until it is thoroughly dry and no sooner than 24 hours after the paint has been applied.

814.03.9--Field Painting. When the erection work is complete, including all bolting and straightening of bent metal, all rust, scale, dirt, grease and other foreign material shall be removed.

As soon as the Engineer has approved all field welding and bolting, the surfaces from which the shop coat of paint has worn off or otherwise become defective shall be cleaned and reprimed with the specified touch-up paint prior to application of the intermediate coat.

Spans with concrete decks shall not be painted until after the deck is placed. All concrete spills and stains shall be washed from the structural steel prior to the mortar taking a set.

Surfaces to be bolted in contact and surfaces which will be in contact with concrete shall not have a field coat applied. When the paint applied for retouching the shop coat has thoroughly dried and the field cleaning has been satisfactorily completed, the intermediate coat shall be applied. After the intermediate coat has thorough dried, the top coat shall be applied. In no case shall a subsequent coat be applied until the previous coat has dried throughout the full thickness of the paint film.

To secure a maximum coating on edges of plates or shapes, bolt heads and other parts subjected to special wear and attack, the edges shall be stripped with a longitudinal motion and bolt heads with a rotary motion of the brush followed immediately by the general painting of the whole surface, including recoating of the edges and bolt heads.

If, in the opinion of the Engineer, traffic produces an objectionable amount of dust, the Contractor shall, at no additional costs to the State, allay the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or surfaces prepared for painting.

The Contractor shall protect pedestrian, vehicular and other traffic upon or underneath the bridge and also all portions of the bridge superstructure and substructure against damage or disfigurement by spatters, splashes and smirches of paint or paint material. Any such disfigurement shall be removed at the direction of and to the satisfaction of the Engineer.

814.03.10--Inspection. The completed shop coat shall be inspected by the Contractor for thickness by means of elcometer or other approved magnetic detector thickness gauge. Detection of insufficiently coated sections shall be marked and shall be coated over or touched up to establish the specified thickness.

All areas of the finished system deficient in thickness shall be coated over with the acrylic latex top coat paint to establish the specified thickness. Excessive thickness in the application of any coating evidenced by mudcracking will be cause for the affected area to be blast-cleaned and repainted.

Where rejection is due to poor workmanship or deficiency in the quality of the work or materials, the Contractor may be required to blast clean the entire defective sections of all previously applied materials prior to repainting.

Inspection shall be done in the presence of and to the satisfaction of the Engineer. The Engineer shall be provided access to the work to allow for proper inspection of the cleaning and painting at both the fabrication plant and the construction site.

814.04--Method of Measurement. Unless shown as a separate pay item in the proposal, painting of metal structures or members will not be measured for separate payment and the cost thereof shall be incidental to and included in the contract unit price(s) bid for other items.

814.05--Basis of Payment. When shown as a separate pay item in the proposal, painting of metal structures or members will be paid for at the contract lump sum price, which price shall be full compensation for completing the work.

Payment will be made under:

814-A: Painting of Metal Structure	- lump sum
814-B: Painting of Description	- lump sum

SECTION 815 - RIPRAP AND SLOPE PAVING

815.01--Description. This work consists of furnishing and placing a protective covering of erosion resistant material including geotextile fabric, where shown

on the plans for pier foundation protection, slope, or ditch protection. This work shall be in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions shown on the plans or established.

815.02--Materials. Materials shall conform to the following:

Geotextile shall meet the requirements of Subsection 714.13.

Aggregate for loose riprap, stone riprap for foundation protection, or that to be grouted shall consist of field stone, broken concrete, or rough, unhewn quarry stone as nearly rectangular in section as is practicable. The stone shall be dense, free of clay or shale seams, resistant to the action of air and water, and suitable in all other respects for the purpose intended. Quality requirements for rock to be furnished under these specifications will be checked or tested as determined by the Testing Engineer prior to use and subsequently if deemed appropriate.

Portland cement concrete aggregates, unless otherwise specified, shall conform to the applicable requirements of Section 703.

Cloth sacks for concrete riprap in bags shall be of suitable cloth or jute which will hold the concrete mixture without leakage when handled. The sacks shall be of uniform size and dimensions, approximately 19½ x 36 inches measured inside the seams when the sack is laid flat. Sound reclaimed cloth sacks meeting the specified requirements may be used.

Paper sacks for concrete riprap in bags shall be a polyester fiber type of scrim reinforced paper. The top and bottom of the sacks shall have a pasted valve. When filled, they shall measure approximately 13 inches wide, 20 inches long, and five inches thick. Perforations shall be overall on one-inch centers with a diameter of 3/32 inch to 1/8 inch per hole. Each bag shall fill a space of approximately 0.71 cubic feet with 38 bags required per cubic yard. Pre-packaged riprap will be accepted on certification from the manufacturer.

Stones for riprap, of the size specified, shall meet the requirements of Subsection 705.04.

Material used for sediment control stone shall be crushed stone meeting the requirements of Subsection 703.03 for Size No. 57.

815.03--Construction Requirements.

815.03.1--Construction Details. Prior to the construction of riprap or slope paving, the slopes or ground surface shall be shaped to lines and grades indicated on the plans or directed, and shall be thoroughly compacted by the use of mechanical or hand tamps. Unless otherwise stipulated or directed, slopes shall

not be steeper than the natural angle of repose of the material upon which riprap is to be constructed.

The outer edges and the top of the riprap or slope paving where the construction terminates shall be formed so that the surface of the riprap or slope paving will be embedded and even with the surface of the adjacent slope or ground, and the bottom of the riprap or slope paving shall be placed at least two feet below the natural ground surface unless otherwise directed.

All riprap or slope paving shall be started at the bottom of the slope and constructed upward.

No grout, bag riprap, or slope paving shall be placed during freezing weather or while there is frost on the ground. Prepackaged riprap in paper bags shall be immediately soaked with water after placement to insure hydration of the cement. In hot or dry weather grout and bag riprap shall be kept moist and protected from the sun for at least three days after placing. Replacement will be required if the bags do not set up to form a solid mass. Slope paving shall be cured in accordance with the provisions of Subsection 815.03.7.4.

815.03.2--Installation of Geotextile. When required by the contract, geotextile shall be placed in the manner and at locations shown on the plans. The area to receive the geotextile shall be prepared to a relatively smooth condition free of obstructions, depressions and debris. The geotextile shall be placed loosely without wrinkles or creases with the long dimension perpendicular to the channel. The strips shall be placed to provide a minimum overlap of 18 inches. Securing pins with washers shall be inserted through both strips of overlapped geotextile at mid-point and not greater than two foot intervals. Additional pins shall be installed throughout the geotextile as necessary to prevent any slippage. The geotextile shall be placed so that the upstream strip overlaps the downstream strip and the higher slope strip overlaps the lower strip. Each securing pin shall be pushed through the geotextile until the washer bears against the geotextile and secures it firmly.

The geotextile shall be protected from contamination and damage during installation and placement of the specified cover material. Riprap shall not be dropped from a height greater than three feet. Contaminated geotextile shall be replaced, and damaged geotextile shall be repaired or replaced as directed at no cost to the Department.

The geotextile shall be covered with a layer of the specified material within 14 calendar days after placement. Geotextile not covered within this time period shall be removed and replaced at the Contractor's expense if damage or deterioration is evident, as determined by the Engineer.

815.03.3--Loose Riprap. The stones shall be placed upon a slope not steeper than the natural angle of repose of the slope material. The stones shall be laid with close joints. The courses shall be laid from the bottom of the bank upward with the larger stones being placed in the lower courses. Interstices shall be filled with smaller stones and spalls.

815.03.4--Grouted Riprap. Grout for grouted riprap shall consist of one part of portland cement and three parts of approved sand thoroughly mixed with water to produce grout having a thick, creamy consistency.
The stones shall be of the size designated in the bid schedule of the contract and shall be placed in the same manner as specified for loose riprap. Care shall be taken during placing to keep earth or sand from filling the spaces between the stones.

After the stones are in place, the spaces between them shall be completely filled with grout from bottom to top and the surface swept with a stiff broom.

815.03.5--Stone Riprap for Foundation Protection. Stone riprap for pier and abutment protection shall range in size up to derrick stone and shall be graded from coarse to fine in such manner as to produce a minimum of voids. It shall be deposited where directed and stone deposited contrary to directions will be considered wasted and will not be paid for.

815.03.6--Concrete Riprap in Bags. Concrete riprap in cloth or jute bags shall consist of Class "D" concrete in approved bags and placed in conformity with contract requirements. Each bag shall be filled with approximately one cubic foot of concrete, securely tied, and immediately placed in the work and lightly trampled to cause them to conform with the slope or section required with adjacent bags in place. Unless otherwise specified in the contract, the bagged concrete shall be packed in such a manner as to give a reasonably uniform thickness of approximately 12 inches and shall be lapped and staggered as directed.

Pre-packaged riprap in paper bags shall be filled with kiln- dried mixture of portland cement and sand, or cement, sand and gravel with a ratio of three parts sand or sand and gravel to one part portland cement. The bags shall be placed to conform with the slope or required section and with adjacent bags in place. The bags shall be lapped and staggered as directed.

When shown on the plans, pipe headwalls shall be constructed of concrete riprap in bags in accordance with these specifications and the plan details. In this construction, it is essential that the successive tiers are securely "keyed" by lapping. The bags shall be lapped one-half their length, when practicable.

815.03.7--Slope Paving. Concrete slope paving shall be constructed in a single layer in conformity with the design dimensions and details indicated on the plans.

815.03.7.1--Forms. Forms shall be wood or metal of sufficient strength to withstand the pressure of the concrete without bulging. They shall be adequately and securely staked true to line and grade.

815.03.7.2--Mixing and Placing Concrete. Unless otherwise stipulated, the concrete used in this construction shall be Class "C" Concrete, mixed and placed in accordance with the provisions and requirements of Section 804, except that volumetric batching may be used. Mixers of less than one bag rated capacity shall not be used.

815.03.7.3--Finishing. Concrete after spreading, shall be tamped and puddled until it is compact and sufficient mortar has been flushed to the surface so that it can be finished smooth with a wooden float. All edges shall be neatly edged using an approved short radius sidewalk edge.

815.03.7.4--Curing. After the concrete has set sufficiently, the surface shall be protected from premature drying by covering as soon as possible with a satisfactory material such as wetted burlap or wetted cotton mats and kept moist for a minimum of three days, or cured by other approved methods. Other approved methods include liquid membrane compound as set out in Subsection 713.01.2 and applied in accordance with the provisions of Subsection 501.03.20, except that approved hand spray methods will be acceptable, and white polyethylene sheeting conforming with the requirements of Subsection 713.01.3 and applied in accordance with the provisions of Subsection 501.03.20. Both liquid membrane compound and polyethylene sheeting shall be maintained in place and intact for a minimum period of three days.

815.03.7.5--Soil Sterilization. Prior to placing slope pavement, the areas beneath the pavement shall receive soil sterilization treatment as set out in Subsection 616.03.2.

815.03.8--Cleaning Up. Upon completion of the work, the surface of the riprap or slope paving shall be cleaned, surplus material and debris removed and disposed of as directed, and the site of the work left in a neat presentable condition.

815.04--Method of Measurement. Loose riprap will be measured in square yards or tons, as specified. Sediment control stone will be measured by the cubic yard (LVM) or ton, as specified. The pay area will be determined by using the outside dimensions of the area covered as directed. Tons or fraction thereof will be determined by railway weights or other satisfactory and approved weighing methods. Stone placed contrary to directions will not be paid for.

Measurement or payment will not be made for grout, and the cost thereof shall be included in the compensation for grouted riprap.

Concrete riprap in cloth or jute bags will be measured in cubic yards as the quantity received or manufactured at the site of the work and acceptably placed in bags as required, but from the amount received or manufactured at the site, there will be deducted all excess determined by the Engineer to have been wasted or placed to unauthorized dimensions.

The cubic yards of pre-package riprap in paper bags will be determined from the actual count of bags placed and accepted based on 38 bags per cubic yard.

Slope paving will be measured by the cubic yard computed using the dimensions shown on the plans, except that if authorized revisions are made in the finish grade or the configuration of the slope pavement, computations will be made considering the changed dimensions.

Geotextile complete in place and accepted will be measured by the square yard of surface area covered. Any overwidth of material installed and additional material required for laps or sewing will not be measured. No separate payment shall be made for shipping, handling, storage, protection, fabrication, securing pins, or installation; the cost of which shall be included in the contract price for geotextile fabric.

815.05--Basis of Payment. Loose riprap will be paid for at the contract unit price per square yard or ton. Sediment control stone will be paid for at the contract unit price per cubic yard or ton. Grouted riprap will be paid for at the contract unit price per square yard. Concrete riprap in bags and concrete slope paving will be paid for at the contract unit price per cubic yard. Geotextile will be paid for at the contract unit price per square yard. Such payment shall be full compensation for completing the work.

Payment will be made under:

815-A: Loose Riprap, Size	- per square yard or ton
815-B: Grouted Riprap	- per square yard
815-C: Concrete Riprap in Bags	- per cubic yard
815-D: Concrete Slope Paving	- per cubic yard
815-E: Geotextile under Description, Type * , AOS *	- per square yard
815-F: Sediment Control Stone	- per cubic yard or ton

* When not designated, see Subsection 714.13.

SECTION 816 - MAINTENANCE PAINTING OF METAL STRUCTURES

816.01--Description. This work consists of furnishing all materials, equipment and labor for the cleaning and painting of metal structures. It shall include, unless otherwise provided in the contract, the preparation of metal surfaces, the application, protection and drying of the paint coatings, supplying all tackle, scaffolding and other essentials necessary to complete the work in accordance with the specifications and as specified on the plans.

816.02--Materials. The coating system selected for maintenance painting must be lead free, VOC compliant and must be listed on the Department's Approved List of Materials under "Approved Coating Systems for Upgrading Existing Coatings by Maintenance Forces". The coating system shall consist of three coats as follows; an approved primer coat paint, intermediate coat paint and a top coat paint. The substitution of a primer, intermediate or top coat paint from one approved coating system to another is not permitted. The integrity of each approved coating system must be maintained.

When the project requires the painting of both new and existing metal structures, the different painting systems selected shall be from the same manufacturer and shall have the same top coat color.

816.03--Construction Requirements.

816.03.1--Weather Limitations. Solvent base paint shall not be applied when the surrounding air temperature is below 40°F. Waterborne paint shall not be applied when the surrounding air temperature is below 50°F. Paint shall not be applied when the surrounding air temperature is expected to drop to 32°F prior to drying of the paint. Paint shall not be applied when the metal is hot enough to cause blistering or produce a porous film. Paint shall not be applied when steel surface is less than 5°F above the dew point nor shall it be applied in rain, snow, wind, fog, mist or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work.

816.03.2--Pollution Control During Surface Preparation And Repainting. Generated debris must be confined to the immediate area of the structure. Appropriate screens and barriers must be erected to protect pedestrian and vehicular traffic during waterblasting and painting operation. Overspray must be kept to a bare minimum.

816.03.3--Surface Preparation. Surface preparation will include waterblasting the entire surface followed by spot cleaning with hand tools to remove any remaining loose or flaking paint or rust, dirt, oil, grease and/or other deleterious matter from the steel surface. Tightly bonded paint is not to be removed and it is not necessary to remove tightly bonded rust.

In areas containing a heavy coating of oil, grease and/or deleterious material that cannot be cleaned by waterblasting, use BIOACT AE-O or an approved biodegradable solvent that is environmentally equivalent. Brush or mop the solvent on the surface with a rubbing action to loosen the film. Wipe off with a clean dry cloth and then rinse by waterblasting. Repeat as necessary until clean. The cleanliness of the surface shall be approved by the Project Engineer or a designated representative prior to beginning painting operations.

816.03.3.1--Waterblasting. The waterblasting unit must be capable of operating at pressures up to 4,000 psi at a water flow rate up to 10 gpm. The unit must be equipped with a water filter, pressure gauge, nozzle with 1/8-inch orifice or one that will provide a jet stream of water, and sufficient length of hydraulic hose. The unit shall be equipped with a deadman control valve or other control valves that will provide automatic shut-off by release of the trigger. Water for blasting must be potable water to prevent damage to the pump and to insure a clean surface on the steel. During waterblasting operation, wood, insulation, electrical, instrumentation, etc., must be protected. After waterblasting, remove any remaining loose paint, loose rust and rust scale with wire brushes or other methods as necessary. Using the waterblast unit or compressed air, remove the loose debris generated from the hand tool cleaning operation. To prevent recontamination of the steel surface, the surface preparation operation should not be completed more than eight hours in advance of the painting operation. Should any recontamination occur prior to painting, repeat surface preparation procedures as necessary for removal. Before painting, the surfaces must be clean and dry. To enhance drying of the surfaces, compressed air may be used.

816.03.3.2--Safety and Clean-Up. During the cleaning of the existing steel, the Contractor may be dealing with hazardous material and the Contractor will be responsible for the health and safety of employees. The Contractor shall provide such items as protective clothing and respirators and make certain that they are used. The Contractor shall also be responsible for the maintenance and/or replacement of these items. The Contractor is advised that safety precautions for workers during each phase of work shall be in compliance with present OSHA standards.

The Contractor shall take necessary precautions to prevent an excessive amount of removed materials from falling beneath the structure. General debris must be confined to the immediate area of the structure. Appropriate measures shall be taken to protect the traveling public during surface preparation and painting operations.

The Contractor shall clean the area of excessive debris generated from cleaning and properly dispose of it at an approved landfill.

The Contractor shall take necessary steps to become familiar with any applicable Federal, State or local regulations and take the necessary actions for compliance when applicable to any portion of the required work.

816.03.4--Packaging and Marking. Multiple component paints shall be furnished in premeasured packages so as to form one unit of mixed paint when mixed with the vehicle in its container.

The containers for all paints shall be coated as necessary to prevent attack by the paint. Each container shall bear a label with the following information shown thereon: name and address of manufacturer, trade mark or trade name, kind of paint, date of manufacture and lot number, mixing instructions and equipment clean up instructions. The VOC content shall be stated either on the label, product data sheet, or Material Safety Data Sheet.

816.03.5--Acceptance Procedure. Prior to use, the Contractor must furnish the Engineer a certificate from the manufacturer, covering each lot of paint in the shipment, attesting that the paint in the shipment conforms to the same formula as that originally approved by the Department.

Final acceptance of the paint will be based on results of tests performed by the Central Laboratory on samples obtained by the Department's representative prior to or after delivery. The use of any lot of paint prior to its final acceptance shall be prohibited.

816.03.6--Mixing, Thinning and Application. All paint shall be mixed and applied in accordance with the manufacturer's printed instructions. Paint shall be thinned only under conditions which follow strict accordance with the manufacturer's recommendations.

At the Engineer's request, the paint manufacturer's technical representative who is certified by the National Association of Corrosion Engineers (NACE) shall be present at the job site at the beginning of each separate coating operation as needed to provide technical expertise in the application of the field coats. This technical expertise shall be provided without additional cost to the Department. The Contractor shall be responsible for arranging for the presence of the manufacturer's technical representative.

Apply the paint to the Wet Film Thickness (WFT) that will obtain the Dry Film Thickness (DFT) required for the film being applied. The DFT required for each paint film of each approved coating system is set out in the Department's Approved List of Materials.

A subsequent coat shall not be applied until the previous coat has dried throughout the film thickness.

To secure a maximum coating on edges of plates or shapes, rivets, bolt heads and other parts subjected to special wear and attack, the edges shall be stripped with a longitudinal motion and the rivets and bolt heads with a rotary motion of a brush followed immediately by general painting of the whole surface, including recoating of the edges, rivets and bolt heads.

If, in the opinion of the Engineer, traffic produces an objectionable amount of dust, the Contractor shall, at no additional costs to the State, allay the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or surfaces prepared for painting.

The Contractor shall protect pedestrian, vehicular and other traffic upon or underneath the bridge and also all portions of the bridge superstructure and substructure against damage or disfigurement by splatters, splashes and smirches of paint or paint material. Any such disfigurement shall be removed at the direction of and to the satisfaction of the Engineer.

816.03.7--Inspection. The Contractor shall measure the paint thickness with an elcometer or other approved magnetic detector thickness gauges. All areas of the finished system deficient in thickness shall be coated over with the finish paint to establish the specified thickness. Excessive thickness in the application of either coating evidenced by mudcracking will be cause for the effected area to be stripped of paint, cleaned and repainted.

Where rejection is due to poor workmanship or deficiency in the quality of the work or materials, the Contractor may be required to strip the entire defective sections of all previously applied materials and clean prior to repainting.

Inspection shall be done in the presence of and to the satisfaction of the Engineer.

816.04--Method of Measurement. Maintenance painting of structures and members will be measured lump sum or per each as provided in the contract.

816.05--Basis of Payment. Maintenance painting of structures and members will be paid for at the contract unit price per each or lump sum, which price will be full compensation for preparation of the surface, for furnishing and applying all materials and for all labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

816-A: Maintenance Painting of Metal Structures - lump sum

816-B: Maintenance Painting of Metal Structure,
Location / Description - per each

816-C: Maintenance Painting of Description - lump sum

SECTION 820 - TIMBER STRUCTURES

820.01--Description. This work consists of constructing timber structures in conformity with these specifications and in accordance with lines, grades, dimensions, and details shown on the plans.

820.02--Materials.

820.02.1--Lumber and Timber. Lumber and timber shall conform to the requirements of Section 718, and in the case of exposed permanent structures shall be treated as set out therein. Certain portions of untreated timber shall be coated as set out hereinafter and as may be shown on the plans.

820.02.2--Rods, plates, Eyebars, and Shapes. Rods, plates, eyebars, and shapes shall be of structural steel conforming to the requirements of Section 717.

820.02.3--Castings. Castings shall be cast steel or gray-iron, as specified, conforming to the requirements of Subsections 716.02 or 716.04.

820.02.4--Hardware. Machine bolts, drift bolts, and dowels may be either wrought iron or medium steel. Washers may be cast ogee or malleable castings, or they may be cut from medium steel or wrought iron plate, as specified.

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

Nails, spikes, bolts, dowels, washers, and lag screws shall be galvanized unless otherwise specified.

820.03--Construction Requirements.

820.03.1--Storage of Material. Lumber and timber stored on the site shall be kept in orderly piles or stacks. Untreated material shall be open-stacked on supports at least 12 inches above the ground surface to avoid absorption of ground moisture and to permit air circulation, and it shall be so stacked and stripped as to permit free circulation of air between the tiers and courses. It will be advisable in particular cases for the Engineer to require protection from the weather by a suitable covering. On glued laminated structural members that are not to be treated, an approved end sealer shall be applied after end trimming of each completed member.

820.03.2--Installing Timber Piling.

820.03.2.1--Driving Piling. Timber piles shall be driven in accordance with the requirements of Subsection 803.02.6, except as modified herein.

820.03.2.2--Pile Hammer Formulas. Pile hammer formulas shall be per the requirements of Subsection 803.03.9.6, except the use of gravity or drop hammers shall be allowed. In the absence of loading test, safe bearing values for piles driven with a gravity or drop hammer shall be determined by the following formula:

$$P = \frac{2WH}{S+1.0}$$ for gravity or drop hammers

820.03.3--Timber Connectors. Timber connectors shall be one of the following types, as specified on the plans: the split ring, the toothed ring, the shear plate, or the spike grid. The split ring and the shear plate shall be installed in pre-cut grooves of dimensions as given herein or as recommended by the manufacturer. The toothed ring and the spike grid shall be forced into the contact surface of the timbers joined by means of pressure equipment. All connectors of this type at a joint shall be embedded simultaneously and uniformly.

Fabrication of all structures using connectors shall be done prior to treatment. When prefabricated from templates or shop details, bolt holes shall not be more than 1/16 inch from required placement. Holes for round drift bolts shall be bored with a bit 1/16 inch less than the bolt to be used. The diameter for square drift bolts shall be equal to the least dimension of the bolt. Holes for machine bolts shall be bored with a bit the same diameter as the bolt. Bolt holes shall be bored perpendicular to the face of the timber.

Timber after fabrication shall be stored in a manner which will prevent changes in the dimensions of the members before assembly.

Dimensions of material and details not otherwise specified shall meet with the approval of the Engineer.

820.03.4--Treated Timber.

820.03.4.1--Handling. Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising, or penetrating the surface with tools. It shall be handled with rope slings. Cant hooks, peaveys, spikes, or hooks shall not be used. Prior to driving, the timber piling shall not be handled in such a manner that it is subjected to excessive and undue abuse that might produce splitting, splintering or brooming of the wood.

820.03.4.2--Placement. All cutting, framing, and boring of treated timber shall be done before treatment insofar as practicable. When treated timbers are to be

placed in waters infected by marine borers, untreated cuts, borings, or other joint framings below high water elevation shall be avoided.

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

820.03.4.4--Bolt Holes. All bolt holes bored after treatment shall be treated with creosote oil by means of an approved pressure bolt hole treater. Any unfilled holes, after being treated with creosote oil, shall be plugged with creosoted plugs.

820.03.4.5--Temporary Attachment. Whenever, with the approval of the Engineer, forms or temporary braces are attached to treated timber with nails or spikes, the holes shall be filled by driving galvanized nails or spikes flush with the surface or plugging holes as required for bolt holes.

820.03.5--Untreated Timber. In temporary structures of untreated timber the following surfaces shall be thoroughly coated with two coats of hot creosote oil before assembling: ends, tops, and all contact surfaces of sills, caps, floor beams, and stringers; and all ends, joints, and contact surfaces of bracing and truss members. The back faces of bulkheads and all other timber which is to be in contact with earth, metal or other timber shall be similarly treated.

Bolts passing through non-resinous wood shall be galvanized.

820.03.6--Treatment of Pile Heads. The heads of treated timber piles shall be protected as specified on the plans. If not specified, the fabric covering shall be used. The heads of timber piles, when the nature of the driving will unduly injure them, shall be protected by driving caps. When the area of the head of a timber pile is greater than that of the face of the pile hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the cross section of the pile. Fresh heading of a timber pile is recommended prior to driving. The head shall be cut square and shall be shaped or chamfered to prevent splitting at its periphery. Heads of all piling shall be square and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer.

820.03.6.1--Cutting Off of Timber Piles. 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. Piles which support timber caps or grillage shall be sawed to conform to the plane of the bottom of the superimposed structure. In general, the length of pile above the cut-off elevation shall be sufficient to permit the complete removal of all material injured by driving, but piles driven to very nearly the cut-off elevation shall be carefully adzed or otherwise freed from all broomed, splintered

or otherwise injured material. Pile heads, after cutting to receive the caps and prior to placing the caps, shall be treated in accordance with Subsection 820.03.6.

820.03.6.2--Defective Piles. All piles damaged because of internal defects or by improper driving, driving out of the proper location, or driving below the specified elevation shall be corrected at no additional costs to the State by one of the following methods approved by the Engineer for the pile in question:

A. The pile shall be withdrawn and replaced by a new, and if necessary, a longer pile.

B. A second pile shall be driven adjacent to the defective or low pile.

C. A sufficient portion of the footing shall be extended to properly embed the pile. Timber piles shall not be spliced. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

820.03.6.3--Metal Covering. The sawed surface shall be covered with three applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or thoroughly brush-coated with three applications of hot creosote oil and covered with hot roofing pitch. Before placing the cap, a sheet of 12 gauge, 0.028-inch zinc of good commercial quality or a sheet of 26 gauge iron or steel of the quality of ASTM Designation: A 525 and galvanized each side shall be placed on each pile head. The sheet shall be of sufficient size to project at least four inches outside of the pile, and it shall be bent down, neatly trimmed and securely fastened to the face of the pile with large headed galvanized roofing nails.

820.03.6.4--Fabric Covering. The heads of all piles shall be covered with alternate layers of hot pitch and loosely woven fabric similar to membrane waterproofing, using four applications of pitch and three layers of fabric. The cover shall measure at least six inches more in dimensions that the diameter of the pile and shall be neatly folded down over the pile and secured by large headed galvanized nails or by binding or serving with not less than seven complete turns of galvanized wire securely held in place by large-headed galvanized nails and staples. The edges of the fabric projecting below the wire wrapping shall be trimmed to present a workmanlike appearance.

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

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

B. The sawed surface shall be heavily coated with paint, after which it shall be covered with cotton duck of a least eight-ounce weight, which shall be

folded down over the sides of the pile and firmly secured thereto with large-headed roofing nails. The edges of the duck shall be trimmed to give a workmanlike appearance. The duck shall then be waterproofed by being thoroughly saturated and coated with one or more applications of red lead paint.

820.03.7--Holes for Bolts, Dowels, Rods and Lag Screws. Holes for round drift bolts and dowels shall be bored with a bit 1/16 inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit the same diameter as the bolt, except as otherwise provided in Subsection 820.03.3.

Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rods.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

820.03.8--Bolts and Washers. A washer, of the size and type specified, shall be used under all bolt heads and nuts which would otherwise come in contact with wood.

The nuts of all bolts shall be effectively locked after they have been finally tightened.

820.03.9--Framing. All lumber and timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth, and tenons shall fit snugly. No shimming will be permitted in making joints, nor will open joints be accepted.

820.03.10--Pile Bents. Pile bents shall be constructed in accordance with applicable provisions of Section 803.

820.03.11--Framed Bents.

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

820.03.11.2--Concrete Pedestals. Concrete pedestals for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them. Dowels of at least 3/4-inch diameter and projecting at least six inches

above the tops of the pedestals shall be set in them when they are cast for anchoring the sills or posts.

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

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

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

A. By dowels of not less than 3/4-inch diameter extending at least six inches into posts and sills.

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

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

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

820.03.14--Stringers. Stringers shall be sized at bearings and shall be placed in position so that knots near edges will be in the top portions of the stringers.

Outside stringers may have butt joints with the ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beams or cap at each end. The lapped ends of untreated stringers shall be separated at least 1/2 inch for the circulation of air and shall be securely fastened by drift-bolting where specified. When stringers are two panels in length the joints shall be staggered.

Cross-bridging between stringers shall be neatly and accurately framed and securely toe nailed with at least two nails in each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Unless

otherwise specified in the contract, cross-bridging shall be placed at the center of each span.

820.03.15--Plank Floors. Unless otherwise specified, planks used in this construction shall conform to the requirements set forth in Subsection 820.02.1.

Single plank floor shall consist of a single thickness of plank supported by stringers or joists. The planks shall be laid heart side down, with 1/4-inch openings between them for seasoned material and with tight joints for unseasoned material. Each plank shall be securely spiked to each joist. The planks shall be carefully graded as to thickness and so laid that no two adjacent planks shall vary in thickness by more than 1/4 inch.

Two-ply timber floors shall consist of two layers of flooring supported on stringers or joists. The lower course shall be pressure treated with creosote oil. The top course may be laid either diagonally or parallel to the centerline of roadway as specified, and each floor piece shall be securely fastened to the lower course. Joints shall be staggered at least three feet. If the top flooring is placed parallel to the centerline of the roadway, special care shall be taken to securely fasten the ends of the flooring. At each end of the bridge these members shall be beveled.

820.03.16--Laminated or Strip Floors. The strips shall be of the grade required in Section 718. The strips shall be placed on edge at right angles to the centerline of the roadway. Each strip shall be spiked to the preceding strip at each end and at approximately 18-inch intervals with the spikes driven alternately near the top and bottom edges. The spikes shall be of sufficient length to pass through two strips and at least half-way through the third strip.

If timber supports are used, every other strip shall be toe-nailed to each timber support. The size of the spikes shall be as shown on the plans. When specified on the plans, the strips shall be securely attached to steel supports by the use of approved galvanized metal clips. Care shall be taken to have each strip vertical and tight against the preceding one and bearing evenly on all the supports.

820.03.17--Wheel Guards and Railing. Wheel guards and railing shall be accurately framed in accordance with the plans and erected true to line and grade. Unless otherwise specified, wheel guards, rails and rail posts shall be surfaced four sides, S4S. Wheel guards shall be laid in sections at least 12 feet long.

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

820.03.19--Painting. Rails and rail posts of untreated timber, or timber treated with preservative salts, shall be painted with three coats of paint.

Parts of the structure, other than rails and rail posts, which are to be painted, will be designated on the plans or in the special provisions.

Metal parts, except hardware, shall be given one coat of shop paint and after erection two coats of field paint as specified on the plans.

820.04--Method of Measurement. Timber remaining in the structure will be measured by the thousand feet board measure (MBM) which shall include the cost of all hardware, galvanizing, paint and painting. Computations of the amount of lumber and timber in the structure will be based on nominal sizes and the lengths indicated on the plans.

Piling will be measured in accordance with Subsection 803.04.

Metal parts, other than hardware, will be measured in accordance with Section 810.

820.05--Basis of Payment. Timber will be paid for at the contract unit price per thousand feet board measure, which price shall be full compensation for completing the work. Acceptable piling will be paid for at the respective contract prices per linear foot for the types and sizes specified, which price shall be full compensation for completing the work.

Payment will be made under:

820-A: Treated Timber	- per MBM
820-B: Untreated Timber	- per MBM
820-C: Untreated Timber Piling	- per linear foot
820-D: Treated Timber Piling	- per linear foot

SECTION 822 - NEOPRENE EXPANSION JOINTS

822.01--Description. This work consists of furnishing and installing neoprene expansion joints in accordance with these specifications and details shown on the plans.

822.02--Materials. Expansion joints shall meet the requirements of Subsection 707.07.

822.03--Construction Methods. Expansion joints shall be installed in accordance with the manufacturer's recommendations. The expansion material shall seal the deck surface, gutters and curbs to prevent moisture or other contaminants from leaking through the joints. Anchor bolts shall be cast-in-place or drilled and grouted at a spacing recommended by the manufacturer. The expansion material shall be installed in such a manner that the top surface of the material will be parallel to but not protrude above the roadway or bridge surface.

822.04--Method of Measurement. Neoprene expansion joints of the types specified will be measured in linear feet.

822.05--Basis of Payment. Neoprene expansion joints will be paid for at the contract unit price per linear foot, which price shall be full compensation for completing the work.

Payment will be made under:

822-A: ___" Neoprene Expansion Joint, Type___ - per linear foot