

Section 553 - Prestressed Concrete Structures

DESCRIPTION

553.01
Work

This work shall consist of the construction of prestressed concrete structures and the prestressed concrete portions of composite structures. The work shall include the furnishing and installing of any appurtenant items necessary for the particular prestressing system to be used, including grout. For cast-in-place prestressed concrete, the term "member" as used in this section shall be considered to mean the concrete that is to be prestressed.

It shall include the manufacture, transportation, and storage of beams, slabs, piling, and other structural members. It shall also include the installation of all precast prestressed members except piling, which shall be placed as provided for in Section 551. Prestressed members shall be furnished complete, including all concrete, prestressing steel, bar reinforcing steel, and incidentals in connection therewith.

553.02
Prestressing Methods

Unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS, only the pretensioning method of stressing will be allowed. The method of pretensioning will be optional with the contractor, subject to the requirements hereinafter specified.

Prior to casting any prestressed members, the contractor shall submit to the Engineer complete details of the method, materials, and equipment proposed for use in the prestressing operations. Such details shall outline the method and sequence of stressing, complete specifications and details of the prestressing steel and anchoring devices proposed for use, anchoring stresses, type of enclosures, and all other data pertaining to the prestressing operations, including the proposed arrangement of the prestressing units in the members, pressure grouting materials, and equipment.

Shop drawings shall be required for all prestressed precast members. Four sets of all shop drawings or two sets plus one reproducible set of all shop drawings, including the concrete mix design for each class of concrete to be used, shall be submitted to the Engineer a minimum of 21 days in advance of planned construction. Mix designs shall have been reviewed and shop drawings shall have been approved by the Engineer and returned to the contractor prior to construction, including fabrication of prestressed members.

Shop drawings for prestressed members shall include the prestressing bed layout and overall length between grips at fixed and jacking ends, the type of equipment to be used, the specific prestressing method, and the strand tensioning sequence. They shall also include the strand pattern at midspan and at centerline of bearing; location of total strand center of gravity at midspan, at hold-down points, at quarter points, and at centerline of bearing; and lifting devices and threaded inserts (brand name and part number). These shop drawings shall be accompanied by the calibration curve for the gauge and jacking system, the prestressing strand certification, the stress-strain curve for the prestressed strands, and computations for strand geometry, pressure gauge readings, and strand elongation measurements.

553.03
Consulting Service

The contractor shall certify to the Engineer that a technician skilled in the approved prestressing method will be available to the contractor to give such aid and instruction in the use of the prestressing equipment and installation of materials as may be necessary to obtain required results.

MATERIALS

553.04
Requirements

Materials shall meet the requirements of the following Subsections:

Concrete	552.03-04
Grout and Mortar	701.02-03
Reinforcing Steel	709.01
Prestressing Steel	709.03
Structural Steel	717.01
Hardware, Nuts, and Bolts.	717.02-03
Joint Fillers	705.01
Elastomeric Bearing Pads	717.13

The concrete shall be Class P unless otherwise SHOWN ON THE DRAWINGS. Concrete in prestressed members shall have a 28-day design compressive strength (f'c) as SHOWN ON THE DRAWINGS. The concrete mix shall be designed by the contractor in accordance with Subsection 552.02(b). Lightweight concrete will not be permitted unless otherwise SHOWN ON THE DRAWINGS.

All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times. Prestressing steel that has sustained physical damage other than that allowed by Subsection 553.10 shall be rejected.

Prestressing steel shall be packaged in containers or other shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete.

All wire shall be free from defects and shall have a smooth surface finish. Material that shows defects will be rejected.

553.05
Testing

All wire, strand, anchorage assemblies, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. All samples submitted shall be representative of the lot to be furnished and, in the case of wire or strand, shall be taken from the same master roll. All of the materials specified for testing shall be furnished free of cost and shall be delivered 30 days prior to the anticipated time of use.

If requested by the Engineer, the vendor shall furnish samples at least 7 feet long for each strand size. A sample shall be taken from each coil. The selection of samples will be made at the manufacturer's plant by the Engineer.

When prestressing systems have been previously tested and approved for similar projects by an agency acceptable to the Engineer, complete tendon samples need not be furnished, provided there is no change in the materials, design, or details previously approved.

The strength of precast concrete required prior to release of pretensioned strands or required prior to lowering of curing temperature of nonprestressed members shall be determined by tests on test cylinders cast and cured under conditions in which the time-temperature relationship of the cylinder will simulate as nearly as possible that obtained during the curing of the structural member. When the forms are heated by steam or hot air, the cylinder will be placed in the lowest heat zone during the curing period. When forms are heated by some other means, a recording of the time-temperature relationship of the test cylinder must be available for comparison with that of the prestressed unit.

The test cylinders shall be molded, cured, and tested in accordance with AASHTO T 126 and T 22 for 28-day test cylinders and AASHTO T 23 for test cylinders cured with the members. When accelerated curing methods are used, the cylinders shall be allowed to cool for at least 1/2 hour prior to capping and caps of sulfur compound shall be allowed to cure 1/2 hour before testing.

As a minimum, the following numbers of test cylinders shall be taken. More shall be taken if the Engineer judges it necessary.

Prestressed members (from the same placements):

Number of Members/Day	Release Test Cylinders Taken ^a	Minimum Cylinders Broken (Release Test)	28-Day Strength Test Cylinders Taken and Broken ^a
1	3	2	3
2	3	1 per beam	4 ^b
3	3 ^c	1 per beam	6 ^b
4	4 ^c	1 per beam	8 ^b
5	5 ^c	1 per beam	10 ^b
6	6 ^c	1 per beam	12 ^b
7	7 ^c	1 per beam	14 ^b
8	8 ^c	1 per beam	16 ^b

- ^aAssumes all concrete is air-entrained or non-air-entrained. If both types of concrete are used in the same member, the number of test cylinders listed shall be taken from the air-entrained concrete and the same number of test cylinders shall be taken from the non-air-entrained concrete.
- ^bTwo test cylinders taken from each member.
- ^cOne test cylinder taken from each member.

CONSTRUCTION

553.06
Performance

Prestressed concrete structural members shall be constructed in accordance with Section 552, and reinforcing steel shall be placed in accordance with Section 554.

The Engineer shall be notified a minimum of 7 days prior to fabrication of any prestressed members so that inspection of fabrication operations can be arranged. Dimensional tolerances for prestressed girders shall be as given in Division 5, Section 5 of PCI Manual 116-77 ("Manual for Quality Control: Precast Prestressed Concrete Products," Prestressed Concrete Institute, Chicago, Illinois).

553.07
Prestressing
Equipment

Hydraulic jacks used to stress tendons shall be equipped with either a pressure gauge or a load cell for determining the jacking stress. The pressure gauge, if used, shall have an accurate reading dial at least 6 inches in diameter and each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force, and shall be accompanied by a certified calibration chart. The load cell, if used, shall be calibrated and shall be provided with an indicator by which the prestressing force in the tendon can be determined. The range of the load cell shall ensure that the lower 10 percent of the manufacturer's rated capacity will not be used in determining the jacking stress.

Safety measures shall be taken by the contractor to prevent accidents due to possible breaking of the prestressing steel or the slipping of the grips during the prestressing process.

553.08
Casting Yard

Prestressed concrete members shall be manufactured in commercial precasting yards unless otherwise approved in writing by the Engineer.

553.09
Placing Steel

All steel units shall be accurately placed in the position SHOWN ON THE DRAWINGS and in accordance with Section 554.

Threaded inserts shall develop the full tensile strength of bars or bolts they secure. Unless otherwise SHOWN ON THE DRAWINGS, lifting devices of adequate strength to safely lift the girders shall be provided within 2 feet of the girder ends.

No welds or grounds for welding equipment shall be made on the forms or on the steel in the member after the prestressing steel has been installed.

Wires, wire groups, parallel-lay cables, and any other prestressing elements shall be straightened to ensure proper position in the enclosures. Suitable horizontal and vertical spacers shall be provided, if required, to hold the wires in position.

553.10
Stressing

The prestressing element shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongations produced. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete nor end anchorages released until the concrete has attained a compressive strength, as shown by cylinder tests, of at least 4,000 psi unless otherwise SHOWN ON THE DRAWINGS. The elements shall be cut or released in such an order that lateral eccentricity of prestress will be at minimum.

Strands should be stressed when the Engineer is present. The contractor or his representative shall record the pretensioning gauge pressures and measured strand elongations and provide a copy to the Engineer.

A seven-wire strand, with one broken wire, may remain in the member, provided it is within the following limits established for the member:

For members with:

Less than 20 strands, no wire breaks permitted.
20 to 39 strands, 1 wire break permitted.
40 to 59 strands, 2 wire breaks permitted.
60 or more strands, 3 wire breaks permitted.

The occurrence of more than the permissible number of wire breaks or more than one broken wire in any individual strand shall require that the strand or strands be removed and replaced. Any wire breaks that are permitted to remain in the member shall be located and the broken ends shall be securely wrapped with tie wire to prevent ravelling.

553.11
Placing Concrete

Concrete should not be deposited in the forms until the Engineer has inspected the placing of the reinforcement, enclosures, anchorages, and prestressing steel. The concrete shall be vibrated in such a way to avoid displacement of reinforcement, conduits, or wires.

Prior to placing concrete, the contractor shall ensure that all ducts are unobstructed.

553.12
Curing

Steam curing or radiant heat with moisture process may be used as an alternative to water curing. The casting bed for any unit cured with steam shall be completely enclosed by a suitable type of housing, tightly constructed to prevent the escape of steam and exclude outside atmosphere. Two to 4 hours after the placement of concrete and after the concrete has undergone initial set, the first application of steam shall be made, unless retarders are used, in which case the waiting period before application of the steam shall be increased to 4 to 6 hours.

For accelerated curing, a minimum of one continuous temperature recording device shall be used per 100 feet of continuous bed length being used. Copies of the temperature records, with the identification of the girder, shall be furnished to the Engineer.

Curbs and diaphragms cast after the prestress member has been cured or separately placed may be steam cured for a minimum of 12 hours at 100 °F to 160 °F or moist cured for a minimum of 3 days in accordance with Subsection 552.14.

The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 40 °F per hour until a maximum temperature of from 140 °F to 160 °F is reached. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 40 °F per hour until a temperature has been reached of 20 °F above the temperature of the air to which the concrete will be exposed. The concrete shall not be exposed to temperatures below freezing until the specified 28-day strength has been achieved.

Radiant heat shall be applied to beds by means of pipes circulating steam, hot oil, or hot water, or by electric blankets or heating elements on forms. Pipes, blankets, or elements shall not be in contact with concrete, form surfaces, or test cylinders.

During the cycle of radiant heat curing, effective means shall be provided to prevent rapid loss of moisture in any part of the member. Moisture may be applied by a cover of moist burlap or cotton matting. Moisture may be retained by covering the member with a plastic sheet in combination with an insulating cover or by applying a liquid seal coat, approved by the Engineer, or membrane curing compound.

To prevent cracking of members, strands shall be detensioned and their stress transferred to the concrete immediately upon attainment of required release strengths and before the members have been allowed to dry and cool. Should this be impractical, the members shall be kept covered and moist and shall be held at a minimum temperature of 60 °F until strands are detensioned.

If the contractor proposes to cure by any other method, the method and its details shall be subject to the approval of the Engineer.

553.13
Bonding Steel

Unless otherwise SHOWN ON THE DRAWINGS, steel shall be bonded to the concrete.

553.14
Finishing

Unless otherwise SHOWN ON THE DRAWINGS, the exterior surface of the exterior girders and the bottom flanges of all girders shall be given a Class 2 Rubbed Finish as specified in Subsection 552.13. The rest of the girders shall be given a Class 1 Ordinary Surface finish.

Portions of prestressed members that will serve as bridge decks will be finished as SHOWN ON THE DRAWINGS.

The contractor, with the approval of the Engineer, will be allowed to repair rock pockets and other minor deficiencies of a nonstructural nature in the girders. Any girders that are repaired without the approval of the Engineer may be rejected regardless of the extent of the repair work.

553.15
Handling

Extreme care shall be exercised in handling, moving, and erecting precast, prestressed concrete members. Precast girders and slabs shall be transported in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position.

Precast, prestressed concrete members shall not be shipped from the casting plant for at least 72 hours after the prestressing strands have been released or the curbs and/or diaphragms have been cured as specified in Subsection 553.12.

553.16
Erecting &
Placement

The contractor shall advise the Engineer a minimum of 48 hours before prestressed girders for multi-beam bridges are to be field welded, and before any field grout or mortar is to be placed.

If necessary, multi-beam girders shall be adjusted, using galvanized steel shims the same length and width as the bearing pad or plate. No more than 1/8 inch vertical difference shall exist between top of adjacent beam edges at each end of the span. When an asphalt wearing surface or cast-in-place deck is to be placed on top of the prestressed beams, this vertical tolerance may be 1/2 inch. Beams will not be loaded to make them assume the same camber as an adjacent beam.

Mortar shall be used in keyways between multi-beam members and to patch defects, blockouts, or other areas on the concrete roadway portion of the structure 1 inch or more depth and over 1 inch in width. Smaller areas on the concrete roadway shall be patched with the grout.

Air and concrete keyway temperatures shall be between 45 °F and 85 °F before placement of mortar. The temperature must be expected to remain within these limits until mortar placement and application of curing method is completed.

Grout shall be used on all anchor bolts and dowels to make all repairs.

Air and concrete temperatures required for grout placement shall be the same as required for mortar. The area to be grouted shall be thoroughly saturated with water and all free-standing water removed just prior to grout placement.

Exposed grout surface shall be struck off flush and given the same surface texture finish as the surrounding concrete as soon as the grout has set sufficiently. The exposed surface shall be cured as specified in Subsection 552.14. When artificial means are used to control the curing temperature of the mortar or grout, as in hot or cold weather, the means shall be approved by the Engineer in advance. Combustion heaters may be used only if fully vented outside their enclosure. All dry mortar materials and mixing and placing equipment shall be stored such that their temperature is above freezing. Mixing water may be warmed to provide mortar or grout at desired temperature, but shall be 90 °F or less when mixed with the dry materials. Ice may be used as part of the mixing water provided it is completely melted prior to the introduction of the water to the dry materials.

Patching mortar and grout shall be the same color as the parent concrete.

Precast prestressed concrete piling shall be placed in accordance with the requirements for precast concrete piling in Section 551. Other precast prestressed structural members shall be placed in the structure as SHOWN ON THE DRAWINGS and in accordance with contract provisions governing the particular type of structure to be built.

Field welding shall meet the requirements of Section 555. When welding or burning on precast members, the ground lead shall be attached directly to the base metal; if a precast prestressed member is used as a conductor for the ground, the member will be rejected and shall be replaced by the contractor without compensation.

MEASUREMENT

553.17
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS. Each member will include the concrete, reinforcement and prestressing steel, enclosures for prestressing steel, anchorages, plates, nuts, elastomeric bearing pads, and other material contained within or attached to the unit.

Piling will be measured as provided in Section 551.

PAYMENT

553.18
Basis

The accepted quantities will be paid at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

<u>Pay Item</u>	<u>Pay Unit</u>
553(01) Prestressed Concrete Structural Member _____ (Identification)	EA.
553(02) Prestressed Concrete Structure	L.S.

Section 553A - Precast Concrete Structures

DESCRIPTION

553A.01
Work

This work shall consist of the construction of precast concrete portions of composite structures. The work shall also include manufacture, materials testing, transportation, storage, and installation of all precast concrete portions, except piling, including all necessary grouting, welding, or other connections. Precast concrete members shall be furnished complete, in place, including all concrete reinforcing steel, and incidentals connected therewith.

MATERIALS

553A.02
Requirements

Materials shall meet the requirements of the following Subsections:

Concrete	552.03-04
Reinforcing Steel	554.02
Grout and Mortar	701.02-03
Joint Fillers	705.01
Structural Steel	717.01
Hardware, Nuts, and Bolts	717.02-03
Elastomeric Bearing Pads	717.13

The contractor shall perform all sampling, testing, and inspection necessary to ensure quality control of the component materials and the concrete. Sampling and testing for quality control and acceptance testing shall be in accordance with the AASHTO or ASTM test methods prescribed in Section 552.

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, the quantities approved and rejected, and the nature of any corrective action taken.

Every batch shall be sampled and tested (100 percent sampling and testing) for air content and slump at the start of concrete production. Random sampling and testing for air content and slump at the rate of one for every five successive batches may be substituted for 100 percent sampling and testing if the test results for three successive batches are within the specification limitations for air content or slump, except that 100 percent sampling and testing will be reinstated if a test result for any random sample is outside the specification limitations for either air content or slump.

Compression tests to determine the minimum strength requirements shall be made on cylinders. A minimum of three cylinders will be made from each day's production and cured in the same manner as the precast units. Testing methods shall be in accordance with AASHTO T 22.

The contractor or the supplier shall furnish the Engineer with a Certificate of Compliance certifying that the above materials comply with the applicable contract specifications. A copy of all test results performed by the contractor or supplier necessary to ensure contract compliance shall also be furnished to the Engineer.

CONSTRUCTION

553A.03
Performance

Precast Concrete Structural Members shall be constructed in accordance with the applicable Sections of the following:

Concrete	552
Curing	552.14
Steam Curing or Radiant Heat	553.12

Finishing	553.14
Handling	553.15
Erecting and Placement	553.16
Reinforcing Steel	554

Four sets of shop drawings or two sets plus one reproducible set shall be submitted to the Engineer for approval, including the concrete mix design for each class of concrete proposed for use, a minimum of 21 days in advance of fabrication of the precast member(s).

553A.04
Casting Yard

The precasting of concrete structural members may be done at a location selected by the contractor.

MEASUREMENT

553A.05
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Each member will include the concrete, reinforcement steel, anchorages, plates, nuts, and other material contained within or attached to the unit.

PAYMENT

553A.06
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

<u>Pay Item</u>	<u>Pay Unit</u>
553A(01) Precast Concrete Structural Member _____	EA
553A(02) Precast Concrete Structure	L.S.

Section 554 - Reinforcing Steel

DESCRIPTION

554.01 This work shall consist of furnishing and placing reinforcing steel of the shape and dimensions SHOWN ON THE DRAWINGS.
Work

MATERIALS

554.02 Reinforcing steel and metal supports shall meet the requirements of Subsection 709.01. The grade of reinforcing steel shall be Grade 60 unless otherwise SHOWN ON THE DRAWINGS or the SPECIAL PROJECT SPECIFICATIONS.
Requirements

CONSTRUCTION

554.03 When SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS, all order lists and bending diagrams shall be submitted to the Engineer. Inspection of the reinforcing steel will be made after installation and prior to placing concrete.
Order Lists

554.04 Reinforcing steel shall be protected at all times from damage by storing on blocking racks or platforms. Prior to placing concrete, reinforcing steel that is to be embedded shall be free from rust that pits the surface or scales off, dirt, mud, loose mill scale, paint, oil, grease, or any other foreign substance.
Protection of Materials

554.05 Cutting and bending of reinforcing bars shall be in accordance with the Manual of Standard Practice published by the CRSI, or ACI Detailing Manual SP-66, unless otherwise detailed. Bars partially embedded in concrete shall not be bent except as SHOWN ON THE DRAWINGS.
Cutting & Bending

554.06 Reinforcing steel shall be accurately placed as SHOWN ON THE DRAWINGS and shall be firmly and securely held in position by wiring at intersections and splices, and by using precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires, and other devices approved by the Engineer of sufficient strength to resist crushing under applied loads. Ferrous metal chairs that extend to within 1/2 inch of the surface shall have epoxy coated feet or be galvanized, or made of stainless steel. Supports made from wood, aluminum, plastic, brick, or rock shall not be used. For epoxy-coated reinforcing bars, use nylon-coated tie wires. Bar supports for epoxy-coated reinforcing bars shall be epoxy or plastic coated.
Placing & Fastening

Unless otherwise SHOWN ON THE DRAWINGS, bars shall be lapped in accordance with the Building Code Requirements for Reinforced Concrete, ACI 318-83, Chapter 12, as published by the American Concrete Institute.

Main reinforcement shall be spliced only where SHOWN ON THE DRAWINGS. All welds shall meet the requirements of AWS D1.4-79.

Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted.

All reinforcement shall have a clear coverage of 2 inches, except as SHOWN ON THE DRAWINGS or specified herein.

In bridge decks, reinforcing shall be fastened at alternate intersections unless this results in ties being more than 12 inches apart, in which case, each intersection shall be tied. All intersections at the outside edges of decks shall be tied. In precast and/or prestressed concrete units, every reinforcing steel intersection shall be tied.

For a protective concrete covering of 1 to 3 inches, reinforcing steel may have an allowable concrete cover variation of 1/4 inch; for a protective concrete covering of 3 inches or more, a 1/2-inch variation in protective cover is allowed. Additionally, the allowable variation for center-to-center spacing and location of reinforcing steel shall be as follows, unless otherwise noted:

Center-to-center spacing of all bars +1/2 inch parallel to the nearest surface.

Location of any bar +1 inch parallel to the nearest surface.

Tack welding in lieu of wire ties will not be permitted. However, tack welding of nonstressed reinforcing bars in prestressed concrete that secure inserts, void ducts, and so forth, may be allowed when SHOWN ON THE DRAWINGS, or permitted in writing by the Engineer. In any case, all welding must be done prior to tensioning of the prestressing steel.

MEASUREMENT

554.07
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

The weights of reinforcing steel calculated will be based upon the following table:

<u>Bar Size</u>	<u>Weight per Linear Foot in Pounds</u>
#3	0.376
#4	0.668
#5	1.043
#6	1.502
#7	2.044
#8	2.670
#9	3.400
#10	4.303
#11	5.313
#14	7.650
#18	13.600

Approved splices added for the contractor's convenience will not be included in the quantity for payment.

PAYMENT

554.08
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
554(01) Reinforcing Steel	LBS.
554(02) Reinforcing Steel	L.S.

Section 555 - Steel Structures

DESCRIPTION

555.01
Work This work shall consist of furnishing and constructing steel structures and the steel structure portions of composite structures.

The work will include the furnishing, fabricating, erecting, and painting of structural metals. Structural metals will include structural, welding, special, and alloy steels; metallic electrodes; steel forgings and castings; and iron castings.

MATERIALS

555.02
Requirements Materials shall meet the requirements of the following Subsections:

Paint	708.03
Structural Steels	717.01
Bolts and Nuts	717.02
High-Tensile-Strength Bolts	717.03
Forgings	717.05
Pins and Rollers	717.06
Castings	717.07
Steel Grid Floors	717.08
Steel Pipe	717.09
Galvanized Metal	717.10
Sheet Lead	717.11
Welded Stud Shear Connectors	717.12
Elastomeric Bearing Pads	717.13
Structural Aluminum Alloy	717.14
Aluminum Alloy Materials for Bridge Rail	717.15
Aluminum Alloy Bolts and Nuts	717.16
Aluminum Alloy Welding Wire	717.17

CONSTRUCTION

555.03
Shop Drawings & Inspection The contractor shall give the Engineer a 30-day notice prior to the beginning of work in the shop so that inspection may be provided.

The contractor shall submit four sets of shop drawings or two sets plus one reproducible set of same of the structural steel work to the Engineer for approval. The shop drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer without delaying the work. Such time shall be proportional to the complexity of the work, but in no case shall such time be less than 21 days.

The shop drawings shall show any changes proposed in the work, details for connections not dimensioned or otherwise SHOWN ON THE DRAWINGS, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout drawing of the entire structure, the location of any temporary supports that are to be used, and the vertical alignment of the steel work at each stage of the erection. Substantiating camber calculations shall be submitted with the shop drawings.

555.04
Fabrication These specifications apply to bolted and welded construction.

Workmanship and finish shall be in accordance with the best general practice in modern bridge shops. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

Structural material, either plain or fabricated, shall be stored above the ground upon platforms, skids, or other supports. It

shall be kept free from dirt, grease, or other foreign matter, and shall be protected as far as practicable from corrosion.

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

Preparation of material shall be in accordance with AWS D1.1, paragraph 3.2, as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.

555.05
Finishing & Shaping

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

(a) Edge Planing. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stresses shall be planed to a depth of 1/4 inch. Reentrant cuts shall be filleted before cutting.

(b) 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 following American National Standards Institute surface roughness requirements as defined in ANSI B46.1-47, Surface Roughness, Waviness, and Lay, Part I:

Steel Slabs	ANSI 2,000
Heavy Plates in Contact in Shoes To Be Welded	ANSI 1,000
Milled Ends of Compression Members, Stiffeners, and Fillers	ANSI 500
Bridge Rollers and Rockers	ANSI 250
Pins and Pin Holes	ANSI 125
Sliding Bearings	ANSI 125

(c) Abutting Joints. Abutting joints in compression members and girder flanges, and in tension members where SHOWN 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.

(d) End Connection Angles. Floor beams, stringers, and girders having end connection angles shall be built to drawing length back to back of connection angle with a permissible tolerance of plus zero to minus 1/16 inch. If end connections are faced, the finished thickness of the angles shall not be less than that SHOWN ON THE DRAWINGS, but in no case less than 3/8 inch.

(e) Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

(f) Web Plates (Bolted). In girders having no cover plates and not to be encased in concrete, the top edge of the web 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 projection beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be not more than 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 top with red lead paste prior to painting.

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

(g) Bent Plates. Cold-bent, load-carrying, rolled-steel plates shall meet the following requirements:

(1) They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling.

(2) The radius of bends shall ensure that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in the following table for all grades of structural steel in this specification:

<u>Plate Thickness</u> <u>in Inches</u>	<u>Up to</u> <u>1/2</u>	<u>Over</u> <u>1/2</u> <u>to 1</u>	<u>Over</u> <u>1 to</u> <u>1-1/2</u>	<u>Over</u> <u>1-1/2</u> <u>to 2-1/2</u>	<u>Over</u> <u>2-1/2</u> <u>to 4</u>
Minimum Bend Radius	2t	2-1/2t	3t	3-1/2t	4t

Note: Low-alloy steel in thickness of over 1/2 inch may require hot bending for small radii.

Allowance for springback of ASTM A 514 and A 517 steels should be approximately three times that for structural carbon steel. For brake 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 1,200 °F, except for ASTM A 514 and A 517 steels. If ASTM A 514 and A 517 steel plates or shapes are bent at a temperature greater than 1,125 °F, they must be requenched and tempered in accordance with the producing mill's practice. Hot-bent plates shall meet requirement (1) above.

(3) Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout that portion of the plate where the bending is to occur.

(h) 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 DRAWINGS) on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless SHOWN ON THE DRAWINGS or specified otherwise, fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

Welding will be permitted instead of milling or grinding if SHOWN ON THE DRAWINGS or SPECIAL PROJECT SPECIFICATIONS. Brackets, clips, gussets, stiffeners, and other detail material shall not be welded to members or parts subjected to tensile stress unless approved by the Engineer.

(i) Eyebars. Pin holes may be flame cut at least 2 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 that the marks will 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 per 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 a manner that will prevent distortion of the plates.

(j) Annealing and Stress Relieving. Structural members that are SHOWN ON THE DRAWINGS to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and annealing (full annealing) shall be in accordance with ASTM E 44. The temperatures shall be maintained uniformly throughout the furnace during heating and cooling so the temperature at any two points on the member will not differ by more than 100 °F at any one time.

Members of ASTM A 514 and A 517 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.

Members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plates together shall be stress relieved in accordance with Subsection 555.12 when SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

(k) Tests. When full-size tests of fabricated structural members or eyebars are required by the specifications, the number and nature of the tests, the results to be attained, and the measurements of strength, deformation, or other performances that are to be made will be SHOWN ON THE DRAWINGS or stated in SPECIAL PROJECT SPECIFICATIONS. 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 in accordance with Subsection 555.26. 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 pay item in the contract, unless otherwise specified.

555.06
Pins & 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 9 inches in diameter shall be forged and annealed. Pins and rollers 9 inches or less in diameter may be either forged and annealed or cold-finished, carbon-steel shafting.

In pins larger than 9 inches in diameter, a hole not less than 2 inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent damage by too rapid cooling, and before being annealed.

Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles to the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than 1/32 inch. Boring of holes in built-up members shall be done after the bolting is completed.

The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter, or 1/32 inch for larger pins.

Two pilot nuts and two driving nuts for each size of pin shall be furnished.

555.07
Fastener 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 fasteners whenever the thickness of the metal is not greater than 3/4 inch for structural steel or 5/8 inch for alloy steel.

When there are more than five thicknesses or when any of the main material is thicker than 3/4 inch (structural steel) or 5/8 inch (alloy steel), or when required under other provisions of this subsection, all the holes shall be subpunched or subdrilled 3/16 inch smaller than the nominal diameter of the fasteners. After assembling, holes shall be reamed 1/16 inch larger or drilled from the solid to 1/16 inch larger than the nominal diameter of the fasteners. For 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 fasteners, they shall be reamed. Holes shall be clean cut, without torn or ragged edges. Poor matching of holes will be cause for rejection.

Reamed holes shall be cylindrical, perpendicular to the member, and not more than 1/16 inch larger than the nominal diameter of the fasteners. Where practicable, reamers shall be directed by mechanical means. Drilled holes shall be 1/16 inch larger than the nominal diameter of the fasteners. 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. 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.

Unless otherwise specified, holes for all field connections and field splices of main truss or arch members, continuous beams, towers (each face), bents, plate girders, and rigid frames shall be subpunched (or subdrilled if subdrilling is required) and subsequently reamed while assembled in the shop in accordance with Subsection 555.08.

All holes for floor beam and stringer field end connections shall be subpunched and reamed to a steel template while assembled.

Reaming or drilling full size of field connections through templates shall be done after the templates have been positioned and angled with the utmost accuracy and firmly bolted in place. Templates used for the reaming of matching members, or of the opposite faces of one member, shall be exact duplicates. Templates for connections that duplicate shall be so accurately located that like members are duplicates and require no matchmarking.

All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole can 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 the 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.

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 thickness of metal.

555.08
Shop Assembly

All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. The centerlines shall be used in locating accurately the template from the milled or scribed ends of the members.

(a) Fitting for Bolting. Surfaces of metal in contact with each other 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 bolting of full-sized punched material, the bolt holes, if necessary, shall be spear reamed for the admission of the bolts. The reamed holes shall not be more than 1/16 inch larger than the nominal diameter of the bolts.

End connection angles, stiffener angles, and similar parts shall be carefully adjusted to correct positions and bolted, clamped, or otherwise firmly held in place until permanently connected.

Parts not completely bolted in the shop shall be secured by temporary bolts, insofar as practicable, to prevent damage in shipment and handling.

(b) Shop Assembling. The field connections of main members of trusses, arches, continuous beam spans, bents, towers (each face), 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 the 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 PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS. Methods of assembly shall be as described below:

(1) "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.

(2) "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 all members in at least three contiguous shop sections or panels, but not less than the number of panels associated with three contiguous chord lengths (that is, 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.

(3) "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; reaming their field connection holes while the members are assembled; and reaming the web member connections 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.

(4) "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."

(5) "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.) The assembly, including camber, alinement, accuracy of holes, and fit of milled joints, shall be approved by the Engineer before reaming is commenced.

A camber diagram shall be furnished to the Engineer by the contractor showing the camber at each panel point of each truss, arch rib, continuous beam line, plate girder, or rigid frame. When 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.

555.09
(Reserved)

555.10
Bolted Connections,
Unfinished, Turned,
& Ribbed Bolts

(a) General. Bolts under this article shall meet the requirements of "Specification for Carbon Steel Externally and Internally Threaded Standard Fasteners," ASTM A 307. Specifications for high-strength bolts are covered under Subsection 555.11.

Bolts shall be unfinished, turned, or an approved form of ribbed bolt with hexagonal nuts and heads, except that ribbed bolts shall have button heads. Bolted connections shall be used only as SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Bolts not tightened to the proof load shall have single self-locking nuts or double nuts. Bevel washers shall be used where bearing faces have a slope of more than 1 to 20 with respect to a plane normal to the bolt axis. Bolts shall be long enough to extend entirely through their nuts, but not more than 1/4 inch beyond them.

Bolts shall be driven accurately into the holes without damage to the threads. A snap shall be used to prevent damage to the heads. The heads shall be drawn tight against the work with full effort of a man using a suitable wrench not less than 15 inches long for bolts of nominal 3/4 inch diameter and over. Heads of bolts shall be tapped with a hammer while the nuts are being tightened.

(b) Unfinished Bolts. Unfinished bolts shall be furnished unless other types are specified. The number of bolts furnished shall be 5 percent more than the actual number SHOWN ON THE DRAWINGS for each size and length.

(c) 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 to provide a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

(d) 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 meeting the requirements of ANSI B18.5 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 ribs shall be sufficiently hard so that they 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. The contractor shall provide oversized bolts and nuts for this replacement in an amount not less than 10 percent of the number of ribbed bolts specified.

555.11
Bolted Connections,
High-Tensile-
Strength Bolts

(a) Bolts. Bolts shall meet the requirements of AASHTO M 164. Other fasteners that meet the chemical requirements of AASHTO M 164, that meet the mechanical requirements of AASHTO M 164 in full-size tests, and that have a body diameter and bearing areas under the head and nut not less than those provided by a bolt and nut of the same nominal dimensions prescribed above, may be used subject to the approval of the Engineer.

Bolt lengths shall be determined by adding the grip-length values given in table 555-1 to the total thickness of connected material. The values of table 555-1 compensate for manufacturer's tolerance; the use of a heavy, semifinished hexagon nut; and a positive "stick-through" at the end of the bolt. For each hardened flat washer that is used, add 5/32 inch to the tabular value and for each beveled washer add 5/16 inch. The length determined should be adjusted to the next longer 1/4 inch.

(b) Parts and Assembly. Bolted parts shall fit solidly together when assembled. Contact surfaces, including those adjacent to the washers, shall be descaled or carry the normal tight mill scale. Contact surfaces shall be free of dirt, oil, loose scale, burrs, pits, and other defects that would prevent solid seating of the parts.

Contact surfaces of joints shall be free of paint, lacquer, galvanizing, or rust inhibitor unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

Table 555-1.--Bolt length.

Bolt Size in Inches	To Determine Required Bolt Length, Add Grip, in Inches ^a
1/2	11/16
5/8	7/8
3/4	1
7/8	1-1/8
1	1-1/4
1-1/8	1-1/2
1-1/4	1-5/8
1-3/8	1-3/4
1-1/2	1-7/8

^aDoes not include allowance for washer thickness.

Connections shall be assembled with a hardened washer under the element (nut or bolt head) turned in tightening. Where an outer face of the bolted parts has a slope of more than 1 to 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. In all cases of only one nonsloping surface, the turned element shall be adjacent to this surface. Where clearance is necessary, washers may be clipped on one side to a point not closer than seven-eighths of the bolt diameter from the center of the washer.

(1) Installation. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in table 555-2 for the size and grade of fastener used.

Table 555-2.--Bolt tension (AASHTO M 164 bolts).

Bolt Size (Inches)	Minimum Bolt Tension ^a (Pounds)
1/2	12,050
5/8	19,200
3/4	28,400
7/8	39,250
1	51,500
1-1/8	56,450
1-1/4	71,700
1-3/8	85,450
1-1/2	104,000

^aEqual to the Proof Load (Length Measurement Method) given in AASHTO M 164.

Threaded bolts shall be tightened with properly calibrated wrenches, by the turn-of-nut method, a direct tension indicator, or other method approved by the Engineer. If required because of bolt entering and/or wrench operation clearances, tightening by any procedure may be done by turning the bolt while the nut is prevented from rotating.

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.

When calibrated wrenches are used to provide the bolt tension specified in table 555-2, their setting shall be sufficient to induce a bolt tension 5 to 10 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 from the bolts to be installed. Power wrenches shall be adjusted to stall or cutout at the selected tension. If manual torque wrenches are used, the torque indicator corresponding to the calibrating tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in tightening motion 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 might have been loosened by the tightening of subsequent bolts, until all are tightened to the prescribed amount.

When the turn-of-nut method is used to provide the bolt tension in lieu of that specified in table 555-2, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into full contact with each other. "Snug tight" shall be defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally to the applicable amount of nut rotation specified in table 555-3 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.

Table 555-3.--Nut rotation^a from snug tight condition.

Bolt Length (Measured from Underside of Head to Extreme End of Point)	Disposition of Outer Faces of Bolted Parts		
	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)	Both 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 ^b	2/3 turn	5/6 turn	1 turn

^aNut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance is plus or minus 30°; for bolts installed by 2/3 turn and more, the tolerance is plus or minus 45°.

^bThe required rotation must be determined by actual tests in a suitable tension device simulating the actual conditions.

(2) Inspection.

a. When the calibrated-wrench method of tightening is used, the Engineer shall have full opportunity to witness the calibration tests.

b. 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.

c. The following inspection shall be used unless a more extensive or different procedure is specified:

In the presence of the Engineer, the contractor shall use an inspecting wrench which may be either a torque wrench or a power wrench that can be accurately adjusted in accordance with Subsection 555.11(b)(1) above.

Three bolts of the same grade, size, and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. Length shall be representative of bolts used in the structure. There shall be a washer under the part turned in tightening each bolt.

When the inspecting wrench is a torque wrench, each of the three bolts specified above shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in table 555-2. The inspecting wrench shall then be applied to the tightened bolt and the torque necessary to run the nut or head 5 degrees (approximately 1 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 inspection torque to be used in the manner specified below.

When the inspecting wrench is a power wrench, it shall be adjusted so that it will tighten each of the three bolts specified to a tension of at least 5 percent but not more than 10 percent greater than the minimum tension specified for its size in table 555-2. This setting of wrench shall be taken as the job-inspecting torque to be used in the manner specified below.

Bolts, represented by the three sample bolts prescribed above, that have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench at its job-inspecting torque to 10 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 may elect the option to retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

(3) Reuse. High-strength bolts, nuts, and washers shall not be reused. Retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts is not considered reuse.

- 555.12
Welding
Welding shall be done in accordance with the best modern practice and the applicable requirements of AWS D1.1 except as modified by AASHTO's "Standard Specifications for Welding of Structural Steel Highway Bridges."
- 555.13
Erection
The contractor shall provide the falsework and all tools, machinery, and appliances, including driftpins and fitting-up bolts, necessary for the expeditious handling of the work, and shall erect the metal work, remove the temporary construction, and do all work necessary to complete the structure.
- 555.14
Handling &
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 turned over to him against the shipping lists and report promptly in writing any shortage or injury discovered. The contractor shall be responsible for the loss of any material, or for any damage caused to it after being received.
- 555.15
Falsework
The falsework shall be properly designed and substantially constructed and maintained for the loads that it will bear. The contractor shall prepare and submit to the Engineer construction drawings for falsework and working drawings for changes in any existing structure necessary for maintaining traffic.
- 555.16
Method &
Equipment
Before starting the work of erection, the contractor shall fully inform the Engineer of the proposed method of erection and the amount and character of equipment to be used.
- 555.17
Straightening Bent
Materials
The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted in writing by the Engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry-red color. After heating, the metal shall be cooled as slowly as possible.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture. Fractured material will be rejected.
- 555.18
Assembling Steel
The parts shall be accurately assembled as per the shop drawings, and any matchmarks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering that 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 placed to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully connected with permanent fasteners and all other truss connections pinned and erection bolted. Splices of butt joints of compression members that are milled to bear and of railing shall not be permanently fastened until the spans have been swung, except that such permanent fastening may be accomplished for the truss members at any time that joint holes are fair. Splices and field connections shall have one-half of the holes filled with erection bolts and cylindrical erection pins (half bolts and half pins) before placing permanent fasteners. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the permanent fasteners, and cylindrical erection pins will be 1/16 inch larger.

555.19
(Reserved)

555.20
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 tight and the threads burred at the face of the nut with a pointed tool.

555.21
Setting Shoes
& Bearings

Shoes and bearing plates shall not be placed on bridge seat bearing areas that are improperly finished, deformed, or irregular. They shall be set level in exact position and shall have full and even bearing. The shoes and bearing plates may be set by either of the following methods:

(a) The bridge seat bearing area shall be heavily coated with mastic and then covered with three layers of 12- to 14-ounce duck, each layer being coated thoroughly on its top surface with mastic. The shoes and bearing plates shall be placed in position while the mastic is plastic.

As alternatives to canvas and mastic, and when SHOWN ON THE DRAWINGS, the following may be used:

(1) Sheet lead of the DESIGNATED thickness.

(2) A preformed fabric pad composed of multiple layers of 8-ounce duck, impregnated and bound with high-quality natural rubber or of equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be sufficient to produce the specified thickness after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 pounds per square inch, without detrimental reduction in thickness or extension.

(3) Elastomeric bearing pads.

(b) The shoes and bearing plates shall be properly supported and fixed with approved nonshrink grout. No load shall be placed on them until the grout has cured in accordance with the manufacturer's instructions for at least 96 hours.

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

555.22
Preparing Metal
Surfaces for
Painting

All surfaces of new structural steel that are to be painted shall be blast cleaned unless otherwise specified in the SPECIAL PROJECT SPECIFICATIONS. Where partial cleaning is required in repainting existing structures, the method of cleaning will be specified in

the SPECIAL PROJECT SPECIFICATIONS. The steel surfaces to be painted shall be prepared as outlined in the Steel Structures Painting Council (SSPC) specifications, meeting one of the following classes of surface preparation:

- (a) SSPC-SP-5 White Metal Blast Cleaning
- (b) SSPC-SP-6 Commercial Blast Cleaning
- (c) SSPC-SP-8 Pickling
- (d) SSPC-SP-10 Near-White Blast Cleaning

Corrosion-resistant (high-strength weathering) steel shall be blast cleaned as provided in SSPC-SP-6 Commercial Blast Cleaning. The surfaces to be cleaned shall be specified in the SPECIAL PROJECT SPECIFICATIONS.

Blast cleaning shall leave all surfaces with a dense and uniform anchor pattern of not less than 1-1/2 mils measured with an approved surface profile comparator or Testx Presse Tape.

Blast-cleaned surfaces shall be primed or treated the same day blast cleaning is done. If cleaned surfaces rust or are contaminated with foreign material before painting is accomplished, they shall be recleaned by the contractor.

When paint systems Number 1 or Number 3 are specified, the steel surfaces shall be blast cleaned in accordance with SSPC-SP-10; otherwise, blast cleaning shall meet the requirements of SSPC-SP-6.

555.23
Systems of Paint

The paint system to be applied shall consist of one as set forth in table 555-4.

Table 555-4.--Paint systems.

Environment ^b	Paint System ^a				
	1	2	3	4	5
High Pollution or Coastal	X	X	X		
Mild Climate				X	X

^aPaint system shown for severe areas are satisfactory in less severe areas.

^bCoastal--within 1,000 feet of ocean or tidal water. High pollution--air pollution environment such as industrial areas. Mild--other than coastal areas not in air pollution environment.

All structural steel shall be painted by one of the following systems. The required system or choice of systems including the color of the final coat will be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

System 4 is intended for use in mild climates or to repaint existing structures where the other systems are not compatible.

Coating	Subsection	Min. Dry Film Thickness (Mils)
System 1--Vinyl Paint System		
Wash primer	708.03(b)	0.5
Intermediate coat	708.03(b)	1.5-2.0
3rd coat	708.03(b)	1.5-2.0
4th coat	708.03(b)	1.5-2.0
Final coat	708.03(b)	1.5-2.0
	Total Thickness	6.5-8.5
System 2--Epoxy-Polyamide System		
Primer coat	708.03(c)	2.0-3.0
Intermediate coat	708.03(c)	2.0-3.0
3rd coat ^a	708.03(c)	2.0-3.0
Final coat	708.03(c)	1.5-2.0
	Total Thickness	7.5-11.0
System 3--Inorganic Zinc Silicate System		
Primer	708.03(d)	3.5-5.0
Intermediate coat	708.03(d)	1.0-2.0
Final coat	708.03(d)	3.0 min
	Total Thickness	7.5-10.0
System 4--Alkyd-Oil Basic Lead Silico-Chromate System ^b		
Primer coat	708.03(e)	2.0-3.0
Intermediate coat	708.03(e)	2.0-3.0
Final coat	708.03(e)	2.0-3.0
	Total Thickness	6.0-9.0
System 5--Organic Zinc-Rich Paint System		
Primer coat	708.03(f)	1.5-2.0
Intermediate coat	708.03(f)	2.0-2.5
Wash prime tie coat	708.03(f)	0.5
Final coat	708.03(f)	1.5-2.0
	Total Thickness	5.5-7.0

^aThe third coat may be eliminated in mild climates.

^bThis paint system may be specified as four coats for new structural steel, in mild climates, with a minimum thickness of 6.0 mils.

(a) Time of Application. The prime coat of paint, or pretreatment when specified, shall be applied as soon as possible after the surface has been cleaned and before deterioration of the surface occurs. Any oil, grease, soil, dust, or foreign matter deposited on the surface after the surface preparation is completed shall be removed prior to painting. In the event rusting occurs after completion of the surface preparation, the surfaces shall be cleaned again.

Particular care shall be taken to prevent the contamination of cleaned surfaces with salts, acids, alkali, or other corrosive chemicals before the prime coat is applied and between applications of the remaining coats of paint. Such contaminants shall be removed from the surface. Under these circumstances, the pretreatments or, in the absence of a pretreatment, the prime coat of paint shall be applied immediately after the surface has been cleaned.

(b) Storage of Paint and Thinner. Preferably, all paint and thinner should be stored in a separate building or room that is well ventilated and free from excessive heat, sparks, flame, or the direct rays of the sun. Paints susceptible to damage from freezing shall be kept in a heated storage space when necessary.

All containers of paint should remain unopened until required for use.

Paint that has livered, jelled, or otherwise deteriorated during storage shall not be used. Thixotropic materials that can be stirred to attain normal consistency are satisfactory.

(c) Mixing and Thinning. All ingredients in any container of paint shall be thoroughly mixed before use and shall be agitated often enough during application to keep the pigment in suspension.

Paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the vehicle. This does not imply that part of the vehicle cannot be poured off temporarily to simplify the mixing.

Mixing shall be by mechanical methods, except that hand mixing will be permitted for containers up to 5 gallons in size.

Mixing in open containers shall be done in a well-ventilated area away from sparks or flames.

Paint shall not be mixed or kept in suspension by means of an air stream bubbling under the paint surface.

Where a skin has formed in the container, the skin shall be cut loose from the sides of the container, removed, and discarded. If such skins are thick enough to have a practical effect on the composition and quality of the paint, the paint shall not be used.

The paint shall be mixed in a manner that will ensure breaking up of all lumps, complete dispersion of settled pigment, and a uniform composition. If mixing is done by hand, most of the vehicle shall be poured off into a clean container. The pigment in the paint shall be lifted from the bottom of the container with a broad, flat paddle; lumps shall be broken up; and the pigment shall be thoroughly mixed with the vehicle. The poured-off vehicle shall be returned to the paint with simultaneous stirring or pouring from one container to another until the composition is uniform. The bottom of the container shall be inspected for unmixed pigment.

Tinting pastes or colors shall be wetted with a small amount of thinner, vehicle, or paint and thoroughly mixed. The thinned mixture shall then be added to the large container of paint and mixed until the color is uniform.

Paint that does not have a limited pot life or does not deteriorate on standing may be mixed at any time before using, but if settling has occurred it must be remixed immediately before using. Paint shall not remain in the spray pots, painter's buckets, etc., overnight, but shall be gathered into a container and remixed before use.

No thinner shall be added to the paint unless necessary for proper application. In no case shall more than one pint of thinner be added per gallon unless the paint is intentionally formulated for greater thinning. The type of thinner shall comply with the paint specification.

When the use of thinner is permissible, thinner shall be added to paint during the mixing process. Painters shall not add thinner to paint after it has been thinned to the correct consistency. All thinning shall be done under supervision of one acquainted with the correct amount and type of thinner to be added to the paint.

(d) Application of Paint

(1) General. Paint shall be applied by brushing or spraying or by a combination of these methods. Daubers or sheepskins may be used when no other method is practicable for proper application in places of difficult access. Dipping, roller coating, or flow coating shall be used only when specifically authorized.

When two coats of the same color are to be applied, the first coat shall be tinted darker with an approved tinting material.

Open seams at contact surfaces of built-up members that would retain moisture shall be caulked with approved material before the second undercoat of paint is applied.

Paint shall not be applied when the surrounding air temperature is below 40 °F. Paint shall not be applied when the temperature is expected to drop to 32 °F before the paint has dried. Paint shall not be applied to steel that is more than 5 °F below the air temperature or that is at a temperature less than 40 °F. Paint shall not be applied when the steel surface is less than 5 °F above the dew point. Paint shall not be applied to steel at a temperature over 125 °F unless the paint is specifically formulated for application at the proposed temperature, nor shall paint be applied to steel which is at a temperature that will cause blistering or porosity or otherwise will be detrimental to the life of the paint.

Paint shall not be applied in fog or mist, when it is raining or snowing, or when the relative humidity exceeds 85 percent. Paint shall not be applied to wet or damp surfaces. Paint shall not be applied on frosted or ice-coated surfaces.

When paint must be applied in damp or cold weather, the steel shall be painted under cover, or protected, or sheltered, or the surrounding air and the steel heated to a satisfactory temperature. In all such cases, the above temperature and humidity conditions shall be met. Steel shall remain under cover or be protected until dry or until weather conditions permit its exposure.

Any applied paint exposed to freezing, excess humidity, rain, snow, or condensation shall first be permitted to dry. Then, damaged areas of paint shall be removed, the surface again prepared, and repainted with the same number of coats of paint of the same kind as the undamaged areas.

If stripe painting is stipulated in the specifications or if the contractor chooses to do so, all edges, corners, crevices, bolts, welds, and sharp edges shall be painted with the priming

paint by brush before the steel receives its first full prime coat of paint. Such striping shall extend for at least 1 inch from the edge. When practicable, this stripe coat shall be permitted to dry before the prime coat is applied; otherwise, the stripe coat shall set to touch before the full prime coat is applied. However, the stripe coat shall not be permitted to dry for a period long enough to allow rusting of the unprimed steel. When desired, the stripe coat may be applied after a complete prime coat.

To the maximum extent practicable, each coat of paint shall be applied as a continuous film of uniform thickness free of pores. Any thin spots or areas missed in the application shall be repainted and permitted to dry before the next coat of paint is applied.

Film thicknesses are included in the description of paint systems.

Each coat of paint shall be in a proper state of cure or dryness before the application of the succeeding coat.

(2) Brush Application. Paint shall be worked into all crevices and corners, and surfaces not accessible to brushes shall be painted by spray, daubers, or sheepskins. All runs or sags shall be brushed out. There shall be a minimum of brush marks left in the applied paint.

(3) Spray Application of Paint. The equipment used for spray application of paint shall be suitable for the intended purpose, shall be capable of properly atomizing the paint to be applied, and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of the equipment for the material being sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application. In closed or recirculating paint spray systems, where gas under pressure is used over the liquid, the gas shall be an inert one, such as nitrogen.

Traps or separators shall be provided to remove oil and water from compressed air. These traps or separators shall be of adequate size and shall be drained periodically during operations. The air from the spray gun impinging against the surface shall show no water or oil.

Paint ingredients shall be kept properly mixed in the spray pots or containers during paint application either by continuous mechanical agitation or by intermittent agitation as frequently as necessary.

The pressure on the material in the pot and of the air at the guns shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to atomize the paint properly but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or loss by overspray.

Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before applying paint to the surface being painted.

Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern shall be adjusted so that the paint is deposited uniformly. During application, the gun shall be held perpendicular to the surface and at a distance that will ensure that a wet layer of paint is

deposited on the surface. The trigger of the gun should be released at the end of each stroke.

All runs and sags shall be brushed out immediately or the paint shall be removed and the surface repainted. Spray application of prime coats shall in all cases be immediately followed by brushing.

Areas inaccessible to the spray gun shall be painted by brush. If not accessible by brush, daubers or sheepskins shall be used. Brushes shall be used to work paint into cracks, crevices, and blind spots that are not adequately painted by spray.

(4) Shop Painting. Shop painting shall be done after fabrication and before any damage to the surface occurs from weather or other exposure. Shop contact surfaces shall not be painted unless specified.

Surfaces not to be in contact but that will be inaccessible after assembly shall receive either the full paint coats specified or three shop coats of the specified primer before assembly.

The areas of steel surfaces to be in contact with concrete shall not be painted. Unless otherwise SHOWN ON THE DRAWINGS, the areas of steel surfaces to be in contact with wood shall receive either the full paint coats specified or three shop coats of the specified primer.

If the paint would be harmful to a welding operator or would be detrimental to the welding operation or the finished welds, the steel shall not be painted within a suitable distance from the edges to be welded.

Antiweld spatter coatings shall be removed before painting. Weld slag and flux shall be removed by methods at least as effective as those specified for the cleaning.

Machine-finished or similar surfaces that are not to be painted but require protection shall be protected with a coating of rust inhibitive petroleum, or other coatings that may be more suitable for special conditions.

Erection marks and weight marks shall be copied on areas that have been previously painted with the shop coat.

(5) Field Painting. Steel structures shall be painted as soon as practicable after erection.

Metal that has been shop coated shall be touched up with the same type and brand of paint as the shop coat. This touch-up shall include cleaning and painting of field connections, welds, and all damaged or defective paint and rusted areas. The contractor may elect the option to apply an overall coat of primer in place of touch-up or spot painting.

Surfaces (other than contact surfaces) which are accessible before erection but which will not be accessible after erection shall receive all field coats of paint before erection.

If possible, the final coat of paint shall not be applied until all concrete work is finished. If concreting or other operations damage any paint, the surface shall be cleaned and repainted. All cement or concrete spatter and drippings shall be removed before any paint is applied.

Wet paint shall be protected against damage from dust or other detrimental foreign matter.

(6) Drying of Painted Metal. The maximum time specified by the manufacturer shall be allowed for paint to dry before

recoating or exposure. No drier shall be added to paint on the job unless specifically called for in the specifications for the paint. No painted metal shall be subjected to immersion before the paint is dried through. Paint shall be protected from rain, condensation, contamination, snow, and freezing until dry.

(7) Handling of Painted Steel. Painted steel shall not be handled until the paint has dried, except for necessary handling in turning for painting or stacking for drying.

Painted surfaces that are damaged in handling shall be scraped off and touched up with the same number of coats and kinds of paint as were previously applied to the steel.

Painted steel shall not be loaded for shipment or shipped until it is dry.

(e) Measurement of Dry Film Thickness of Paints

(1) Instrumentation. Dry paint film thicknesses will be measured using pull-off (Type 1) or fixed-probe (Type 2) magnetic gauges. Type 1 gauges include Tinsley, Elecometer, Microtest, and Inspector models. Type 2 gauges include Elcometic, Minitector, General Electric, Verimeter, and Accuderm models. The contractor shall provide one gauge with instructions, in "as new" condition, to be operated under the observation of the Engineer. Operation and calibration shall be in accordance with manufacturer's instructions.

555.25
(Reserved)

MEASUREMENT

555.26
Method

The method of measurement, as described in Section 106 will be DESIGNATED in the SCHEDULE OF ITEMS.

Components fabricated from metals listed in (a) below, such as castings, alloy steels, steel plates, anchor bolts and nuts, shoes, rockers, rollers, pins and nuts, expansion dams, roadway drains and scuppers, weld metal, bolts embedded in concrete, cradles and brackets, posts, conduits and ducts, and structural shapes for expansion joints and pier protection, will be considered as structural steel.

Unless otherwise provided, the weight of metal will be computed and based upon the following weights:

(a) Unit Weights, Pounds Per Cubic Foot

Aluminum, cast or rolled	173.0
Bronze or copper alloy	536.0
Copper sheet	558.0
Iron, cast	445.0
Iron, malleable	470.0
Lead, sheet	707.0
Steel, cast or rolled, including alloy, copper bearing, and stainless	490.0
Zinc	450.0

(b) Shapes, Plates, Railing, and Flooring. The weights of steel shapes and plates will be computed on the basis of their nominal weights and dimensions as SHOWN ON THE APPROVED SHOP DRAWINGS, without deducting for copes, cuts, and open holes. The weights of all plates shall be computed on the basis of nominal dimensions with no additions for overrun.

The weight of railing will be included as structural steel unless the SCHEDULE OF ITEMS contains a separate item for bridge railing under Section 556. The weight of steel grid flooring will be computed separately.

(c) Castings. The weight of castings will be computed from the dimensions SHOWN ON THE APPROVED SHOP DRAWINGS, deducting for open holes. To this weight will be added a 5-percent allowable for fillets and overruns.

Scale weights may be substituted for computed weights in the case of castings of small, complex parts for which accurate computations of weight would be difficult.

(d) Miscellaneous. The weight of the following will be excluded:

- (1) Erection bolts placed for the convenience of the contractor.
- (2) Shop and field paint.
- (3) Galvanizing.
- (4) Boxes, crates, and other containers used for shipping, together with sills, struts, and rods used for supporting members during transportation.
- (5) High-strength steel bolts, nuts, and washers.
- (6) Welds (shop and field).

PAYMENT

555.27
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
555(01) Structural Steel, Furnished, Fabricated, and Erected	LBS.
555(02) Structural Steel, _____ Furnished, Fabricated, and Erected	LBS.
555(03) Structural Steel, Furnished and Fabricated	LBS.
555(04) Structural Steel, _____ Furnished and Fabricated	LBS.
555(05) Structural Steel, Erected	LBS.
555(06) Structural Steel, _____ Erected.	LBS.
555(07) Structural Steel, Furnished, Fabricated and Erected	L.S.

Section 556 - Bridge Railing

DESCRIPTION

- 556.01 Work This work shall consist of furnishing and installing bridge railing and bridge approach railing.
- 556.02 Classification Bridge railings will be classified as Concrete Bridge Railing, Steel Bridge Railing, Steel Bridge Approach Railing, Aluminum Bridge Railing, or Timber Bridge Railing in accordance with the predominate material contained in each.

MATERIALS

- 556.03 Requirements Materials shall meet the requirements of the following Subsections:
- | | |
|-------------------------------------|-----------------|
| Concrete | 552.03-04 |
| Joint Fillers | 705.01 |
| Paint | 708.03 |
| Reinforcing Steel | 709.01 |
| Beam-Type Steel Railing | 710.04 (606.02) |
| Timber | 710.05 (557.02) |
| Structural Steel | 717.01 |
| Hardware, Nuts, and Bolts | 717.02-03 |
| Aluminum Alloy | 717.15 |
| Aluminum Bolts and Nuts | 717.16 |
| Aluminum Welding Wire | 717.17 |

CONSTRUCTION

- 556.04 Performance Four sets of shop drawings or two sets and one reproducible set of same for steel or aluminum bridge railing, except beam-type steel railing, shall be submitted to the Engineer for review a minimum of 2 weeks prior to fabrication, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Inspection of the railing will be made after installation.

The railing shall be constructed so as not to reflect any unevenness in the structure or approach fills. Unless otherwise specified, all railing posts shall be vertical. Railing shall not be placed on a span until centering or falsework has been removed, rendering the span self-supporting.

- 556.05 Concrete Railing All concrete shall be Class A and all concrete construction shall meet the requirements of Section 552.

- 556.06 Steel Railing Erection of steel railing shall meet the applicable requirements of Sections 555 and 606.

- 556.07 Aluminum Railing The fabrication and erection of aluminum railing shall meet the requirements of Section 555 subject to the following amendments and additions:

(a) Cutting. Material 1/2 inch thick or less may be cut by shearing, sawing, or milling. Material over 1/2 inch thick shall be sawed or milled.

Cut edges shall be true, smooth, and free from burns or ragged breaks. Reentrant cuts shall be filleted by drilling prior to cutting.

Flame cutting will not be permitted.

(b) Bending. Material may be heated to a temperature not exceeding 400 °F for a period not exceeding 30 minutes to facilitate bending, unless cold bending is required to retain the original mechanical properties of the material furnished.

(c) Bolt Holes. Bolt holes shall be drilled to finished size or subpunched smaller than the nominal diameter of the fastener and reamed to size. The amount by which the diameter of a subpunched hole is smaller than that of the finished hole shall be at least one-quarter the thickness of the piece. The finished diameter of holes shall be not more than 7 percent greater than the nominal diameter of the fastener except:

(1) Slotted bolt holes, to take care of expansion, shall be provided as SHOWN ON THE DRAWINGS.

(2) Anchor bolt holes may be up to 25 percent greater than the nominal bolt diameter with a maximum of 1/2 inch greater than the nominal bolt diameter, unless otherwise SHOWN ON THE DRAWINGS.

(d) Contact with Other Materials. Where aluminum alloys come in contact with other metals, the contacting surfaces shall be thoroughly coated with an aluminum-impregnated calking compound approved by the Engineer, or a synthetic rubber gasket meeting the requirements of the SPECIAL PROJECT SPECIFICATIONS may be placed between the two surfaces. Aluminum alloys shall not be placed between the two surfaces and shall not be placed in contact with copper, copper-base alloys, lead, or nickel.

Where aluminum alloys come in contact with concrete or stone, the contact surfaces shall be thoroughly coated with an aluminum-impregnated calking compound approved by the Engineer. When a bond between aluminum and concrete is desired, the aluminum shall be coated with zinc-chromate paint and allowed to dry before installation.

Where aluminum alloys come in contact with wood, the contacting aluminum surface shall be coated with an approved aluminum calking compound.

Erection of timber railing shall meet the requirements of Section 557. Erection of the posts for bridge approach railing shall meet the applicable requirements of Section 606.

556.08
Timber Railing

556.09
Painting

All steel railing, except beam-type railing, shall be cleaned and given one primer coat and two field coats of paint meeting the requirements of Subsections 555.22 and 555.24 when SHOWN ON THE DRAWINGS. Beam-type railing shall be painted to meet the requirements of Section 606. If galvanizing is SHOWN ON THE DRAWINGS instead of painting, the requirements of AASHTO M 111, ASTM A 123, or AASHTO M 180, as applicable, shall apply.

MEASUREMENT

556.10
Method

The method of measurement as described in Section 106 will be DESIGNATED in the SCHEDULE OF ITEMS.

The length of railing will be along the line and grade of the railing from end to end of the rail except when terminal sections are in the SCHEDULE OF ITEMS.

The following incidental items will be included in payment for railing, and separate measurement and payment will not be made:

- (a) Fastenings, anchors, and posts.
- (b) Sheets, pads, shims, plates, etc.
- (c) Reinforcing steel and portions of reinforcing steel extending into curbs and parapets.
- (d) Approach railing, end anchorages, and terminal sections unless separate pay items are included in the SCHEDULE OF ITEMS for approach railing, end anchorages, or terminal section.

PAYMENT

556.11
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
556(01) Concrete Bridge Railing	L.F.
556(02) Steel Bridge Railing	L.F.
556(03) Aluminum Alloy Bridge Railing	L.F.
556(04) Timber Bridge Railing	L.F.
556(05) Bridge Railing	L.S.
556(06) Bridge Approach Railing	L.F.
556(07) End Anchorage	EA.
556(08) Terminal Section, Class _____	EA.

Section 557 - Timber Structures

DESCRIPTION

557.01
Work

This work shall consist of construction of timber structures and timber portions of composite structures. It shall include furnishing and installing or installing only, all hardware, lumber, and timbers SHOWN ON THE DRAWINGS.

MATERIALS

557.02
Requirements

Materials shall meet the requirements of the following Subsections:

Structural Timber and Lumber	716.01
Hardware and Structural Steel	716.02
Preservative Treatments	716.03
Structural Glued Laminated Timber	716.04

Paint for timber structures shall be white and shall meet the requirements of AASHTO M 70, Type I, Class A. The paint, as specified, is intended for use in covering previously painted surfaces. When applied to unpainted timber, turpentine and linseed oil shall be added as required by the character of the surface in an amount not to exceed 1 pint each per gallon of the paint.

The contractor shall furnish the following compliance certificates to the Engineer upon delivery of the materials to the jobsite:

(a) Verification of compliance with grading rules and species of timber and lumber. Certification shall be by an agency accepted as competent by the American Lumber Standards Committee.

(b) Certification of preservative, penetration in inches, and retention in pounds per cubic foot (assay method) either by a qualified inspection and testing agency or by supplier certification if each piece is stamped or branded with the AWPB quality mark.

(c) Certification from a qualified inspection and testing agency indicating all glue-laminated members are in accordance with U.S. Department of Commerce Voluntary Standard PS 56, "Structural Glued Laminated Timber" (AITC A190) modified as SHOWN ON THE DRAWINGS.

(d) Such other certifications as SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS.

CONSTRUCTION

557.03
Performance

Excavation, foundation, backfill, and embankments shall be in accordance with Section 206.

557.04
Storage & Handling
of Material

All materials shall be so handled, stacked, and protected as to prevent scarring, breaking, warping, or weathering. Corners of heavy construction timbers and banded packages of lighter construction timber shall be protected when handled by slings.

All field cuts or abrasions made in fabricated timber after treatment shall be carefully trimmed and given three brush coats of the same type of preservative used in the original treatment unless otherwise SHOWN ON THE DRAWINGS. Field cuts shall be limited to holes and minor trimming, and cuts SHOWN ON THE DRAWINGS.

In addition to the requirement for field treatment, all field cut end grain of main stringers or timber members to be buried under ground shall be coated with an asphalt, coal tar, or creosote water proofing material meeting the requirements of AASHTO M115, 116, 118, or 121.

557.05
Workmanship

All lumber and construction timber shall be cut and framed so all joints will have even bearing over the entire contact surface. No shimming shall be done in making joints, and all joints shall be closed. Nails and spikes shall be driven to set the heads flush with the wood surface. All holes for smooth dowels, except for the dowels used to join glue-laminated deck panels, and drift pins shall be 1/16 inch less in diameter than the dowels or pins. Holes for bolts shall be bored with a bit of the same diameter as that of the bolt, except when galvanized hardware is specified, then all holes shall be drilled 1/16 inch greater than the bolt size. Holes for lag screws shall have the same diameter and depth as the shank of the screw, plus a lead hole for the threaded portion with the diameter approximately 75 percent of the shank diameter. Before driving bolts or pins, all holes bored after treatment shall be treated as specified in Subsection 557.04. Any holes drilled but not used after being treated shall be plugged with treated plugs.

557.06
Bolts & Washers

Washers of the size and type SHOWN ON THE DRAWINGS shall be placed under all bolt heads and nuts. All nuts shall be finally tightened to provide proper bearing and excess bolt lengths of more than 1 inch shall be cut off. After being finally tightened, all nuts shall be checked or burred effectively with a pointing tool to prevent loosening.

557.07
Framed Bents

Mud sills shall be firmly and evenly bedded to solid bearing and carefully tamped in place. Concrete pedestals for the support of framed bents shall be finished carefully so that sills or posts will bear evenly and uniformly over the entire bearing surface.

557.08
Pile Bents

Treatment, furnishing, and driving of construction piles shall be in accordance with Section 551.

557.09
Caps for All Bents

Timber caps shall be placed to obtain even and uniform bearing over the tops of all supporting construction posts or construction piles. Ends of caps shall be in true alinement.

557.10
Bracing

Bracing shall be bolted through at intersections with the construction piling and construction posts and shall be capped or sealed as SHOWN ON THE DRAWINGS.

557.11
Solid-Sawn
Stringers

Stringers shall be size matched at bearings and shall be positioned so that the camber is up and if possible so that knots near the edge will be in the top portion of the stringers. Bridging between stringers shall be neatly and accurately framed and securely fastened.

557.12
Glue-Laminated
Panel Decks

Panels shall not be dragged or skidded. When lifted, they shall be supported in the weak-moment plane at a sufficient number of points to avoid overstressing, and the edges shall be protected from damage.

When dowels are SHOWN ON THE DRAWINGS between deck panels, a template or drilling jig shall be used to ensure that dowel holes are accurately spaced. The holes shall be drilled to a depth 1/4 inch greater than one-half the dowel length and of the same diameter as the dowel unless otherwise SHOWN ON THE DRAWINGS. A temporary dowel shall be used as a check for snug fit prior to production drilling. The dowels shall be of the size SHOWN ON THE DRAWINGS with the tips slightly tapered or rounded. A lubricant may be used to facilitate the connection process.

The tips of all dowels shall be partially and equally started into the holes of the two panels being joined. The panels shall be drawn together keeping the edges parallel, until the panels abut tightly. Each panel shall be securely fastened to each stringer as SHOWN ON THE DRAWINGS.

MEASUREMENT

557.13
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS. Lumber and timber used for falsework, bracing, or sheeting will not be included. Furnishing and installation of piling and guardrail will be in accordance with Sections 551 and 556, respectively. Structure excavation will be in accordance with Section 206.

PAYMENT

557.14
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
557(01) Treated Timber Structure	L.S.
577(02) Treated Timber for Structure	MFBM

Section 558 - Prefabricated Bridge Structures

DESCRIPTION

558.01
Work

This work shall consist of furnishing and erecting the prefabricated superstructure portions of bridges and/or the erecting of Government-furnished prefabricated superstructure units. The length and width of the structure, including curbs and railings and the horizontal and vertical alignment will be as SHOWN ON THE DRAWINGS.

This work shall also include construction of bearing caps, bulkhead walls, and other supports, including excavation and backfill, when SHOWN ON THE DRAWINGS or on approved manufacturers' drawings. Unless furnished by the Government, prefabricated bridge units shall be furnished complete, in place, including deck, and railing when required, and all incidental materials connected therewith.

When there are specified limitations on acceptable girder, deck, and railing materials and type, they shall be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

MATERIALS

558.02
Requirements

Materials shall meet the requirements of the following Subsections:

Concrete	552.03-04
Prestressed Concrete	553.04-07
Precast Concrete	553A.02
Structural Steel Components	555.02
Railing	556.03
Timber and Hardware	557.02
Reinforcing Steel	709.01

Concrete compressive strength, structural steel ultimate strength and designation, timber species, grade, and treatment, and other material specifications shall be designated on the manufacturer's drawings and will be subject to approval by the Engineer prior to fabrication.

558.03
Design Requirements

Prefabricated bridges shall be designed in accordance with the AASHTO Standard Specifications for Highway Bridges, latest edition and addendums, for the HS20-44 loading, including impact, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

558.04
Design Drawings
& Calculations

The contractor shall submit to the Engineer for approval four copies of the design drawings, calculations, and shop drawings. They shall include any manufacturer's installation special handling specifications. The drawings shall be certified and bear the stamp of a registered professional engineer. Drawings shall be submitted sufficiently in advance of the start of the work to allow time for review by the Engineer and correction of any changes by the contractor. Such time shall be proportional to the complexity of the work, but not less than 21 days.

When Government-furnished units are specified, erection drawings and manufacturer's handling specifications will be furnished to the contractor by the Government.

CONSTRUCTION

558.05
Performance

The work shall conform to the applicable construction provisions of the following Subsections:

Concrete Structures	552.05-14
Prestressed Concrete Structures	553.06-16
Precast Concrete Structures	553A.03-04

Steel Structures	555.03-25
Timber Structures	557.03-12
Structure Excavation and Backfill	206.02-07
Reinforcing Steel	554.03-06
Bridge Railing	556.04-09

558.06
Government-Furnished
Bridges

When Government-furnished prefabricated bridge units are specified, the contractor shall transport the units from the storage site designated in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS to the bridge site, and shall erect the units complete in place, including connection of all girders, diaphragms, railings, and other elements.

Upon taking possession of the Government-furnished units at the storage site, the contractor shall assume all liability for damage from his operations, including handling, transporting, and erecting the units in place, until final acceptance of the project by the Contracting Officer.

558.07
Manufacturer's
Requirements

The contractor shall furnish all tools, devices, special equipment, and incidentals, and comply with all manufacturer's erection requirements. This manufacturer's requirement also applies to the movement and erection of Government-furnished units.

MEASUREMENT

558.08
Method

The method of measurement, as described in Section 106, will be designated in the SCHEDULE OF ITEMS.

PAYMENT

558.09
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
558(01) Prefabricated Bridge	EA.
558(02) Install Government-furnished Prefabricated Bridge	EA.

Section 559 - Log Structures

DESCRIPTION

559.01
Work This work shall consist of cutting, hauling, and installing the timber for constructing log bridges, including abutments, piers, and superstructure.

This work shall also include structure excavation and backfill for abutments and piers and furnishing and installing all hardware.

MATERIALS

559.02
Requirements The Government will provide trees from which the contractor can cut the required logs. The Government will mark trees for cutting or identify the general area from which trees shall be cut at locations SHOWN ON THE DRAWINGS. Trees to be cut for stringers shall be approved by the Engineer. The contractor shall dispose of all debris resulting from this operation in accordance with Section 201.

559.03
Lumber Lumber shall be in accordance with the species, grades, and dimensions SHOWN ON THE DRAWINGS.

559.04
Aggregate Aggregate, when shown for decking/surfacing, shall meet the requirements SHOWN ON THE DRAWINGS.

559.05
Hardware All hardware shall be of the sizes, shapes, types, and finishes for specific uses as SHOWN ON THE DRAWINGS.

559.06
Matting Fabric mat as SHOWN ON THE DRAWINGS shall meet the requirements of Section 720.

CONSTRUCTION

559.07
Performance Excavation, foundation, backfill, and embankment work shall be in accordance with Section 206.

Timber caps shall be placed to obtain even and uniform bearing over the tops of supporting posts or piles and with post and pile ends in true alignment. All caps shall be secured as SHOWN ON THE DRAWINGS.

Stringers shall be size matched at bearings and shall be placed in position so that the crown is up and, if possible, so that knots that may affect the strength of the member will be in the top portion of the stringer.

Stringers shall be cut to the exact length with a square cut. A sufficient depth of material shall be removed from the top surface of the stringer to provide a bearing area for the decking as SHOWN ON THE DRAWINGS. Hewing shall not exceed 3/4 inch depth at the small end of the log. Hewing of the top of the butt end shall not exceed 3 inches in depth for a distance not to exceed one-fourth span length.

Bottom surface of the small end of the logs shall be cut or hewed only to the depth necessary to achieve the required bearing area. Tip ends smaller than the largest tip shall be blocked or shimmed. Butt ends may be cut or dapped to the depth of the largest top end. The maximum slope of any tip shall be 1 to 10. Top and bottom cuts shall be parallel. Where shims or blocks are used under small ends, the shims should cover the entire bearing area.

All logs, including face logs, tie logs, mud sills, and anchor logs, shall be notched together as SHOWN ON THE DRAWINGS and shall be tied or drift pinned together.

All necessary clearing, grubbing, and excavation shall be completed and approved prior to starting the bridge erection. Wood chinking or rock may be hand placed for backing behind minor open spacing between logs, provided that their least dimension is greater than the minimum opening between logs. When rock is used, the larger rocks shall be placed against the logs and backed up with smaller rocks in such a manner that no materials can escape or be washed out.

MEASUREMENT

559.08
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Excavation and Backfill are included in the measurement for the item for Log Structure and no separate measurement and payment will be made.

PAYMENT

559.09
Basis

The accepted quantities will be paid for at the contract unit price for the pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
559(01) Log Structure	EA.

