

Section 555—Steel Structures

Description

555.01 Work. Construct steel structures and the steel structure portions of composite structures. Furnish, fabricate, and erect structural steels, and perform incidental metal construction.

Materials

555.02 Requirements. Furnish material that conforms to specifications in the following sections and subsections:

Bearing Devices	564
Bolts & Nuts	717.01(d)
Castings	717.04
Elastomeric Compression Joint Seals	717.16
Falsework	562
Galvanized Coatings	717.07
High-Strength Bolts, Nuts, & Washers	717.01(e)
Painting	563
Pins & Rollers	717.03
Sheet Lead	717.08
Steel Forgings	717.02
Steel Grid Floors	717.09
Steel Pipe	717.06
Structural Steel	717.01
Welded Stud Shear Connectors	717.05

Construction

555.03 General. Fabricate the structural steel in a fabricating plant that is certified under the American Institute of Steel Construction (AISC) Quality Certification Program. Fabricate “fracture-critical” elements in accordance with the AASHTO “Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members.”

Perform welding and weld qualification tests in accordance with the provisions of American National Standards Institute (ANSI)/AASHTO/AWS Bridge Welding Code D 1.5.

555.04 Notice of Beginning of Work. Give written notice 30 days before beginning work at the shop. Do not manufacture any material or perform any work in the shop before notification.

555.05 Inspection. Structural steel may be inspected at the fabrication site.

Ultrasonically inspect all girder flanges before fabrication, in accordance with ASTM A 578, except as follows:

- (a) Inspect after the flanges are stripped from the master plate.
- (b) Section 6 and 7 acceptance standards do not apply. Use supplementary requirement S2.1 for acceptance standards.
- (c) Flanges may be inspected in the plant or warehouse where the flanges are stripped.

Furnish a copy of all mill orders and certified mill test reports. Show on the mill test reports the chemical analyses and physical test results for each heat of steel used in the work.

If approved, furnish production certificates in lieu of mill test reports for material that normally is not supplied with mill test reports and for items such as fills, minor gusset plates, and similar material when quantities are small and the material is taken from stock.

Include in the certified mill test reports for steels with specified impact values, in addition to other test results, the results of Charpy V-notch impact tests. When fine-grain practice is specified, confirm on the test report that the material was so produced. Furnish copies of mill orders at the time orders are placed with the manufacturer. Furnish certified mill test reports and production certificates before the start of fabrication using material covered by these reports. Furnish, from the manufacturer, a Certificate of Compliance in accordance with Subsection 106.03.

555.06 Drawings (Shop Drawings, Erection Drawings, & Transportation Drawings). Prepare and submit drawings at the times indicated herein. Approval of the drawings covers the requirements for strength and detail only. No responsibility is assumed for errors in dimensions.

(a) **Shop Drawings.** Submit four copies of shop drawings at least 21 days in advance of the start of fabrication to allow time for review without delaying the work. Show full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts (such as pins, nuts, bolts, drains, weld symbols, and so forth) on shop drawings for steel structures.

Where specific orientation of plates is required, show the direction of rolling of plates. Cut flanges and webs of plate girders from plates so the long dimension of the girder parallels the rolling direction.

Show the sequence of shop and field assembly and erection, and all welding sequences and procedures.

Identify on the shop drawings the type and grade of each piece.

Show on the shop drawings assembly marks that are cross-referenced to the original pieces of mill steel and their certified mill test reports.

The location of all shop-welded splices shown on the shop drawings is subject to approval. Locate all shop-welded splices to avoid points of maximum tensile or fatigue stress. Locate splices in webs at least 300 mm from shop splices, butt joints in flanges, or stiffeners. Additional nondestructive tests may be required on shop-welded splices.

(b) Erection Drawings. Submit drawings fully illustrating the proposed method of erection a minimum of 21 days before field assembly and erection. Show details of all falsework bents, bracing, guys, dead-men, lifting devices, and attachments to the bridge members. Show the sequence of erection, location of cranes and barges, crane capacities, location of lifting points, and weights of bridge members. Show complete details for all anticipated phases and conditions of erection. Calculations may be required to demonstrate that allowable stresses are not exceeded and that member capacities and final geometry will be correct. See Subsection 562.03 for additional requirements.

(c) Camber Diagram. Along with the shop drawings, furnish a camber diagram complete with substantiating calculations that show the camber at each panel point of trusses or arch ribs and at the location of field splices and fractions of span length (one-quarter points minimum) of continuous beams and girders or rigid frames. On the camber diagram, show calculated cambers to be used in preassembly of the structure, as required in Subsection 555.15.

(d) Transportation Drawings. If required, furnish transportation drawings for approval a minimum of 10 days prior to shipment.

Show all support points, tie-downs, temporary stiffening trusses or beams, and any other details needed to support and brace the member. Provide calculation sheets showing the dead load plus impact stresses induced by the loading and transportation procedure. Use impact stresses of at least 200 percent of the dead load stress. Use a total load, including impact, of not less than 300 percent of the dead load.

Ship and store all members, both straight and curved, with their webs vertical.

555.07 Storage of Material. Store structural material above the ground on platforms, skids, or other supports. Keep material free from dirt, grease, and other foreign matter, and provide appropriate protection from corrosion.

555.08 Fabrication. Provide a workmanship and finish in accordance with the best general practice in modern bridge shops. Finish neatly all portions of the work exposed to view. Perform shearing, flame cutting, and chipping carefully and accurately.

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

Heat curving of steel girders is not allowed.

(a) Identification of Steels. Use a system of assembly-marking of individual pieces and cutting instructions to the shop (generally by cross-referencing of the assembly marks shown on the shop drawings with the corresponding item covered on the mill purchase order) that maintains the identity of the original piece.

Material may be furnished from stock that can be identified by heat number and mill test report.

During fabrication, up to the point of assembling members, show clearly and legibly the specification of each piece of steel by writing the material specification on the piece or using the identification color code shown in table 555-1.

Table 555-1.—Identification color codes.

Grade	Color
345	Green and yellow
345W	Blue and yellow
485W	Blue and orange
690	Red
690W	Red and orange

For other steels not shown in table 555-1 or included in AASHTO M 160M, provide information on the color code used.

Mark for grade by steel-die stamping, or by firmly attaching a substantial tag, pieces of steel that, before assembling into members, will be subject to fabrication operations (such as blast cleaning, galvanizing, heating for forming, or painting) that

might obliterate paint color code marking. Where the steel-stamping method is used, place the impressions on the thicker tension-joint member in transition joints.

The maximum allowed depth of the impression is 0.25 mm. Use a tool that will make character sizes with corresponding face radii as shown in table 555-2. Avoid impressions near edges of tensile-stressed plate members.

Table 555-2.—Size of steel die stamp markings.

Character Size	Minimum Face Radii
3 mm	0.2 mm
5 mm	0.1 mm
6 mm	0.3 mm

Use low-stress-type steel die stamps. Do not use die stamps on fracture-critical members.

If requested, furnish an affidavit certifying that the identification of steel has been maintained throughout the fabrication operation.

(b) Plates. Conform to the following:

(1) Direction of Rolling. Unless otherwise SHOWN ON THE DRAWINGS, cut and fabricate steel plates for main members and splice plates for flanges and main tension members, not secondary members, so that the primary direction of rolling is parallel to the direction of the principal tensile and/or compressive stresses.

(2) Plate Cut Edges. Conform to the following:

(a) Edge Planing. Remove sheared edges on plates thicker than 15 mm to a depth of 5 mm beyond the original sheared edge, or beyond any re-entrant cut produced by shearing. Fillet re-entrant cuts before cutting.

(1) Oxygen Cutting. Oxygen cut structural steel in accordance with ANSI/AASHTO/AWS Bridge Welding Code D 1.5.

(2) Visual Inspection & Repair of Plate Cut Edges. Visually inspect and repair plate cut edges. Ensure that cut edges conform to ANSI/AASHTO/AWS Bridge Welding Code D 1.5.

(b) Flange Plates. Furnish flange plates with oxygen-cut edges that have the corners chamfered at least 2 mm by grinding, or furnish universal mill plates unless oxygen-cut edges are required.

(c) *Web Plates.* Oxygen cut to the prescribed camber web plates of built-up beams and girders, box girders, and box arches. Cut sufficient extra camber into the webs to provide for all camber losses due to welding, cutting, and so forth.

(d) *Truss Members.* Use oxygen cutting to prepare all longitudinal edges of all plates in welded sections of truss web and chord members. Chamfer at least 2 mm by grinding the edges of the corners of plates not joined by welding.

(e) *Stiffeners & Connection Plates.* Stiffeners and connection plates welded transverse to girder webs and flanges may be furnished with sheared edges, provided that the plate thickness does not exceed 20 mm. Universal mill plate may be used, provided that its thickness does not exceed 25 mm. Furnish other stiffeners and connection plates with oxygen-cut edges.

(f) *Lateral Gusset Plates.* Oxygen cut, parallel to lines of stress, gusset plates and other connections that are welded parallel to lines of stress in tension members where the plate thickness exceeds 10 mm. Bolted lateral gusset plates may be furnished with sheared edges, provided the thickness is less than or equal to 20 mm.

(g) *Splice Plates & Gusset Plates.* Furnish girder and stringer splice plates and truss gusset plates with oxygen-cut edges.

(h) *Bent Plates.* Furnish unwelded, load-carrying, rolled-steel plates to be bent as shown in table 555-3.

Table 555-3.—Minimum bending radii.^a

Plate Thickness (m m)	Bending Radius ^b
$t \leq 13$	2 (t)
$13 < t \leq 25$	2.5 (t)
$25 < t \leq 38$	3 (t)
$38 < t \leq 64$	3.5 (t)
$64 < t \leq 102$	4 (t)

a. t = plate thickness.

b. For all grades of structural steel.

Take material from the stock plates such that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic deck bridges may be bent with bend lines in the direction of rolling.

Before bending, round the corners of the plates to a radius of 2 mm throughout the portion of the plate where the bending occurs.

(1) *Cold Bending.* Cold bend so that no cracking of the plate occurs. Use the minimum bend radii shown in table 555-3 measured to the concave face of the metal.

Allow for springback of grade 690 and grade 690W steels equal to about 3 times that for grade 250 steel. Use a lower die span of at least 16 times the plate thickness for break press forming.

(2) **Hot Bending.** If a radius shorter than the minimum specified for cold bending is essential, hot bend the plates at a temperature not greater than 650 °C, except for grades 690 and 690W. When grade 690 and grade 690W steel plates are heated to temperatures greater than 610 °C, reheat and temper in accordance with the producing mill's standard practice.

(c) **Fit of Stiffeners.** Fabricate (mill, grind, or weld as SHOWN ON THE DRAWINGS or as specified) end-bearing stiffeners for girders and stiffeners intended as supports for concentrated loads to provide full bearing on the flanges to which they transmit load or from which they receive load. Fabricate intermediate stiffeners not intended to support concentrated loads to provide a tight fit against the compression flange.

(d) **Abutting Joints.** Mill or saw-cut abutting joints in compression members of trusses and columns to give a square joint and uniform bearing. The maximum allowed opening at other joints, not required to be faced, is 10 mm.

(e) **Facing of Bearing Surfaces.** Finish bearing and base plates and other bearing surfaces that will come in contact with each other or with concrete to the ANSI surface roughness defined in ANSI B46.1, "Surface Roughness, Waviness and Lay, Part I," as shown in table 555-4.

Table 555-4.—ANSI surface roughness values.

Bearing Surface	Surface Roughness Value (µm)
Steel slabs	50
Heavy plates in contact in shoes to be welded	25
Milled ends of compression members, milled or ground ends of stiffeners and fillers	13
Bridge rollers and rockers	6
Pins and pin holes	3
Sliding bearings	3

Machine sliding bearings that have a surface roughness greater than 2 µm according to ANSI, so the lay of the cut is parallel to the direction of movement.

Fabricate parts in bearing to provide a uniform, even contact with the adjacent bearing surface when assembled. Limit the maximum gap between bearing surfaces to 1 mm. Base and sole plates that are plane and true and have a surface roughness

not exceeding the above-tabulated values need not be machined, except machine sliding surfaces of base plates.

Do not machine surfaces of fabricated members until all fabrication on that particular assembly or subassembly is complete. Machine metal components that are to be heat-treated after heat treatment.

(f) Straightening Material. If approved, straighten plates, angles, other shapes, and built-up members by methods that will not produce fracture or other damage to the metal. Straighten distorted members by mechanical means or, if approved, by carefully planned procedures and supervised application of a limited amount of localized heat. Use rigidly controlled procedures and do not exceed the temperatures specified in table 555-5 when heat straightening grades 485W, 690, and 690W steel members.

Table 555-5.—Heat-straightening temperatures.

Material To Be Straightened	Maximum Temperature
Grade 485W > 150 mm from weld	580 °C
Grade 485W < 150 mm from weld	480 °C
Grade 690 or 690W > 150 mm from weld	605 °C
Grade 690 or 690W < 150 mm from weld	510 °C

In all other steels, do not exceed 650 °C in the heated area. Control the application by temperature-indicating crayons, liquids, or bimetal thermometers.

Keep parts to be heat-straightened substantially free of external forces and stress, except stresses resulting from mechanical means used in conjunction with the application of heat.

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

555.09 Annealing & Stress Relieving. Machine, finish bore, and straighten annealed or normalized structural members subsequent to heat treatment. Normalize and anneal (full annealing) in accordance with ASTM A 919. Maintain uniform temperatures throughout the furnace during the heating and cooling so that the temperature at any two points on the member does not differ by more than 60 °C at any one time.

Do not anneal or normalize members of grades 690/690W or 485W steels. Stress relieve these grades only with approval.

Record each furnace charge, identify the pieces in the charge, and show the temperatures and schedule actually used. Provide proper instruments, including recording pyrometers, for determining at any time the temperatures of members in the furnace. Make records of the treatment operation available for approval. The maximum allowed holding temperature for stress relieving grades 690/690W and 485W steels is 605 °C and 580 °C, respectively.

Stress relieve members (such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together) in accordance with subsection 4.4 of ANSI/AASHTO/AWS Bridge Welding Code D 1.5.

555.10 Bolt Holes. Punch or drill all bolt holes. Material forming the parts of a member that is composed of not more than five thicknesses of metal may be punched 2 mm larger than the nominal diameter of the bolts where the thickness of the material is not greater than 20 mm for structural steel, 15 mm for high-strength steel, or 15 mm for quenched and tempered alloy steel, unless subpunching and reaming is required under Subsection 555.10(h), Preparation of Field Connections.

Where there are more than five thicknesses or where any of the main material is thicker than 20 mm for structural steel, 15 mm for high-strength steel, or 15 mm for quenched and tempered alloy steel, either subdrill and ream or drill all holes full size.

If required, either subpunch or subdrill (subdrill if thickness limitation governs) 5 mm smaller and, after assembling, ream 2 mm larger or drill full size to 2 mm larger than the nominal diameter of the bolts.

(a) Punched Holes. Use a die diameter that is not more than 2 mm larger than the punch diameter. Ream holes that require enlarging to admit bolts. Cut the holes clean without leaving torn or ragged edges.

(b) Reamed or Drilled Holes. Ream or drill holes so they are cylindrical and perpendicular to the member. Where practical, direct reamers by mechanical means. Remove burrs on the outside surfaces. Ream and drill with twist drills, twist reamers, or roto-broach cutters. Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling.

(c) Accuracy of Holes. Holes not more than 1 mm larger in diameter than the true decimal equivalent of the nominal diameter of the drill or reamer are acceptable. The slightly conical hole resulting from punching operations is acceptable. Ensure that the width of slotted holes produced by flame cutting or a combination of drilling or

punching and flame cutting is no more than 1 mm greater than the nominal width. Grind flame-cut surfaces smooth.

(d) Accuracy of Hole Group Before Reaming. Accurately punch full-size, subpunched, or subdrilled holes so that after assembling (before any reaming is done) a cylindrical pin 3 mm smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. Punched pieces not meeting this requirement will be rejected. Holes through which a pin 5 mm smaller in diameter than the nominal size of the punched hole cannot be inserted will be rejected.

(e) Accuracy of Hole Group After Reaming. After reaming, the maximum allowed offset of 85 percent of any contiguous group of holes through adjacent thicknesses of metal is 1 mm.

Use steel templates with hardened-steel bushings in holes accurately dimensioned from the centerlines of the connection, as inscribed on the template. Use connection centerlines when locating templates from the milled or scribed ends of members.

(f) Numerically Controlled (N/C) Drilled Field Connections. In lieu of drilling undersized holes and reaming while assembled, or drilling holes full-size while assembled, drilling or punching bolt holes full-size is allowed in unassembled pieces and/or connections, including templates for use with matching undersized and reamed holes by means of suitable N/C drilling or punching equipment.

(g) Holes for Ribbed Bolts, Turned Bolts, or Other Approved Bearing-Type Bolts. Provide finished holes with a driving fit.

(h) Preparation of Field Connections. Subpunch or subdrill and ream while assembled, or drill full-size to a steel template, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames.

Holes for field splices of rolled beam stringers continuous over floor beams or cross frames may be drilled full-size unassembled to a steel template. Holes for floor beams or cross frames may be drilled full-size unassembled to a steel template. Subpunch and ream while assembled, or drill full-size to a steel template, all holes for floor beam and stringer field end connections.

When reaming or drilling full-size field connection holes through a steel template, carefully locate and position the template and firmly bolt in place before drilling. Use exact duplicates of templates used for reaming matching members, or the opposite faces of a single member. Accurately locate templates used for connections

on like parts or members so that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, holes drilled full-size through all thicknesses or material assembled in proper position may be used.

555.11 Pins & Rollers. Accurately fabricate pins and rollers that are straight, smooth, and free from flaws. Forge and anneal pins and rollers more than 225 mm in diameter. Pins and rollers 225 mm or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than 225 mm in diameter, bore a hole not less than 50 mm in diameter full length along the pin 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).

(a) Boring Pin Holes. Bore pin holes true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other. Produce the final surface using a finishing cut.

Produce a pin hole diameter that does not exceed that of the pin by more than 0.5 mm for pins 125 mm or less in diameter, or by 1 mm for larger pins.

The maximum allowed variation of the outside-to-outside distance of end holes in tension members and the inside-to-inside distance of end holes in compression members is 1 mm from that specified. Bore pin holes in built-up members after the member has been assembled.

(b) Threads for Bolts and Pins. Provide threads on all bolts and pins for structural steel construction that conform to the Unified Standard Series UNC ANSI B1.1, class 2A for external threads and class 2B for internal threads; but when pin ends have a diameter of 35 mm or more, provide six threads per 25 mm.

555.12 Eyebars. Pin holes may be flame cut at least 50 mm smaller in diameter than the finished pin diameter. Securely fasten together (in the order to be placed on the pin) all eyebars that are to be placed side by side in the structure and bore at both ends while clamped. Pack and match-mark eyebars for shipment and erection. Stamp with steel stencils, so as to be visible when the bars are nested in place on the structure, all identifying marks on the edge of one head of each member after fabrication is completed. Use low-stress-type steel die stamps.

Provide eyebars, straight and free from twists, with pin holes accurately located on the centerline of the bar. Do not allow the inclination of any bar to the plane of the truss to exceed 5.25 mm/m.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically operated torches abreast of each other, guided by a substantial template to prevent distortion of the plates.

555.13 Assembly—Bolting. Clean surfaces of metal in contact before assembling. Assemble parts of a member. Securely pin and firmly draw together before beginning drilling, reaming, or bolting. Take assembled pieces apart, if necessary, for the removal of burrs and shavings produced by the operation. Assemble members so that they are free from twists, bends, and other deformation.

Drift during assembling only enough to bring the parts into position without enlarging holes or distorting the metal.

555.14 Welded Connections. Fabricate surfaces and edges to be welded smooth, uniform, clean, and free of defects that would adversely affect the quality of the weld. Prepare edge in accordance with ANSI/AASHTO/AWS Bridge Welding Code D 1.5.

555.15 Preassembly of Field Connections. Preassemble field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers, and rigid frames before erection to verify the geometry of the completed structure or unit and to verify or prepare field splices. Present the method and details of preassembly for approval.

Use methods and details of preassembly that are consistent with the procedure shown on the approved erection camber diagrams. Assemble all girders and beams in their cambered (no-load) condition.

When members are assembled with their webs vertical, support them at intervals of 6 m, or two-tenths of the span length, whichever is less. When the webs are horizontal, the above intervals of support may be increased, provided there is no noticeable deflection between points of support.

Assemble trusses in full dead-load position, unless the design of the structure provides for the secondary stresses created by assembling the truss in the fully cambered (no-load) position. Support trusses during assembly at each panel point. Preassemble at least three contiguous panels that are accurately adjusted for line and camber. For successive assemblies, include at least one section or panel of the previous assembly (repositioned if necessary and adequately pinned to assure accurate alignment) plus two or more sections or panels added at the advancing end. For structures longer than 50 m, make each assembly not less than 50 m long, regardless of the length of individual continuous panels or sections. Assembly may start from any location in the structure and proceed in one or both directions, as long as the preceding requirements are satisfied.

(a) **Bolted Connections.** Where applicable, assemble major components with milled ends of compression members in full bearing and then ream subsized holes to the specified size while the connections are assembled.

(b) **Check Assembly—N/C Drilling.** When using N/C drilling or punching, make a check assembly for each major structural type of each project. Fabricate the check assembly of at least three contiguous shop sections or, for a truss, all members in at least three contiguous panels, but not less than the number of panels associated with three contiguous chord lengths (such as the length between field splices). Base check assemblies on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Shop assemblies other than the check assemblies are not required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required.

Receive approval of each assembly (including camber, alignment, accuracy of holes, and fit of milled joints) before reaming is commenced or before any N/C-drilled check assembly is dismantled.

(c) **Field-Welded Connections.** Field-welded connections are prohibited unless specifically SHOWN ON THE DRAWINGS. Verify the fit of members (including the proper space between abutting flanges) with the preassembled segment.

(d) **Match-Marking.** Match-mark connecting parts preassembled in the shop to assure proper fit in the field. Provide a diagram showing such match-marks.

555.16 Connections Using Unfinished, Turned, or Ribbed Bolts. Use unfinished, turned, or ribbed bolts, where specified, that conform to ASTM A 307 for grade-A bolts. Use bolts with approved single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

(a) **Turned Bolts.** Furnish turned bolts with a body-surface ANSI roughness not exceeding 3 μm . Furnish hex-headed bolts and nuts of the nominal size specified. Carefully ream holes for turned bolts, and furnish bolts to provide for a light driving fit. Keep bolt threads entirely outside of the holes. Provide a washer under the nut.

(b) **Ribbed Bolts.** Use approved form of ribbed body with continuous longitudinal ribs. Provide a body diameter measured on a circle through the points of the ribs 2 mm greater than the nominal diameter specified for the bolts.

Furnish ribbed bolts with round heads conforming to ANSI B18.5. Furnish hexagonal nuts that are either recessed or have a washer of suitable thickness. Furnish

ribbed bolts that have a driving fit when installed in holes. Provide sufficiently hard ribs such that the ribs do not compress, deform, or allow the bolts to turn in the holes during tightening. If the bolt twists before drawing tight, ream the hole and provide an oversized replacement bolt.

555.17 Connections Using High-Strength Bolts. Assemble structural joints using AASHTO M 164M or M 253M high-strength bolts, or equivalent fasteners, as SHOWN ON THE DRAWINGS, tightened to a high tension.

(a) Bolted Parts. Use steel material within the grip of the bolt with no compressible material such as gaskets or insulation. Fabricate bolted steel parts to fit solidly together after the bolts are tightened. Limit the maximum slope of the surfaces of parts in contact with the bolt head or nut to 1:20 with respect to a plane normal to the bolt axis.

(b) Surface Conditions. At the time of assembly clean all joint surfaces (including surfaces adjacent to the bolt head and nut) of dirt or foreign material and scale, except tight mill scale. Remove burrs that would prevent solid seating of the connected parts in the snug-tight condition.

Paint or other coatings are not permitted on the faying surfaces of slip-critical connections. All connections are considered to be slip-critical, unless otherwise SHOWN ON THE DRAWINGS. Exclude paint (including any inadvertent overspray) from areas closer than one bolt diameter, but not less than 25 mm, from the edge of any bolt hole and all areas within the bolt pattern.

(c) Installation. Install fasteners of the same lot number together. Protect fasteners from dirt and moisture. Take from protected storage only as many fasteners as are anticipated to be installed and tightened during a work shift. Return to protected storage fasteners not used at the end of the shift. Do not clean lubricant from fasteners where the lubricant is required to be present in the as-delivered condition. Clean and relubricate, before installation, fasteners for slip-critical connections that accumulate rust or dirt.

Provide a tension-measuring device (a Skidmore-Willhelm calibrator or other acceptable bolt-tension-indicating device) at all job-sites where high-strength fasteners are being installed and tightened. Use the tension-measuring device to perform the rotational-capacity test and to confirm all of the following:

- The requirements of table 555-6 of the complete fastener assembly.
- The calibration of the wrenches, if applicable.
- The understanding and proper use of the tightening method.

For short grip bolts, direct tension indicators (DTI's) with solid plates may be used to perform this test. First check the DTI with a longer grip bolt in the Skidmore-Wilhelm calibrator. The frequency of confirmation testing, number of tests to be performed, and test procedure shall conform to Subsection 555.17(c)(3) through (5), as applicable. Confirm the accuracy of the tension-measuring device through an approved testing agency at least once per year.

Install fasteners together with washers of the size and quality specified, located as required below, in properly aligned holes and tightened using any of the methods described in Subsection 555.17(c)(3) through (6) to at least the minimum tension specified in table 555-6 after all the fasteners are tight.

Table 555-6.—Minimum fastener tension.^a

Nominal Bolt Diameter and Tread Pitch	AASHTO M 164M (kN)	AASHTO M 253M (kN)
M16 x 2	91	114
M20 x 2.5	142	179
M22 x 2.5	176	221
M24 x 3	205	258
M27 x 3	267	334
M30 x 3.5	326	408
M36 x 4	475	595

a. Equal to 70 percent of the specified minimum tensile strength of bolts (as specified for tests of full-size ASTM A 325M and ASTM A 490M bolts), rounded to the nearest kilonewton.

If approved, tightening may be performed by turning the bolt while the nut is prevented from rotating when it is impractical to turn the nut. If impact wrenches are used, provide adequate capacity and sufficient air to tighten each bolt in approximately 10 seconds.

Do not reuse AASHTO M 253M fasteners and galvanized AASHTO M 164M fasteners. If approved, other AASHTO M 164M bolts may be reused once. Touching up or retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts will not be considered to be reuse, provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance, than that specified in table 555-7.

(1) *Rotational-Capacity Tests.* Subject high-strength fasteners, black and galvanized, to jobsite rotational-capacity tests performed in accordance with AASHTO M 164M, subsection 8.5, and the following:

- (a) After tightening to a snug-tight condition, as defined in Subsection 555.17(c)(3), tighten the fastener twice the required number of turns indicated in table 555-7, in a Skidmore-Wilhelm calibrator or equivalent tension-measuring device, without stripping or failure.

Table 555-7.^a—Nut rotation from the snug-tight condition.^b

Bolt Length Measured From Underside of Head to End of Bolt	Geometry of Outer Faces of Bolted		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis and Other Face Sloped Not More Than 1:20 (Bevel Washers 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 ^c	2/3 turn	5/6 turn	1 turn

a. Applicable only to connections where all material within the grip of the bolt is steel.

b. Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. The tolerance is $\pm 30^\circ$ for bolts installed by 1/2 turn or less. The tolerance is $\pm 45^\circ$ for bolts installed by 2/3 turn or more.

c. Determine the required rotation by actual tests in a suitable tension device simulating the actual conditions.

- (b) During this test, the maximum recorded tension must be equal to or greater than the turn test tension, which is 1.15 times the required minimum fastener tension indicated in table 555-6.
- (c) Ensure that the measured torque at a tension P , after exceeding the turn test tension required above, does not exceed the value obtained by the following equation:

$$\text{Torque} = PD/4,000$$

where

Torque = measured torque in newton meters (N•m)

P = measured bolt tension in newtons (N)

D = nominal bolt diameter in millimeters (mm)

For rotational-capacity tests, use washers even though their use may not be required in the actual installation.

(2) *Washers.* Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels conforming to AASHTO M 293.

Where necessary, washers may be clipped on one side not closer than seven-eighths of the bolt diameter from the center of the washer.

Hardened washers are not required for connections using AASHTO M 164M and M 253M bolts except under the following conditions:

- (a) Use hardened washers under the element turned in tightening when the tightening is done by the calibrated wrench method.
- (b) Use hardened washers under both the head and the nut when AASHTO M 253M bolts are installed in material with a specified yield point less than 275 MPa, regardless of the tightening method.
- (c) Use a hardened washer conforming to ASTM F 436M where AASHTO M 164M bolts of any diameter or AASHTO M 253M bolts equal to or less than M 24 are to be installed in oversize or short-slotted holes in an outer ply.
- (d) Use hardened washers conforming to ASTM F 436M, except with 8 mm minimum thickness, under both the head and the nut in lieu of standard-thickness hardened washers where AASHTO M 253 bolts over M 24 are to be installed in an oversize or short-slotted hole in an outer ply. Multiple hardened washers with combined thickness equal to or greater than 8 mm do not satisfy this requirement.
- (e) Where AASHTO M 164M bolts of any diameter or AASHTO M 253M bolts equal to or less than M24 are installed in a long-slotted hole in an outer ply, provide a plate washer or continuous bar that has a thickness of at least 8 mm, with standard holes of sufficient size to cover the slot after installation, and is of structural-grade material that need not be hardened.

When AASHTO M 253M bolts over M24 are used in long-slotted holes in external plies, use a single hardened washer conforming to ASTM F 436M with an 8-mm minimum thickness in lieu of washers or bars of structural steel. Multiple hardened washers with combined thickness equal to or greater than 8 mm do not satisfy this requirement.

Alternate design fasteners conforming to Subsection 717.01, with a geometry that provides a bearing circle on the head or nut with a diameter equal to or greater than the diameter of hardened washers conforming to ASTM F 436M, satisfy the requirements for washers specified herein and may be used without washers.

(3) *Turn-of-Nut Tightening.* At the start of work, test nut tightening using a device capable of indicating bolt tension. Test not less than three bolt-and-nut assemblies of each diameter, length, and grade to be used in the work. Demonstrate with the test that the method to be used for estimating the snug-tight condition and controlling the turns from snug tight develops a tension not less than 5 percent greater than the tension specified in table 555-6. Perform periodic retesting when required.

Install bolts in all holes of the connection and initially tighten to a snug-tight condition. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench.

Systematically snug-tighten bolt groups from the most rigid part of the connection to the free edges. Then retighten the bolts of the connection in a similar systematic manner as necessary until all bolts are snug tight and the connection is fully compacted. Following the snug-tightening operation, tighten all bolts in the connection by the applicable amount of rotation specified in table 555-7.

During all tightening operations, do not allow rotation of the fastener part not turned by the wrench. Tighten systematically from the most rigid part of the joint to its free edges.

(4) *Calibrated Wrench Tightening.* Calibrated wrench tightening may be used only when installation procedures are calibrated on a daily basis and when a hardened washer is used under the element turned in tightening. Standard torques taken from tables or from formulas that assume to relate torque to tension are not acceptable.

If calibrated wrenches are used for installation, set them to provide a tension not less than 5 percent in excess of the minimum tension specified in table 555-6. Calibrate the installation procedure at least once each working day for each bolt diameter, length, and grade using fastener assemblies that are being installed in the work.

Perform the calibration with a device capable of indicating actual bolt tension by tightening three typical bolts of each diameter, length, and grade from the bolts and washers being installed using a job-supplied washer under the element turned in tightening. Recalibrate wrenches when significant difference is noted in the surface condition of the bolts, threads, nuts, or washers. Verify during use that the wrench adjustment selected by the calibration does not produce a nut or bolt head rotation from snug tight greater than permitted in table 555-7. Turn nuts in the tightening direction when measuring the torque of manual torque wrenches.

If calibrated wrenches are used to install bolts in a connection, install bolts with hardened washers under the turned element. When tightening bolts in all holes of the connection, tighten to a snug-tight condition. Following this initial tightening

operation, tighten all bolts in the connection using a calibrated wrench. Tighten systematically from the most rigid part of the joint to its free edges. "Touch up" previously tightened bolts that may have been relaxed during the subsequent tightening of adjacent bolts until all bolts are properly tightened.

(5) *DTI Tightening.* When tightening bolts using DTI devices, assemble a representative sample of not less than three devices for each diameter and grade of fastener to be used in the work in a calibration device capable of indicating bolt tension. Include in the test assembly flat-hardened washers, if required in the actual connection, arranged like those in the actual connections to be tensioned. The calibration test must demonstrate that the device indicates a tension not less than 5 percent greater than that specified in table 555-6.

Follow the manufacturer's installation procedures for installation of bolts in the calibration device and in all connections. Give special attention to proper installation of flat-hardened washers when DTI devices are used with bolts installed in oversize or slotted holes, and where the load-indicating devices are used under the turned element.

When bolts are installed using DTI's conforming to ASTM F 959, install bolts in all holes of the connection and bring to a snug-tight condition. Snug tight is indicated by partial compression of the DTI protrusions. Then tighten all fasteners systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. Comply with the installation instructions portion of section 11.5.6.4.7, division II, of AASHTO's "Standard Specifications for Highway Bridges." Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final tightening to deform the protrusion to the specified gap.

(6) *Installation of Alternate Design Bolts.* When fasteners that incorporate a design feature intended to indirectly indicate the bolt tension or to automatically provide the tension specified in table 555-6 and that conform to Subsection 717.01 are to be installed, test a representative sample of not less than three bolts of each diameter, length, and grade at the jobsite with a device capable of indicating bolt tension.

Include in the test assembly flat-hardened washers, if required in the actual connection, arranged as in the actual connections to be tensioned. The calibration test must demonstrate that each bolt develops a tension not less than 5 percent greater than the tension specified in table 555-6. Follow manufacturer's installation procedure. Perform periodic retesting when required.

When alternate design fasteners that are intended to control or indicate bolt tension of the fasteners are used, install bolts in all holes of the connection and initially tighten sufficiently to bring all plies of the joint into firm contact, but without

yielding or fracturing the control or indicator element of the fasteners. Continue to tighten systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners.

Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final twist-off or pull-off of the control or indicator element of individual fasteners.

(7) *Inspection.* Inspect the tightened bolts in the presence of the CO. Use an inspection torque wrench to verify tightening of threaded fasteners. For nonthreaded fasteners, ping each fastener with a hammer to test for soundness. Replace or retighten any loose or relaxed fastener. Cutting with a torch will not be permitted for removal of bolts.

Individually place three bolts of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Perform this calibration operation at least once each inspection day. Permit the CO full opportunity to witness calibration tests.

Use a washer under the part turned in tightening each bolt if washers are used on the structure. If washers are not used on the structure, use the same specification material that abuts the part turned in the tension-measuring device as used on the structure. In the calibrated device, tighten each bolt by any convenient means to the specified tension. Apply the inspecting wrench to the tightened bolt to determine the torque required to turn the nut or head 5°, approximately 30 mm at a 300-mm radius, in the tightening direction. Use the average of the torque required for all three bolts as the job-inspection torque.

Select at random in each connection 10 percent (at least two) of the tightened bolts on the structure represented by the test bolts, and apply the job-inspection torque to each selected bolt with the inspecting wrench turned in the tightening direction. If this torque turns no bolt head or nut, the bolts in the connection will be considered to be properly tightened. If the torque turns one or more bolt heads or nuts, apply the job-inspection torque to all bolts in the connection. Tighten and reinspect any bolt whose head or nut turns at this stage. As an option, retighten all bolts in the connection and resubmit for inspection.

555.18 Welding. Ensure that welding, welder qualifications, prequalification of weld details, and inspection of welds conform to ANSI/AASHTO/AWS Bridge Welding Code D 1.5. Delete the provisions of section 9.25.1.7. Do not underrun the nominal fillet weld size.

Do not weld or tack brackets, clips, shipping devices, or other material not required to any member unless SHOWN ON THE DRAWINGS.

555.19 Erection. Ensure that falsework and forms conform to Section 562.

(a) **Handling & Storing Material.** Place material stored at the jobsite on skids above ground. Keep material clean and properly drained. Place and shore girders and beams upright. Support long members, such as columns and chords, on skids placed near enough together to prevent damage due to deflection.

(b) **Bearings & Anchorages.** Furnish and install bridge bearings in accordance with Section 564. If the steel superstructure is to be placed on a substructure that was built under a separate contract, verify that the masonry has been correctly constructed before ordering material.

(c) **Erection Procedures.** Follow the procedures shown below.

(1) **Conformance to Drawings.** Erect as SHOWN ON THE DRAWINGS. Modifications to or deviations from the approved erection procedure will require revised drawings and verification of stresses and geometry.

(2) **Erection Stresses.** Allow for erection stresses induced in the structure as a result of the use of a method of erection or equipment that differs from that previously approved, and that will remain in the finished structure as locked-in stresses. Provide additional material, as needed, to keep both temporary and final stresses within the allowable limits used in the design.

Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.

(3) **Maintaining Alignment & Camber.** During erection, support segments of the structure in a manner that will produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing as necessary during erection to provide stability and assure correct geometry. As necessary, provide temporary bracing at any stage of erection.

(d) **Field Assembly.** Accurately assemble as SHOWN ON THE DRAWINGS and required by match-marks. Carefully handle the material. Do not hammer, damage, or distort the members. Clean bearing surfaces and permanent contact surfaces before assembly.

Assemble splices and field connections with at least two cylindrical erection pins per part (a minimum of four per splice or connection). Use cylindrical erection pins 1 mm larger than the bolts to be used. A plate girder splice requires, for example, at least four cylindrical erection pins for the top flange splice, four pins for the web splice, and four pins for the bottom flange splice. (These provide two pins for each part.) Place the pins in the corner holes of the splice plates.

Install more cylindrical erection pins, if necessary, to accurately align the parts. Fill the remaining holes in the connection with bolts, and tighten systematically in accordance with Subsection 555.17 from the most rigid part of the connection to the free edges. Remove cylindrical erection pins and replace with tightened bolts.

Release temporary erection supports at a splice or connection only after all bolts are installed and tightened. Special assembly and support situations are SHOWN ON THE DRAWINGS or approved submittals.

Fitting-up bolts may be the same high-strength bolts used in the installation. If other fitting-up bolts are required, use the same nominal diameter as the high-strength bolts.

(e) Pin Connections. Use pilot and driving nuts in driving pins. Drive the pins so that the members will fully bear on the pins. Screw pin nuts tight, install nut retaining devices as SHOWN ON THE DRAWINGS, and burr the threads at the face of the nut with a pointed tool.

(f) Misfits. Correction of minor misfits involving minor amounts of reaming, cutting, and chipping may be done, if approved. Any error in the shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

Measurement

555.20 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure structural steel by the kilogram or lump sum computed in accordance with the AASHTO "Standard Specifications for Highway Bridges." The quantity will include metal items incidental to the structure, such as castings, steel plates, anchor bolts and nuts, bearings, 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.

Changes in quantities resulting from alternative details proposed by the Contractor and approved by the CO are not subject to price adjustment.

Payment

555.21 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
555 (01) Structural steel, _____, furnished, <div style="text-align: center;"><i>Description</i></div> fabricated, and erected	Kilogram
555 (02) Structural steel, _____, furnished, <div style="text-align: center;"><i>Description</i></div> fabricated, and erected	Lump Sum

Section 556—Bridge Railing

Description

556.01 Work. Furnish and erect and/or remove and reset bridge railing and bridge approach railing.

Bridge railing is designated as concrete, steel, aluminum, or timber in accordance with the predominant material contained in the railing.

Materials

556.02 Requirements. Furnish material that conforms to specifications in the following sections and subsections:

Aluminum Bolt Heads and Nuts	717.14
Aluminum Alloy for Bridge Rail	717.13
Aluminum-Impregnated Caulking Compound	725.27
Aluminum Welding Wire	717.15
Box Beam Rail	710.07
Guardrail	606
Painting	563
Reinforcing Steel	554
Steel Structures	555
Structural Concrete	552
Timber Structures	557

Construction

556.03 General. Accurately place anchor bolts to provide correct and true alignment of the railing. Set anchor bolts so that they project not more than 10 mm beyond the nut when tightened. Chamfer or round by grinding or filing all sharp exposed metal edges.

Provide bridge rail shop drawings when SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS.

Do not erect railing until centering or falsework for the supporting span is removed. Construct bridge railing so that it does not follow any unevenness in the curb, sidewalk, or wall that supports the railing. The railing shall present a smooth, uniform appearance in its final position. Set all posts vertical.

556.04 Concrete Railing. Construct in accordance with Section 552 and the following:

- Construct expansion joints that permit freedom of movement. After all other work is completed, use a sharp chisel to remove all loose or thin shells of concrete likely to spall under movement at expansion joints.

(a) **Fixed Forms.** Construct forms that are smooth and tight fitting, rigidly held in line and grade, and removed without damage to the concrete. Make form joints in vertical planes. Construct all moldings, panel work, and bevel strips as SHOWN ON THE DRAWINGS. Make corners in the finished work true and free from cracks, spalls, or other defects.

(b) **Slipformed.** Concrete rails may be slipformed if the DRAWINGS contain details for slipforming. Before slipforming any permanent rail, one or both of the following requirements shall be met, as directed by the CO:

- (1) Cast a test section at least 6 m long that shall:
 - (a) Be placed off the structure.
 - (b) Have the same section and reinforcement as detailed for use on the structure.
 - (c) Include one typical contraction or open joint.
 - (d) Be removed and disposed of without compensation.
- (2) Identify, for the purposes of evaluating work quality, at least two recent slipformed rail projects completed by the Contractor.

The CO will make the final decision about the use of slipforming on the project based on work quality. If slipforming is approved by the CO:

- Provide concrete with a slump of $25 \text{ mm} \pm 12 \text{ mm}$.
- Keep the top and faces of the finished rail free from sags, humps, and other irregularities.
- Maintain contraction joints, open joints, and expansion joints to the dimensions SHOWN ON THE DRAWINGS until the concrete sets.
- Use slipforming only for section of rail with constant dimensions. Use fixed forms where dimensions vary, as at luminaire or signal supports and at rail end transitions.

- Brush finish exposed rail surfaces with vertical strokes. Do not grind brush finished surfaces that are to receive a class 1 finish as specified in Subsection 552.18(a).
- Remove and replace any unsatisfactory work without compensation.

(c) **Surface Finish.** Apply a general surface finish using a class 2 finish to all exposed concrete surfaces as specified in Subsection 552.18(b).

556.05 Steel Railing. Construct in accordance with Section 555. Ensure that structural tubing conforms to AASHTO M 183 (ASTM A 500, grade B).

If required, galvanize in accordance with AASHTO M 111, and furnish nuts, bolts, and washers galvanized in accordance with AASHTO M 232. Repair minor abrasions with zinc-rich paint.

For exposed weathering steel, use railing fasteners, railing hardware, rail post anchor bolts, nuts, washers, and shims with the same atmospheric corrosion resistance and weathering characteristics as the railing and posts. Use hand methods to clean erected steel railing of all oil, dirt, grease, mortar, and other foreign substances. Use weld metal with similar atmospheric corrosion resistance and coloring characteristics as the base metal. Clean welds by power brushing or blast cleaning to remove welding flux, slag, and spatter.

Unless a coating is required, clean all weathering steel in accordance with Steel Structures Painting Council (SSPC) standard SSPC-SP 6 and remove all mill scale and other foreign substances so that the steel surface is uniformly exposed to the atmosphere.

556.06 Aluminum Railing. Construct in accordance with Section 555, except as amended by the following:

(a) **Cutting.** Material that is 13 mm thick or less may be cut by shearing, sawing, or milling. Saw or mill material that is more than 13 mm thick. Do not flame cut. Make cut edges true, smooth, and free from excessive burrs or ragged breaks. Fillet re-entrant cuts by drilling before cutting.

(b) **Bending.** Material may be heated to a maximum 200 °C for a period not to exceed 30 minutes to facilitate bending.

(c) **Rivet & Bolt Holes.** Drill rivet and bolt holes to finished size or subpunch smaller than the nominal diameter of the fastener and ream to size. Subpunch to a diameter that is smaller than that of the finished hole by at least one-quarter the thickness of the piece. Make the finished diameter of holes not more than 7 percent greater than the nominal diameter of the fastener, except:

- (1) Fabricate slotted bolt holes as required.
- (2) Fabricate anchor bolt holes up to 25 percent larger, not to exceed 15 mm larger than the nominal bolt diameter.

(d) Welding. Weld in accordance with AWS Structural Aluminum Welding Code D 1.2.

(e) Contact With Other Material. Do not place aluminum alloys in contact with copper, copper base alloys, lead, or nickel. Where aluminum alloys come in contact with other metals, coat the contacting surfaces thoroughly with an approved aluminum-impregnated caulking compound or place a neoprene gasket between the surfaces.

Where aluminum alloys come in contact with concrete or stone, coat the contacting surfaces with an aluminum-impregnated caulking compound. When bond between aluminum and concrete is required, coat the aluminum with zinc-chromate paint and allow to dry before installation.

Where aluminum alloys come in contact with wood, coat the contacting wood surface with three coats of paint in accordance with Section 563 and coat the contacting aluminum surface with an aluminum caulking compound.

556.07 Timber Railing. Construct in accordance with Section 557.

When SHOWN ON THE DRAWINGS or directed in the SPECIAL PROJECT SPECIFICATIONS, clean all exposed surfaces of timber railing treated with pentachlorophenol or creosote that are located where contact by people may occur. Seal these surfaces with two coats of urethane, shellac, latex epoxy, enamel, or varnish.

556.08 Approach Railing. Construct in accordance with Subsection 556.05 and Section 606.

556.09 Remove & Reset Bridge Railing. Remove and store the existing bridge railings and appurtenances. Replace all railings, supports, and hardware damaged during removal, storage, or resetting.

556.10 Painting. Paint in accordance with Section 563.

Measurement

556.11 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure bridge railing by the meter or by the lump sum. Measure removed and reset bridge railing by the meter. When bridge railing is measured by the meter, measure along the top of the railing center to center of end posts.

When bridge approach railing is measured by the meter, measure the total approach railing length along the face of the railing from the ends of the bridge railing, as SHOWN ON THE DRAWINGS, to the center of the end approach railing posts, unless otherwise SHOWN ON THE DRAWINGS.

Payment

556.12 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
556 (01) _____ bridge railing	Meter
556 (02) _____ bridge railing	Lump Sum
556 (03) Remove and reset bridge railing	Meter
556 (04) Bridge approach railing, type _____, class _____	Meter
556 (05) Terminal section, _____	Each
<i>Description</i>	
556 (06) Anchorage	Each

Section 557—Timber Structures

Description

557.01 Work. Furnish, fabricate, erect, and paint structural timber, including all required yard lumber and hardware.

Materials

557.02 Requirements. Furnish material that conforms to specifications in the following section and subsections:

Hardware & Structural Steel	716.02
Painting	563
Structural Glued Laminated Timber	716.04
Treated Structural Timber & Lumber	716.03
Treated Timber Piles	715.02
Untreated Structural Timber & Lumber	716.01

Furnish the following compliance certificates to the CO upon delivery of the materials to the jobsite:

- (a) Verification of compliance with grading rules and species of timber and lumber. Provide certification by an agency accepted as competent by the American Lumber Standards Committee (ALSC).
- (b) Lot certification of each charge for preservative, penetration in millimeters, and retention in kilograms per cubic meter (assay method) by a qualified independent inspection and testing agency. In addition, have the producer of the treated products provide written certification that Best Management Practices (BMP's) in accordance with "Best Management Practices for Treated Wood in Western Aquatic Environments," published by the Western Wood Preservation Institute (WWPI) and Canadian Institute of Treated Wood, were followed, including a description and appropriate documentation of the applicable BMP's used.
- (c) Certification from a qualified inspection and testing agency indicating that all glued laminated members are in accordance with the requirements of American National Standard for Wood Products, "Structural Glued Laminated Timber" (ANSI/AITC A190.1), modified as SHOWN ON THE DRAWINGS.

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

Incise all glued laminated and solid sawn members thicker than 50 mm in accordance with AWPAs standard C1, unless otherwise SHOWN ON THE DRAWINGS.

Provide shop drawings for all timber 21 days in advance of fabrication when SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Show all dimensions and fabrication details for all cut, framed, or bored timbers.

Construction

557.03 General. Perform the work under Section 206. Furnish structural lumber and timber of the required stress grade.

Clear stacks of weeds, rubbish, or other objectionable material from the ground under and in the vicinity of all stored material. Place the bottom layer of material at least 200 mm above the ground level. Provide sufficient support to prevent sagging.

Open-stack untreated material to shed water. Stack material in layers on spacers (stickers) that extend across the full width of the stack to allow for free air circulation. Align all stickers vertically and space them at regular intervals.

Close-stack treated material to shed water.

Protect material from the weather. If covered, use sheet material such as water-resistant paper or opaque polyethylene film. Do not cover with impervious membranes, such as polyethylene film, during dry weather. Slit individual wrappings full length or puncture on the lower side to permit drainage of water.

Store and protect glued laminated timber in accordance with the recommendations for Loading and Handling, Job Site Storage, and Erection in "Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage, and Erection," published by the American Institute of Timber Construction, AITC 111.

Use slings or other devices to protect corners of heavy construction timbers and banded packages of lighter construction timber.

557.04 Treated Timber. Fabricate timbers before treatment. Handle treated timber according to the Consumer Information Sheet published by AWPAs. Do not cut, frame, or bore treated timber after treatment unless approved by the CO. Handle

treated timbers carefully and do not drop, damage outer fibers, or penetrate the surface with tools. Do not use cant dogs, hooks, or pike poles. In coastal waters, do not cut or bore timber below the highwater mark.

For timbers originally treated with pentachlorophenol, creosote, creosote solutions, or waterborne preservatives, field treat all cuts, abrasions, bolt holes, and recesses that occur after treatment with two liberal applications of a compatible preservative in accordance with the requirements specified in AWPA standard M4, Standard for the Care of Pressure-Treated Wood Products.

Unless otherwise specified, copper naphthenate solutions may be used for field treatments of material originally treated with copper naphthenate, pentachlorophenol, creosote, creosote solution, or waterborne preservatives. Prepare the preservative solution by blending copper naphthenate preservative that meets P8 requirements with a solvent conforming to AWPA standard P9. Ensure that the resulting preservative solution concentration contains a minimum of 2 percent copper metal.

Plug all unused holes with preservative-treated plugs. Perform all field-applied preservative treatment with necessary precautions so as to prevent any soil and/or water contamination.

557.05 Untreated Timber. Coat the following untreated timber surfaces in accordance with AWPA standard M4:

- (a) All ends and tops, and all contact surfaces of posts, sills, and caps.
- (b) All ends, joints, and contact surfaces of bracing and truss members.
- (c) All surfaces of timber bumpers and the back faces of bulkheads.
- (d) All other timber that will be in contact with earth.

557.06 Workmanship. Cut and form all lumber and construction timber so all joints will have even bearing over the entire contact surface. Do not use shims in making joints. Construct all joints to be closed. Drive nails and spikes to set the heads flush with the wood surface. Use the same end, face, and edge of the timber member for all layout dimensions. Bore all holes from mating faces.

557.07 Holes for Bolts, Dowels, Rods, & Lag Screws. Bore all holes before preservative treating the wood. Bore holes for round driftbolts and dowels 2 mm smaller in diameter than that of the bolt or dowel to be used. Ensure that the diameter of holes for square driftbolts or dowels is equal to the side dimension of the bolt or dowel.

Bore holes for machine bolts with a bit 1.5 mm larger than the diameter, except when galvanized bolts are specified. In this case, drill all holes 3 mm greater than the bolt size. Bore holes for lag screws with a bit not larger than the body of the screw at the base of the thread. Drill the depth of lag screw bolt holes 25 mm less than the length under the screw head and with a diameter approximately 75 percent of the shank diameter.

557.08 Hardware. Furnish the hardware as SHOWN ON THE DRAWINGS, as specified below.

(a) **Bolts & Washers.** Finally tighten all nuts to provide proper bearing, and cut off excess bolt lengths of more than 25 mm. After final tightening, check or burr all bolts effectively with a pointing tool to prevent loosening of the nuts.

Use malleable iron washers with a diameter approximately three times the bolt diameter under all bolt heads or nuts in contact with wood. Use cast-iron washers when the timber is in contact with the ground. Use square washers only when SHOWN ON THE DRAWINGS or with the approval of the CO.

(b) **Galvanizing.** Unless otherwise SHOWN ON THE DRAWINGS, ensure that all hardware for timber structures is galvanized, except for the glued laminated deck panel dowels. Ensure that all fasteners, including nails, spikes, bolts, washers, and timber connectors, other than malleable iron, are galvanized.

557.09 Countersinking. Countersink nuts and bolt heads where SHOWN ON THE DRAWINGS. Paint recesses formed for countersinking with an approved preservative, except in railing. After bolts or screws are in place, fill the holes with hot pitch or other approved filler.

557.10 Framing. Do not slab or trim treated piles for fitting sway or sash braces. Fill all gaps that occur between braces and piles with treated blocks so that the bracing is securely fastened to the piles.

557.11 Framing Bents. Bed mud sills firmly, evenly, and level to solid bearing, and tamp in place.

When concrete is cast and dowels are used for anchoring sills and posts, install dowels (18 mm minimum diameter) that project at least 150 mm above the tops of the pedestals. Carefully finish concrete pedestals supporting framed bents so that sills or posts bear evenly on the pedestals.

Provide firm, uniform bedding for mud sills. Make sills bear true and even on mud sills, piles, or pedestals. Drift bolt sills with bolts that extend into the mud sills or piles for at least 150 mm. Where possible, remove all earth in contact with sills for circulation of air around the sills.

557.12 Posts. Fasten posts to pedestals with dowels not less than 18 mm in diameter that extend at least 150 mm into the posts, or with other types of connectors as SHOWN ON THE DRAWINGS. Fasten posts to sills using one of the following methods, as SHOWN ON THE DRAWINGS:

- (a) With dowels not less than 18 mm in diameter that extend at least 150 mm into posts and sills.
- (b) With drift bolts not less than 18 mm diameter driven diagonally through the base of the post and extending at least 175 mm into the sill. Drive drift bolts into holes at a 45° angle to enter the post at least 150 mm above the post base.
- (c) With other types of connectors as SHOWN ON THE DRAWINGS.

557.13 Pile Bents. Treat, furnish, and drive piles in accordance with Section 551.

557.14 Caps for All Bents. Make timber caps bear even and uniform over the tops of the supporting posts or piles, with their ends in alignment. Secure all caps with drift bolts and set approximately at the center of and extending into the posts or piles at least 230 mm.

557.15 Bracing. Bolt the ends of bracing through the pile, post, cap, or sill. Brace intermediate intersections with posts or piles with bolts or spikes, as required. In all cases, use galvanized spikes in addition to bolts.

Make all bracing bear firmly against the pile or cap to which it is bolted. Provide and place shims as necessary to prevent bending the bracing more than 25 mm out of line when bracing bolts are tightened.

Where the space between the bracing and cap or pile is less than 25 mm, shims need not be used.

Where the space between the bracing and the cap or pile is 40 mm ± 15 mm, place two ogee washers, with their narrow faces together, or other approved washers on each bolt that passes through the space.

Where the space between the bracing and the cap or pile is over 55 mm, use wooden shims of the proper thickness. Fabricate the wooden shims from White Oak or from other approved hardwood. Do not use built-up wooden shims. Make wooden shims from a single piece of lumber with the width not less than 100 mm and the length not less than the width of the bracing measured along the cap or pile. Do not adze, trim, or cut any treated member to avoid the use of shims.

557.16 Stringers. Place solid sawn stringers in position so that knots near edges are in the top portions of the stringers.

Outside stringers may have butt joints with the ends cut on a taper. Lap interior stringers to take bearing over the full width of the floor beam or cap at each end. Separate the lapped ends of untreated stringers by at least 15 mm for air circulation. Securely fasten the lapped ends with drift bolts, as required. Stagger the joints where stringers are two panels in length.

Install cross-bridging between stringers as SHOWN ON THE DRAWINGS. If timber cross-bridging members are used, cut for a full bearing at each end against the sides of the stringers. Place cross-bridging at the center of each span or as SHOWN ON THE DRAWINGS.

557.17 Plank Floors. Use plank that is surfaced on four sides (S4S).

Single-ply timber floors consist of a single thickness of planks supported on stringers. Lay the planks heart side down with 5 mm space between them for seasoned material, and with tight joints for unseasoned material. Spike each plank securely to each stringer. Carefully grade the planks as to thickness and lay so that no two adjacent planks vary in thickness by more than 2 mm.

Two-ply timber floors consist of two layers of flooring supported on stringers. Pressure treat the lower layer with creosote oil or with another preservative as SHOWN ON THE DRAWINGS. Lay the top layer either diagonal or parallel to the centerline of roadway as required. Securely fasten each floor piece to the lower layer. Stagger joints at least 1 m. Where the top layer is placed parallel to the centerline of the roadway, use special care to securely fasten the ends of the flooring. Bevel the ends of top layer members at each end of the structure.

557.18 Transversely Nail-Laminated Decks. Use 50-mm nominal thickness laminations; surface one edge hit or miss 3 mm scant (SIE-H or M 3 mm scant), and one side hit or miss 3 mm scant (SIS-H or M 3 mm scant).

Place the laminations on edge and at right angles to the centerline of the roadway. Spike each piece to the preceding piece at each end and at approximately 450-mm intervals, with the galvanized spikes driven alternately near the top and bottom edges. Use spikes of sufficient length to pass through two pieces and at least halfway through the third piece.

Where timber stringers are used, toenail every other piece to every other stringer. Use the size spikes specified. When steel stringers are used, securely attach the pieces using approved galvanized metal clips.

Use pieces of sufficient length to bear on at least four stringers. Do not splice pieces between stringers. Space end joints on any one stringer no closer than every third piece. Space end joints in adjoining pieces no closer than every second stringer.

557.19 Glued Laminated Panel Decks. Do not drag or skid panels. When lifted, support panels in the weak-moment plane at a sufficient number of points to avoid overstressing, and protect the edges from damage.

When dowels are SHOWN ON THE DRAWINGS between deck panels, use a template or drilling jig to ensure that dowel holes are accurately spaced and drilled parallel to one another and to the horizontal surfaces of the panel. Drill holes to a depth 6 mm greater than one-half the dowel length, and of a diameter that is 2 mm greater than the dowel, unless otherwise SHOWN ON THE DRAWINGS. Use a temporary dowel as a check for snug fit prior to production drilling. Use dowels of the size SHOWN ON THE DRAWINGS, with the tips slightly tapered or rounded. Use an approved lubricant to facilitate the connection process.

Start the tips of all dowels partially and equally into the holes of the two panels being joined. Draw the panels together keeping the edges parallel, until the panels abut tightly. Securely fasten each panel to each stringer as SHOWN ON THE DRAWINGS.

Assemble and match-mark panels prior to delivery to the construction site when SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS. Follow erection procedures given in FPL-263, Forest Service, Forest Products Laboratory (FPL), Madison, Wisconsin.

557.20 Wheel Guards & Railings. Surface (S4S) wheel guards, rails, and posts. Place wheel guards in sections not less than 4 m in length. Squarely butt-joint all rails at posts.

557.21 Trusses. Fabricate trusses to show no irregularities of line when completed. Fabricate chords straight and true from end to end in horizontal projection. In vertical projection, fabricate chords to a smooth chorded curve through panel points conforming to the correct camber. Do not make uneven or rough cuts at the points of bearing.

557.22 Drains. Hot-dip galvanize drains, including anchorages, after fabrication.

557.23 Painting. Paint in accordance with Section 563.

Measurement

557.24 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure untreated and treated structural timber and lumber by the cubic meter of lumber and timber in place in the completed structure. Compute the quantities from nominal dimensions and actual lengths, except for transversely nail-laminated decks. Measure transversely nail-laminated decks in place after dressing.

Measure timber piles under Subsection 551.16.

Measure timber bridge rail under Subsection 556.11.

Measure structural excavation under Subsection 206.12.

Payment

557.25 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
557 (01) Untreated structural timber and lumber	Cubic Meter
557 (02) Treated structural timber and lumber	Cubic Meter
557 (03) Untreated structural timber and lumber	Lump Sum
557 (04) Treated structural timber and lumber	Lump Sum
557 (05) Treated structural timber, glued laminated	Cubic Meter
557 (06) Treated structural timber, glued laminated	Lump Sum

Section 558—Prefabricated, Modular Bridge Superstructure

Description

558.01 Work. Design, fabricate, deliver, and install a prefabricated, modular bridge superstructure, or transport and install Government-furnished prefabricated, modular superstructure and components as DESIGNATED IN THE SCHEDULE OF ITEMS. Construct the length, width, and capacity of the structure, including curbs and railings and the horizontal and vertical alignment, as SHOWN ON THE DRAWINGS.

Also furnish material for, and construct, bridge railing as SHOWN ON THE DRAWINGS or on approved manufacturer's drawings. Unless components are furnished by the Government, furnish prefabricated, modular bridge superstructure components complete and in place, including deck and railing, when required, to form a bridge superstructure capable of supporting traffic as soon as construction of approaches is complete. Include all incidental materials required to provide a completed structure ready for use.

When there are specific requirements for design, materials, appearance, and/or construction, they shall be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

Materials

558.02 Requirements. Furnish materials that meet the requirements specified in the following sections and subsections:

Bridge Railing	556
Hardware & Structural Steel	716.02
Precast Concrete Structures	553A
Prestressed Concrete	553
Reinforcing Steel	554
Steel Structures	555
Structural Concrete	552
Timber Structures	557

Concrete compressive strength, structural steel tensile strength, finish, designation, timber species, grade, treatment, and other material specifications shall be as SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. If material specifications are not in the contract documents, take them from the manufacturer's drawings, and have them approved by the CO prior to fabrication.

558.03 Design Requirements. Design in accordance with the AASHTO “Standard Specifications for Highway Bridges,” latest edition and interims, for the HS20–44 loading, including impact, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

When design of the structure is required, provide on all the drawings and calculations that are submitted for review the signature and seal of a professional engineer who is currently licensed in the State where the bridge will initially be located.

Use materials that are durable enough to allow removal, transportation, and re-installation using typical forest logging or construction equipment. Use design techniques and fabrication methods to minimize field erection difficulties. Fabricate primary components from steel unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

Rig main superstructure components with permanent lifting devices to facilitate efficient installation and removal of these items with equipment common to logging or construction operations. Place lifting devices so as not to interfere with traffic utilizing the structure.

558.04 Design Drawings. When furnishing a prefabricated bridge superstructure, submit design drawings, calculations, and/or shop drawings sufficiently in advance of the start of fabrication to allow time for review by the CO and correction of any changes. Such time shall be proportional to the work, but not less than 21 days. Include plan, elevation, and section views of the modular bridge superstructure, dimensions of all components, welding and connection details, and general and specific notes regarding design and construction.

When Government-furnished prefabricated bridge superstructure components are specified, material lists, erection information, and manufacturer’s instructions will be furnished by the Government.

Construction

558.05 General. Perform excavation, backfill, and embankment work under Sections 203 and 206.

Dispose of all debris resulting from operations in accordance with Section 202.

Perform all construction of substructures, riprap, and signs under Sections 206, 206A, 251, 551, 552, 553A, 554, 555, 557, 564, 602, and 633, as applicable.

558.06 Performance. Provide 2 weeks’ notice prior to delivery and/or installation.

If the prefabricated superstructure is not installed immediately upon delivery to the project site, provide appropriate equipment and labor to unload and stack, support, and store all material at the delivery point. Support and stack all components to prevent damage. Furnish and install blocking such that all components are supported at least 300 mm above the ground.

Furnish all tools, devices, special equipment, and material needed for installation in well-marked watertight containers suitable for long-term, outdoor storage.

558.07 Contractor-Furnished Prefabricated Bridge Superstructure. As applicable, furnish the CO with the following items for approval prior to delivery of the bridge component:

- (a) Supplier or inspection agency certification of wood species and grade of all timber and a conformance certificate for all sawn and glued laminated members.
- (b) Certification by an approved inspection and testing agency of wood treatment, listing method of treatment, type of preservative, retention, and penetration. Supplier certification is permitted if each piece is stamped or branded with a legible American Wood Preservers Bureau quality mark.
- (c) Certification of structural steel, fasteners, and hardware.
- (d) Certification of galvanizing process used.
- (e) Steel fabricator certification that steel fabrication and quality control meet the requirements of the AISC Code of Standard Practice; and that all welding meets the requirements of ANSI/AASHTO/AWS D 1.5 Bridge Welding Code.
- (f) A complete list of all bridge components, hardware, and fasteners.
- (g) Complete erection instructions and drawings. Provide drawings that are black line, on a reproducible mylar media, on ANSI sheet size B or D.

As appropriate to the type of modular bridge, mark each major component of the bridge superstructure with the same serial number. Ensure that the marking is permanent and clearly visible on each component, both when stacked in storage and when erected on a bridge site.

When called for in the SPECIAL PROJECT SPECIFICATIONS, assemble each bridge superstructure prior to delivery to ensure proper fit-up of all components. Notify the CO of the assembly 2 weeks in advance so that inspection of the assembly can be arranged.

558.08 Government-Furnished Prefabricated Bridge Superstructure. When Government-furnished prefabricated bridge units are specified, transport all designated material from the storage site(s) designated in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS to the bridge site, and install the superstructure complete and in place, including connection of all girders, diaphragms, railings, panels, transoms, and other elements.

Upon taking possession of the Government-furnished units at the storage site, assume all liability for damage resulting from handling, transporting, and/or erecting the units in place, until final acceptance of the project.

Measurement

558.09 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure prefabricated bridge superstructures on a lump sum basis. Include all materials and work necessary to furnish, transport, and install the superstructure, including the deck and railing, as SHOWN ON THE DRAWINGS.

Payment

558.10 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
558 (01) Prefabricated bridge superstructure— design, fabricate, deliver, and install	Each
558 (02) Government-furnished prefabricated bridge superstructure—transport and install	Each

Section 559—Log Bridges

Description

559.01 Work. Furnish, fabricate, and install the logs and timber for constructing log bridges, including abutments, piers, and superstructure. In addition, furnish and install all hardware and other required material.

Materials

559.02 Requirements. Furnish materials that conform to specifications in the following section and subsections:

Geotextiles	714.01
Reinforcing Steel	554
Structural Concrete	552
Timber Structures	557

559.03 Logs. Furnish logs used for stringers within the dimensional tolerance and of the species SHOWN ON THE DRAWINGS. They must be of high quality, straight, sound, and free of wind shake, decay, or excessive twist (spiral grain with a slope of grain relative to the longitudinal axis of the log exceeding 1 in 8). Ensure that knots in the middle half of the stringer length do not significantly affect structural capacity.

If SHOWN ON THE DRAWINGS, peel logs and provide preservative treatment as SHOWN ON THE DRAWINGS. Obtain written approval from the CO for all logs to be used in the structure.

559.04 Timber & Lumber. Furnish structural lumber and timber in accordance with the species, grades, and dimensions SHOWN ON THE DRAWINGS and in accordance with Section 557.

559.05 Aggregate. When required, furnish aggregate for decking or surfacing to meet the requirements SHOWN ON THE DRAWINGS.

Construction

559.06 General. Perform excavation, foundation, backfill, and embankment work specified in Sections 203 and 206, as applicable.

Handle all logs and timber carefully to prevent damage to the wood and/or preservative treatment.

Dispose of all debris resulting from operations in accordance with Section 202.

Construct abutments and pier as SHOWN ON THE DRAWINGS.

559.07 Performance. Construct bridge superstructure and substructures as SHOWN ON THE DRAWINGS, with attention paid to the details of erection, fit-up, and connection. Obtain written approval for all deviations from the CO.

Place timber caps to obtain even and uniform bearing over the tops of supporting posts or piles and with post and pile ends in true alignment. Secure all caps as SHOWN ON THE DRAWINGS.

Match stringers for size at the bearings and place them in position so that the crown is up. Alternate stringers butt to tip. Locate any knots that may affect the strength of the member in the top portion of the stringer.

Cut stringers to length with a square cut. Remove sufficient material from the top surface of the log stringer to provide an adequate bearing area for the decking as SHOWN ON THE DRAWINGS. Do not allow hewing to exceed 19 mm in depth at the small end of the log. Do not allow hewing of the top of the butt end to exceed 75 mm in depth for a distance not to exceed one-fourth span length.

Cut or hew the bottom surface of the small end of the stringer logs only to the depth necessary to achieve the required bearing area. Block or shim tip ends that are smaller than the largest tip. Cut or dap butt ends to the depth of the largest top end. Allow the maximum slope of any dap to be 1 to 10. Make top and bottom cuts parallel. Require shims or blocks used under small ends to cover the entire bearing area.

Notch all logs together, including face logs, tie logs, mud sills, and anchor logs as SHOWN ON THE DRAWINGS, and drift pin all connections.

Use an approved type of suitable granular, free-draining material and/or rock for backfill when crib abutments are to be constructed.

Use tiebacks or other abutment anchoring devices as SHOWN ON THE DRAWINGS or as approved in writing by the CO.

Measurement

559.08 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

When untreated and treated timber and lumber is measured, measure by the cubic meter of timber and lumber in place in the completed structure. Compute the quantities from nominal cross section dimensions and actual lengths.

When bridge railing is measured, measure under Subsection 556.11. When concrete is measured, measure under Subsection 552.21.

Measure log bridges on a lump sum basis, including all work necessary to furnish, prepare, and install the log portions of the bridge superstructure and substructure units.

Payment

559.09 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
559 (01) Log bridge	Lump Sum

Section 561—Structural Concrete Bonding

Description

561.01 Work. Repair cracks in concrete structures by pressure injecting epoxy.

Materials

561.02 Requirements. Furnish material that conforms to specifications in the following subsections:

Epoxy Resin Adhesives	725.21
Low-Strength Grout	701.03(b)
Polymer Grout	701.05

Construction

561.03 Crack Preparation. Provide notice of crack sealing at least 14 days before beginning work. The work areas will be identified and the locations of the cracks to be repaired will be marked.

Remove all dirt, laitance, and other debris from the exterior and interior of cracks. Apply a temporary surface seal material to the face of cracks. Use surface seal material with sufficient strength and adhesion to confine the injected epoxy material until cured.

Provide openings (entry ports) in the surface seal along the crack. Make the distance between entry ports at least the thickness of the concrete member being repaired.

After the injection adhesive has cured, remove the surface seal. Finish the face of the crack and entry ports flush with the adjacent surface.

561.04 Injection Procedures. Begin injecting epoxy at the lowest entry port. Continue injection at the first port until epoxy begins to flow out of the next highest port. Plug the first port and inject epoxy in the second port until the epoxy flows from the next highest port. Continue this sequence until the entire crack is filled. Use a two-component epoxy system. Maintain the mix ratio for the epoxy as prescribed by the manufacturer within 5 percent by volume at any discharge pressure not to exceed 1.4 MPa. Do not use solvents to thin the epoxy.

Use positive inline displacement-type equipment to meter, mix, and inject the epoxy at pressures not to exceed 1.4 MPa.

(a) Test for Proper Ratio. Perform this test for each injection unit at the beginning and end of every day that the unit is used. Disconnect the mixing head of the injection equipment and pump the two adhesive components through a ratio check device with two independent valved nozzles capable of controlling flow rate and back pressure by opening or closing valves on the check device. Use a pressure gage capable of sensing the back pressure behind each valve to adjust the discharge pressure to 1.4 MPa for both epoxy components. Simultaneously discharge both epoxy components into separate calibrated containers. Compare the discharged amounts to determine the mix ratio.

After the test is completed at 1.4 MPa discharge pressure, repeat the procedures for zero MPa discharge pressure.

(b) Test for Pressure Check. Perform this test for each injection unit at the beginning and end of every day that the unit is used.

Disconnect the mixing head of the injection equipment and attach the two adhesive component delivery lines to a pressure check device with two independent valved nozzles capable of controlling flow rate and pressure by opening or closing the valves. Use a pressure gage capable of sensing the pressure buildup behind each valve. Close the valves on the pressure check device and operate the equipment until the gage pressure on each line reads 1.4 MPa. When the pumps are stopped, the gage pressure must not drop below 1.3 MPa within 3 minutes.

(c) Records. Maintain and make available complete and accurate records of the ratio check tests and the pressure check tests. Additional ratio and pressure check tests may be required.

561.05 Coring. Take one 50-mm diameter test core, in accordance with AASHTO T 24, for every 15 m of repaired crack at designated locations. The crack repair is acceptable if the core sample indicates that 90 percent or more of the crack has been successfully bonded.

When a test core shows that the epoxy bonding has penetrated less than 90 percent of the crack volume within the core sample, redo that 15-m crack segment, or the segment that the core represents, and resample. Repeat this procedure until acceptable crack repair is achieved.

Fill all sample core holes with polymer grout and finish the surface to match the adjacent concrete.

Measurement

561.06 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure crack preparation by the meter or lump sum. Measure structural concrete bonding by the meter, liter, or lump sum. When measurement is by the meter, measure the actual meters of surface crack acceptably repaired.

When measurement is by the liter, measure the actual number of liters of bonding material injected in the marked cracks that are acceptably repaired.

Payment

561.07 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
561 (01) Structural concrete bonding	Meter
561 (02) Structural concrete bonding	Liter
561 (03) Structural concrete bonding	Lump Sum
561 (04) Crack preparation	Meter
561 (05) Crack preparation	Lump Sum

Section 562—Forms & Falsework

Description

562.01 Work. Design, construct, and remove forms and falsework to temporarily support concrete, girders, and other structural elements until the structure is completed to the point where it can support itself.

Design & Construction

562.02 Drawings. When complete details for forms and falsework are not shown, prepare and submit drawings as SHOWN ON THE DRAWINGS or as directed in the SPECIAL PROJECT SPECIFICATIONS. Perform the following, as applicable:

- (a) Design and show the details for constructing safe and adequate forms and falsework that provide the necessary rigidity, support the loads imposed, and produce the required lines and grades in the finished structure. See Subsection 562.03 for design loads; Subsection 562.04 for design stresses, loadings, and deflections; and Subsection 562.05 for manufactured assemblies.
- (b) Show the maximum applied structural load on the foundation material. Include a drainage plan or description of how foundations will be protected from saturation, erosion, and/or scour. See Subsection 562.06.
- (c) Precisely describe all proposed material. Describe the material that is not describable by standard nomenclature (such as AASHTO or ASTM specifications) based on manufacturer's tests, and recommended working loads. Evaluate falsework material and ascertain whether the physical properties and conditions of the material are such that the material can support the loads assumed in the design.
- (d) Furnish design calculations and material specifications showing that the proposed system will support the imposed concrete pressures and other loads. Provide an outline of the proposed concrete placement operation listing the equipment, labor, and procedures to be used for the duration of each operation. Include proposed placement rates and design pressures for each pour. Include a superstructure placing diagram showing the concrete placing sequence and construction joint locations.
- (e) Provide design calculations for proposed bridge falsework. Appoint a licensed professional engineer proficient in structural design to design, sign, and seal the drawings. Ensure that the falsework design calculations show the stresses and deflections in load supporting members.

- (f) Show anticipated total settlements of falsework and forms. Include falsework footing settlement and joint takeup. Design for anticipated settlements not to exceed 25 mm. Design and detail falsework supporting deck slabs and overhangs on girder bridges so there is no differential settlement between the girders and the deck forms during placement of deck concrete. Design and construct the falsework to elevations that include anticipated settlement during concrete placement and required camber to compensate for member deflections during construction.
- (g) Show the support systems for form panels supporting concrete deck slabs and overhangs on girder bridges.
- (h) Show details for strengthening and protecting falsework over or adjacent to roadways and railroads during each phase of erection and removal. See Subsection 562.07.
- (i) Include intended steel erection procedures with calculations in sufficient detail to substantiate the girder geometry. See Subsection 562.08.
- (j) Submit details of proposed anchorage and ties for void forms. See Subsection 562.10 for void form requirements.

Submit separate falsework drawings for each structure, except for identical structures with identical falsework design and details. Do not start construction of any unit of falsework until the drawings for that unit are reviewed and accepted.

562.03 Design Loads. Conform to the following:

(a) Vertical Design Loads. Dead loads include the weight of concrete, reinforcing steel, forms, and falsework. Consider the entire superstructure, or any concrete mass being supported by falsework, to be a fluid dead load with no ability to support itself. If the concrete is to be prestressed, design the falsework to support any increased or readjusted loads caused by the prestressing forces.

Assume that the density of concrete, reinforcing steel, and forms is not less than 2,600 kg/m³ for normal concrete, and not less than 2,100 kg/m³ for lightweight concrete.

Consider live loads to be the actual mass of equipment to be supported by falsework applied as concentrated loads at the point of contact plus a uniform load of not less than 1,000 Pa applied over the area supported, plus 1,100 N/m applied at the outside edge of deck falsework overhangs.

The total vertical design load for falsework is the sum of vertical dead and live loads. Use a total vertical design load of not less than 4,800 Pa.

(b) Horizontal Design Loads. Use an assumed horizontal design load on falsework towers, bents, frames, and other falsework structures to verify lateral stability. The assumed horizontal load is the sum of the actual horizontal loads due to equipment, construction sequence, or other causes and an allowance for wind. However, in no case is the assumed horizontal load to be less than 2 percent of the total supported dead load at the location under consideration.

The minimum wind allowance for each heavy-duty steel shoring with a vertical load carrying capacity exceeding 130 kN per leg is the sum of the products of the wind impact area, shape factor, and applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face normal to the applied wind. Assume that the shape factor for heavy-duty shoring is 2.2. Determine design wind pressure values from table 562-1.

Table 562-1.—Design wind pressure—heavy duty steel shoring.

Height Zone Above Ground (m)	Wind Pressure Value (Pa)	
	Adjacent to Traffic	At Other Locations
0	960	720
9–15	1,200	960
15–30	1,450	1,200
Over 30	1.675	1.450

The minimum wind allowance on all other types of falsework, including falsework supported on heavy-duty shoring, is the sum of the products of the wind impact area and the applicable wind pressure value for each height zone. The wind impact area is the gross projected area of the falsework and unrestrained portion of the permanent structure, excluding the areas between falsework posts or towers where diagonal bracing is not used. Determine design wind pressure values from table 562-2.

Table 562-2.—Design wind pressure—other types of falsework.

Height Zone Above Ground (m)	Wind Pressure Value (Pa)	
	For Members Over and Bents Adjacent to Traffic Openings	At Other Locations
0	320 Q	240 Q
9–15	400 Q	320 Q
15–30	480 Q	400 Q
Over 30	560 Q	480 Q

Note: $Q = 0.3 + 0.2W$, but not more than 3. W is the width of the falsework system in meters measured in the direction of the wind force being considered.

Design the falsework to have sufficient rigidity to resist the assumed horizontal load without vertical dead load. Neglect the effects of frictional resistance.

(c) **Lateral Fluid Pressure.** For concrete with retarding admixture, fly ash, or other pozzolan replacement for cement, design forms, form ties, and bracing for a lateral fluid pressure based on concrete with a density of 2,400 kg/m³. For concrete containing no pozzolans or admixtures, which affect the time to initial set, determine the lateral fluid pressure based on concrete temperature and rate of placement in accordance with ACI standard 347R, "Guide for Formwork for Concrete."

562.04 Design Stresses, Loads, & Deflections. The allowable maximum design stresses and loads listed in this section are based on the use of undamaged, high-quality material. If lesser quality material is used, reduce the allowable stresses and loads. Do not exceed the following maximum stresses, loads, and deflections in the falsework design:

(a) **Timber.** For timber, use the following values:

$$\begin{aligned} \text{Compression perpendicular to the grain} &= 3,100 \text{ kPa} \\ \text{Compression parallel to the grain}^1 &= 3,309 \text{ MPa}/(L/d)^2 \end{aligned}$$

¹Compression parallel to the grain is not to exceed 11 MPa.

where

$$\begin{aligned} L &= \text{unsupported length.} \\ d &= \text{least dimension of a square or rectangular column or the width} \\ &\quad \text{of a square of equivalent cross-sectional area for round columns} \end{aligned}$$

$$\text{Flexural stress}^1 = 12.4 \text{ MPa}$$

¹Reduce flexural stress to 10 MPa for members with a nominal depth of 200 mm or less.

$$\begin{aligned} \text{Horizontal shear} &= 1,300 \text{ kPa} \\ \text{Axial tension} &= 8.3 \text{ MPa} \end{aligned}$$

Deflection due to the weight of concrete may not exceed 1/500 of the span, even if the deflection is compensated for by camber strips.

$$\begin{aligned} \text{The modulus of elasticity } (E) \text{ for timber} &= 11.7 \text{ GPa} \\ \text{Maximum axial loading on timber piles} &= 400 \text{ kN} \end{aligned}$$

Design timber connections in accordance with the stresses and loads allowed in the "National Design Specification for Wood Construction," published by the National Forest Products Association, except:

- (1) Reductions in allowable loads required for high moisture condition of the lumber and service conditions do not apply.
- (2) Use 75 percent of the tabulated design value as the design value of bolts in two member connections (single shear).

(b) Steel. For identified grades of steel, do not exceed the design stresses (other than stresses due to flexural compression) specified in the “Manual of Steel Construction,” Allowable Stress Design, as published by the AISC.

When the grade of steel cannot be positively identified, do not exceed the design stresses, other than stresses due to flexural compression, specified in the AISC Manual for ASTM A 36 steel or the following:

$$\begin{aligned} \text{Tension, axial and flexural} &= 150 \text{ MPa} \\ \text{Compression, axial}^1 &= 110,000 - 2.6(L/r)^2 \text{ kPa} \end{aligned}$$

¹ L/r is not to exceed 120.

$$\begin{aligned} \text{Shear on the web gross section of rolled shapes} &= 100 \text{ MPa} \\ \text{Web crippling for rolled shapes} &= 185 \text{ MPa} \end{aligned}$$

For all grades of steel, do not exceed the following design stresses and deflection:

$$\text{Compression, flexural}^1 = 82,750 \text{ MPa}/(Ld/bt)$$

¹Not to exceed 150 MPa for unidentified steel or steel conforming to ASTM A 36. Not to exceed $0.6 F_y$ for other identified steel.

where

$$\begin{aligned} L &= \text{unsupported length} \\ d &= \text{least dimension of a square or rectangular column or the width} \\ &\quad \text{of a square of equivalent cross sectional area for round columns} \\ &\quad \text{or depth of beams} \\ b &= \text{width of the compression flange} \\ t &= \text{thickness of the compression flange} \\ F_y &= \text{specified minimum yield stress for the grade of steel used} \end{aligned}$$

Deflection due to the mass of concrete may not exceed 1/500 of the span, even if the deflection is compensated for by camber strips.

The modulus of elasticity (E) for steel = 210 GPa

(c) **Other Requirements.** Limit falsework spans supporting T-beam girder bridges to 4.3 m plus 8.5 times the overall depth of the T-beam girder.

562.05 Manufactured Assemblies. For jacks, brackets, columns, joists, and other manufactured devices, do not exceed the manufacturer's recommendations or 40 percent of the ultimate load-carrying capacity of the assembly based on the manufacturer's tests or additional tests ordered. Limit the maximum allowable dead load deflection of joists to 1/500 of their spans.

Furnish catalog or equivalent data showing the manufacturer's recommendations, or perform tests, as necessary, to demonstrate the adequacy of any manufactured device proposed for use. Do not substitute other manufacturers' components unless the manufacturer's data encompass such substitutions, or field tests reaffirm the integrity of the system.

If a component of the falsework system consists of a steel frame tower more than two or more tiers high, the differential leg loading within the steel tower unit shall not exceed 4 to 1. An exception may be approved if the manufacturer of the steel frame certifies, based on manufacturer's tests, that the proposed differential loadings are not detrimental to the safe load-carrying capacity of the steel frame.

562.06 Falsework Foundations. Field-verify all ground elevations at proposed foundation locations before design.

Where spread footing type foundations are used, determine the bearing capacity of the soil. The maximum allowable bearing capacity for foundation material, other than rock, is 190 kPa.

Do not locate the edge of footings closer than 300 mm from the intersection of the bench and the top of the slope. Unless the excavation for footings is adequately supported by shoring, do not locate the edge of the footings closer than 1.2 m or the depth of excavation, whichever is greater, from the edge of the excavation.

When a pile type foundation is used, use in accordance with Section 551. When falsework is supported by footings placed on paved, well-compacted slopes of berm fills, do not strut the falsework to columns unless the column is founded on rock or supported by piling.

Size spread footings to support the footing design load at the assumed bearing capacity of the soil without exceeding anticipated settlements. Provide steel reinforcement in concrete footings.

When individual steel towers have maximum leg loads exceeding 130 kN, provide for uniform settlement under all legs or each tower under all loading conditions.

Protect the foundation from adverse effects for the duration of its use. Advise the CO of actions that will be taken to protect the foundation.

562.07 Falsework Over or Adjacent to Roadways & Railroads. Design and construct the falsework to be protected from vehicle impact. This includes falsework posts that support members crossing over a roadway or railroad and other falsework posts if they are located in the row of falsework posts nearest to the roadway or railroad and if the horizontal distance from the traffic side of the falsework to the edge of pavement or to a point 3 m from the centerline of track is less than the total height of the falsework.

Provide additional features to ensure that this falsework will remain stable if subjected to impact by vehicles. Use vertical design loads for these falsework posts, columns, and towers (but not footings) that are not less than either of the following:

- (a) 150 percent of the design load calculated in accordance with Subsection 562.03, but not including any increased or readjusted loads caused by prestressing forces.
- (b) The increased or readjusted loads caused by prestressing forces.

Install temporary traffic barriers before erecting falsework towers or columns adjacent to an open public roadway. Locate barriers so that falsework footings or pile caps are at least 75 mm clear of concrete traffic barriers, and all other falsework members are at least 300 mm clear. Do not remove barriers until approved.

Use falsework columns that are steel with a minimum section modulus about each axis of $156,000 \text{ mm}^3$ or sound timbers with a minimum section modulus about each axis of $4,100,000 \text{ mm}^3$.

Mechanically connect the base of each column or tower frame supporting falsework over or immediately adjacent to an open public road to its supporting footing or provide other lateral restraint to withstand a force of not less than 9 kN applied to the base of the column in any direction. Mechanically connect such columns or frames to the falsework cap or stringer to resist a horizontal force of not less than 4.5 kN in any direction. Neglect the effects of frictional resistance.

For exterior girders upon which overhanging bridge deck falsework brackets are hung, brace or tie them to the adjacent interior girders as necessary to prevent rotation of the exterior girders or overstressing of the exterior girder web.

Mechanically connect all exterior falsework stringers and stringers adjacent to the end of discontinuous caps, the stringer or stringers over points of minimum vertical clearance, and every fifth remaining stringer to the falsework cap or framing. Provide mechanical connections capable of resisting a load in any direction, including uplift

on the stringer, of not less than 2.2 kN. Install connections before traffic is allowed to pass beneath the span.

Use 16-mm-diameter or larger bolts to connect timber members used to brace falsework bents located adjacent to roadways or railroads.

Sheath falsework bents within 6 m of the centerline of a railroad track solid in the area between 1 and 5 m above the track on the side facing the track. Construct sheathing of plywood not less than 16 mm thick or lumber not less than 25 mm nominal thickness. Provide adequate bracing on such bents so that the bent resists the required assumed horizontal load or 22 kN, whichever is greater, without the aid of sheathing.

Provide at least the minimum required vertical and horizontal clearances through falsework for roadways, railroads, pedestrians, and boats.

562.08 Falsework for Steel Structures. Conform to the following:

- (a) Use falsework design loads consisting of the mass of structural steel, the load of supported erection equipment, and all other loads supported by the falsework.
- (b) Design falsework and forms for concrete supported on steel structures so that loads are applied to girder webs within 150 mm of a flange or stiffener. Distribute the loads in a manner that does not produce local distortion of the web. Do not use deck overhang forms that require holes to be drilled in the girder webs.
- (c) Strut and tie exterior girders supporting overhanging deck falsework brackets to adjacent interior girders to prevent distortion and overstressing of the exterior girder web.
- (d) Do not apply loads to existing, new, or partially completed structures that exceed the load-carrying capacity of any part of the structure in accordance with the Load Factor Design methods of the AASHTO "Standard Specifications for Highway Bridges" using Load Group IB.
- (e) Build supporting falsework that will accommodate the proposed method of erection without overstressing the structural steel, and will produce the required final structural geometry, intended continuity, and structural action.

562.09 Falsework Construction. Construct falsework as SHOWN ON THE DRAWINGS.

When welding is required, submit a welder certification for each welder, in accordance with Subsection 555.18.

Build camber into the falsework to compensate for falsework deflection and anticipated structure deflection. Camber as SHOWN ON THE DRAWINGS or specified by the CO is for anticipated structure deflection only.

Attach tell-tales to soffit of concrete forms in enough systematically placed locations to be able to determine from the ground the total settlement of the structure while concrete is placed.

Do not apply dead loads, other than forms and reinforcing steel, to any falsework until authorized.

When the falsework installation is complete and when SHOWN ON THE DRAWINGS or specified in the SPECIAL PROJECT SPECIFICATIONS, have the falsework inspected by a licensed professional engineer proficient in structural engineering. Certify in writing that the falsework installation conforms to accepted falsework drawings, specifications, and acceptable engineering practices. Provide a copy of the certification to the CO prior to concrete placement.

Discontinue concrete placement and take corrective action if unanticipated events occur, including settlements that cause a deviation of more than 10 mm from those SHOWN ON THE DRAWINGS. If satisfactory corrective action is not taken before initial set, remove all unacceptable concrete.

562.10 Forms. For exposed concrete surfaces, use U.S. Product Standard 1 for Exterior B-B (Concrete Form) class I plywood or other approved material that will produce a smooth and uniform concrete surface. Use only form panels in good condition and free of defects on exposed surfaces. If form panel material other than plywood is used, ensure that it has flexural strength, modulus of elasticity, and other physical properties equal to or greater than the physical properties for the type of plywood specified.

Furnish and place form panels for exposed surfaces in uniform widths of not less than 1 m and in uniform lengths of not less than 2 m, except where the width of the member formed is less than 1 m.

Arrange panels in symmetrical patterns conforming to the general lines of the structure. Place panels for vertical surfaces with the long dimension horizontal and with horizontal joints level and continuous. For walls with sloping footings that do not abut other walls, panels may be placed with the long dimension parallel to the footing.

Precisely align form panels on each side of the panel joint by means of supports or

fasteners common to both panels. Provide 19-mm triangular fillets at all sharp edges of the concrete, unless otherwise SHOWN ON THE DRAWINGS.

Devices may be cast into the concrete for later use in supporting forms or for lifting precast members. Do not use driven devices for fastening forms or form supports to concrete. Use form ties consisting of form bolts, clamps, or other devices necessary to prevent spreading of the forms during concrete placement.

Do not use form ties consisting of twisted wire loops. Use form ties and anchors that can be removed without damaging the concrete surface. Construct metal ties or anchorages within the forms to permit their removal to a depth of at least 25 mm from the face without damage to the concrete. Fill cavities with cement mortar in accordance with Subsection 701.04, and finish to a sound, smooth, uniform colored surface.

Construct all exposed concrete surfaces that will not be completely enclosed or hidden below the permanent ground surface so the formed surface of the concrete does not undulate more than 2.5 mm or 1/360 of the center-to-center distance between studs, joists, form stiffeners, form fasteners, or wales. Interior surfaces of underground drainage structures are considered to be completely enclosed surfaces. Form all exposed surfaces for each element of a concrete structure with the same forming material or with material that produces similar surface textures, color, and appearance.

Support forms for cast-in-place concrete bridge decks on the girders upon which the deck is to be cast. Do not shore deck forms to the ground or to the substructure.

Support roadway slab forms of box girder type structures on wales or similar supports fastened, as nearly as possible, to the top of the web walls.

Construct concrete forms mortar-tight, true to the dimensions, lines, and grades of the structure, and of sufficient strength to prevent appreciable deflection during placement of concrete. Place all material required to be embedded in the concrete before concrete placement. Clean inside surfaces of forms of all dirt, mortar, and foreign material. Remove all loose material before the completion of forming for the roadway deck slab of cast-in-place box girders or cells or voids of other members in which the forms are to either remain in place or be removed.

Form exposed curved surfaces to follow the shape of the curve. However, on any retaining walls that follow a horizontal curve, the wall stems may be a series of short chords if all of the following conditions apply:

- The chords within the panel are the same length.
- The chords do not vary from a true curve by more than 15 mm at any point.

- All panel points are on the true curve.

When architectural treatment is required, make the angle points for chords in wall stems fall at vertical rustication joints.

Coat with form oil all forms to be removed. Use commercial-quality form oil or an equivalent coating that permits release of the forms and does not discolor the concrete. Do not place concrete in forms until the forms have been inspected and approved.

(a) Stay-in-Place Deck Forms. Use permanent or stay-in-place forms only when SHOWN ON THE DRAWINGS.

Fabricate permanent steel bridge deck forms and supports from steel conforming to ASTM A 653M, coating designation 2600, any grade except 340, class 3.

Install forms in accordance with approved fabrication and erection drawings. Do not rest form sheets directly on the top of stringer or floor beam flanges. Securely fasten sheets to form supports. Place form supports in direct contact with the stringer flange or floor beam. Make all attachments with permissible welds, bolts, or clips. Do not weld form supports to flanges of steels not considered weldable or to portions of flanges subject to tensile stresses.

Clean, wire brush, and paint with two coats of zinc dust zinc-oxide primer (FSS TT-P-641 type II, no color added) any permanently exposed form metal where the galvanized coating has been damaged. Minor heat discoloration in areas of welds need not be touched up.

Locate transverse construction joints in slabs at the bottom of a flute. Field-drill 6-mm-diameter weep holes at not less than 300 mm on center along the line of the joint.

(b) Void Forms. Store void forms in a dry location to prevent distortion. Secure the forms using anchors and ties that leave a minimum of metal or other supporting material exposed at the bottom of finished slab.

Make the outside surface of the forms waterproof. Cover the ends with waterproof mortar-tight caps. Use a premolded 6-mm-thick rubber joint filler around the perimeter of the caps to permit expansion.

Provide a PVC vent near each end of each void form. Construct vents so the vent tube does not extend more than 13 mm below the bottom surface of the finished concrete after form removal. Protect void forms from the weather until concrete is placed.

(c) **Metal Forms.** The specifications for forms relative to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms.

562.11 Removal of Forms & Falsework. Remove all forms except:

- (a) Interior soffit forms for roadway deck slabs of cast-in-place box girders.
- (b) Forms for the interior voids of precast members.
- (c) Forms for abutments or piers when no permanent access is available into the cells or voids.

To facilitate finishing, when approved by the CO, the removal of forms that do not support the dead load of concrete members and of forms for railings and barriers may begin 24 hours after the concrete for the member has been placed. Protect exposed concrete surfaces from damage. Cure all exposed concrete surfaces in accordance with Subsection 552.17, if forms are removed less than 7 days after concrete placement.

Do not remove forms and falsework until the concrete strength and time requirements in table 562-3 have been met.

Do not remove falsework under concrete that has been cured at a temperature continuously under 10 °C without first determining if the concrete has gained the specified strength, no matter how much time has passed.

Ensure that substructure concrete has reached the required 28-day compressive strength prior to erecting any superstructure or additional substructure elements, unless approved otherwise by the CO.

Do not release falsework in any span in continuous structures until the first and second adjoining spans on each side have reached the strength specified herein or in the SPECIAL PROJECT SPECIFICATIONS.

Uniformly and gradually remove falsework for arch bridges, beginning at the crown and working toward the springing. Remove falsework for adjacent arch spans simultaneously.

Completely release the falsework under all spans of continuous structures before concrete is placed in curbs, railings, and parapets.

Remove forms from columns before releasing supports from beneath beams and girders in order to determine the condition of column concrete.

Table 562-3.—Minimum form/support release criteria.

Structural Element	% of Specified 28-Day Strength (f_c')	Minimum Number of Days Since Last Pour	
		Standard Concrete	Type III Concrete
Columns and wall faces (not yet supporting loads)	50	3	2
Mass piers and mass abutments (not yet supporting loads) except pier caps	50	3	N/A
Box girders	80	14	7
Simple span girders, T-beam girders, slab bridges, cross beams, caps, pier caps not continuously supported, struts, and top slabs of concrete box culverts	80	14	7
Trestle slabs where supported on wood stringers	70	10	4
Slabs and overhangs where supported on steel stringers or prestressed concrete girders	70	10	4
Pier caps continuously supported	60	7	3
Arches, continuous span bridges, and rigid frames	90	21	10

Remove all forms from the cells of concrete box girders unless otherwise SHOWN ON THE DRAWINGS or permitted by the CO. Leave no forms that might jeopardize drainage or enclosed utilities.

Do not release falsework for cast-in-place prestressed portions of structures until after the prestressing steel has been tensioned.

Do not remove falsework supporting the deck of rigid frame structures, excluding box culverts, until compacted backfill material has been placed against vertical legs of the frame.

Install a reshoring system if the falsework supporting the sides of girder stems with slopes steeper than 1:1 are removed before placing deck slab concrete. Design a reshoring system with lateral supports that resist all rotational forces acting on the

stem, including those caused by the placement of deck slab concrete. Install the lateral supports immediately after each form panel is removed and before release of supports for the adjacent form panel.

Completely remove falsework material. Remove falsework piling at least 0.5 m below the surface of the original ground or stream bed. Where falsework piling is driven within the limits of ditch or channel excavation, remove the piling to at least 0.5 m below the bottom and side slopes of the excavated areas.

Leave the forms for footings constructed within a cofferdam or crib in place when their removal would endanger the safety of the cofferdam or crib, and where the forms will not be exposed to view in the finished structure.

Remove all other forms, whether above or below groundline or water level.

Measurement & Payment

562.12 Method & Basis. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Do not measure forms and falsework for payment.

Section 563—Painting

Description

563.01 Work. Apply protective coatings to metal, timber, or concrete surfaces to control corrosion and deterioration.

Materials

563.02 Requirements. Furnish material that conforms to specifications in the following section and subsections:

Boiled Linseed Oil	725.14(a)
Paint	708
Petroleum Spirits (Mineral Spirits)	725.14(b)
Water	725.01

Construction

563.03 Protection of Public, Property, & Workers. Comply with the SSPC’s “SSPC–PA Guide 3—A Guide to Safety in Paint Application” and with OSHA requirements. If the paint being removed is a hazardous material containing lead chromium, comply with all of the following:

- SSPC Guide 6I(CON)—“Guide for Containing Debris Generated During Paint Removal Operations.”
- SSPC Guide 7I(DIS)—“Guide for the Disposal of Lead-Contaminated Surface Preparation Debris.”
- 29 CFR 1926.62—“OSHA Construction Industry Standards for Lead.”
- 40 CFR 50.6—“EPA National Primary and Secondary Ambient Air Quality Standards for Particulate Matter.”
- 40 CFR, 50.12—“EPA National Primary and Secondary Ambient Air Quality Standards for Lead.”
- 40 CFR, parts 260–268—“Resource Conservation and Recovery Act (RCRA).”

At least 28 days before beginning surface preparation, submit a written plan for approval that details the measures to be used for the protection of the environment, public, adjacent property, and the workers while performing the work. Include in the plan the following:

- (a) Manufacturer's material safety data sheets and product sheets for all cleaning and painting products.
- (b) A detailed containment plan for removed material, cleaning products, and paint debris. Include details of attachment to the structure.
- (c) A detailed disposal plan for removal, cleaning products, and paint debris.
- (d) Specific safety measures to protect workers from site hazards, including falls, fumes, fires, or explosions.
- (e) If paint being removed is hazardous material, include specific safety measures to comply with 29 CFR 1962.26, 40 CFR 50.6, 40 CFR 50.12, and 40 CFR, parts 260–268. Document compliance upon request.
- (f) A written plan for emergency spill procedures.
- (g) A competent person responsible for ensuring that all necessary health, safety, and containment measures are enacted and maintained.

After acceptance, perform work according to the plan. If the measures fail to perform as intended, immediately stop work and take corrective action. Collect and properly dispose of all material, including wastewater that is used in preparing, cleaning, or painting.

563.04 Protection of the Work. Use tarps, screens, paper, cloth, or other suitable means to protect adjacent surfaces that are not to be painted. Prevent contamination of freshly painted surfaces by dust, oil, grease, or other harmful and deleterious material.

563.05 Surface Preparation, General. Notify the CO in writing at least 7 days before beginning operations. Immediately before painting, prepare the surface according to the following:

- (a) Clean the surface to the specified cleanliness level.
- (b) Remove dirt, dust, and other contaminants from the surface using methods recommended by the paint manufacturer.

- (c) Thoroughly dry the surface.
- (d) Determine that the surface temperature is between 10 °C and 40 °C.
- (e) Determine that the surface temperature is 3 °C or more above the dew point according to ASTM 337.
- (f) Determine that the humidity is 85 percent or less, unless specified otherwise on the manufacturer's product data sheet.

Suitable engineering control, such as enclosures and dehumidification, may be used to provide the conditions required above.

563.06 Paint Application, General. Use safe handling practices that conform to the manufacturer's safety data sheet and instructions. Mix and apply paint according to the product instructions. Mix paint with mechanical mixers for a sufficient length of time to thoroughly blend the pigment and vehicle together. Continue the mixing during application. Do not thin paint that is formulated ready for application.

Paint in a neat and workmanlike manner that does not produce excessive paint buildup, runs, sags, skips, holidays, or thin areas in the paint film. Measure the wet film thickness during application, and adjust the application rate such that, after curing, the desired dry film thickness is obtained. Apply paint by brush, spray, roller, or any combination thereof if permitted by the manufacturer's product data sheet.

Use brushes that have sufficient bristle body and length to spread the paint in a uniform film. Use round, oval-shaped, or flat brushes no wider than 120 mm. Evenly spread and thoroughly brush out the paint as it is applied.

Use airless or conventional spray equipment with suitable traps, filters, or separators to exclude oil and water from the compressed air. Use the spray gun tip sizes and pressures recommended by the manufacturer. Use compressed air that is free from oil or moisture and does not show black or wet spots when tested in accordance with ASTM D 4285.

Use rollers only on flat, even surfaces. Do not use rollers that leave a stippled texture in the paint film.

Use sheepskin daubers, bottle brushes, or other acceptable methods to paint surfaces that are inaccessible for painting by regular means.

Cure each coat of paint according to the manufacturer's recommendations. Correct all thin areas, skips, holidays, and other deficiencies before the next application of paint. Tint succeeding applications of paint to contrast with the paint being covered. The CO will approve the color for the finish coat before application.

Coat structures with the total thickness of undercoats before erection. Coat any surfaces that will be inaccessible after erection with the full number of required applications before erection. After erection and before applying the final coat, thoroughly clean all areas where coating has been damaged or has deteriorated, or where there are exposed unpainted surfaces, and spot coat with the specified undercoats to the specified thickness.

563.07 Structural Iron & Steel. Conform to the following:

(a) **Paint Systems.** Conform to the following:

(1) *New Surfaces or Surfaces With All Existing Paint Removed.* Furnish a paint system shown in table 563-1.

(2) *Surfaces With Existing Sound Paint.* Furnish a paint system that is compatible with the existing paint. Any of the systems listed in table 563-2 or any system that is approved for use on steel structures by the State department of transportation in the State in which the structure is located is acceptable if the proposed system is compatible with the existing system.

At least 14 days before ordering paint, verify compatibility of the proposed system with the existing system as follows:

- (a) Select a test area of at least 3 m² in a condition representative of the condition of the structure. Perform the specified level of surface preparation and apply the proposed system to the existing topcoat and primer. Watch for lifting, bleeding, blistering, wrinkling, cracking, flaking, or other evidence of incompatibility.
- (b) Verify that no indication of incompatibility exists at least 14 days after the application of each product. Perform adhesion tests according to ASTM D 3359, method A. Notify the CO immediately if adhesive testing fails at the interface of the existing finish coat and primer. An adhesion failure indicates incompatibility. Choose a more compatible paint system.

(b) **Surface Preparation.** Do not remove sound paint unless SHOWN ON THE DRAWINGS.

(1) *New Surfaces or Surfaces With All Existing Paint Removed.* Remove all dirt, mill scale, rust, paint, and other foreign material from exposed surfaces by blast cleaning to near white metal in accordance with SSPC-SP 10.

Use compressed air that is free from oil or moisture and does not show black or wet spots when tested in accordance with ASTM D 4285. Do not use unwashed sand or abrasives that contain salts, dirt, oil, or other foreign matter. Before blast cleaning

Table 563-1.—Structural iron and steel coating systems for new surfaces and surfaces with all existing paint removed.

Coat	Paint System ^a				
	1	2	3	4	5
	Aggressive Environments (Salt)	Aggressive Environments (Salt)	Aggressive Environments (Salt)	Less Aggressive Environments (No Salt)	Less Aggressive Environments (No Salt)
Primer	Inorganic zinc, type II, 75–100 µm dry	Zinc-rich epoxy, 75–100 µm dry	Moisture-cured urethane, 50–75 µm dry	Acrylic latex, 50–75 µm dry	Low-VOC alkyd, 50–75 µm dry
Intermediate	Epoxy, 75–100 µm dry	Epoxy, 75–100 µm dry	Moisture-cured urethane, 50–75 µm dry	Acrylic latex, 50–75 µm dry	Low-VOC alkyd, 50–75 µm dry
Top	Aliphatic urethane, 50–75 µm dry	Aliphatic urethane, 50–75 µm dry	Moisture-cured or aliphatic urethane, 50–75 µm dry	Acrylic latex, 50–75 µm dry	Low-VOC alkyd, 50–75 µm dry
Total thickness	200–275 µm dry	200–275 µm dry	150–225 µm dry	150–225 µm dry	150–225 µm dry

a. System 1, 2, or 3 is for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments, such as marine, industrial, or high-humidity environments, and in structures exposed to deicing salts. System 4 or 5 is for use in environments that are free from high concentrations of salts or pollutants that cause aggressive corrosion.

Table 563-2—Structural iron and steel coating systems for surfaces with existing sound paint.

Coat	Paint System ^a		
	6	7	8
	Aggressive Environments (Salt)	Less Aggressive Environments (No Salt)	Less Aggressive Environments (No Salt)
Primer	Moisture-cured urethane, 50–75 µm dry	Low-VOC alkyd, 50–75 µm dry	Low-viscosity epoxy sealer, 25–50 µm dry
Intermediate	Moisture-cured urethane, 50–75 µm dry	Low-VOC alkyd, 50–75 µm dry	Epoxy, 75–100 µm dry
Top	Moisture-cured or aliphatic urethane, 50–75 µm dry	Low-VOC silicone alkyd, 50–75 µm dry	Aliphatic urethane, 50–75 µm dry
Total thickness	150–225 µm dry	150–225 µm dry	150–225 µm dry

a. System 6 is for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments, such as marine, industrial, or high-humidity environments, and in structures exposed to deicing salts. System 7 or 8 is for use in environments that are free from high concentrations of salts or pollutants that cause aggressive corrosion.

near machinery, seal all bearings, journals, motors, and moving parts against entry of abrasive dust.

Blast clean with clean, dry sand, mineral grit, steel shot, or steel grit. Use a suitable gradation to produce a dense, uniform anchor pattern. Produce an anchor profile height of 25 to 50 µm, but not less than that recommended by the manufacturer's product data sheet for the paint system specified. Measure anchor profile height using the tape method in accordance with ASTM D 4417.

The same day cleaning is performed, remove dirt, dust, and other debris from the surface by brushing, blowing with clean, dry air, or vacuuming and apply the first coat of paint to the blast-cleaned surfaces. If the cleaned surfaces rust or become contaminated before painting, repeat blast cleaning.

(2) *Surfaces With Existing Sound Paint.* Wash all areas to be painted with pressurized water to remove dirt, surface chalking, loose rust, and contaminants such as chlorides. Maintain a washwater pressure of at least 3.5 MPa. Capture all washwater and removed waste according to appropriate regulations.

Clean according to SSPC–SP 2, Hand Tool Cleaning; SSPC–SP 3, Power Tool Cleaning; or SSPC–SP 6, Commercial Blast Cleaning, to remove dirt, loose mill scale, loose rust, or paint that is not firmly bonded to the underlying surface. Clean

small areas that show pinhole corrosion, stone damage from traffic, or minor scratches. Clean at least 50 mm beyond the damaged areas. Feather edges of remaining old paint to achieve a reasonably smooth surface.

The same day hand- or power-tool cleaning is performed, remove dirt, dust, and other contaminants from the surface with solvent cleaning methods according to SSPC-SP 1, and spot paint all bare steel areas cleaned with the first coat of paint. If the cleaned surfaces rust or become contaminated before painting, repeat solvent cleaning. Repair all damage to sound paint by applying the entire system.

(c) Application of Paints. Apply each coat to the wet film thickness as recommended by the paint manufacturer to obtain the specified dry film thickness. Verify the application rate of each coat with a wet film paint thickness gauge immediately after applying paint to the surface. Confirm the application rate by measuring the dry film thickness after the solvent has evaporated from the surface.

For example, if 75 μm of dry thickness is desired and the volatile content of the paint is 50 percent, the wet film paint thickness gauge must read at least 150 μm immediately after application of the paint to achieve the desired dry coat thickness of 75 μm .

563.08 Painting Galvanized Surfaces. Clean and prepare the surface to be painted by washing with a mineral spirit solvent to remove all oil, grease, or other contaminants on the surface, in accordance with SSPC-SP 1.

Apply the coating system shown in table 563-3 for other metals.

563.09 Painting Timber Structures. Dry timber to a moisture content of 20 percent or less. On previously painted timber, remove all cracked or peeled paint, loose chalky paint, dirt, and other foreign material by wire brushing, scraping, or other approved methods. On timber treated with creosote or oilborne pentachlorophenol preservative, wash and brush away visible salt crystals on the wood surface and allow to dry. Remove all dust or other foreign material from the surface to be painted.

Apply the coating system shown in table 563-3. The primer may be applied before erection. After the primer dries and the timber is in place, fill all cracks, checks, nail holes, or other depressions flush with the surface using approved putty. Evenly spread and thoroughly work the paint into all corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the next coat.

Table 563-3—Coating systems for other structures.

Paint Coatings				
Substrate	Primer	Intermediate	Finish	Total Thickness
Smooth wood	Exterior wood primer, ^a 60–70 µm dry	Exterior latex or alkyd, 35–50 µm dry	Exterior latex or alkyd, 35–50 µm dry	130–170 µm dry
Rough lumber	Exterior latex or alkyd, ^a 35–50 µm dry	Exterior latex or alkyd, 35–50 µm dry	Exterior latex or alkyd, 35–50 µm dry	105–150 µm dry
Concrete	Epoxy single coat, 80–100 µm dry. For gloss finish, finish with aliphatic polyurethane (50 µm dry).			80–150 µm dry
Masonry block	Masonry block filler, 50–60 µm dry	Exterior latex or alkyd, 35–50 µm dry	Exterior latex or alkyd, 35–50 µm dry	120–160 µm dry
Aluminum	Metal primer, 30–40 µm dry	Exterior latex or alkyd, 35–50 µm dry	Exterior latex or alkyd, 35–50 µm dry	100–140 µm dry
Other metals	Metal primer, ^b 35–45 µm dry	Exterior latex or alkyd, 35–50 µm dry	Exterior latex or alkyd, 35–50 µm dry	105–145 µm dry

a. For untreated wood, thin the primer with up to 0.1 L of turpentine and 0.1 L of linseed oil per liter of paint.

b. For galvanized surfaces, use an epoxy primer (35–45 µm dry thickness) or a vinyl wash primer (7–13 µm dry thickness).

563.10 Painting Concrete Structures. Clean and prepare the concrete surface to be painted by removing all laitance, dust, foreign material, curing compound, form oil, grease, or other deleterious material. If form oil, grease, or curing compound is present, wash the surface clean with a 5 percent solution of trisodium phosphate. After washing, thoroughly rinse the surface with clean water and allow to dry completely.

Give the cleaned surface a light abrasive sweep to remove mortar wash or other contaminants. Remove all residue and dust by hand, broom, compressed air, or other approved methods.

Apply the coating system shown in table 563-3. Evenly spread and thoroughly work the paint into all corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the succeeding coat.

Measurement

563.11 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure painting by the square meter or lump sum.

When measurement is by the square meter, measure the visible surface area painted.

Payment

563.12 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
563 (01) Painting, _____ structure	Lump Sum
<i>Description</i>	
563 (02) Painting, _____ structure	Square Meter
<i>Description</i>	

Section 564—Bearing Devices

Description

564.01 Work. Furnish and install bridge bearings. Bearing devices are designated as elastomeric, rocker, roller, and sliding plate.

Materials

564.02 Requirements. Furnish material that conforms to specifications in the following subsections:

Elastomeric Bearing Pads	717.10
TFE Surfaces for Bearings	717.11

Construction

564.03 General. Conform to the following:

(a) Drawings. Prepare and submit drawings for the bearings in accordance with section 18, AASHTO “Standard Specifications for Highway Bridges,” division II, volume II, when SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Show all details of the bearings, including the material proposed for use. Obtain approval before beginning fabrication.

(b) Fabrication. Fabricate bearings in accordance with section 18 of the AASHTO “Standard Specifications for Highway Bridges,” division II, volume II. Ensure that the surface finish of bearing components in contact with each other or with concrete, but not embedded in concrete, conforms to Subsection 555.08(e).

Preassemble bearing assemblies in the shop and check for proper completeness and geometry. Galvanize steel bearing components and anchor bolts in accordance with Subsection 717.07. Do not galvanize stainless steel bearing components or anchor bolts.

(c) Packaging, Handling, & Storage. Before shipping from the manufacturer, clearly identify each bearing component, and mark on its top the location and orientation in the structure. Securely bolt, strap, or otherwise fasten the bearings to prevent any relative movement.

Package bearings so they are protected from damage due to shipping, handling, weather, or other hazards. Do not dismantle bearing assemblies at the site except for inspection or installation.

Store all bearing devices and components at the worksite in a location that provides protection from environmental and physical damage.

(d) Construction & Installation. Clean the bearings of all deleterious substances. Install the bearings at the positions SHOWN ON THE DRAWINGS. Set bearings and bearing components to the dimensions SHOWN ON THE DRAWINGS or as prescribed by the manufacturer. Adjust in accordance with the manufacturer's instructions to compensate for installation temperature and future movements of the bridge.

Set bridge bearings level at the exact elevation and position. Provide full and even bearing on all external bearing contact surfaces. If bearing surfaces are at improper elevations or not level, or if bearings cannot otherwise be set properly, notify the CO and submit a written proposal to modify the installation for approval.

Bed metallic bearing assemblies that are not embedded in concrete on concrete with an approved filler or fabric material.

Set elastomeric bearing pads directly on properly prepared concrete surfaces without bedding material.

Machine all bearing surfaces that are seated directly on steel to provide a level and planar surface upon which to place the bearing.

564.04 Elastomeric Bearings. The bearings include nonreinforced pads (consisting of elastomer only) and reinforced bearings with steel or fabric laminates.

Reinforce elastomeric bearings that are more than 15 mm thick with laminates every 15 mm through the entire thickness.

If not specified, use 50 durometer elastomer that is capable of sustaining an average compressive stress of 7 MPa.

Fabricate elastomeric bearings in accordance with AASHTO M 251. Use material that meets the flash tolerance, finish, and appearance requirements of the "Rubber Handbook" published by the Rubber Manufacturer's Association Incorporated, RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings. Determine compliance with AASHTO M 251, level I acceptance criteria.

Mark each reinforced bearing with indelible ink or flexible paint. Mark the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified, mark on a face that is visible after erection of the bridge. Furnish a list of all individual bearing numbers.

Place bearings on a level surface. Correct any misalignment in the support to form a level surface. Do not weld steel girders or base plates to the exterior plates of the bearing unless there is more than 40 mm of steel between the weld and elastomer. Do not expose the elastomer or elastomer bond to instantaneous temperatures greater than 200 °C.

564.05 Rocker, Roller, & Sliding Bearings. When TFE coatings are required, use coatings that conform to Subsection 564.07.

Fabricate rocker, roller, and sliding bearings in accordance with the details SHOWN ON THE DRAWINGS and with Section 555. Perform fabrication in accordance with standard practice in modern commercial shops. Remove burrs, rough and sharp edges, and other flaws. Stress-relieve rocker, roller, and other bearings that are built up by welding sections of plate together before boring, straightening, or finished machining.

Thoroughly coat all contact surfaces with oil and graphite just before placing roller bearings. Install rocker, roller, and sliding bearings so they are vertical at the specified mean temperature after release of falsework and after any shortening due to prestressing forces. Take into account any variation from mean temperature of the supported span at time of installation and any other anticipated changes in length of the supported span.

Make sure the superstructure has full and free movement at movable bearings. Carefully position cylindrical bearings so that their axes of rotation align and coincide with the axis of rotation of the superstructure.

564.06 Masonry, Sole, & Shim Plates for Bearings. Provide metal plates used in masonry, sole, and shim plates that conform to AASHTO M 270M, grade 250.

Fabricate and finish steel in accordance with Section 555. Form holes in bearing plates by drilling, punching, or accurately controlled oxygen cutting. Remove all burrs by grinding.

Accurately set bearing plates in level position as SHOWN ON THE DRAWINGS and provide a uniform bearing over the bearing contact area. When plates are embedded in concrete, make provision to keep them in correct position as the concrete is placed.

564.07 TFE Surfaces for Bearings. Furnish TFE material that is factory bonded, mechanically connected, or recessed into the backup material, as SHOWN ON THE DRAWINGS.

Bond or mechanically attach the fabric containing TFE fibers to a rigid substrate. Use a fabric capable of carrying unit loads of 70 MPa without cold flow. Use a fabric-substrate bond capable of withstanding, without delamination, a shear force equal to 10 percent of the perpendicular or normal application loading, plus any other bearing shear forces.

Determine compliance using approved test methods and procedures in accordance with section 18, subsection 18.8.3, AASHTO "Standard Specifications for Highway Bridges," division II, volume II. If the test facility does not permit testing completed bearings, manufacture extra bearings and prepare samples of at least 450 kN capacity at normal working stresses.

Determine static and dynamic coefficient of friction at first movement of the test bearing at a sliding speed of less than 25 mm per minute. Ensure that the coefficient of friction does not exceed the coefficient of friction specified in table 564-1 or by the manufacturer.

Table 564-1.—Coefficient of friction.

Material	Bearing Pressure (MPa)	Friction Coefficient
Unfilled TFE, fabric containing TFE fibers, or TFE-perforated metal composite	3.5	0.08
	14	0.06
	24	0.04
Filled TFE	3.5	0.12
	14	0.10
	24	0.08
Interlocked bronze and filled TFE structures	3.5	0.10
	14	0.07
	24	0.05

Furnish a listing of all individual bearing numbers.

564.08 Anchor Bolts. Furnish wedge or thread anchor bolts that conform to ASTM A 307 or as SHOWN ON THE DRAWINGS.

Drill holes for anchor bolts and set them in Portland cement nonshrink grout or preset them before placing the concrete.

Adjust bolt locations for superstructure temperature as required. Do not restrict free movement of the superstructure at movable bearings through anchor bolts or nuts.

564.09 Bedding of Masonry Plates. Place filler or fabric as bedding material under masonry plates, as SHOWN ON THE DRAWINGS. Use the type of filler or fabric specified and install to provide full bearing on contact areas. Thoroughly clean the contact surfaces of the concrete and steel immediately before placing the bedding material and installing bearings or masonry plates.

Measurement

564.10 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Measure bearing devices by the each.

Payment

564.11 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
564 (01) _____ bearing device	Each
<i>Description</i>	