506 Steel Bridges

506.1 Description

(1) This section describes fabricating, furnishing, casting, machining or preparing otherwise, delivering, and erecting the steel and miscellaneous metals required for steel bridges, or metal parts of other bridges.

506.2 Materials

506.2.1 General

(1) Furnish materials conforming to the specifications for the several parts of the completed structure.

506.2.2 Structural Steel

506.2.2.1 General

(1) Furnish structural steel for highway structures conforming to the ASTM specifications the plans show. For material that the plans do not indicate the ASTM specifications, furnish structural carbon steel conforming to ASTM A709 grade 36.

(2) Ensure that girder flange plates, girder web plates, flange splice plates, floor beams, stringers, pier diaphragm members for tub girders, in-span external diaphragm members for tub girders, hanger bars, links, rolled beams, flange cover plates, and plates and angles connecting floor beams to girders conform to zone 2 toughness requirements for longitudinal Charpy V-Notch tests specified in ASTM A709. Sample and test according to ASTM A673. Use the (H) frequency of testing.

(3) Ensure that structural steel members included in the structural design capacity, and that will be welded, have a maximum carbon equivalent (CE) of 0.48. Steels conforming to ASTM A709 HPS 50W or 70W with carbon contents 0.10 percent or less are exempted from this rule. The engineer may allow steels with up to CE 0.58 only if the contractor uses an engineer-approved adjusted welding procedure. Submit steel mill certifications indicating the composition of the steel provided under the contract. The engineer will calculate the carbon equivalent as follows:

$$CE = C + (Mn+Si)/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15$$

506.2.2.2 Structural Carbon Steel

(1) Use structural carbon steel conforming to ASTM as follows:

Thickness <= 4 inches ..... ASTM A709 grade 36
Thickness > 4 inches ..... ASTM A36

506.2.2.3 High-Strength Structural Steel

(1) Use high-strength structural steel conforming to ASTM A 709 as follows:

HSLA columbium-vanadium structural steel ..... grade 50
HSLA weathering steel ..... grade 50W
High Performance Steel - quenched and tempered ..... grade HPS 100W or HPS 70W
High Performance Steel ..... grade HPS 50W or HPS 70W

506.2.3 Miscellaneous Metals

506.2.3.1 Steel Castings

506.2.3.1 Update references to current ASTM and AASHTO steel specifications

(1) If using carbon steel castings for bridges and general use, conform to ASTM A781 class 70, AASHTO M103 class 70 or grade 70-36, or AASHTO M163 grade CA 15 and the following:

1. Furnish the specific class of steel castings the plans show or are specified in the contract.
2. The plans will specify the nondestructive tests to perform and their extent.
3. Use steel castings that are true to pattern in form and dimensions and free from defects affecting strength or service life.
4. The contractor may weld defects using an engineer-approved process. Perform weld repairs before annealing the casting. If the engineer requires, re-anneal castings after welding.
5. If the engineer requires, the contractor shall test castings by radiography or ultrasonic testing to determine the presence of cracks, flaws, or other defects.
6. Ensure that the metal thickness remaining after completing the machining is not less than the thickness the plans show.
7. Thread the ends of the tensile test specimens for at least 3/4 inch with 3/4-inch American N.C. threads.

506.2.3.2 Bronze Castings

(1) If using bronze castings for bearings, trunnions, journals of bridges, and expansion plates, conform to ASTM B22, alloy No. C91100.

506.2.3.3 Cold-Finished Carbon Steel Shafting

(1) Use cold-finished carbon steel shafting conforming to AASHTO M169, grades 1016 through 1030. If used for structural pins, then conform to ASTM A434, grade BC, quenched and tempered.

506.2.3.4 Lubricated Bronze Plates

(1) Fabricate lubricated bronze plates as the plans show and with materials conforming to ASTM B100, copper alloy No. C51000 or to ASTM B22, alloy No. C91100.

(2) Provide to the engineer a certified report of test or analysis indicating the manufacturer's test results for the lubricated bronze plates on their chemical and physical properties, including the coefficient of friction of the material used.

(3) Bore or cast the surface of the lubricated bronze plates in a geometric pattern of recesses. Fill the recesses with a lubricating compound consisting of graphite and metallic substances with a lubricating binder capable of withstanding the atmospheric elements. Hydraulically press the compound into the recesses to form dense, non-plastic lubricating inserts. Ensure the lubricated area is within a range of 25 to 33 percent, inclusive, of the bearing face with a coefficient of friction not greater than 0.1. Unless the plans show or the contract directs otherwise, only lubricate the top face of the bronze plate.

506.2.3.5 Steel Forgings

(1) Use steel forgings for pins, rollers, trunnions, and other forged parts conforming to the requirements for class M quenched and tempered forgings of ASTM A668. Thread the ends of the tensile test specimens for at least 3/4 inch with 3/4-inch American N.C. threads.

506.2.3.6 Welded and Seamless Steel Pipe

(1) Furnish welded and seamless steel pipe for general use conforming to ASTM A53, type F, type E grade B, or type S grade B. Unless provided otherwise, use black, standard weight pipe.

506.2.3.7 Pipe Fittings

(1) Use malleable cast iron or pressed steel pipe fittings for required uses. If galvanized fittings are required, the coating shall conform to ASTM A123.

506.2.3.8 Sheet Lead

(1) Furnish lead in sheet form conforming to ASTM B29.

(2) Use lead sheets of uniform thickness throughout, free from cracks, seams, slivers, scale, and other surface defects.

(3) Unless the plans show otherwise, use sheet lead 1/8 inch thick with a tolerance of +/- 1/32 inch. Ensure that the length and width are within 1/8 inch of the plan dimensions.

506.2.3.9 Sheet Copper

(1) Furnish strip or sheet copper conforming to ASTM B152 and suitable for the purpose intended. Unless specified otherwise, use sheet copper with a minimum thickness of 0.02 inch.

506.2.3.10 Sheet Zinc

(1) For sheet or plate zinc, conform to Prime Western Grade ASTM B6.

(2) Use sheet and plate zinc of uniform thickness, free from cracks, seams, slivers, scale, surface corrosion, adhering matter, and other surface defects.

(3) Use sheet and plate zinc of the zinc gauge the plans show, with a thickness tolerance of +/- 6 percent. Use sheets within 1/8 inch of the length and width the plans show.

506.2.4 Name Plates

(1) Furnish bronze nameplates for bridges, culverts, and retaining walls cast from material conforming to ASTM B62 for copper alloy UNS No. C83600, common trade name 85-5-5-5. Provide raised lettering in a block gothic font and polish the raised surface of the lettering and borders.

506.2.5 High-Strength Bolts

506.2.5.1 General

(1) Furnish A325 high-strength bolts conforming to ASTM F3125, nuts conforming to ASTM A563, and flat washers conforming to ASTM F436. Use type 1 galvanized bolts, galvanized grade DH nuts, and type 1 galvanized washers. For weathering steel connections use type 3 bolts, grade DH3 or C3 nuts, and type 3 washers.

(2) Hot-dip galvanize according to ASTM A153 supplemented by ASTM F2329 or mechanically galvanize according to ASTM B695, class 50. Remove excess hot-dip galvanizing on threads by centrifuging or air blasting immediately after withdrawal. Do not flame-chase. Ensure that the same galvanization process is used for bolts and nuts within a bolt/nut/washer assembly.

(3) Ensure that the supplier lubricates galvanized nuts with a lubricant containing dye that contrasts with the color of the galvanizing according to ASTM A563 supplementary requirements S1 and S2.

(4) For, uncoated nuts use grade C, D, or C3 with a minimum Rockwell hardness of 89 HRB or minimum Brinell hardness of 180 HB, or use heat treated grade DH or DH3.

506.2.5.2 Bolt and Nut Dimensions

(1) Use high-strength bolts and nuts conforming to the dimensions the plans show and as specified in ASTM F3125. Determine the length as specified in 506.2.5.4.

506.2.5.3 Washer Dimensions

(1) Use flat, smooth, and hardened circular washers conforming to dimensions specified in ASTM F436.

(2) Install bolts with a washer under the nut or bolt head, whichever is turned to tighten. If the bearing faces of the bolted parts have a slope of more than 1:20 with respect to a plane normal to the bolt axis, use smooth, hardened, and beveled washers to compensate for lack of parallelism.

(3) If clearance is necessary, the contractor may clip washers on one side to a point not closer than 7/8 of the bolt diameter from center of washer.

506.2.5.4 Update bolt lengths and guidance to agreement with RCSC requirements.

506.2.5.4 Bolt Lengths

(1) The required bolt length is the grip, total thickness of the connected material, plus the tabulated length added to the grip for each bolt size as follows:

BOLT SIZE	LENGTH ADDED TO THE GRIP
5/8-inch	1 1/16 inches
3/4-inch	1 3/16 inches
7/8-inch	1 5/16 inches
1-inch	1 3/8 inches
1 1/8	1 5/8 inches
1 1/4	1 13/16 inches
1 3/8	1 7/8 inches
1 1/2-inch	2 1/16 inches

(2) The above values are generalized, with allowance for manufacturing tolerances, to provide for a standard flat washer and using a heavy nut, with adequate stick-through at the end of the bolt. For each additional ASTM F436 standard flat washer that is used add 5/32 inch; for each beveled washer add 15/16 inch. Adjust the length determined from the above table increment and allowances for additional washers to the next 1/4 inch length increment for bolts up to 6 inches length and to the next 1/2 inch length increment for lengths over 6 inches.

(3) Select bolt length and use ASTM F436 washers to provide enough thread within the grip to ensure that the bolt can be properly tensioned and, if practicable or specified, exclude threads from the shear plane. The full thread may extend into the grip by as much as 3/8 inch for 1/2, 5/8, 3/4, 7/8, 1 1/4, and 1 1/2-inch diameter bolts and as much as 1/2 inch for 1, 1 1/8, and 1 3/8-inch diameter bolts.

506.2.5.5 Identification

(1) Ensure that the manufacturer provides identification marks for high-strength bolts and nuts according to ASTM F3125.

506.2.5.6 Testing and Reporting

(1) Provide manufacturer's mill test certificates for high strength bolts, nuts, and washers; tested according to ASTM F3125, ASTM A563, and ASTM F436.

(2) Provide manufacturer rotational-capacity test results for fastener assemblies with ASTM F3125 A325 bolts tested according to ASTM F3125 Annex A2.

506.2.6 Elastomeric Bearings

506.2.6.1 General

(1) Furnish laminated bearings from the APL of laminated elastomeric bearings

(2) Manufacture bearings according to AASHTO M251 except replace the requirements of sections 4.1 and 4.2 with the following:

- Use virgin crystallization resistant polychloroprene, or virgin natural polyisoprene as the raw polymer. Use only new material with no reclaimed material incorporated in the finished bearing.

- Provide elastomer with durometer hardness of 60 on the Shore “A” scale. Provide elastomer compounds classified as low-temperature zone D, grade 4 or 5, meeting the requirements of AASHTO LRFD Bridge Design Specifications, table 14.7.5.2-1.
- Conform to the following physical properties:

	POLYISOPRENE (NATURAL RUBBER)	POLYCHLOROPRENE (NEOPRENE)
Grade (durometer)	60±5	60±5
Physical properties		
Hardness (ASTM D2240)	60+/-5	60+/-5
Tensile strength (ASTM D412), psi	2500	2500
Ultimate elongation, minimum percent	400	400
Heat resistance (ASTM D573)	168 hrs. @ 158°F	70 hrs. @ 212°F
Hardness, maximum points change	+10	+15
Tensile strength, maximum percent change	-25	-15
Ultimate elongation, maximum percent change	-25	-40
Compression set (ASTM D395, method B)	22 hrs. @ 158°F	22 hrs. @ 212°F
Maximum percent	25	N.A.
Maximum percent	N.A.	35
Low temperature brittleness (ASTM D746, procedure B)		
Brittleness at -54.4°F	No Failure	No Failure
Laminated pad adhesion test (ASTM D429, method B)		
Bond strength, psi	40	40

506.2.6.2 Non-Laminated Elastomeric

(1) Form non-laminated elastomeric bearings by casting or extruding rubber or neoprene in a single, integral layer to the required plan thickness. Avoid heating or damaging the material if cutting.

506.2.6.3 Laminated Elastomeric

(1) Furnish alternate layers of elastomer and steel reinforcement integrally bonded together, with reinforcement spaced as the plans show and parallel to the pad top and bottom surfaces. Cover reinforcement edges with a minimum of 1/4 inch of elastomer. Seal edge cavities using heat bonded vulcanized patching or an engineer-approved elastomeric sealant.

(2) Conform to AASHTO M251 tolerances, dimensions, and configurations; except cover the top and bottom steel plates with 1/4 inch of elastomer with a +1/8 to -1/16-inch thickness tolerance. Use rolled steel conforming to ASTM A36 or ASTM A1011 grade 36 or higher, for internal steel reinforcement.

(3) Ensure that the manufacturer molds their name or trademark into the edge of each pad on a face visible after structure erection.

(4) Submit shop drawings to the engineer conforming to 105.2 with electronic submittal to the fabrication library under 105.2.2.

506.2.6.4 Testing

(1) Conform to the bearing testing and acceptance criteria specified in AASHTO M251, section 8 as follows:

- Determine compressive strain according to section 8.8.1. Ensure that compressive strain in any layer of an elastomeric bearing does not exceed 7 percent at 800 psi average unit pressure for the full size bearing.
- Proof load each bearing according to section 8.8.2. Use a compressive load of 1200 psi for non-laminated bearings and 1800 psi for laminated bearings.

(2) Provide a manufacturer's certified report of test or analysis to the engineer for each production lot of bearings at least 30 days before shipment to the contractor. The department may require additional test samples from the bearings to confirm manufacturer test results before shipment.

(3) Ensure that each bearing delivered to the project is labelled to clearly indicate its production lot and can be tied to its associated test results.

506.2.7 Welded Stud Shear Connectors

(1) For shear connector studs conform to ASTM A108, cold-finished bars, grades 1015, 1018, or 1020, either semi- or fully killed. If using flux-retaining caps, use low carbon grade steel for the caps suitable for welding that comply with ASTM A109.

(2) Tensile properties, determined testing bar stock after drawing, or of finished studs, shall conform to the following:

Minimum tensile strength ..... 60 ksi
Minimum yield strength[1] ..... 50 ksi
Minimum elongation ..... 20 percent in 2 inches
Minimum reduction of area ..... 50 percent

[1] As determined by the 0.2 percent offset method.

(3) Determine tensile properties according to ASTM A370. Perform tensile tests of finished studs on studs welded to test plates using a test fixture similar to figure 7.2 of clause 7 of AWS D 1.5. If fracture occurs outside the middle half of the gauge length, repeat the test.

(4) Ensure that finished studs are of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. Produce the finish by cold drawing, cold rolling, or machining.

(5) Furnish arc shield (ferrule) of heat-resistant ceramic or other material with each stud that does not damage the welds, or does not cause excessive slag, and will not crumble or break due to thermal or structural shock before completing the weld.

(6) The contractor shall submit the following information on the studs to the engineer for approval before installation:

- The name of the manufacturer.
- A detailed description of the stud and arc shield.
- Documentation that the studs qualify as specified in AWS D 1.5.

506.2.8 Bearing Assemblies

506.2.8.1 General

(1) Use bearing assemblies conforming to the material requirements, sizes, and details the plans show.

(2) Blast clean fabricated structural steel bearing components as specified in 506.3.31.3 before galvanizing. After galvanizing, apply a wash primer to the components and the coating system in the color selected for the structural steel under the concrete. If using weathering steel, paint the bearing assemblies with one coat of organic zinc-rich primer and one shop coat of high-build brown epoxy paint. The contractor shall not blast clean, galvanize, or paint stainless steel and teflon surfaces.

506.2.8.2 Fixed Bearing Assemblies

(1) Galvanize the complete bearing assembly, including anchor bolts, nuts and washers, but excluding elements welded to the girder. Galvanize anchor bolts, nuts, and washers, according to ASTM A153, class C, supplemented by ASTM F2329. Galvanize the remainder of the assembly according to ASTM A123.

506.2.8.3 Expansion Bearing Assemblies

(1) An expansion bearing assembly unit consists of a top sole plate, a bottom masonry plate, a rocker plate, a slide plate, side retainers, anchor bolts with nuts and washers, and a lead plate, all as described below and as the plans show.

(2) Galvanize all structural steel surfaces, including anchor bolts, nuts and washers, that do not come in contact with other structural steel surfaces, or stainless steel, or polytetrafluoroethylene (PTFE) surfaces, as specified in 506.2.8.2 for fixed bearing assemblies.

(3) For the stainless steel sheet for the top element of sliding bearings use type 304 conforming to ASTM A240 and ensure it is not less than 1/16 inch thick after finishing. Make the finished stainless surface a plane within a tolerance of 1/32 inch and with a 2B finish as specified in ASTM A480.

(4) During welding, protect the surface of the stainless steel plate from weld splatter.

(5) After fabrication, provide a near mirror finish on the surface of the stainless steel plate.

(6) Use PTFE materials that are virgin polytetrafluoroethylene fluorocarbon resin, unfilled conforming to ASTM D4894. The finished materials shall exhibit the following physical properties:

REQUIREMENT	TEST METHOD	UNFILLED VALUE
Hardness at 78 F	ASTM D2240 Shore "D"	50-65
Tensile strength, psi	ASTM D1708	2800 Min.
Elongation, percent	ASTM D1708	200 Min.
Specific gravity	ASTM D792	2.16 +/- 0.03
Melting point	ASTM D4591	621 +/- 18 F

(7) Ensure the finished PTFE sheet is not less than 1/16 inch or more than 3/32 inch thick.

(8) Bond the PTFE sheet to the 1/2-inch steel sheet with extreme care using a proven high-temperature-resistant epoxy bonding material. Use a 2-component, medium viscosity epoxy resin conforming to ASTM D1763 for this purpose.

(9) The engineer may allow welding to steel plate that has a bonded PTFE surface provided welding procedures are established that restrict the maximum temperature reached by the bond area to less than 300 F. Monitor temperature using temperature-indicating crayons, liquids, or bimetal thermometers.

(10) If epoxy bonding PTFE sheets, ensure that one side of the PTFE sheet is factory treated by the sodium naphthalene or sodium ammonia process by a department-approved manufacturer.

(11) Perform PTFE bonding at the bearing manufacturer's factory under controlled conditions and according to the engineer-approved adhesive systems manufacturer's written instructions. The bonding operation should produce a PTFE surface that is smooth and free from bubbles.

(12) At installation, ensure the stainless steel sliding face of the upper element and the PTFE sliding face of the lower element have the surface finish specified and are clean and free of dust, dirt, moisture, or any other foreign matter.

506.2.8.4 Preformed Fabric Pads, Class A

(1) Furnish fabric pads for use under steel bearings the plans show. Use preformed pads composed of multiple layers of 8-ounce cotton duck impregnated and bound with natural rubber, or of equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall produce the specified thickness after compression and vulcanizing. When tested according to MIL-C-882E, finished pads shall withstand compression loads of 10,000 psi or more perpendicular to the plane of the laminations without harmful extrusion or reduced thickness.

506.2.9 Steel Diaphragms

(1) Furnish steel diaphragms conforming to the plan details.

506.2.10 Galvanized Fabrication

(1) Conform to ASTM A385 for fabricating galvanized work.

506.3 Construction

506.3.1 General

506.3.1.1 Primary Members

(1) Ensure that the following are fabricated by an approved fabricator selected from the APL for primary members:

- Webs and flanges of plate, tub, and box girders.
- Stringers, rolled beams and their cover plates.
- Main truss members (chords, verticals, and diagonals of truss panels, transverse wind bracing, floor system).
- Floor beam webs and flanges.
- Arch ribs, ties, and hangers.
- Pier diaphragm members and in-span external diaphragm members for tub girders.
- Splice plates for primary members.
- Columns.

(2) Ensure that the fabricator does the following:

- Submits department form DT2330 electronically to the department's fabrication library for each structure before fabrication.
- Submits and updates weekly fabrication progress reports on department form DT2172 electronically to the department's fabrication library for each structure during fabrication.

506.3.1.2 Fabricated Bridge Components

(1) Ensure that the following are fabricated by an approved fabricator selected from the APL for fabricated bridge components:

- Railing assemblies
- Expansion devices
- Bearing assemblies
- Structural steel diaphragms for concrete girders

(2) Ensure that the fabricator does the following:

- Submits a fabrication progress report on department form DT2334 electronically to the department's fabrication library. Update this form weekly for each component in fabrication.

506.3.2 Shop Drawings

(1) Ensure that shop drawings conform to the contract plans and provide additional details, dimensions, computations, and other information necessary for completely fabricating and erecting the work. Include project and structure numbers on each shop drawing sheet.

(2) Submit shop drawings to the engineer conforming to 105.2 with electronic submittal to the fabrication library under 105.2.2. Also certify that shop drawings conform to quality control standards before fabrication by submitting department form DT2333 for primary members and department form DT2327 for fabricated bridge components with each set of shop drawings. Department review does not relieve the contractor from responsibility for errors or omissions on shop drawings.

(3) Shop drawings are part of the contract. The department must approve differences between shop drawings and contract plans. The contractor bears the costs of department-approved substitutions. Do not deviate from or revise drawings without notifying the department and resubmitting revised drawings and an updated department form DT2333.

(4) Ensure that the fabricator submits a PDF file of shop drawings for railroad structures to the railroad company's chief engineering officer upon contract completion.

506.3.3 Structural Steel Identification

(1) In addition to ordinary mill identification, paint the appropriate color, according to ASTM A6, on all structural steel, except steel conforming to ASTM A709, grade 36 without toughness requirements, on each end of each piece before shipment from the mill. Before working any piece in the shop, move the identifying paint marks a sufficient distance away from the end to ensure the identity of the piece during fabrication. Mark angles on the inside of a leg. Mark beams and channels on the inside of a flange. Paint the ends of pieces if assembly will destroy or make identification by the above methods impossible. If the contractor fails to exercise the above precautions, the engineer will reject the piece.

506.3.4 Rolled Material

506.3.4.1 Straightening

(1) Ensure rolled material is straight before being laid off or worked. If straightening is necessary, perform it without injuring the metal. The engineer may reject material with sharp kinks and bends.

506.3.4.2 Allow either cold or heat cambering methods.

506.3.4.2 Camber

(1) If the plans show, camber rolled beams conforming to a uniform, approximately circular curve for the entire length of the beam or between designated points. Ensure the camber is within the tolerance specified in the American Institute of Steel Construction Manual.

(2) Use engineer-approved cambering methods, either cold or with heat. Select heat areas so that no distortion other than the required camber occurs. Use a procedure that prevents beam flange warpage.

(3) Support the beam near its ends facing the side made concave upward. Apply propane, natural gas, or other engineer-approved gas flame to areas selected. Play the flame over the section until the metal attains a maximum temperature of 1100 F for A709 HPS 70W and 100W steel or a maximum of 1200 F for other A709 steels. Monitor the temperature using temperature-indicating crayons, liquids, or bimetal thermometers. Notify the engineer before applying any heat.

(4) Heat the areas in generally wedge- or triangular-shaped areas with an included angle between 10 and 20 degrees. Locate the vertex of the angle on the web midway between flanges. Slowly play the flame over the area heated, starting at the vertex of the angle and finishing at the widest part of the heated wedge, extending across the flange width. Manipulate the torch, or torches, to rapidly bring the total area heated to the proper temperature at the same time.

(5) Space the heated sections to produce uniform curvature. Heat no less than 3 sections. It may require heating additional sections if the beam is unusually long or heavily cambered. Do not use water to cool the metal, or heat any area more than once. Air cool the heated metal slowly away from wind or drafts. The engineer may reject the beam if improper heating or cooling occurs that might affect the strength or ductility of the metal.

506.3.5 Allow holes made with CNC equipment.

506.3.5 Bolt Holes

(1) The standard hole size for bolts smaller than 1-inch diameter is the nominal bolt diameter plus 1/16 inch. For 1-inch and larger diameter bolts, the standard hole size is the nominal bolt diameter plus 1/8 inch. Punch or drill bolt holes.

(2) The contractor may punch bolt holes full-size in material forming a member made of no more than 5 metal thicknesses and if the metal is not thicker than 3/4 inch for structural carbon steel, 5/8 inch for high-strength structural steel, or 1/2 inch for quenched and tempered alloy steel. For more than 5 metal thicknesses, or if the main material is thicker than 3/4 inch for structural carbon steel, 5/8 inch for high-strength structural steel, 1/2 inch for quenched and tempered alloy steel, or if required otherwise, subpunch, or subdrill holes 3/16 inch smaller. After assembling, ream or drill from the solid to full-size. The contractor may use oversized holes in secondary members if the engineer allows.

(3) Obtain written approval from the bureau of structures before using computer-numerically-controlled (CNC) equipment to drill full-size holes in components otherwise requiring reamed, sub-sized holes. Perform periodic check assemblies of components to verify CNC system accuracy. Notify the bureau of structures immediately and stop production if errors are detected by check assemblies. The bureau of structures may restrict or prohibit subsequent CNC operations pending resolution of problems exposed by check assemblies.

(4) The die diameter shall not exceed the punch diameter by more than 1/16 inch. If enlarging holes to admit the bolts, then ream the holes. Ensure clean-cut holes without torn or ragged edges. The engineer may reject poorly matched holes.

(5) Make reamed or drilled holes cylindrical, perpendicular to the member and not more than the standard full-size diameter. If possible, direct the reamers by mechanical means. Remove burrs on the outside surfaces. Poor matching of holes shall be cause for rejection. Perform reaming with tapered reamers. If removing burrs caused by drilling, take apart the assembled parts. For connecting parts that require reamed or drilled holes, assemble them first and then hold securely during reaming or drilling.

(6) Do not shear cut or punch full-sized holes in members requiring Charpy testing.

506.3.6 Accuracy of Holes

506.3.6.1 Punched and Drilled Holes

(1) Ensure that holes punched full size, subpunched, or subdrilled are so accurate that after assembling (before performing reaming) a cylindrical pin 1/8 inch smaller in diameter than that of the punched hole can enter it, without drifting, in at least 75 percent of the contiguous holes in the same plane. Failure to conform to this requirement will result in rejection of the badly punched pieces. In addition, the engineer will reject any hole that will not pass a pin 3/16 inch smaller in diameter than that of the punched hole.

506.3.6.2 Reamed and Drilled Holes

(1) If holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thicknesses of metal.

(2) Use steel templates that have hardened steel bushings in the holes, and are accurately dimensioned from the connection centerlines as inscribed on the template. Use the centerlines to accurately locate the template from the milled or scribed ends of the members.

506.3.7 Shop Assembly

506.3.7.1 General

(1) Unless specified otherwise, subpunch or subdrill, and ream while shop assembled bolt holes in connections and splices (shop and field) of main truss or arch members, continuous beams, floor beam connections to girder or truss, continuous plate girders, and rigid frames; or drill them full size from the solid while assembled at the shop. Subpunch or subdrill floor beam connections for plate girders and trusses and ream or drill full size from the solid in assembly. The contractor may use engineer-approved alternate procedures.

(2) Unless the engineer authorizes otherwise, assemble each individual truss, arch, continuous beam, or girder full length at the shop. Obtain approval of other than full-length assembly before submitting the shop drawings and show engineer-approved alternate assembly procedures on the shop drawings. During shop assembly, support members in a way that does not cause undesirable deflections. Ensure that the inspector approves the assembly, including camber, alignment, accuracy of holes, and milled joints, before final drilling or reaming.

(3) Conform to 506.3.27 for pickup points and girder handling equipment.

(4) Ensure that the component parts of a built-up member are straight and close fitting. Matchmark the members and parts of the built-up members before disassembling.

506.3.7.2 Fitting for Bolting

(1) Clean the metal surfaces in contact with other each other before assembling. Before drilling, reaming, or bolting, assemble the parts of a member, pin, and draw together. Take apart the assembled pieces in order to remove the burrs and shavings this operation produces. Ensure the member is free from twists, bends, and other deformation.

(2) During assembly tolerate only the drifting necessary to bring the parts into position and not sufficient to enlarge the holes or distort the metal.

506.3.8 Flame Cutting

(1) The contractor may flame cut structural steel, provided this process produces a smooth surface free from cracks and notches and a mechanical guide is used to produce an accurate profile. The engineer must approve hand cutting.

(2) Flame cut plates in a direction that allows the stress in the plate, when assembled, to be parallel to the direction the plate was rolled.

(3) Ensure that flame cutting is adjusted and manipulated to cut within the prescribed lines. Flame cut surfaces shall conform to the ANSI surface roughness value of 1000 for material up to 4 inches thick and 1600 for material 4 to 8 inches thick, except that the ends of members not subject to calculated stress at the ends shall have a surface roughness value of 2000. Round the corners of flame cut surfaces of members that carry calculated stress to approximately a 1/16-inch radius by grinding after flame cutting.

(4) Cut re-entrant cuts to a radius of not less than one inch.

(5) Remove surface roughness exceeding the above values and occasional gouges not more than 3/16 inch deep on otherwise satisfactory flame cut surfaces by machining or grinding. Correct defects by flairing into the cut surface on a slope of at least 1 to 10. Repair gouges of flame cut edges more than 3/16 inch deep but not more than 7/16 inch deep by welding, if the engineer approves, with low-hydrogen electrodes not exceeding 5/32 inch in diameter and with a preheat of 250 F. Grind the completed weld smooth and flush with the adjacent surface.

506.3.9 Edge Planing

(1) Plane the sheared edge of plates more than 5/8-inch thick and carrying calculated stress to a depth of 1/4 inch.

506.3.10 Connections

(1) Unless specified otherwise, make connections with 3/4-inch ASTM F3125 A325 high-strength bolts.

506.3.11 (Vacant)

506.3.12 Bolts and Bolted Connections

506.3.12.1 General

(1) Furnish sufficient bolts of each type, size, and length required with an ample surplus to replace those lost or rejected.

(2) Perform shop assembly and matchmarking as specified in 506.3.7.

(3) If assembled, ensure joint surfaces, including those adjacent to washers, are free of scale, dirt, oil, burrs, pits, and other defects that prevent solid seating of the parts.

506.3.12.2 Unfinished Bolts

(1) If using unfinished bolts for temporary connections and other specifically allowed uses, use standard bolts with hexagon heads and nuts. Ensure the bolt hole diameters are 1/16 inch greater than that of the bolt.

(2) Thread bolts transmitting shear so that not more than one thread is within the grip of the metal. Use lock washers under the nuts for unfinished bolts used in permanent connections.

506.3.12.3 Remove DTI installation method and update table 506-1 tension values to match ASTM F3125.

506.3.12.3 High-Strength Bolts

506.3.12.3.1 General

(1) Install bolts according to AASHTO LRFD Bridge Construction Specifications, article 11.5.5, with the following exceptions:

1. If connections are assembled, install bolts with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

2. If using oversized holes, 2 hardened washers are required, one under the bolt head and one under the nut.
3. Bring the bolted parts into solid contact bearing before final tightening. Use not less than 25 percent of the total number of bolts in a joint to serve as fitting up bolts.
4. For steel diaphragms on prestressed concrete bridges do the following:
   4.1. For steel-to-steel connections within diaphragms:
      - No field rotational capacity testing is required. Provide a certified report of test or analysis from the bolt supplier. The department may require field testing to determine inspection torque.
      - Re-lubricate bolt threads with a wax-based lubricant.
      - Tension by the turn-of-nut method.
   4.2. For steel-to-concrete girder connections:
      - No testing is required.
      - Tighten as the plan details specify.

(2) The contractor may use a flat washer if the surface adjacent to and abutting the bolt head or nut does not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. For slopes greater than 1:20, use smooth, beveled washers to produce parallelism.

(3) Tighten each fastener to provide, if all fasteners in the joint are tight, at least the minimum bolt tension as follows:

TABLE 506-1 BOLT TENSION

BOLT SIZE	REQUIRED MINIMUM BOLT TENSION[1]
1/2-inch	12,050 pounds
5/8-inch	19,200 pounds
3/4-inch	28,400 pounds
7/8-inch	39,250 pounds
1-inch	51,500 pounds
1 1/8-inch	64,900 pounds
1 1/4-inch	82,400 pounds
1 3/8-inch	98,200 pounds
1 1/2-inch	119,500 pounds

[1] Equal to the proof load by the length measurement method as specified in ASTM F3125.

(4) Tighten threaded bolts by the turn-of-nut method while holding the bolt head. Where clearance is an issue, the contractor may tighten the bolt head while holding the nut.

(5) The contractor may use alternate tightening methods if the engineer approves before use.

(6) Snug all bolts during installation according to AASHTO LRFD Bridge Construction Specifications, article 11.5.5.4.1.

(7) Do not reuse galvanized F3125 A325 bolts. The contractor may reuse uncoated F3125 A325 bolts, if the engineer approves, but not more than once. The department will not consider re-tightening previously tightened bolts that become loosened by the tightening of adjacent bolts as reuse.

(8) Provide and use a Skidmore-Wilhelm Calibrator or an acceptable equivalent tension measuring device at each job site during erection. Perform rotational capacity and pre-installation testing in the field conforming to the procedures enumerated in department forms DT2113 and DT2114 and submit 2 copies of each form to the engineer.

(9) Check galvanized nuts to verify that a visible dyed lubricant is on the threads and at least one bolt face.

(10) Ensure that uncoated bolts are oily to the touch over their entire surface when delivered and installed.

(11) Clean and re-lubricate weathered or rusted bolts or nuts not conforming to the requirements above before installation. Retest re-cleaned or re-lubricated bolt/nut/washer assemblies for rotational capacity before installation. Test conforming to department form DT2113 and submit 2 copies to the engineer.

(12) Install bolt, nut, and washer combinations from the same rotational-capacity lot.

506.3.12.3.2 Turn-of-Nut Method

(1) Snug bolts to ensure connection faying surfaces are in firm contact. Snug-tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a person using an ordinary spud wrench. Snug systematically from the most rigid part of the connection to free edges repeating

until all bolts in the connection are snug-tight. Then tighten all bolts in the connection by the nut rotation specified in table 506-2. Ensure the part not turned by the wrench does not rotate.

TABLE 506-2 NUT ROTATION FROM SNUG-TIGHT CONDITION[1]

DISPOSITION OF OUTER FACES OF BOLTED PARTS			
Bolt length measured from underside of head to extreme end of point	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20(bevel washer not used)	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[2]	2/3 turn	5/6 turn	1 turn

[1] Nut rotation is relative to bolt regardless of the element, nut, or bolt, being turned. For bolts installed by 1/2 turn and less, the tolerance should be +/- 30 degrees; for bolts installed by 2/3 turn and more, the tolerance should be +/- 45 degrees.

[2] No research work has been performed by the Research Council on Riveted and Bolted Structural Joints to establish the turn-of-nut procedure when bolt lengths exceed 12 diameters, therefore, determine the required rotation by actual tests in a suitable tension device simulating the actual conditions.

506.3.12.3.3 Contractor QC Testing

506.3.12.3.3.1 General

(1) Notify the engineer before performing the required field rotational-capacity and pre-installation testing. Do not begin bolt installation without the engineer's approval. The engineer may verify bolt installation by periodically testing with a calibrated torque wrench for bolts tensioned by turn-of-the-nut.

506.3.12.3.3.2 Turn-of-Nut Method QC

(1) In the presence of the engineer, use a torque wrench to perform QC testing for each completed bolted connection.

(2) Calibrate the torque wrench using 3 bolt/nut/washer assemblies of the same rotational-capacity lot and condition as those undergoing QC testing. Place a washer under the part turned and tighten each bolt in a contractor-furnished bolt tension calibration device to the minimum inspection tension required on department form DT2114 using a torque wrench. Average the 3 tests to determine the inspection torque for that rotational-capacity lot.

(3) Perform QC testing on a minimum of 10 percent of the bolts, but not less than 2 bolts, selected randomly in each connection. Test bolts by applying the inspection torque determined in the pre-installation test in the tightening direction. If any nut or bolt turns, check all bolts in that connection, or alternatively, the fabricator or erector may re-tighten all bolts in the connection and retest the retightened connection at the prescribed QC testing frequency.

506.3.13 Abutting Joints

(1) Mill or saw cut abutting joints in compression members of trusses and in columns to give a true and square cut.

(2) Openings at abutting joints in tension members in continuous I-beams and plate girders shall not exceed 3/8 inch.

506.3.14 Facing of Bearing Surfaces

(1) Make the top and bottom surfaces of steel slabs and the base plate and cap plates of columns and pedestals straight, smooth, and free from warp and must bear evenly throughout.

(2) If necessary, plane the bases of welded steel bearings after welding to secure an even bearing.

(3) Plane the bases of cast steel bearings after annealing to secure an even bearing.

(4) Ensure that the sole plates of beams and girders have full contact with the flanges, and that the bearing surface is smooth, true, and perpendicular to the web of the member. Ensure that curved sole plates make full line bearing with masonry or bearing plates, and that the line is at right angles to the axis of the member and perpendicular to the web of the member unless the plans show otherwise.

(5) If planing the curved surfaces of expansion bearings, operate the tool so that the cut is in the expansion direction. If the cut of the tool is at right angles, make the finished surface the true arc of a circle, smooth and free from ridges.

(6) Finish contact steel surfaces subject to sliding motion in the direction of motion as specified in ANSI No. 125.

(7) Machine finish surfaces that the plans show to receive a surface finish.

(8) Polish finish the surfaces of bronze bearing plates intended for sliding contact.

(9) If using lubricated bronze plates, cover the finished surface of the expansion plate assembly in contact with the lubricated bronze plate with a plastic or other engineer-approved coating after machining. Before erecting the girder, remove this coating and coat the surface with graphite.

506.3.15 Web and Flange Plates

(1) At bolted splices, the clearance between the ends of the web and flange plates shall not exceed 3/8 inch.

(2) If the plans show camber for welded girders, produce the camber by machine flame cutting the web plate. Cut cambers on a continuous smooth curve. If the engineer approves, correct moderate deviations from specified camber by a carefully supervised application of heat.

(3) For welded girders, if detailed to a horizontal curve greater than 3 degrees, cut the flange plates to a continuous smooth curve by machine flame cutting. If the curve is 3 degrees or less, curve the girder by either heat curving methods that the engineer approves, unless the plans specify otherwise. The contractor may curve the girder by machine flame cutting.

(4) Assemble the web and flange plates in the work so that the direction of stress in the plate, as assembled, is parallel with the direction that the plate was rolled.

506.3.16 Fit of Stiffeners

(1) Ensure that the end stiffeners of girders and stiffeners intended as supports for concentrated loads bear fully on the flanges that they transmit load to or from which they receive load. Obtain full bearing by milling, or grinding, or in the case of weldable steel in compression areas, by welding as the plans show or as specified.

(2) If the clearance between the end of the stiffener and the flange for stiffeners is not intended to support concentrated loads, then the gap shall not exceed 1/16 inch unless the plans show or the contract specifies otherwise.

506.3.17 Pin and Roller Details

506.3.17.1 Pins and Rollers

(1) Turn pins and rollers to the dimensions the plans show and make them straight, smooth, and free from flaws.

(2) Forge and anneal pins and rollers more than 9 inches in diameter. For pins and rollers 9 inches or less in diameter use either forged and annealed or cold-finished, carbon-steel shafting.

(3) In pins larger than 9 inches in diameter, bore a hole, not less than 2 inches in diameter and full length along the axis after the forging cools below the critical range under conditions suitable to prevent injury by too rapid cooling and before annealing.

(4) Use standard recessed pin nuts for nuts in connection with pins.

506.3.17.2 Pinholes

(1) Bore pinholes true to the specified diameter, smooth, straight, at right angles with the axis of the member, and parallel with each other unless required otherwise. Produce the final surface by using a finishing cut.

(2) The pinhole diameter for pins without bushings shall not exceed the pin diameter by more than 1/50 inch for pins 5 inches or less in diameter, or 1/32 inch for larger pins. For pins with bushings, follow the manufacturer's recommendations for tolerances of pins and bushings.

506.3.17.3 Threads for Bolts and Pins

(1) Threads for bolts and pins for structural steel construction shall conform to the Unified Standard Series UNC-ANSI B1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends with a diameter of 1 3/8 inch or more shall have 6 threads per one inch.

506.3.18 Finished Members

(1) Make finished members true to line and ensure they are free from twists, bends, and open joints.

506.3.19 Welding

506.3.19.1 Include exceptions for field welding on primary members.

506.3.19.1 General

(1) Weld steel structures as the plans show and conforming to the AWS D 1.5, Bridge Welding Code. Furnish welders or welding operators certified to the requirements of AWS D 1.5. If the engineer questions a welder or welding operator's ability, requalification tests are required under AWS D 1.5. Have a department-approved independent testing agency perform requalification testing.

(2) Submit an annual field welding plan conforming to CMM 520.6.5.4 on department form DT2337. Do not begin field welding without a department-approved welding plan that includes the specific welding procedures required to perform the work under the contract.

(3) Notify the engineer before field welding on primary members and do not begin welding without department approval, except notification and approval is not required for the following:

- Welding shear studs when with a stud gun.
- Field welding bearing sole plates to steel girder flanges.
- Welding threaded rods to the top flange of girders to install new expansion joints.

(4) Visually inspect and certify the quality of field welds as follows:

1. Designate an inspector listed in the contractor's current approved field welding plan. For primary members, if welding requires department notification and approval, ensure the inspector is an AWS certified welding inspector.
2. Have the designated inspector complete department form DT2320 for each day of field welding and submit to the engineer for inclusion in the permanent project record.

506.3.19.2 Include AWS D 1.1 welders and procedure submittal through the fabrication library.

506.3.19.2 Procedures

(1) Do not fabricate structural steel until the department approves welding procedures required under AWS D 1.1 and AWS D 1.5. Submit procedures for approval to the department's fabrication library at:

https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/strct/fab-sharepoint.aspx

(2) Use automated submerged arc welding for primary shop welds in the flat position unless the engineer approves another welding process. Place joint designations indicating "automatic welding" by each primary weld on the shop drawings. Primary shop welds are defined as flange and butt welded splices in I-beams, box members, and plate girders; plate girder or box flange to web groove and fillet welds; and cover plate to flange fillet welds.

(3) Do not use electroslag or electrogas welding.

(4) Grind flange butt welds flush. Grind web butt welds to 1/6 of the web depth beginning at the point of maximum tension,1/6 of the web depth beginning at the point of maximum compression, and grind the entire outside surface of exterior girders. Ground surfaces that require grinding before performing radiographic or ultrasonic inspection. Grind plates with a surface or surfaces in the same plane flush. Grind plates with surfaces not in the same plane smooth.

(5) Ensure that weld metal for fillet and groove welds for exposed, bare, unpainted applications of ASTM A709 grade 50W steel possess similar atmospheric corrosion resistance and the same coloring characteristics as that of the base metal.

506.3.19.3 Procedure Qualifications

(1) Ensure that procedure qualifications conform to Section 5 of AWS D 1.5.

(2) Complete qualification tests of the welding procedures and obtain the engineer's acceptance of them before beginning steel fabrication or field welding. Submit revisions in the welding procedure specifications to the engineer for approval and qualify them in the presence of the department's inspector to qualify for acceptance.

(3) Before welding under a procedure, confer with the department's inspector to ensure agreement regarding the procedure details, the welding sequence, the handling of materials to be inspected, the status of welders and welding inspectors qualifications, and the approval of electrodes, wire, flux, and other welding materials and equipment.

(4) Assign each welder or welding operator an identification mark for them to paint on the pieces welded. The welder or welding operator shall use these identification marks for the duration of the contract.

506.3.19.4 Shop Welding Inspection

(1) Inspect shop welding according to AWS D 1.5. Unless specified otherwise, test butt welds in main members by either the radiographic or the ultrasonic method.

(2) Test fillet welds and groove welds not covered otherwise in main members in a non-destructive manner by the magnetic particle method according to ASTM E709, utilizing the yoke method. This includes, but is not limited to, a minimum of 12 inches in every 10 feet or portion thereof of each weld connecting web to flange, bearing stiffener to web or flange, framing connection bar to web or flange, and longitudinal stiffener to web or vertical bar.

506.3.20 Stud Shear Connectors

(1) Use studs for shear connectors if the plans show. Weld conforming to chapter 7 of AWS D 1.5 except as follows:

1. Fillet welds varying in size from 3/16 to 5/16 inch are satisfactory provided the studs pass all other required tests. Make adequate provision in structural member fabrication to compensate for camber loss due to shear connector welding.
2. Ensure the studs are free from rust, scale, rust pits, and oil at the time of welding and immediately before placing the concrete.
3. Longitudinal and lateral spacing of studs with respect to each other and to edges of beam or girder flanges shall not vary more than 1/2 inch from the dimensions the plans show, except that the engineer will allow a variation of one inch if required to avoid obstruction of other attachments on the beam, or if welding a new stud to replace a defective one. Ensure a minimum distance from the edge of a stud shank to the edge of a beam or plate of one inch exists, but preferably 1 1/2 inch or more.
4. Notify the engineer promptly of any changes in the welding procedure at any time during construction.
5. If welding the studs reduces their height to less than normal, immediately stop welding and do not resume until correcting the cause.
6. After welding the studs to the beams, perform a visual inspection and give each stud a light blow with a hammer. Bend test studs without a complete 360-degree end weld, studs that do not ring when given a light blow with a hammer, studs repaired by welding, or studs reduced to less than normal in height due to welding. The bend test consists of bending the stud 15 degrees from its correct installation axis by striking with a hammer. In cases of a defective or a repaired weld, bend the stud in the direction that places the weld's defective portion in the greatest tension. Replace studs that crack either in the weld or in the shank.
7. The engineer may select additional studs to subject to the bend test specified in item 6 above.

506.3.21 Require submittal of material certified reports of test and analysis to the fabrication library.

506.3.21 Mill Inspection and Tests

(1) Ensure that the structural steel fabricator submits a certified report of test or analysis showing both physical and chemical tests of the material for each heat to the fabrication library. Also provide a copy to the inspector for examination before requesting the fabrication shop inspection, or when requesting the material prepayment inspection. The engineer will not approve prepayment for material without mill test reports.

506.3.22 Shop Inspection

(1) The engineer or an independent inspection agency under department contract may inspect all structural steel and miscellaneous metals furnished. The department will provide the contractor with monthly consultant inspection invoices and identify any quality deficiencies at the fabrication facility.

(2) Give the engineer advanced notice before beginning shop work.

(3) Before requesting inspection, the fabricator shall submit a list of main stress-carrying members and associated material heat numbers. Preserve the heat number, as marked by the rolling mill, for inspector identification. If fabrication obscures the original heat number, the fabricator shall paint the number on the material in a conspicuous location.

(4) Provide facilities in the fabrication shop for inspection and allow inspectors necessary access to the work. Include office space at the fabrication shop for inspector use during fabrication, assembly, cleaning, and painting. Provide lighting, heating, and ventilation and ensure cleanliness. Ensure that office space is partitioned off from the fabricator's activities, has a separate locking door; or is part of a larger facility set aside for the exclusive use of outside inspection personnel. Provide telephone service, internet access, and adequate sanitary facilities in the immediate area. The engineer may require additional facilities to accommodate the number of inspectors necessary to inspect the volume of work. At engineer-determined major fabrication shops, provide at least 100 square feet of floor space with at least 2 desks, or a desk and table, and a file cabinet.

(5) The inspector may reject any material or work that does not conform to the specification requirements.

(6) The inspector's acceptance of any material or finished members will not preclude their subsequent rejection if found defective.

(7) Inspection at the shop is intended as a means of facilitating the work and avoiding error. It shall not relieve the contractor of responsibility for imperfect material, or technique, or for replacing the same.

506.3.23 Marking and Shipping

(1) Paint or mark each member with erection marks for identification and furnish a diagram showing the erection marks. Mark members weighing more than 3 tons with their weight. Load, transport, and unload without excessively stressing, deforming, or otherwise damaging. Ship girders and rolled beams in a standing position, maintain this position in subsequent operations. Fabricators may ship haunched sections of built-up girders in an inverted position.

(2) Ship high-strength bolts, nuts, and washers from each rotational-capacity lot in the same container. If there is only one production lot number for each size of nut and washer, the supplier may ship the nuts and washers. Pack separately non-high-strength bolts of one length and diameter, and the loose nuts and washers supplied for each size of bolt, except ship galvanized bolts, nuts, and washers of the same size in the same containers. Ship bolts, nuts, washers, pins, and small parts in boxes, crates, kegs, or barrels, but the gross weight of any container shall not exceed 300 pounds. Clearly and permanently, mark a list on the outside of each shipping container that describes the contained material. Clearly and permanently, mark on the outside of each shipping container of bolts, nuts, and washers the rotational-capacity lot number, in addition to a list and description of the contained material.

506.3.24 Handling and Storing

(1) Place material to be stored on skids above the ground. Keep it clean and properly drained. Place girders and beams upright, shore, and tie or brace to preclude tipping or overturning if exposed to high winds. Support long members, such as columns and chords, on skids placed near enough together to prevent injury from deflection. Loss of any material, or any damage caused after receiving it is the contractor’s responsibility.

(2) Store bolts, nuts, and washers in closed containers in a protected shelter to protect them from dirt and moisture until used. Maintain fastener system components as nearly as possible in the as-manufactured condition until installed. Remove from storage only as needed and promptly return unused components to storage.

506.3.25 Field Inspection

(1) The department may inspect fabrication work at the construction site. Provide on-site facilities and access for department inspectors to inspect materials and work not previously inspected at the shop.

506.3.26 Falsework

(1) The contractor may furnish used materials for falsework. Ensure proper design, construction, and maintenance of falsework in order to handle the loads placed upon it. Falsework shall provide the required construction camber.

(2) Submit detailed plans for falsework to the engineer if requested. The engineer's approval of these plans, or acceptance in work constructed according to them shall not relieve the contractor of responsibility for successful erection or satisfactory results.

(3) If building falsework over a stream or lake subject to boating use, construct it to provide horizontal and vertical clearance adequate for passage of rowboats and small powerboats. If building falsework over a highway or street used by traffic provide a minimum clearance, unless the plans or special provisions require otherwise, of 22 feet horizontal and 13 1/2 feet vertical.

(4) After completing the work, remove falsework piles down to at least 2 feet below streambed or finished ground line. Remove entirely any temporary bents, mudsills, and footings.

(5) Do not attach overhang bracket form supports to the girder web.

506.3.27 Erection

(1) Do not apply any part of the steel superstructure load to any concrete substructure unit until the concrete in that unit cures for at least 48 hours. Do not apply loads to beams of open-type structure units until the end of the required period for falsework support of these beams.

(2) Unless specified otherwise the minimum number of pickup points are as follows:

GIRDER LENGTH	MINIMUM NUMBER OF PICKUPS
0-50 feet	1
50 feet and over	2 or more

(3) Use an appropriate balance beam or spreader bar for 2 or more pickup points with a single crane. Locate pickup points to avoid damage to the girder and to balance the load at each point.

(4) The contractor shall not place any bent or twisted member until correcting its defects. The engineer will reject any members seriously damaged in handling or transporting.

506.3.28 Straightening Bent Material

(1) Notify the engineer before straightening structural steel plates, angles, or other shapes. Describe the process that will be used. Do not proceed with the repair unless the engineer allows that process.

(2) Do not heat beyond a dull red condition, 1100 F for A709 HPS 70W and 100W steel or 1200 F for other A709 steels. Monitor temperature using temperature-indicating crayons, liquids, or a bimetal thermometer. Ensure that parts to be heated are substantially free of stress and external forces, except for stresses resulting from mechanical means used in the application of heat. After heating, cool the metal as slowly as possible away from drafts. Do not use water for cooling.

(3) After straightening a bend or buckle, inspect the repair and notify the engineer if fracture is identified.

506.3.29 Field Assembling and Bolting

(1) Conform to the foregoing requirements for shop assembling. Make field connections, unless specified otherwise, with high-strength bolts as specified in 506.3.12.

(2) Unless the engineer allows, do not use a burning torch to make adjustments or cuts as an aid to field assembling.

(3) Before beginning the field bolting on a continuous span, adjust the span and the immediately adjacent continuous spans to the correct grade, construction camber, and alignment.

(4) Complete field bolting, except for compression joints in trusses, connections for laterals and railings, and connections for those nominal members the plans or contract specifically designates, before releasing and swinging free any part of the span from its supporting falsework.

(5) Swing the span free from falsework before making connections for laterals.

(6) After placing and curing the concrete floor, and sidewalks if any, on all spans of the structure, make the connections for those nominal members as the plans show or the contract specifically designates. Erect, align, and fasten the railings in place.

(7) For splices and field connections using high-strength bolts, fill at least 25 percent of the holes with cylindrical erection pins before placing the permanent high-strength bolts. Fill at least 25 percent of the holes with erection bolts for temporary connections. Place all bolts before proceeding with final tightening as specified in 506.3.12.

(8) Ensure that erection bolts are the same nominal diameter as the high-strength bolts and that cylindrical erection pins are 1/32 inch larger.

(9) The contractor may assemble girders or portions of girders or other units on cribbing to the required blocking before erection or placement in the structure, if the engineer approves. Any necessary adjustments in the joints or splices of the assembled units after erection or placement are the contractor's responsibility.

506.3.30 Bearings and Anchorage

(1) Do not place masonry bearing plates on bridge seat bearing areas improperly finished, deformed, or irregular.

(2) Set the bearing plates level in exact position and have full and even bearing on the masonry. Unless required otherwise, place them on bearing pads conforming to 506.2.6.

(3) After properly aligning and finally connecting the steel in the superstructure, drill the holes in the concrete and set the anchor bolts except if the bolts are built into the masonry.

(4) Set anchor bolts in an engineer-approved, premixed, non-shrink commercial grout, except during freezing weather, or in an epoxy conforming to 416.2.3.2. Place grout according to manufacturer instructions and fill holes before ramming bolts in place. Overfill holes with just enough grout or epoxy to produce a watertight fit when the bearing plate is installed. Remove excess grout or epoxy from the bolt and bearing area.

506.3.31 Cleaning of Surfaces

506.3.31.1 General

(1) Blast clean the surfaces of structural steel to remove rust, mill scale, dirt, oil, or grease and other foreign substances until obtaining the specified finish.

(2) Blast clean all non-machined surfaces of a casting before machining the casting.

506.3.31.2 Coated Surfaces

(1) As specified in 506.3.32, blast clean structural steel and ferrous metal products to be coated as specified for blast cleaning in 517.3.1.3.3 to a near-white finish according to SSPC-SP 10. Blast clean steel that will be encased in concrete to SSPC-SP 6 standards or cleaner.

506.3.31.3 Unpainted Weathering Steel

(1) Blast clean all surfaces of weathering steel, unless designated for coating, until obtaining a finish as described for commercial blast cleaning in SSPC-SP 6. Perform blast cleaning with sand, grit, or steel shot as described for SSPC-SP 6.

(2) Keep or place the following markings on material shipped to the field:

- Weights of members weighing 3 tons or more.
- Piece marks.
- Matchmarks if required.

(3) Place weight markings on interior surfaces of exterior girders and on interior girders in locations inconspicuous after erection and their removal are not required except if the engineer directs.

(4) After erection, clean steel in the completed structure by hand, until free of oil, dirt, grease, mortar and other foreign substances.

506.3.32 Painting Metal

(1) Unless the contract provides otherwise, apply 3 coats of paint to structural steel and ferrous metal products. Furnish and apply paints according to the epoxy system or as specified in the special provisions. The requirements for this system are set forth in 517.

(2) For structural steel, including weathering steel, and miscellaneous metals that will be encased in concrete, paint as specified in 517.3.1.

(3) Use the 3-coat epoxy system to paint the end 6 feet of structural weathering steel at the abutments, the 6 feet on each side of piers, joints, downspouts, hinges, and galvanized bearings in contact with weathering steel. Use a coat of brown urethane matching AMS Standard 595A: AMS-STD 20059. Apply one coat of zinc-rich paint to surfaces of expansion joint assemblies and other surfaces not in contact with the weathering steel but inaccessible after assembly or erection.

(4) Do not paint structural steel to be welded before completing welding. If welding only in the fabricating shop and subsequently erecting by bolting, coat it after completing shop welding. Apply one coat of weldable primer or other engineer-approved protective coating to steel surfaces to be field welded after completing shop welding and shop fabrication. Protect machine-finished surfaces that do not receive a paint or galvanizing from contamination during the cleaning and painting process.

(5) Upon fabrication and acceptance, coat pins and pinholes with a plastic or other engineer-approved coating before removing from the shop.

(6) Mark members weighing 3 tons or more with their weights on areas that will be encased in concrete, or paint with a compatible paint on zinc-rich primer, or mark with soapstone on an epoxy-coated surface. Wait until material is dry, inspected, and approved for shipment before loading for shipment.

506.3.33 Name Plates

(1) Install nameplates conforming to 506.2.4 at the locations the plans show. Embed in concrete as specified in 502.3.11; do not bolt to steel components. Except for survey benchmarks, do not attach other permanent plates or markers to a structure.

506.3.34 Steel Diaphragms

(1) Install steel diaphragms as the plans show.

506.4 Measurement

(1) The department will measure Structural Steel Carbon, Structural Steel HS, the Castings bid items, Forgings Steel Carbon, Lubricated Plates Bronze, and the Sheet bid items by the pound acceptably completed based on plan quantities the department-approved bridge plans show.

(2) The department will use the following unit weights to compute the weight of metals:

MATERIAL	UNIT WEIGHT
Steel: structural carbon, high-strength structural, castings, or forgings	490 lb/ft^3
Bronze plate and castings	536 lb/ft^3
Sheet copper 0.02 inches thick	0.93 lb/ft^2
Sheet zinc No. 12 zinc gauge, 0.028-inch	1.05 lb/ft^2
Sheet zinc No. 18 zinc gauge, 0.055-inch	2.06 lb/ft^2

Sheet zinc No. 20 zinc gauge, 0.070-inch ..... 2.62 lb/ft^2

(3) Compute the weights of rolled shapes based on their nominal weights and dimensions. Compute the weights of plates, including those of zinc and copper based on their nominal weights and dimensions and make full deduction for cuts except interior cuts, beveled cuts on edges for butt welding, and cuts made by machining to provide other than plane surfaces.

(4) The department will not include the weight of paint, galvanization, or weld metal in the computed weight.

(5) The department will include the weight of heads, nuts, single washers, and threaded stick-through of high-strength bolts and heads, based on the following weights:

BOLT DIAMETER	WEIGHT PER 100 BOLTS
1/2-inch	19.7 pounds
5/8-inch	31.7 pounds
3/4-inch	52.4 pounds
7/8-inch	80.4 pounds
1-inch	116.7 pounds
1 1/8-inch	165.1 pounds
1 1/4-inch	212.0 pounds

(6) Compute the weight of castings from their dimensions and add 3 percent for fillets and overruns, however, if the scale weight of any casting is less than the computed weight, the department will pay for the weight of that casting at the scale weight. If the scale weight of any casting is less than 97 percent of the computed weight, the department may reject the casting.

(7) If the computed weights of metals, from engineer-approved shop drawings, varies more than one percent from those the engineer-approved bridge plans show for an individual structure, the department will base quantities for that structure on those computed from the engineer-approved shop drawings. The exception is if the contractor elects, with the engineer's permission, to use equivalent sections of greater weight than those the engineer-approved bridge plans show, then the contractor shall bear all additional costs.

(8) The department will measure Bearing Pads Elastomeric Non-laminated and Bearing Pads Elastomeric Laminated as each individual pad acceptably completed.

(9) The department will measure the Welded Stud Shear Connectors bid items as each individual stud acceptably completed.

(10) The department will measure the Steel Diaphragms bid items as each individual diaphragm acceptably completed.

(11) The department will measure the Bearing Assemblies bid items as each individual bearing acceptably completed.

506.5 Payment

(1) The department will pay for measured quantities at the contract unit price under the following bid items:

ITEM NUMBER	DESCRIPTION	UNIT
506.0105	Structural Steel Carbon	LB
506.0605	Structural Steel HS	LB
506.1000 - 1099	Castings (type)	LB
506.1105	Forgings Steel Carbon	LB
506.1405	Lubricated Plates Bronze	LB
506.1500 - 1599	Sheet (type)	LB
506.2105	Bearing Pads	SF
506.2605	Bearing Pads Elastomeric Non-Laminated	EACH
506.2610	Bearing Pads Elastomeric Laminated	EACH
506.3000 - 3099	Welded Stud Shear Connectors (diameter x length)	EACH
506.4000	Steel Diaphragms (structure)	EACH
506.5000	Bearing Assemblies Fixed (structure)	EACH
506.6000	Bearing Assemblies Expansion (structure)	EACH

(2) Payment for Structural Steel Carbon, Structural Steel HS, the Castings bid items, Forgings Steel Carbon, Lubricated Plates Bronze, and the Sheet bid items is full compensation for providing,

fabricating, casting, machining or otherwise preparing, transporting, and erecting materials; for providing name plates; and for furnishing radiographic films to the inspector.

(3) Payment for Bearing Pads Elastomeric Non-Laminated and Bearing Pads Elastomeric Laminated is full compensation for providing the pads, and for testing.

(4) Payment for the Welded Stud Shear Connectors bid items is full compensation for providing the shear connectors.

(5) Payment for the Bearing Assemblies bid items is full compensation for providing bearing assemblies, including the anchor bolts, and for fabricating and installing the assemblies.

(6) Payment for the Steel Diaphragms bid items is full compensation for providing, fabricating, galvanizing, transporting, and erecting.

(7) Perform work the plans or contract specify but is not included in other contract bid items, except as follows:

- If the contract does not contain the Welded Stud Shear Connectors, Bearing Assemblies Fixed, or Bearing Assemblies Expansion bid item, the department will pay for this work as Structural Steel Carbon.
- The department will pay for painting structural steel and miscellaneous metals as specified in 517.5.

(8) The department will limit costs for inspections conducted under 506.3.22 to $0.05 per pound of material and deduct excess costs payment due the contractor. The department will determine costs for in-house inspections based on hourly rates for department staff plus overhead and use invoiced costs for contracted-out inspections. The department will administer deductions for the contractor's share of the total inspection cost under the Excess Costs For Fabrication Shop Inspection administrative item.