

Section 707. STRUCTURAL STEEL CONSTRUCTION

707.01. Description. This work consists of fabricating, shop cleaning and coating, providing, delivering, and erecting structural steel and other materials.

A. Steel Fabrication Requirements. American Institute of Steel Construction (AISC) certification is required for the steel fabrication work listed below.

1. Category Simple Steel Bridges (Sbr) for un-spliced rolled beams or other bridge related components including but not limited to pin and hanger assemblies, excluding machining operations; diaphragms, cross-frames, and connection angles and plates.
2. Category Major Steel Bridges (Cbr) for welded plate girders.
3. Fracture Critical Members Endorsement in addition to Category Major Steel Bridges for fracture critical members.
4. Sophisticated Paint Endorsement for painted steel surface areas greater than 500 square feet. The Engineer will accept Society of Protective Coatings, SSPC QP3 Shop Painting Certification Program as an acceptable alternate.
5. Category Bridge and Highway Metal Components when fabricating bridge tube railing, bearing assemblies (including pot and disc bearings), modular bridge expansion joints, sidewalk and deck grating (welded only), and miscellaneous steel components permanently attached to the structure as determined by the Engineer

B. Welding Requirements. Weld in accordance with AWS D1.5, Bridge Welding Code, as modified by this section. The Engineer will consider rolled beams, cover plates, flange and web plates, link bars, end diaphragms, and end diaphragm connection plates and stiffeners as primary members. For horizontally curved girders the Engineer will consider intermediate cross frames and connection plates and stiffeners as primary members.

C. Shop Cleaning and Coating. Shop clean and coat in accordance with section 716.

707.02. Materials. Provide material in accordance with the following:

Structural Steel	<u>906</u>
High Strength Steel Bolts, Nuts and Washers.....	<u>906</u>
Pins.....	<u>906</u>
Shear Developers.....	<u>906</u>
Miscellaneous Metals	<u>908</u>
Elastomeric Bearings.....	<u>914</u>

Non-Metallic Washers914

Provide bushings with a nominal wall thickness of ¼ inch, selected from the Qualified Products List.

Provide steel castings unless cast iron or other material is required or approved by the Engineer in writing.

Provide the Engineer with one copy of Mill Test Reports, from the manufacturer's records, of chemical composition and physical properties of structural steel members. Provide an affidavit stating that the material meets specifications. If Mill Test Reports are unavailable, arrange for tests of chemical and physical properties and provide two certified copies of the test reports and affidavits to the Engineer, at no additional cost to the Department.

For materials not requiring Mill Test Reports, provide two copies of an affidavit stating that the material meets the specifications, to the Engineer.

Identify each test report and affidavit with the relevant Department structure number and the specific structure members to which the test reports or affidavits apply.

707.03. Construction.

A. Shop Inspection. The Department will provide shop inspection for structural steel, castings, and similar materials. The fabricator must establish and maintain effective quality control procedures. The Department inspection is not a substitute for fabricator quality control procedures.

1. **Notice of Beginning of Work.** Give two weeks notice to the Engineer before beginning work in the shop.

If the fabricator suspends work for a period in which the Inspector leaves the shop, provide two weeks notice, or a period, agreed upon in advance with the Engineer and fabricator, before restarting work.

2. **Facilities for Inspection.** Provide facilities for inspection of material and workmanship, at no additional cost to the Department. Include a desk, locker, plan rack, secure storage space for testing equipment, high-speed broadband internet service, and a telephone. Allow the Inspector access to parts of the shop relating to the work.

Provide an office close to the work with at least 120 square feet of floor space, lighted, heated or air conditioned, ventilated, and shared by no more than one other Inspector. The Engineer may approve sharing larger offices with additional Inspectors. Provide equipment

in the office in working order. Provide a parking space for the Inspector next to the office.

3. **Shop Inspector's Authority.** The Inspector has the authority to reject material or construction that does not meet the contract requirements. The Inspector may suspend the use of equipment or an operation that does not produce desired results, until the fabricator takes corrective action. If problems arise that the Inspector cannot resolve, conduct a three-way conversation between the Engineer, the Inspector, and the fabricator.

The Inspector will report final decisions back to the fabricator.

4. **Rejections.** The Engineer may reject finished members at the project site that the Inspector approved at the shop for material and workmanship. Correct or replace damaged or defective material or workmanship at no additional cost to the Department.

B. Prefabrication Meeting. Do not begin fabrication work until the Engineer and the fabricator conduct a prefabrication meeting at the fabricating plant. Verify the date of the prefabrication meeting. The prefabrication meeting must include the Engineer, other Department representatives, and the fabricator's representatives directly responsible for supervision and control of the work. Finalize procedures relating to shop fabrication of the material included in the contract and the proposed schedule of fabrication and delivery at the prefabrication meeting.

C. Furnishing and Fabricating.

1. **Shop Plans.** Prepare working drawings of fabrication details in accordance with subsection 104.02. Do not use design drawings in lieu of shop plans. Submit one set of drawings and one electronic file copy to the Engineer for review and approval. After the Engineer approves the working drawings, provide the Engineer one complete sets of prints, one electronic file copy, and three sets of shop bills. After fabrication is complete, provide the Engineer one complete set of working drawings in ink on white, 3-mil polyester/Mylar drafting film, 24 inches by 36 inches and an electronic file copy. Include changes from the time the Engineer approved the original drawings.

2. Welded Plate Girders and Rolled Beam Fabrication.

- a. **General.** Show, on the working drawings, the procedure for each type and size of welded joint or bolted connection.

Weld the plates that comprise the flange and web of the girders into a single plate before welding flanges and webs together to form individual girders or box girders.

Use the automatic Submerged Arc Welding (SAW) process to make flange and web butt welds, to connect the flanges to the webs, to attach cover plates to beam flanges, and to attach stiffener and connection plates to webs, including flange-to-web welds in box girders, arches, towers, and truss web and chord members.

Use flat (1F) or horizontal (2F) positions for flange-to-web and cover plate-to-flange fillet welding. Limit the use of the Shielded Metal Arc Welding (SMAW) process to welding stiffeners or connection plates to rolled beams, stiffener-to-flange welding on plate girders, and welding bearing assemblies. Use SMAW for other welding applications if the limited access, isolated locations, or short weld lengths render the use of automatic or semi-automatic welding equipment impractical. Use E7018 electrodes for the SMAW process.

Do not use electroslog or electrogas welding processes.

Remove weld metal splatter on adjacent base metal, as approved by the Engineer, before blast cleaning and coating.

Determine fillet weld size by the thicker of the two parts joined, unless the calculated stress requires a larger size. The Engineer does not require exceeding the thickness of the thinner part joined with fillet welds. If the weld size is smaller than the minimum required due to plate thickness, preheat to ensure weld soundness. Provide a minimum $\frac{5}{16}$ inch fillet weld for a flange weld. Provide the minimum fillet weld sizes specified in Table 707-1 and Table 707-2.

Table 707-1 Minimum Fillet Weld Size	
Base Metal Thickness of Thicker Part Joined (in)	Minimum Size of Fillet Weld (in)
$\leq \frac{3}{4}$	$\frac{1}{4}$
$> \frac{3}{4} - 1\frac{1}{2}$	$\frac{5}{16}$
$> 1\frac{1}{2} - 2\frac{1}{4}$	$\frac{3}{8}$
$> 2\frac{1}{4} - 6$	$\frac{1}{2}$
> 6	$\frac{5}{8}$

Table 707-2 Minimum Effective Weld Size for Partial Joint Penetration Groove Welds	
Based Metal Thickness of Thicker Part Joined (in)	Minimum Effective Weld Size (a) (in)
$\leq \frac{3}{4}$	$\frac{1}{4}$
$> \frac{3}{4} - 1\frac{1}{2}$	$\frac{5}{16}$
$> 1\frac{1}{2} - 2\frac{1}{4}$	$\frac{3}{8}$
$> 2\frac{1}{4} - 6$	$\frac{1}{2}$
> 6	$\frac{5}{8}$
a. Except the effective throat need not exceed the thickness of the thinner part.	

- b. **Lifting Methods.** If using lifting lugs, weld them to the upper flange in areas subjected to compression. Submit the proposed details and design calculations to the Engineer for approval before fabricating. Conduct nondestructive testing on the welds connecting lifting lugs to the girder, as directed by the Engineer. Note on shop drawings if lugs will lift one piece, or will lift assemblies of two pieces or more.

Immediately after erecting the steel girder, remove lifting lugs by cutting and grind the area smooth.

Provide lifting devices with softeners to prevent damage. If using hooks for lifting, provide jaw and throat widths large enough to prevent damage. Provide spreader beams or multiple cranes for lifting plates and long slender members to prevent overstress and distortion.

3. **Straightening.** Straighten material in accordance with the tolerances in AWS D1.5, Bridge Welding Code, Section 3.5, before laying or working the material. Obtain the Engineer's approval for straightening methods. The Engineer may reject material with kinks or bends.

Straighten flanges joined by butt welds before fitting to the webs. Remove distortion, due to welding or handling, by applying heat over the full width of the flange. Do not heat to greater than 1,200 °F. Cool slowly. Complete straightening before testing in accordance with subsection 707.03.C.9.

4. **Cambering.** Accomplish cambering, camber adjustment, and horizontal curvature by heat in accordance with Section 11.4.12, Curved Girders, of AASHTO LRFD Bridge Construction Specifications. Provide dimensional tolerances in accordance with AWS D1.5, Bridge Welding Code, Section 3.5.

During the heating process, verify the temperature using temperature monitoring devices.

Measure the camber of each member in the shop and with the Inspector present, as a condition for approval for shipment.

5. **Cutting and Planing.** Plane $\frac{1}{4}$ inch of metal from sheared edges of steel greater than $\frac{5}{8}$ inch thick and alloy steel greater than $\frac{1}{2}$ inch thick. Fillet a $\frac{3}{4}$ -inch radius on re-entrant angles.

If flame cutting flange and web plates, cut edges simultaneously.

At the time of cutting, transfer heat numbers to the pieces of primary member material cut from large plates. Mark with white paint that lasts through fabrication.

6. **Splices and Connections.**

- a. **Shop Splices.** The fabricator may splice girder web plates, unless prohibited by the contract.

Only splice flange plates in girders greater than 50 feet long.

If the Engineer approves, provide one splice per cover plate.

Obtain the Engineer's approval for the location of optional web and flange splices.

Separate girder flange plate and web plate butt welds, as well as stiffener and connection plate attachment welds, by at least one foot

- b. **Holes for High Strength Bolts.** Punching holes is limited to AASHTO M 270 Grade 36 steel no greater than $\frac{3}{4}$ -inch thick or high-strength steel no greater than $\frac{5}{8}$ inch thick. Provide a die with a diameter that does not exceed the diameter of the punch by more than $\frac{1}{16}$ inch for punching full-size. Provide a die that does not exceed the diameter of the punch by more than $\frac{3}{32}$ inch for sub-punching.

Sub-drill or sub-punch holes for primary member splices two sizes undersize and ream full size.

Drilling holes full size is permitted while working on the splice if all material is assembled as it will be used in the final joint assembly. When drilling assembled splices, pre-drilling one plate full-size for use as a template is acceptable.

Drilling holes full size with computer numerically controlled (CNC) equipment is permitted.

Match-mark all joints, which have been reamed or drilled, with the parts assembled. Partially assemble joints with plates attached so erecting crews do not misplace, interchange, or reverse joint parts. Match-mark in one location using low stress stamping. Show match-marking schemes on the shop drawings and obtain the Engineer's approval for mark locations.

For primary members, load carrying diaphragms, and load carrying cross-frame connections, drill finished holes $\frac{1}{16}$ inch larger than the nominal bolt diameters required. Ensure finished holes are clean cut, without torn, ragged, burred, or crimped edges. Make finished holes in other diaphragms and cross-frames no more than $\frac{3}{16}$ inch larger than the nominal bolt diameter. Do not use welding to fill or repair misplaced drilled or punched holes.

7. **Assembly.** Assemble field connections of primary members in the shop and ream sub-size holes to the size required. Assemble using full truss or girder assembly methods, unless otherwise required.

- a. **Full Truss or Girder Assembly.** Assemble members of each truss, arch rib, bent, tower face, continuous beam line, plate girder or rigid frame at one time.
- b. **Progressive Truss or Girder Assembly.** Assemble for each truss, arch ribs, bents, tower faces, continuous beam lines, plate girders, or rigid frame, at least three consecutive shop sections or members in at least three consecutive panels. For structures longer than 150 feet, assemble at least the number of panels associated with three consecutive chord lengths, but no less than 150 feet of panels.

Before removing a member from the rearward end, maintain the assembled length by adding at least one shop section or panel, or as many panels as associated with a chord length at the advancing end of the assembly.

- c. **Full Chord Assembly.** Assemble, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower. Ream field connection holes while the members are assembled. Ream the web member connections to steel templates set at geometric angular relation to the chord lines.

Ream field connection holes in web members to steel templates. Mill or scribe at least one end of each web member normal to the

longitudinal axis of the member. Position templates at both ends of the member from one milled end or scribed line.

- d. **Progressive Chord Assembly.** Assemble consecutive chord members as required for full chord assemblies and in the number and length required for progressive truss or girder assemblies.
- e. **Special Complete Structure Assembly.** Assemble the entire structure, including the floor system.

Before reaming, obtain the Engineer's approval of each assembly, including camber, alignment, accuracy of holes, and fit of milled joints. Maintain a gap no greater than $\frac{3}{8}$ inch between girder ends at bolted field splices.

Provide a camber diagram to the Engineer, showing the camber at each panel point of each truss, arch rib, continuous beam line, plate girder, or rigid frame. Show the camber measured in assembly on the camber diagram if shop assembly is full truss, girder, or special complete structure assembly. For other shop assembly methods, show calculated camber on the camber diagram.

Use bolts for assembly of the same diameter as bolts required for erection. Use pins for assembly of the same diameter as the hole and in sufficient number to ensure accuracy.

Ensure drifting done while assembling field connections does not enlarge holes or distort metal. Ream under size holes to admit bolts. Do not move assemblies while drilling a joint, nor disassemble until drilling or reaming is complete and the Inspector approves the holes and markings.

Ensure the Engineer approves tack welding temporary fitting aids during fabrication. Do not tack weld fitting aids to the flange.

- 8. **High Strength Steel Bolts.** If high strength steel bolts are required for connections, provide heavy hexagon structural bolts. Provide heavy, semi-finished, hexagonal nuts with one circular washer for each bolt. Lubricate galvanized nuts with a lubricant with a visible dye. Supply two washers for oversize holes, one under each element. Supply 5 percent more high strength steel bolts of each size and length than required.

9. **Welding.** Ensure shop welders, welding operators, welding equipment, and welding procedures are qualified in accordance with AWS D1.5, Bridge Welding Code, as modified by the contract.

Make test welds under the supervision of a Department representative. The Engineer will not accept weld tests by other agencies.

Shop welder and welding operator qualifications remain in effect for three years unless welders or welding operators are not engaged in a welding process for at least three months, or a specific reason exists to question the welder's ability. The Engineer may require a confirming qualification test during the progress of the work. The Department considers welders and welding operators, qualified on Grade 50 high-strength steel, qualified to weld Grade 36 steel if the shop qualifies the procedure as required.

10. **Nondestructive Testing of Welds.** Nondestructive testing of welds is required. The fabricator must provide labor, equipment, and materials for making inspections. The Engineer will determine the adequacy of the equipment, materials, and procedures and witness testing.

Make required identification marks on butt welds with paint. Do not stencil or punch the marks.

Ensure technicians approved by the Department perform ultra-sonic testing.

- a. **Scope of Examination of Groove Welds.** Use radiographic test methods in accordance with AWS D1.5, Bridge Welding Code. Use ultrasonic test methods for examining full penetration corner joints and T-joints if radiographic testing is not possible. If the Engineer allows ultrasonic testing, use glycerine as the coupling agent. Test butt welds, or other full penetration welds in primary members as follows:
 - i. Flange splices, 100 percent;
 - ii. Splices subject to reversal of stress, 100 percent;
 - iii. Web splices, beginning at the point of maximum tension, 12 inches, or at least $\frac{1}{3}$ the length plus 12 inches of the web splice beginning at the compression end, including splices connecting pin plates to webs;
 - iv. Compression and shear splices in built-up members, 25 percent;
 - v. Flange to web connections of box girders, 25 percent, unless otherwise shown on the plans;

- vi. Similar welds in a member subject to partial examination if the Engineer finds a defect in the member welds, 100 percent;
- vii. Butt weld repairs requiring weld defect removal and replacement, 100 percent; and
- viii. Ultrasonically tested plug and slot welds, 100 percent.

For thickness transition joints, place radiographic film on both sides of the joint, position the pack, and use tapered edge blocks. If substandard images result from film placement on transition sides, move the film to the planar side.

Submit for the Engineer's approval, a proposed procedure for ultrasonic testing of corner joints or joints with backup bars.

Complete radiographic or ultrasonic tests on groove welds and obtain written approval before assembling and welding the flange plates and web plates to form girders.

Check full penetration butt welds on both ends for surface defects using dye penetrant inspection, in accordance with ASTM E 165. Inspection is mandatory for welds inspected by radiography or ultrasonic testing.

Use extension blocks to extend radiographic film at least 1 inch beyond the edges of the radiographed section.

If using ultrasonic testing, perform radiography on one out of four welds. The Engineer may waive this requirement if the welders demonstrate and maintain a high level of competence.

- b. **Scope of Examination of Fillet Welds.** Magnetic particle testing of fillet welds is required. Perform magnetic particle testing in accordance with ASTM E 709, using the yoke, or aluminum prod method. Use half-wave rectified alternating current (direct current) for magnetic particle testing.

Test fillet welds, including welds connecting bearings and intermediate stiffeners to girder tension flanges and sole plates welded to girders using the magnetic particle process. Do not test fillet welds connecting intermediate stiffeners to the girder web, diaphragm assemblies, sway bracing, and other secondary members.

Test stiffener end to tension flange welds over the entire length. Test other fillet welds on at least 10 percent of the length of every weld, or at least 10 inches, whichever is greater for each fillet weld size. Include all primary members such as girders;

floor beams; stringers; truss members including end connections; and bearing blocks and assemblies including their attachment to members.

Locate the tests randomly in members to produce results typical for each weld size. If test results show unacceptable defects, test the full length of the weld, or 5 feet on each side of the tested length, whichever is less.

- c. **Weld Condition.** Clean paint, scale, grease, and other deleterious material from welded edges and surfaces. Grind flange welds flush on aligned sides and merge smoothly on transition sides.

Maintain areas requiring automatic and semi-automatic welding at a temperature of at least 40 °F for at least 1 hour before beginning work. Maintain the temperature during work.

If conducting radiography testing, grind web, shear, or pin plate splices. Grind the length of the film on the film side of the web, and begin merging smoothly at ends beyond the film. Grind fascia beams on the inside of the girder.

Grind surfaces to a roughness rating of 125 micro inches per inch root mean square. Remove loose mill scale on joint sides ultrasonically tested to allow one bounce of the ultrasound with a 70-degree transducer. Remove glycerine with a solvent before welding or blast cleaning the steel.

- d. **Defective Welds.** Repair and replace welds with rejectable defects documented by Contractor personnel or Department personnel, regardless of testing method and regardless of conflicts in test results from other methods. Submit repair procedures in writing and obtain the Engineer's approval for the repair method of weld defects before beginning repairs.

Repair, or remove and replace welds in accordance with AWS Code. Retest repaired or replaced welds, including at least 3 inches on all sides of the repair, by non-destructive testing method.

Remove and replace the entire weld if second repair attempts do not succeed. If the Engineer determines defects, or repairs to defects excessive, or the same defect undergoes repair more than twice, the Engineer may reject the entire piece.

11. **Fit of Stiffeners.** Remove and correct stiffeners showing evidence of compressive stress after fitting is completed, including waviness along the stiffener length, before final welding.

12. **Pins and Link Plates.** The contract drawings show the nominal diameter of pins. The fabricator may establish the exact diameter of the pin, show it on the shop drawings within +0 inch and $-1/32$ inch of the nominal diameter and then fabricate the pin to within ± 0.005 inch.

Use stainless steel hanger pins. Finish the surface to less than 16 micro inches per inch, root mean square (rms) on the bearing surface, and less than 125 micro inches per inch rms on the ends.

Finish the surface on link plates to less than 125 micro inches per inch rms on cut edges and bored holes.

Orient the longitudinal axis of the link plates and pins in the direction of rolling or forging of plates or bars.

Do not weld on pins or link plates. Finish pin holes smooth, straight, at right angles to the axis of the member, and parallel to each other.

Do not exceed $1/32$ inch variation from the required distance from outside to outside of adjacent pin holes in tension members, or from inside to inside of adjacent pin holes in compression members. Bore built-up members after welding. Drill or bore link plates in a jig or in assembled pairs.

Drill or bore the pin hole in the web $1/32$ inch ± 0.005 inch, larger than the pin diameter.

13. **Bushings for Pins and Link Plates.** Prime the inside of the holes in the link plate with an organic zinc-rich primer before installing bushings. Install bushings before the primer dries. Install bushings with an interference fit of at least 0.001 inch. Provide a clearance from 0.005 inch to 0.015 inch between the inside diameter of the bushing and the finished diameter of the stainless steel pin.

14. **Bearings and Bearing Surfaces.** The Contractor may build up sole plates 3 inches thick, or greater, by welding together plates at least $1\frac{1}{2}$ inches thick.

Bevel plate edges $\frac{1}{4}$ inch and weld with a continuous weld along the full perimeter. Plane the top and bottom surfaces of column and pedestal base plates and cap plates or, if less than 4 inches thick, flatten by pressing. Face member parts, contacting column and pedestal base plates and cap plates, to fit.

Ensure sole plates on beams and plate girders fully contact flanges. Seal weld around sole plates. Plane, heat straighten, or flatten by pressing, sole plates and masonry plates. If planing is required on welded pedestals, complete the welding first. The Engineer does not require planing surfaces bearing on elastomeric bearing pads. Ensure planed or bored bearing surfaces meet the following roughness rating values:

- a. Bridge rockers, 250 micro inches per inch rms; and
- b. Pin holes and sliding bearings, 125 micro inches per inch rms,

Galvanize and apply the tie coat, intermediate coat, and top coat to steel material for bearings, except the portion welded to beams, after fabricating the bearing.

15. **Finished Members.** Provide finished members, true to the line shown on the plans, and free of twists, bends, and open joints.

Dull or flatten the corners of exposed steel edges by grinding or other Engineer-approved methods before shop cleaning.

Repair damage caused by handling, to the Engineer's satisfaction.

16. **Correction of Errors or Defects.** Obtain the Engineer's approval for the proposed method of correcting errors or defects in fabricated material, before beginning work. Perform corrections in a timely manner, unless the Engineer approves delaying the work until later fabrication stages.

Obtain written approval from the Engineer before beginning corrective work paid by the Department. Maintain an accurate record of the labor, equipment, and materials and present an itemized bill for approval by the Engineer. Correlate records daily with those kept by the Inspector.

17. **Galvanizing Structural Steel.** Hot-dip galvanize position dowels and anchor bolts, including nuts and washers, in accordance with AASHTO M 232. Tap oversized galvanized nuts in accordance with AASHTO M 291 or AASHTO M 292 and meet Supplementary Requirement S1 of AASHTO M 291 or AASHTO M 292. Remove excess hot-dip galvanizing on threaded portions by centrifuging or air blasting upon withdrawal. Do not flame-chase.

Before galvanizing, prepare steel components in accordance with SSPC-SP8 Pickling.

Galvanize portions of bearings not welded to the beam or girder, and other structural members and parts requiring galvanizing in

accordance with AASHTO M 111. Blast clean fabricated components to remove mill scale and welding slag before galvanizing.

If top coating galvanized surfaces, use the “dry process” during galvanizing. Do not quench galvanized components following galvanizing. Do not apply chromate surface passivation treatments to galvanized components requiring top coats.

18. **Handling and Storing Materials.** Store structural material on platforms, skids, or other supports above high water elevations. Maintain materials free of dirt, oil, or other contaminants and protect from corrosion. Pad structural members in storage at points of contact. Pitch trough sections to provide drainage. Support long members at frequent intervals to prevent deflection. Handle, store, and brace girders and beams in the erected position, unless otherwise authorized by the Engineer, and avoid distortion.

Protect fasteners from dirt and moisture on the project. Remove from protected storage, the number of fasteners required to be installed and tightened during a work shift. Return unused fasteners to protected storage at the end of shifts. Do not remove lubricant required for fasteners in the as-delivered condition. Clean, relubricate, and test fasteners for slip-critical connections that accumulate rust or dirt from site conditions, before installation.

Handle structural steel members and parts of primary member with clamps or plate hooks that do not leave nicks, gouges, or depressions. Repair damage to primary members using methods approved by the Engineer. Repair damage consistent with the delivery of structural steel in accordance with ASTM A 6, and AWS D 1.5, Bridge Welding Code, Section 3. Do not use chains or chokers for handling structural steel, unless placing a protective shield between the chain and the steel. Minimize handling stresses on beams and girders during transportation, storage, and erection. Use one-point pickup so overhang does not exceed the values specified in Table 707-3. Do not exceed the distances specified in Table 707-3 between hooks for two-point pickup.

Table 707-3 Rigging Requirements				
Beam Size	30 inch WF	33 inch WF	36 inch WF	Plate Girders
Overhang for One-Point or 2-Point Pickup, Max	37 ft	40 ft	42 ft	50 ft
Distance Between Hooks for 2-Point Pickup, Max	74 ft	80 ft	85 ft	100 ft

19. **Marking and Shipping.** Provide the Department with copies of material orders and shipping statements, as directed by the Engineer. Show the weights of individual members on the statements. Mark weights on the member if greater than 6 tons.

If using low stress stamping equipment, the fabricator may stamp members if approved by the Engineer. Do not stamp link plates, pin plates, or pins. If stamping primary members, stamp before coating, in the top flange cross-sectional area or on the top of the compression flange, within 6 inches of the end. Show the match-marking scheme on the shop drawings. Markings must be legible after completion of the final coating system.

Load, transport, and unload structural members using trucks or railcars, without stressing, deforming, or otherwise damaging members. Place a protective shield between the chain or chain binder and primary members during shipping, to prevent gouging the flange edges or damaging the coating.

Pack bolts, loose nuts, and washers of each length, diameter, or size, separately. Store and ship pins, small parts, and packages of bolts, washers, and nuts in clean, moisture proof boxes, crates, kegs, or barrels. Limit the gross weight of each package to 300 pounds. Provide a list and description of contents on the outside of each shipping container.

D. Erection of Structural Steel.

1. **Methods and Equipment.** Before beginning work, obtain the Engineer's approval for proposed equipment and erection methods. Do not use material intended for the finished structure for erection or temporary purposes unless otherwise shown on the plans or approved by the Engineer.

The Engineer's approval does not relieve the Contractor of the responsibility for the safety of the method or equipment.

2. **Bearings.** Position column bases, truss and girder pedestals, shoes, and bearing plates with a full, uniform bearing on the substructure concrete. Adjust bearing plate and masonry plate locations and rocker positions to compensate for temperature at the time of erection.
3. **Falsework.** Build and remove falsework in accordance with subsection 706.03.C and subsection 706.03.O.
4. **Straightening and Repair of Damaged Material.** Straighten plates, angles, other shapes, and built-up members, with the Engineer's

approval, without producing cracks or other damage. Straighten distorted members by carefully planned and supervised application of limited localized heat. Do not exceed 1,200 °F on heated areas, as determined by temperature-indicating crayons, liquids, or bimetal thermometers. Do not apply mechanical forces for straightening.

Inspect the surface of the metal for damage after straightening. Perform nondestructive testing, as directed by the Engineer.

5. **Assembling Steel.** Assemble parts according to the plans and shop drawings. Do not damage steel during erection. Clean rust, loose mill scale, dirt, oil or grease, and other deleterious material from bearing surfaces and surfaces in permanent contact before assembly.

At the time of erection, coat machine finished surfaces with a commercial grade lubricant approved by the Engineer. Lubricate pedestal and rocker-to-sole plate surfaces and sliding metal-on-metal bearing surfaces.

Align all parts in splices and field connections before inserting connection bolts. The Engineer may direct filling at least 10 percent of each splice connection with temporary bolts to bring the plies of steel tight before installing permanent bolts. Install permanent bolts in remaining splice locations and commence turn-of-nut tightening of the permanent bolts in accordance with subsection 707.03.D.7.c. Remove temporary bolts and replace with permanent bolts. Tighten using turn-of-nut method.

In bolted connections, do not expose nuts in fascia girder outer faces or on the bottom faces of lower flanges.

If field splicing girders in the air, install $\frac{1}{3}$ of the bolts, evenly distributed over the connecting elements, and snug tighten before releasing lifting devices.

Tighten bolts in spans of continuous girders in accordance with subsection 707.03.D.7.c before casting deck concrete.

6. **Misfits.** Correct and replace misfits, errors, and damage at no additional cost to the Department. Obtain the Engineer's approval for correction methods. Do not force structural members into place.

The Engineer will witness correction methods.

7. **Bolted Connections.** Do not exceed a 1:20 slope on the surfaces of bolted parts in contact with bolt heads and nuts, with respect to a plane perpendicular to the bolt axis. Use beveled washers to

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compensate for slopes greater than 1:20. Fit bolted parts solidly together and do not separate with compressible material.

During assembly, maintain joint surfaces free of mill scale, burrs, dirt, and other deleterious material. Use the same combinations of tested nut, bolt, and washer lots for field assembly as those tested and approved by the Engineer for use in combination.

- a. **Washers.** Install a hardened washer under the fastener element turned during tightening. Seat the element for turning during tightening against a non-sloping surface.

Use smooth beveled washers where necessary to compensate for the surface slope of bolted parts with respect to the bolt head or nut.

- b. **Bolt Tension.** Tighten each fastener in accordance with Table 707-4.

Tighten bolts using the turn-of-nut method in accordance with subsection 707.03.D.7.c. If required because of bolt entering and wrench operation clearances, tighten by turning the bolt while preventing the nut from rotating.

If using impact wrenches, provide wrenches sufficient to tighten each bolt in approximately 10 seconds. Perform verification testing, witnessed by the Engineer, on a representative sample of at least three bolt assemblies of each diameter, length, and heat or lot. Test at the beginning of work in a device that shows bolt tension. Show that the method for estimating the snug tight condition, and controlling the turns from snug tight, develops a tension of at least 5 percent greater than the tension specified in Table 707-4, when performed by the bolting crew. Perform periodic retesting if directed by the Engineer.

Table 707-4 Minimum Bolt Tension for ASTM M 164 Bolts	
Bolt Size (in)	Minimum Bolt Tension (lb), (a)
1/2	12,050
5/8	19,200
3/4	28,400
7/8	39,250
1	51,500
1 1/8	56,450
1 1/4	71,700
1 3/8	85,450
1 1/2	104,000
a. Equal to 70% of specified minimum tensile strength of bolts.	

- c. **Turn-of-Nut Tightening.** Bring enough bolts to a snug tight condition to ensure parts of the joint fully contact. Snug tight is the tightness attained by a few impacts of an impact wrench, or the full effort of a person using an ordinary spud wrench. Place bolts in remaining holes in the connection and bring to snug tightness. Mark each bolt to reference the rotation required for tightening. Tighten all bolts in the joint by rotating the nut in accordance with Table 707-5. Tighten systematically from the most rigid part of the joint to the free edges. Ensure parts, not turned by the wrench, do not rotate during tightening operations.

Do not reuse AASHTO M 164 bolts and nuts. The Engineer will not consider re-snugging previously tightened bolts loosened by the tightening of adjacent bolts, as reuse.

Table 707-5			
Nut Rotation from Snug Tight Condition (a)			
Disposition of Outer Faces of Bolted Parts			
Bolt Length (b)	Two Normal (c)	One Normal One Sloped (c, d)	Two Sloped Faces (c, d)
≤4D	120°+30°	180°+30°	240°+45°
>4D – 8D	180°+30°	240°+45°	300°+45°
>8D – 12D	240°+45°	300°+45°	360°+45°
>12D	No data; determine required rotation by tests simulating actual conditions		
a. Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned.			
b. Measured from underside of head to extreme end of point. “D” is nominal bolt diameter.			
c. Relative to bolt axis.			
d. Sloped face not more than 1:20; no bevel washer.			

- d. **Inspection.** The Engineer will determine if bolts meet the requirements for bolt tension. Provide the Engineer with the opportunity to witness the bolt snugging, marking for final rotation, and tightening.
8. **Field Welding.** Do not field weld unless otherwise shown on the plans or approved by the Engineer. Obtain Engineer's approval for welding procedures before beginning field welding. Perform field welding and nondestructive testing in accordance with AWS D1.5, Bridge Welding Code.

Perform structural field welding by the SMAW process using E7018 electrodes. Do not use Gas Metal Arc Welding (GMAW), or other gas shielded processes. The Engineer may approve SAW and Flux Cored Arc Welding (FCAW) for field welding.

- a. **Qualification.** For welder qualification, test field welders. The Engineer will witness testing. The Engineer will not accept welder tests by other agencies. Perform welder qualification tests in accordance with AWS D1.5, Part B, Section 5, in the same position required for field welding, as determined by the Engineer. Field welder qualifications remain in effect for two years, unless the welder does not engage in welding for at least three months, or a specific reason exists to question the welder's ability.

For procedure qualification, do not perform field welding until preparation of written welding procedures, as established by testing. Perform weld procedure tests in the same position and joint configuration required for the field welding. The Engineer will approve the written welding procedures after completion of successful weld testing. Test in accordance with AWS D1.5, Section 5. Perform tests on the same steel plate material type for welding, and provide mill certification.

- b. **Welding Requirements.** Blast clean or grind contact surfaces, joints, and surrounding area before field welding. Remove loose mill scale, paint, galvanizing, grease, oil, rust, moisture, and other deleterious material from base metal before welding. Grind joints before field welding to remove pitting and irregularities. Prepare joints and remove deleterious material in accordance with AWS D1.5, Section 3.

Bring parts into close contact. If the separation between parts exceeds $\frac{1}{16}$ inch, increase the legs of the fillet weld by the separation distance. Do not weld if the separation between parts exceeds $\frac{3}{16}$ inch.

Transition weld profiles by grinding stop-start areas or other irregularities.

Do not perform field welding if the ambient air temperature falls below 40 °F or during periods of precipitation, unless heating and housing the area as approved by the Engineer.

Dry electrodes in an oven at a temperature of at least 500 °F for at least 2 hours before use. Store the electrodes at a temperature of at least 250 °F after drying. Use electrodes within 2 hours of exposure to the atmosphere, or redry. Do not redry electrodes more than once. Do not use electrodes that have been wet.

Preheat surfaces for welding 3 inches in every direction from the weld. Before welding, preheat surfaces to at least 250 °F for base metal no greater than 1½ inches thick. For base metals from 1½ inches thick to 2½ inches thick, preheat to at least 300 °F. If welding on plates greater than 2½ inches thick, preheat to at least 400 °F.

- c. **Inspection.** The Engineer will verify that the nondestructive testing, including visual inspection has been performed in accordance with, and the welds are acceptable according to, AWS D1.5. The Contractor is responsible for nondestructive testing of field welds. Blast clean or grind welds before conducting nondestructive testing. Use liquid dye penetrant or magnetic particle testing for fillet and partial penetration butt welds. Use ultrasonic testing for complete penetration butt welds, plug welds, and slot welds.

Perform nondestructive testing in accordance with subsection 707.03.C.10 and AWS D1.5. The Engineer will determine the frequency, location, and type of nondestructive testing. Personnel qualified as Level II or Level III in accordance with the American Society for Nondestructive Testing (ASNT), Recommended Practice No. SNT-TC-1A must perform all tests. Ensure an AWS Certified Weld Inspector (CWI) inspects all welds. Ensure testing personnel provide certifications to the Engineer before beginning the work. The Engineer will witness nondestructive testing.

Repair cracked welds, or welds the Engineer determines are unacceptable. Repair welds in accordance with AWS D1.5, Section 3.7. Inspect and test repaired welds before the Engineer's acceptance. Repair and retest welds at no additional cost to the Department.

- d. **Welding Piles or Falsework.** Agencies approved by the Department may perform welder qualification tests for welding piles or falsework. Structural welding or welding repair work requires Department qualification testing.

Ensure field welders present a certificate documenting qualification within the previous two years in accordance with the Department's Welder Certification by Agency program. Conform welding to AWS D1.1. The Engineer may require a confirming qualification test during the progress of the work.

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- e. **Welding for Form Supports and Accessories.** If no other methods exist, the Engineer may allow welding to primary steel members. Prepare and submit to the Engineer for written approval, a detailed plan of operations if welding to primary steel members is anticipated. If the Engineer allows, weld to steel beams in compression areas only.

Ensure the field welder presents a certificate documenting qualification within the previous two years in accordance with the Department's Welder Certification by Agency program. Conform welding to AWS D1.1.

- f. **Shear Developers.** Do not weld if the temperature falls below 32 °F or if the surface is wet or exposed to rain or snow.

Remove rust, mill scale, paint, and galvanizing from the base metal at the stud location by grinding. Clean the stud end. End weld stud shear connectors to steel beams or girders with automatically timed stud welding equipment. When using automatically timed stud welding equipment, do not preheat the top of the beam flange. Perform and test stud welding in accordance with AWS D1.5, Bridge Welding Code.

Repair studs without a full 360-degree fillet weld by adding a 5/16-inch fillet weld to replace missing welds.

707.04. Measurement and Payment.

Pay Item	Pay Unit
Structural Steel, Rolled Shape, Furn and Fab.....	Pound
Structural Steel, Rolled Shape, Erect.....	Pound
Structural Steel, Plate, Furn and Fab	Pound
Structural Steel, Plate, Erect	Pound
Structural Steel, Mixed, Furn and Fab.....	Pound
Structural Steel, Mixed, Erect.....	Pound
Bearing, Elastomeric, __ inch.....	Square Inch
Shear Developers (Structure No.)	Lump Sum
Bushing.....	Each

A. **Structural Steel.** The Engineer will measure structural steel by the calculated weight of metal in the finished structure, excluding filler metal in welding, as shown on shop plans or working drawings. The Engineer will calculate the weight using the rules and assumptions specified in this subsection.

Unless otherwise required, the following metal weights apply:

- 1. Steel — 0.2833 pound per cubic inch;

2. Cast iron — 0.26 pound per cubic inch;
3. Bronze — 0.315 pound per cubic inch; and
4. Lead — 0.411 pound per cubic inch.

The Engineer will calculate the weights of rolled shapes and plates incorporated in the finished work on the basis of nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts, and holes, except those for high strength bolts.

The Engineer will include the total calculated weight of bolts, nuts, and washers in the finished work in the weight of structural steel.

The Engineer will calculate the weight of castings from the dimensions shown on the approved shop drawings with an addition of 10 percent for fillets and overrun.

The Engineer will not make allowance for galvanizing, optional splices, lifting lugs, shop coating, or excess bolts in the calculated weight.

The Engineer will not include the weight of lifting lugs in the calculated weight for structural steel. The unit prices for structural steel pay items include the cost of providing, welding, and removing the lugs.

B. Welding. The Department will not pay for welding and nondestructive testing required for new, retrofitting, repairing, rehabilitation, or replacing structural steel components, including shop fabrication and field welding.

The Department will not pay for welding and submittal of qualification specimen costs, including nondestructive testing of weld specimens by radiography or ultrasonic testing and confirming test specimens. The Department will cut, machine, and test specimens without charge, except the Contractor is responsible for the cost of testing additional specimens if the first test specimens fail.

C. Structural Steel Plants. The Department will not allow additional compensation for costs incurred in the certification of structural steel plants, or claims by the Contractor for delays and inconvenience attributed to certification requirements.

D. General. The unit prices for **Structural Steel, Erect** pay items include the cost of installing and removing temporary bolts as directed by the Engineer. The unit price for **Structural Steel, Erect** pay items include the cost of field drilling.

The unit prices for **Structural Steel, Furn and Fab** pay items include the cost of shop cleaning and coating the steel.

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The Engineer will measure **Bearing, Elastomeric**, of the size required, by area, with no deductions for holes. The unit price for **Bearing, Elastomeric** includes the cost of steel laminates bonded to the elastomeric bearing.

The Engineer will measure **Shear Developers** as a unit for each structure. The unit price for **Shear Developers** includes the cost of providing studs, cleaning the surface by grinding, and welding studs to the girder flanges.

The unit price for **Bushing** includes the cost of priming the inside holes in the link plate and providing and installing the bushing.

The cost of supplying, installing, and removing temporary bolts at splice connections when this work is required by subsection 707.03.D, is included in the unit price for relevant pay items.