Section 707. STRUCTURAL STEEL CONSTRUCTION

707.01 Description. This work consists of fabricating, shop cleaning and coating, furnishing, delivering, and erecting all structural steel and other materials. The fabrication and construction methods specified here may be modified by contract documents.

Plants shall be certified by the American Institute of Steel Construction (AISC) for Category Simple Steel Bridges (Sbr) when fabricating rolled beams or other bridge related components including, but not limited to, bridge tube railing, bearing assemblies (including pot and disc bearings), modular bridge expansion joints, sidewalk and deck grating, pin and hanger assemblies (excluding the machining operations), diaphragms, cross-frames, connection angles and plates, and miscellaneous steel components permanently attached to the structure as determined by the Engineer. Plants shall be certified by AISC for Category Major Steel Bridges (Cbr), when fabricating welded plate girders. In addition to the requirements of AISC Category Major Steel Bridges, plants fabricating fracture critical members shall also have the AISC Fracture Critical Members Endorsement. AISC Sophisticated Paint Endorsement is required when more than 500 square feet of steel surface area is painted. This AISC certification is in addition to the requirements specified herein.

Work shall be as shown on the plans, approved shop plans or working drawings, or as approved by the Engineer.

The requirements for welding as specified in AWS D 1.5, *Bridge Welding Code*, shall apply as amended herein, or by contract documents. Primary members include but are not limited to rolled beams, cover plates, flange and web plates, link bars, end diaphragms, end diaphragm connection plates/stiffeners. For horizontally curved girders, intermediate cross frames and connection plates/stiffeners are also considered primary members.

Shop clean and coat according to section 716.

707.02 Materials. The materials shall meet the following requirements:

Bushings shall have a nominal wall thickness of ¼ inch and shall be selected from the Qualified Products List.

Castings shall be steel unless cast iron or other material is specifically called for or authorized in writing.

Mill Test Reports and Certifications. The Contractor shall require the fabricator to furnish the Engineer with two copies of Mill Test Reports, from the manufacturer's records, of chemical composition and physical properties of structural steel members. The fabricator shall also provide an affidavit stating that the material furnished meets the specifications. Where such Mill Test Reports are not available, the Contractor shall have tests made of the chemical and physical properties at the Contractor's expense and furnish the Engineer with two certified copies of the test reports and affidavits.

For materials not requiring Mill Test Reports, the Contractor shall furnish the Engineer with two copies of an affidavit stating that the material furnished meets the specifications.

All test reports and affidavits shall be identified with the Department's structure number and the particular members of the structure to which these test reports or affidavits apply.

707.03 Construction.

A. **Shop Inspection.** Shop inspection will be provided by the Department for structural steel, castings and similar materials. It is the fabricator's responsibility to establish and maintain effective quality control procedures. Inspection by the Department is not a substitute for use of quality control procedures by the fabricator.

1. **Notice of Beginning of Work.** The Contractor shall give two weeks notice to the Department of the beginning of work in the shop so that inspection may be provided. No work shall be done in a shop before the Department has been notified.

   If work on a project is suspended for a period of time in which the Inspector leaves the shop, two weeks notice, or a period of time agreed upon in advance by the Engineer and the fabricator, shall be required prior to restart of the project.

2. **Facilities for Inspection.** The Contractor shall provide, without charge, facilities for inspection of materials and workmanship. These facilities shall include a desk, locker, plan rack, secure storage space for testing equipment, and a telephone. The Inspector shall be allowed free access to all parts of the shop relating to the work.

   The office shall contain at least 120 square feet of floor space, shall be adequately lighted, heated or cooled, and ventilated, and shall not be shared by more than one other Inspector. Offices considerably larger than the minimum specified may be shared by additional Inspectors, if approved by the Engineer.

   The office shall be located reasonably close to where the work will be performed and a parking space for the Inspector shall be provided adjacent to the office. All equipment in the office shall be in proper working order.

3. **Shop Inspector's Authority.** The Inspector shall have authority to reject materials or workmanship which do not meet the specified requirements. Use of equipment or an operation which is not producing desired results shall be suspended until corrective

action has been taken. If any problems arise which are not resolvable at the Inspector's level, a three-way conversation will be conducted between the Engineer, the Inspector, and the fabricator.

All final decisions will come back through the Inspector.

4. **Rejections.** The Inspector's acceptance at the shop of all material and workmanship on finished members shall not prevent their subsequent rejection at the site. The manufacturer or Contractor shall correct or replace damaged or defective material or workmanship at their own expense.

B. **Prefabrication Meeting.** No work shall begin until the Engineer and the fabricator have had an opportunity to have a prefabrication meeting at the fabricating plant. The fabricator's representatives, who have direct responsibility for supervision and control of the work, will meet with the Engineer and other authorized representatives of the Department. This meeting shall finalize all procedures relating to the shop fabrication of the material included in the contract and the proposed schedule of fabrication and delivery.

C. **Furnishing and Fabricating.**

1. **Shop Plans.** Complete working drawings of all details of fabrication shall be prepared as specified in subsection 104.02. The use of design drawings in lieu of shop plans will not be permitted. The Contractor shall submit four sets of these drawings to the Engineer for review and acceptance. The Contractor shall be responsible for the correctness of working drawings. Following acceptance of working drawings, the Department shall be furnished with 7 to 12 complete sets of prints, as required by the Engineer, and three sets of all shop bills. Following completion of the fabrication, the Department shall be furnished with one complete set of working drawings in ink on white, 3 mils (minimum) polyester/mylar drafting film, 24 by 36 inches. These drawings shall include any changes made from the time the original drawings were accepted.

2. **Welded Plate Girders and Rolled Beam Fabrication.**

a. **General.** The working drawings shall show in detail the procedure to be used for each type and size of welded joint or bolted connection.

The plates that comprise the flange and web of the girders shall be completely welded into a single plate before these flanges and webs are welded together to form the individual girders or box girders.

The automatic submerged arc process shall be used 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. This includes flange-to-web welds in box girders, arches, towers, and truss web and chord members. Fillet welding of cover plate-to-flange shall be done in the flat (1F) position. Either flat (1F) or horizontal (2F) position shall be used for flange-to-web fillet welding.

The use of the shielded metal arc welding (SMAW) process shall be limited to welding stiffeners or connection plates to rolled beams, stiffener-to-flange welding on plate girders, welding bearing assemblies, and other limited welding applications where the use of automatic or semi-automatic welding equipment is impracticable because of limited access or the isolated location and short length of welds involved.

Electroslag and electrogas welding processes are not allowed. Use only E7018 electrodes when using the shielded metal arc welding process.

Weld metal splatter on adjacent base metal shall be removed, as approved by the Engineer, prior to blast cleaning and painting.

The minimum fillet weld size is shown in Table 707-1. Fillet weld size is determined by the thicker of the two parts joined unless a larger size is required by the calculated stress. The weld size need not exceed the thickness of the thinner part joined unless designated as such on the design plans. In cases where the weld size is smaller than the minimum designated due to plate thickness, particular care should be taken to provide sufficient preheat to ensure weld soundness. The minimum size fillet weld for any flange weld shall be 5/16 inch.

Table 707-1 Weld Sizes

Minimum Fillet Weld Size	
Base Metal Thickness of Thicker Part Joined (inch)	Minimum Size of Fillet Weld (inch)
to ¾ inclusive	¼
Over ¾ to 1-½	5/16
Over 1-½ to 2-¼	⅜
Over 2-¼ to 6	½
Over 6	⅝
Minimum Effective Weld Size for Partial Joint Penetration Groove Welds	
Based Metal Thickness of Thicker Part Joined (inch)	Minimum Effective Weld Size (inch)(a)
to ¾ inclusive	¼
Over ¾ to 1-½	5/16
Over 1-½ to 2-¼	⅜
Over 2-¼¼ to 6	½
Over 6	⅝
a. Except the effective throat need not exceed the thickness of the thinner part.	

b. **Lifting Methods.** When lifting lugs are used, they shall be welded to the upper flange in areas subjected to compression only. The Contractor shall submit the proposed details and design calculations to the Engineer for approval before fabricating. The weldments connecting the lifting lug to the girder shall be subject to nondestructive testing as directed by the Engineer. Shop drawings shall note whether lugs are to be used in lifting one piece only or to lift assemblies of two or more pieces.

Immediately after erecting the steel girder, lifting lugs shall be removed by cutting and grinding the area smooth.

Lifting devices shall be provided with adequate softeners to prevent damage. If hooks are used for lifting, they shall have sufficient width of jaw and throat to prevent damage. Spreader beams, or multiple cranes, shall be provided for lifting plates and long slender members to prevent overstress and distortion.

3. **Straightening.** Material shall be straight according to the tolerances specified in AWS D 1.5 *Bridge Welding Code*, Section 3.5, before being laid out or worked. Straightening shall be done by methods that have been approved by the Engineer. Kinks or bends may be cause for rejection.

   Flanges joined by butt welds shall be straight before fitting to webs. Distortion due to welding or handling shall be removed by the application of heat over the full width of the flange. Heating shall not exceed 1200 °F and shall be followed by slow cooling. All straightening shall be done prior to performing the nondestructive tests specified in subsection 707.03.C.9.

4. **Cambering, Camber Adjustment, and Horizontal Curvature.** Cambering, camber adjustment, and horizontal curvature shall be accomplished by heat. Camber for girders shall be cut into the web and adjustments made by heat after flange to web welding is complete. Heating steel shall conform with the V-type method specified under Division II, Straightening Material and Curving Rolled Beams and Welded Girders, of the AASHTO *Standard Specifications for Highway Bridges.* Dimensional tolerances shall be according to AWS D 1.5, *Bridge Welding Code,* Section 3.5.

   Temperature shall be maintained according to subsection 707.03.C.3 by the use of temperature monitoring devices.

   The camber of each member shall be measured in the shop in the presence of the Inspector and will be one of the conditions for approval for shipment.

5. **Cutting and Planing.** Steel exceeding ⅝ inch in thickness and alloy steel exceeding ½ inch in thickness shall have ¼ inch of metal planed from sheared edges. Re-entrant angles shall be filleted to ¾ inch radius.

   When flame cutting flange and web plates, both edges shall be cut simultaneously to minimize distortion.

   Heat numbers shall be transferred at the time of cutting to all pieces of primary member material cut from large plates. Marking shall be done with a white paint which will last through fabrication.

6. **Splices and Connections.**

   a. **Shop Splices.** Girder web plates may be spliced at the option of the fabricator, unless prohibited on the plans or in the proposal.

Flange plate splices will be permitted only in girders over 50 feet in length.

Only one splice per cover plate will be permitted and then only with the approval of the Engineer.

The location of the optional web and flange splice is subject to the approval of the Engineer.

b. **Holes for High Strength Bolts.** Punching of holes is limited to material not greater than ¾ inch thick for AASHTO M 270 Grade 36 steel or ⅝ inch thick for high-strength steel. The diameter of the die for punching full-size shall not exceed the diameter of the punch by more than $^{1}/_{16}$ inch. The diameter of the die for sub-punching shall not exceed the diameter of the punch by more than $^{3}/_{32}$ inch.

Holes for primary member splices shall be sub-drilled or sub-punched two sizes undersize and then reamed full size. While working on the splice, holes may also be drilled full size with all material assembled and securely held while working on the splice in the manner in which it will be used in the final joint assembly. When drilling assembled splices, one plate may be pre-drilled full-size and used as a template.

Drilling full size holes from the solid with computer numerically controlled (CNC) equipment is allowed.

All joints which have been reamed or drilled with the parts assembled shall be match marked and be partially assembled with plates attached to the joint in such a manner that erecting crews are not likely to misplace, interchange or reverse parts of the joint. Match marking shall consist of low stress stamping at one location only and shall have the prior approval of the Engineer. The match marking scheme shall be shown on the approved shop drawings.

For primary members, load carrying diaphragms and load carrying cross-frame connections, finished holes shall be $^{1}/_{16}$ inch larger than the nominal diameters of the bolts required and shall be clean cut without torn, ragged, burred or crimped edges. Finished holes in other diaphragms and cross-frames may be up to $^{3}/_{16}$ inch larger than the nominal bolt diameter. Welding shall not be used to fill or repair misplaced drilled or punched holes.

c. **Assembly.** The field connections of primary members shall be assembled in the shop and then have their sub-size holes reamed to specified size while the connections are assembled. Assembly shall be full truss or girder assembly unless progressive truss or girder assembly, full chord assembly, progressive chord assembly, or special complete structure assembly is specified.

Full Truss or Girder Assembly. Full truss or girder assembly shall consist of assembling, at one time, all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder or rigid frame.

Progressive Truss or Girder Assembly. Progressive truss or girder assembly shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame, at least three consecutive shop sections or all members in at least three consecutive panels but not less than the number of panels associated with three consecutive chord lengths (i.e., length between field splices) and not less than 150 feet in the case of structures longer than 150 feet. At least one shop section or panel or as many panels as are associated with a chord length shall be added at the advancing end of the assembly before any member is removed from the rearward end, so that the assembled portion of the structure is never less than that specified above.

Full Chord Assembly. Full chord assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connections to steel templates set at geometric (not cambered) angular relation to the chord lines.

Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member and the templates at both ends of the member shall be accurately located from one of the milled ends or scribed lines.

Progressive Chord Assembly. Progressive chord assembly shall consist of assembling consecutive chord members in the manner specified for full chord assembly and in the number and length specified for progressive truss or girder assembly.

Special Complete Structure Assembly. Special complete structure assembly shall consist of assembling the entire structure, including the floor system. This procedure is ordinarily needed only for complicated structures such as those having curved girders, or extreme skew in combination with severe grade or camber.

Each assembly, including camber, alignment, accuracy of holes and fit of milled joints, shall be approved by the Engineer before reaming is commenced. A maximum gap of ⅜ inch shall be maintained between girder ends at bolted field splices.

The fabricator shall furnish 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. When the shop assembly is full truss or girder assembly or special complete structure assembly, the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly are used, the camber diagram shall show calculated camber.

Bolts used for assembly shall be of the same diameter as the bolts required for erection and pins used for assembly shall be the same diameter as the hole and shall be of sufficient number to assure accuracy.

The drifting done during assembling shall not enlarge holes, or distort metal. If holes must be enlarged to admit bolts, they shall be reamed. The assemblies shall not be moved during the drilling of a joint nor disassembled until all drilling or reaming is complete and the Inspector has approved the holes and markings.

Temporary fitting aids used during any phase of fabrication shall use tack welds only as approved by the Engineer. Tack welding of fitting aids to the flange is prohibited.

7. **High Strength Steel Bolts.** Where high strength steel bolts are specified for connections, heavy hexagon structural bolts shall be furnished and the nuts shall be heavy, semifinished, hexagon nuts with one circular washer provided for each bolt. Galvanized nuts shall be lubricated with a lubricant containing a visible dye. Where oversize holes are permitted, two washers will be required; one under each element. The quantity of each size and length of 5 percent more than high strength steel bolts shall be the number required.

8. **Welding.** Shop welders, welding operators, welding equipment, and welding procedures to be used in production of steel structures shall have been qualified according to the qualification procedure of AWS D 1.5, *Bridge Welding Code,* as modified in these specifications or by contract documents.

   Test welds, required by these specifications, will be made under the supervision of a representative of the Department.

   Shop welder and welding operator qualifications shall remain in effect for three years unless the welder or welding operator is not engaged in a given process of welding for a period of three months or more, or unless there is some specific reason to question the welder's ability. The Engineer may require a confirming qualification test during the progress of the work. Welders and welding operators who have qualified on grade 50 high-strength steel will be considered as qualified to weld grade 36 steel provided that the shop has qualified the procedure as required above.

9. **Nondestructive Testing of Welds.** Nondestructive testing of welds will be required. The fabricator will be required to provide labor, equipment, and materials for making such inspections and the adequacy of the equipment, materials, and procedures will be determined by the Engineer.

   Identification marks required on butt welds for radiographic purposes shall be made with paint. Steel stenciling or punch marking will not be permitted.

   Only technicians approved by the Department may perform ultra-sonic testing.

   a. **Scope of Examination of Groove Welds.** The fabricator shall use radiographic test methods to perform this work according to AWS D 1.5, *Bridge Welding Code.* Ultrasonic test methods shall be used only for the examination of full penetration corner joints and T-joints where radiographic testing is not possible, or where specified by contract documents. Where ultrasonic testing is permitted, only

glycerine shall be used as the coupling agent. Unless otherwise specified, butt welds or other full penetration welds in primary members shall be tested as follows.

- 100 percent of all flange splices.
- 100 percent of all splices subject to reversal of stress.
- 12 inches, but not less than ⅓ the length of all web splices beginning at the point of maximum tension, plus 12 inches of the web splice beginning at the compression end. (This includes splices connecting pin plates to webs.)
- 25 percent of compression and shear splices in built-up members.
- 25 percent of flange to web connections of box girders unless otherwise specified on the plans.
- 100 percent of all similar welds in a member subject to partial examination when a rejectable defect is found in any weld of that member.
- 100 percent of all butt weld repairs requiring removal and replacement of weld defects.
- 100 percent of plug and slot welds shall be ultrasonically tested.

For thickness transition joints, radiographic film may be placed on either side of the joint, subject to properly positioning the pack and use of appropriately tapered edge blocks. Substandard image quality resulting from film placed on the transition side shall require relocating the film to the planer side.

Ultrasonic testing of corner joints or those using backup bars will require approval of the Engineer and the submittal of a proposed procedure by the fabricator.

Radiographic or ultrasonic tests on groove welds must be made and written approval obtained before the flange plates and web plates are assembled and welded to form the girders.

Full penetration butt weldments shall be checked on both ends for surface defects using dye penetrant inspection, according to ASTM E 165. This inspection is mandatory for weldments that are inspected by either radiography or ultrasonic testing.

All radiographic film shall extend at least one inch beyond the edges of the part being radiographed utilizing extension blocks.

Where ultrasonic testing is used, one weld out of every four welds tested shall be randomly tested by radiography as a check on the quality of sonic testing. The Department may waive this requirement when a high level of competence has been demonstrated and is maintained.

b. **Scope of Examination of Fillet Welds.** Magnetic particle inspection of fillet welds shall be required. The inspection shall be witnessed by the Inspector. Magnetic particle inspection procedure and technique shall be according to ASTM E 709, using the yoke or aluminum prod method. For magnetic particle testing use half-wave rectified alternating current (direct current).

All fillet welds, including the welds connecting the bearing and intermediate stiffeners to the tension flanges of girders and all sole plates welded to the girders, shall be inspected by the magnetic particle process. Fillet welds connecting intermediate stiffeners to the girder web, assemblies of diaphragms, sway bracing and other secondary members need not be tested. Stiffener end to tension flange welds shall be tested over their entire length. The inspection of other fillet welds shall be made on at least 10 percent of the length of every weld, but not less than 10 inches of each weld less than 100 inches in length for each size of fillet weld. This includes all primary members such as: girders, floor beams, stringers, truss members including the end connections for such members and bearing blocks and assemblies and their attachment to members. The tests shall be located at random in the members so as to be typical for each size of weld. If unacceptable defects are found in any test length of weld, the full length of the weld, or 5 feet on either side of the test length, whichever is less, shall be tested.

c. **Weld Condition.** All welded edges and surfaces shall be free of paint, scale, grease, etc. and shall be ground to meet the following conditions; all flange welds shall be flush on aligned sides and made to merge smoothly on transition sides.

   Areas where automatic and semi-automatic welding is to be performed shall be kept at a temperature of 40 °F or more for at least one hour before work begins and this temperature shall be maintained at all times when work is being performed.

   Web, shear or pin plate splices need not be ground except when radiography is the method of testing. Grinding shall then be slightly in excess of the length of film used on the film side of the web only and made to merge smoothly where terminated. Fascia beams shall be ground on the inside of the girder only.

   Surfaces which have been ground shall meet the surface roughness rating of 125 microinches per inch root mean square (rms). Joints to be ultrasonically inspected shall be free of all loose mill scale on all sides for a distance which will permit one bounce of the ultrasound with a 70 degree transducer. The fabricator shall remove all glycerine by cleaning with a proper solvent prior to further welding or blast cleaning of the steel.

d. **Defective Welds.** Welds determined to have rejectable defects by any method of testing, either by Contractor personnel or by Department personnel, shall be repaired or replaced. Such repairs shall be made regardless of whether other methods of testing may not have found the weld to be unsound. The method of repair of weld defect shall have prior approval of the Engineer.

   Welds which require repair, or removal and replacement, shall be done according to the applicable AWS Code. The entire piece may be rejected by the Engineer if defects and/or repairs to defects are excessive or the same defect is repaired more than twice.

   All repair procedures must be submitted to the Engineer, in writing, and be approved prior to starting any repair. Repaired or replaced welds shall be

reinspected, including 3 inches minimum on all sides of the repair, by the applicable non-destructive testing method. Only two attempts are allowed for repairing a flawed weld. If the second repair attempt is not successful, the entire weld shall be removed and replaced.

10. **Fit of Stiffeners.** Stiffeners which show evidence of being under compressive stress after fitting is completed, such as waviness along the length of the stiffener, shall be removed and corrected prior to final welding.

11. **Pins and Link Plates.** The contract drawings show the nominal diameter of the pins. The fabricator has the option of establishing the exact diameter of the pin and showing it on the shop drawings within +0 and -$^{1}/_{32}$ inch and shall then meet this diameter to within ± 0.005 inch.

    Hanger pins shall be stainless steel. The surface finish shall be less than 16 microinches per inch rms on the bearing surface and less than 125 microinches per inch rms on the ends.

    Surface finishes on link plates shall be less than 125 microinches per inch rms on all cut edges and bored holes.

    The longitudinal axis of the link plates and pins shall be oriented in the direction of rolling or forging of the plates or bars.

    No welding repairs will be permitted on pins or link plates. The pin holes shall be smooth, straight, at right angles to the axis of the member and parallel to each other.

    The variation from the specified distance from outside to outside of adjacent pin holes in tension members, or from inside to inside of adjacent pin holes in compression members, shall not exceed $^{1}/_{32}$ inch. In built-up members, the boring shall be done after the member is welded. Link plates shall be drilled or bored in a jig or in assembled pairs.

    The diameter of the pin hole in the web shall exceed that of the pin by $^{1}/_{32}$ inch with a tolerance of ± 0.005 inch.

12. **Bushings for Pins and Link Plates.** The inside hole in the link plate shall be primed with an organic zinc-rich primer prior to installing the bushing. The bushing shall be installed with an interference fit of 0.001 inch minimum. The inside diameter of the bushing shall provide a clearance of 0.005 inch minimum and 0.015 inch maximum over the finished diameter of the stainless steel.

13. **Bearings and Bearing Surfaces.** Sole plates 3 inches or more in thickness may be built up by welding together plates not less than 1½ inches in thickness. Plate edges shall be beveled ¼ inch and welded with a full continuous weld for the full perimeter. The top and bottom surfaces of base plates and cap plates of columns and pedestals shall be planed or, if less than 4 inches thick, may be flattened by pressing. The parts of members in contact with them shall be faced to fit.

Sole plates of beams and plate girders shall have full contact with the flanges. Sole plates and masonry plates shall be planed, heat straightened, or flattened by pressing. Where planing is required on welded pedestals, it shall be done after the welding is completed. Surfaces that are to bear on elastomeric bearing pads do not need to be planed. Planed or bored bearing surfaces shall meet the following roughness rating values.

Bridge rockers . . . . . 250 microinches per inch rms
Pinholes and sliding bearings . . . . . 125 microinches per inch rms

All steel material used for bearings, with the exception of the portion welded to beams (sole plates), shall be galvanized and the tie coat, intermediate coat, and top coat applied after fabrication of the bearing.

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

    Exposed edges of all steel shall have their corners dulled or flattened by grinding or other approved methods before shop cleaning.

    Damage caused by improper handling shall be repaired to the satisfaction of the Engineer.

15. **Correction of Errors or Defects.** The correction of errors or defects in the fabricated material shall not begin until the proposed corrective method has been approved by the Engineer. This work shall be performed in a timely manner but may be delayed until later stages of fabrication if approved by the Engineer.

    When the cost of performing the corrective work is to be paid by the Department, written approved by the Engineer by the Department shall be received before the corrective work is started. The fabricator shall keep an accurate record of the labor, equipment, and materials used and shall render an itemized bill for approval. The fabricator shall correlate his records daily with those of the Inspector.

16. **Galvanizing Structural Steel.** Position dowels and anchor bolts, including nuts and washers, shall be hot-dip galvanized according to AASHTO M 232. Galvanized nuts shall be tapped oversize according to ASTM A 563 and shall meet the requirements of Supplementary Requirement S1 of ASTM A 563. Excess hot-dip galvanizing on threaded portions shall be removed by centrifuging or air blasting immediately upon withdrawal; flame-chasing is prohibited.

    Prior to galvanizing, all steel components shall be prepared according to SSPC-SP8.

    All portions of bearings not welded to the beam or girder and other structural members and parts required to be galvanized shall be galvanized according to ASTM A 123. Fabricated components shall be blast cleaned to remove all mill scale and welding slag prior to galvanizing.

When top coating galvanized surfaces, use the “dry process” during galvanizing. Galvanized components shall not be quenched following galvanizing. Chromate surface passivation treatments shall not be applied to galvanized components which are to be top coated.

17. **Handling and Storage of Materials.** Structural materials, either plain or fabricated, at the fabrication shop or project site, shall be stored on platforms, skids or other supports above high water elevation. These materials shall be kept free from dirt, oil or other contaminants and shall be protected as far as practicable from corrosion. While in storage, structural members shall be padded at points of contact to prevent damage to the coating system. All trough sections which might retain water shall be slightly pitched to provide drainage. Long members shall be supported at frequent intervals to prevent injury from deflection. Girders and beams shall be handled, stored, and braced in the erected position, unless otherwise authorized, and in a manner to avoid injurious distortion.

    Fasteners shall be protected from dirt and moisture at the project site. Only as many fasteners as are anticipated to be installed and tightened during a work shift shall be taken from protected storage. Fasteners not used shall be returned to protected storage at the end of the shift. Fasteners shall not be cleaned of lubricant that is required to be present in as-delivered condition. Fasteners for slip-critical connections which accumulate rust or dirt resulting from job site conditions shall be cleaned, relubricated and tested prior to installation.

    Structural steel members and parts of primary members shall be handled with suitable clamps or plate hooks which will not leave nicks, gouges, or depressions during handling. Damage to primary members shall be repaired by methods approved by the Engineer. The extent and method of repair of damage shall be consistent with the requirements for delivery of structural steel specified in ASTM A 6 and in Section 3 of AWS D 1.5, *Bridge Welding Code.* Chains and chokers of any type shall not be used for handling structural steel unless a protective shield is placed between the chain and the steel. Beams and girders shall be handled during transportation, storage, and erection to keep the handling stresses at a minimum. One-point or two-point pickup shall be employed so that the amount of overhang for a one-point pickup and the amount of overhang and distance between hooks for a two-point pickup shall not exceed the values shown in Table 707-2.

Table 707-2 Rigging Requirements

Beam Size	30" WF	33" WF	36" WF	Plate Girders
Overhang for One-Point or 2-Point Pickup, Max	37 feet	40 feet	42 feet	50 feet
Distance Between Hooks for 2-Point Pickup, Max	74 feet	80 feet	85 feet	100 feet

18. **Marking and Shipping.** The Contractor shall furnish to the Department as many copies of material orders and shipping statements as the Engineer may direct. The weights of the individual members shall be shown on the statements. Members weighing more than 6 tons shall have the weights marked on the member.

    Stamping for identification will be permitted provided low stress stamping equipment is used. If stamped, primary members shall be stamped before coating in the top flange cross-sectional area or on the top of the compression flange within 6 inches of its end. Match marking systems shall be shown and identified on the approved shop drawings. Markings shall be legible after the final coating system is completed.

    Structural members shall be loaded on trucks or railcars so that they may be transported and unloaded at their destination without being excessively stressed, deformed or otherwise damaged. Chains and chain binders will be permitted for securing primary members during shipping only when adequate measures have been taken to prevent gouging of flange edges and damaging the coating by the use of an approved protective shield.

    Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts and packages of bolts, washers and nuts shall be stored and shipped in clean, moisture proof boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contents shall be plainly marked on the outside of each shipping container.

D. **Erection.** These provisions apply to the erection of structural steel.

1. **Methods and Equipment.** Before starting work, the Contractor shall obtain the approval of the Engineer for the proposed equipment and methods of erection to be used. The approval of the Engineer shall not relieve the Contractor of the responsibility for the safety of the method or equipment or from carrying out the work according to the plans and specifications. The Contractor shall not use material intended for use in the finished structure for erection or temporary purposes unless such use is provided for on the plans or by approved by the Engineer.

2. **Bearings.** Column bases, truss and girder pedestals, shoes, and bearing plates shall have a full and uniform bearing upon the substructure concrete. Bearing plate and masonry plate locations and rocker position shall be adjusted as necessary to compensate for temperature at the time of erection as shown on the plans.

3. **Falsework.** The falsework shall be built and removed according to subsection 706.03.B and O.

4. **Straightening and Repair of Damaged Material.** Straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce cracks or other damage. Distorted members shall be straightened by carefully planned and supervised application of a limited amount of localized heat. The temperature of the heated area shall not exceed 1200 °F as

controlled by temperature-indicating crayons, thermometers or other heat indicating devices approved by the Engineer. Mechanical forces shall not be applied for straightening.

Following straightening, the surface of the metal shall be carefully inspected for evidence of damage. Nondestructive testing shall be required as specified by the Engineer.

5. **Assembling Steel.** The parts shall be assembled as shown on the plans and shop drawings. The erection procedures used shall not damage the steel. Bearing surfaces and surfaces to be in permanent contact shall be thoroughly cleaned of rust, loose mill scale, dirt, oil or grease, and all other substances before the members are assembled.

   At the time of erection, machine finished surfaces shall be coated with a commercial grade lubricant suitable for bearings and meeting the approval of the Engineer. Surfaces to be lubricated include pedestal and rocker to sole plate surfaces and all sliding metal on metal bearing surfaces.

   All parts involved in splices and field connections shall be carefully aligned before connection bolts are inserted. The Engineer may require a minimum of ten percent of each splice connection be filled with temporary bolts to bring the plies of steel tight prior to installing permanent bolts. Install permanent bolts in the remaining locations of the splice and commence turn-of-nut tightening of the permanent bolts according to subsection 707.03.D.7.c. Remove the temporary bolts and replace with permanent bolts. Tighten using turn-of-nut method.

   In bolted girder splices, nuts shall not be exposed in fascia girder outer faces or on the bottom faces of lower flanges.

   When girders are field spliced in the air, ⅓ of the bolts, evenly distributed over the connecting elements, shall be installed and snug tightened before lifting devices are released.

   Fully tighten bolts in all spans of continuous girders according to subsection 707.03.D.7 prior to casting deck concrete.

6. **Misfits.** The Contractor shall be responsible for all misfits, errors and damage and shall make the necessary corrections and replacements. The method of correction shall be approved by the Engineer and shall be witnessed by the Engineer. Forcing structural members into place will not be permitted.

7. **Bolted Connections.** The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together and shall not be separated by any compressible material.

   When assembled, all joint surfaces shall be free of mill scale, burrs, dirt and other foreign material that would prevent the solid seating of parts. Nuts, bolts and washers

that are combinations of tested lots that have been tested and approved for use shall remain in that combination of lots when assembled in the field.

a. **Washers.** All fasteners shall have a hardened washer under the element (nut or bolt head) being turned during tightening. The element to be turned in tightening must be seated against a nonsloping surface.

   Where a face of the bolted parts has a slope of more than 1:20 perpendicular to the bolt axis, a smooth beveled washer shall be used to compensate for slope.

b. **Bolt Tension.** Each fastener shall be tightened to provide the minimum bolt tension shown in Table 707-3 for the size of fastener used, when all fasteners in the joint are tight.

   All bolts shall be tightened by the turn-of-nut method according to subsection 707.03.D.7.c. If required because of bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating. The washer shall always be placed under the element being turned. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds. Verification testing, using a representative sample of not less than three bolt assemblies of each diameter, length and heat or lot to be used in the work, shall be performed at the start of work in a device capable of indicating bolt tension. This verification test shall demonstrate that the method for estimating the snug tight condition and controlling the turns from snug tight to be used by the bolting crew develops a tension of not less than five percent greater than the tension required by Table 707-3. Periodic retesting shall be performed when ordered by the Engineer.

Table 707-3 Minimum Bolt Tension for ASTM A 325 Bolts

Bolt Size inches	Minimum Bolt Tension (Equal to 70% of specified minimum tensile strength of bolts.) Pounds
½	12,050
⅝	19,200
¾	28,400
⅞	39,250
1	51,500
1 ⅛	56,450
1 ¼	71,700
1 ⅜	85,450
1 ½	104,000

c. **Turn-of-Nut Tightening.** There shall first be enough bolts brought to a snug tight condition to ensure that the parts of the joint are brought into full contact with each other. Snug tight 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. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. After all bolts in a connection are snugged, they shall be marked to reference the rotation required for tightening. All bolts in the joint shall then be tightened by rotating the nut the amount specified in Table 707-4. Tightening shall progress systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

   ASTM A 325 bolts shall not be reused. Resnugging previously tightened bolts which may have been loosened by the tightening of adjacent bolts shall not be considered as a reuse.

d. **Inspection.** The Engineer will determine if the requirements for bolt tension are met. The Engineer shall have the opportunity to witness the bolt snugging, marking for final rotation, and tightening.

Table 707-4 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)
Up to and incl. 4 D	120° -0°, +30°	180° -0°, +30°	240° -0°, +45°
Over 4 D to 8 D	180° -0°, +30°	240° -0°, +45°	300° -0°, +45°
Over 8 D to 12°	240° -0°, +45°	300° -0°, +45°	360° -0°, +45°
Over 12 D	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.

8. **Field Welding.** Field welding and nondestructive testing shall be performed according to the AWS D1.5 *Bridge Welding Code*. Field welding is not allowed unless shown on the plans or approved by the Engineer.

   All structural field welding shall be done by the shielded metal arc welding (SMAW) process using E7018 electrodes. Gas metal arc welding (GMAW) and other gas welded processes are prohibited. Submerged arc welding (SAW) and flux cored arc welding (FCAW) may be allowed for field welding when approved by the Engineer.

a. **Qualification.**

Welder Qualification. Field welders shall be tested. This testing shall be witnessed by the Engineer. Welder tests by other agencies are not acceptable. As a minimum, this testing will involve running welder qualification tests according to AWS D1.5, Part B, Section 5 in the same position required for field welding as determined by the Engineer. Field Welder qualification shall remain in effect for two years unless the welder is not engaged in welding for a period of three months or more, or unless there is some specific reason to question the welder's ability.

Procedure Qualification. No field welding shall be performed until acceptable welding procedures have been written and established by test. The weld procedure tests shall be done in the same position and joint configuration required for the field welding (e.g., 3F and 4F for fillet welding and 3G and 4G for groove welding). The written welding procedures shall be approved after testing of the welds is completed. These tests shall be according to AWS D1.5, Section 5. Tests shall be performed on steel plate material the same type as that to be welded, with mill certification provided.

b. **Welding Requirements.** The contact surfaces and joints to be field welded and the surrounding area shall be blast cleaned or ground prior to welding. Loose mill scale, paint, galvanizing, grease, oil, rust, moisture, or other contaminates shall be removed from the base metal prior to welding. Joints to be field welded shall be ground to remove pitting and irregularities. Joints to be welded shall be prepared and any foreign material removed according to AWS D 1.5, Section 3.

The parts to be joined shall be brought into as close contact as practicable. If the separation between parts is greater than $^{1}/_{16}$ inch, the legs of the fillet weld shall be increased by the amount of the separation. The separation between parts shall not exceed $^{3}/_{16}$ inch.

Field welding shall not be allowed when the ambient air temperature is below 40 °F or during periods of precipitation unless the area to be welded is heated and housed in a manner approved by the Engineer.

All electrodes shall be dried in an oven at a minimum of 500 °F for a minimum of two hours prior to use. The electrodes shall be stored at a minimum of 250 °F after drying. Electrodes exposed to the atmosphere upon removal from the storage ovens shall be used within two hours or redried as described above. Electrodes shall be redried no more than one time. Electrodes that have been wet shall not be used.

All surfaces to be welded shall be preheated 3 inches in all directions from the weld. All surfaces shall be preheated in advance of the weld to a minimum of 250 °F for base metal up to 1½ inches thickness. For base metal exceeding 1½ inches thickness up to 2½ inches thickness, minimum preheat temperature shall be 300°F. If welding is done on any plate exceeding 2½ inches thickness, the minimum preheat temperature shall be 400 °F.

c. **Inspection.** Weld profiles shall be accepted by visual inspection according to the criteria of AWS D1.5, Section 3.6, and free of defects according to Section 6.26 (i.e., cracks, lack of fusion, overlap, craters, porosity or undercut). Weld profiles shall be smoothly transitioned by grinding where stop/start areas or other irregularities occur.

Welds shall be blast cleaned or ground prior to conducting nondestructive testing (NDT). NDT shall include liquid dye penetrant (PT), magnetic particle testing (MT) or ultrasonic testing (UT). Liquid dye penetrant or magnetic particle testing shall be used for all fillet and partial penetration butt welds. Ultrasonic testing shall be used for all complete penetration butt welds, plug welds and slot welds.

Nondestructive testing methods shall be according to subsection 707.03.C.9 and AWS D1.5. The Engineer shall determine the frequency, location and type of NDT performed by the Contractor prior to accepting the work. Personnel qualified as NDT Level II or Level III according to the American Society for Nondestructive Testing (ASNT), Recommended Practice No. SNT-TC-1A shall perform all tests. The NDT personnel shall provide proper certifications to the Engineer prior to doing the work. The Engineer shall witness all nondestructive testing. Welds that are cracked or determined to be unacceptable by the Engineer shall be rejected and repaired at the Contractor's expense. All welds that require repair shall be repaired according to AWS D1.5, Section 3.7.

All welds that have been repaired shall be inspected and tested prior to acceptance as outlined above.

d. **Welding Piles or Falsework.** Agencies approved by the Department may be used to perform welder qualification tests for welding piles or falsework.

Structural welding or welding repair work shall require Department qualification testing.

The field welder shall present a certificate stating qualification according to AWS specifications within the previous two year period. The Engineer may require a confirming qualification test during the progress of the work.

e. **Field Welding for Form Supports and Accessories.** Whenever the Contractor plans to weld to primary steel members, the Contractor shall prepare and submit to the Department a detailed plan of such operations. Welding will only be permitted with written approval by the Engineer by the Engineer and only if no other means are available. If permitted, welding to steel beams shall only be made in compression areas. Agencies approved by the Department may be used to perform welder qualification tests.

f. **Shear Developers.** Stud shear connectors shall be end welded to steel beams or girders with automatically timed stud welding equipment. Stud welding shall be done and tested according to AWS D 1.5, *Bridge Welding Code.*

Studs on which a full 360-degree fillet weld is not obtained shall be repaired by adding a 5/16-inch fillet weld to replace the missing weld. All rust, mill scale, paint, and galvanizing at the location of the stud shall be removed from the base metal by grinding. The end of the stud shall also be clean.

Welding shall not be done when the temperature is below 32 °F or when the surface is wet or exposed to rain or snow. No preheat will be allowed on the top of the beam flange when automatically timed stud welding equipment is used.

707.04 Measurement and Payment.

Contract Item (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 Foot
Shear Developers	Lump Sum
Bushing	Each

A. Structural steel will be measured by the computed weight of all metal in the finished structure, excluding filler metal used in welding, as shown on approved shop plans or working drawings. The computed weight will be determined by use of the following rules and assumptions:

1. Except as otherwise provided, weights of metal will be assumed as follows:

Material	Pounds per cubic inch
Steel	0.2833
Cast Iron	0.26
Bronze	0.315
Lead	0.411

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

3. The total calculated weight of bolts, nuts and washers in the finished work will be included in the computed weight of structural steel.

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

5. No allowance for galvanizing, optional splices, lifting lugs, shop coating, or excess bolts will be made in the computed weight.

6. The weight of lifting lugs will not be included in the computed weight for structural steel and the cost for furnishing, welding, and removing the lugs will not be measured or paid for separately.

B. Cost for welding and nondestructive testing required for new, retrofitting, repairing, rehabilitation, or replacing structural steel components shall be borne by the Contractor. This applies to shop fabrication and field welding.

Costs of welding qualification specimens, including nondestructive testing of the weld specimens by radiography or ultrasonic testing, confirming test specimens, and the submitting thereof to the Department, shall be borne by the Contractor. The cost of cutting, machining, and testing these specimens will be borne by the Department, except that the cost of testing the additional specimens, for retest after the first test specimen fails, shall be borne by the Contractor.

C. No additional compensation shall be allowed for costs incurred in the certification of structural steel plants. Claims by the Contractor for delays and inconvenience attributed to this certification requirement will not be allowed.

D. **General.**

1. Work required to install and remove temporary bolts as directed by the Engineer will be included in the pay item **Structural Steel, (Rolled Shape, Plate, Mixed), Erect**.

2. **Structural Steel, (Rolled Shape, Plate, Mixed), Furn and Fab** shall include shop cleaning and coating the steel.

3. **Bearing, Elastomeric** will be measured by area with no deductions for holes. The contract unit price for **Bearing, Elastomeric** shall include payment for steel laminates bonded to the elastomeric bearing.

4. **Shear Developers** will be measured as a unit for each structure. Payment for the cost of furnishing studs, cleaning the surface by grinding, and welding the studs to the girder flanges is considered included in the payment for **Shear Developers.**

5. Payment for **Bushing** includes payment for priming the inside of the hole in the link plate and for furnishing and installing the bushing.

6. The cost for field drilling shall be included in the pay item **Structural Steel, (Rolled Shape, Plate, Mixed), Erect.**