ITEM 513 STRUCTURAL STEEL MEMBERS

513.01 Description. This work consists of preparing shop drawings, furnishing and fabricating structural steel members, nondestructive testing, fabricator performed quality control, documentation, cleaning, shop coating, and erecting structural steel and other structural metals. The work also includes any work required to move existing steel structures to the plan location, making necessary repairs and alterations, and connecting or joining new and old construction.

The terms “main,” “secondary,” or “detail,” as referred to in Item 513, are defined as follows: “main” refers to material, members, and fasteners that are primarily stressed by live load and structure weight; “secondary” refers to material, members, and fasteners that do not directly support live load or main members; “detail” refers to essential non-structural material, members, and fasteners.

513.02 Fabricator Approval Procedure. Select fabricators that are listed by ODOT before the Contract letting date as evaluated by the Laboratory and pre-qualified according to ODOT Supplement 1078.

The Laboratory may accept subletting of processes that require specialized machinery or knowledge. Submit written requests for subletting to the Laboratory. The Laboratory will determine if the process is uncommon and will evaluate the qualifications of the proposed sublet fabricator. The fabricator's quality control staff shall witness and perform quality control of the sublet work.

513.03 Levels of Fabricator Qualification. There are eight levels of fabricator qualification. The Laboratory will classify each fabricator at the highest level of fabrication it is qualified to perform.

Level	Description of Capabilities
SF	Standard fabricated members described and paid for as Item 516, 517, and 518 and detailed by standard bridge drawings. Material and fabrication acceptance by certification with random City audits of the work and documentation.
UF	Unique fabricated members not covered by standard bridge drawings and not designed to carry tension live load. Examples include curb plates, bearings, expansion joints, railings, catwalk, inspection access, special drainage, or other products. Examples also include retrofit cross frames, retrofit gusset plates, retrofit lateral bracing, or other miscellaneous structural members not included in Levels 1 through 6. Quality assurance of shop drawings, material test reports, and inspection according to Item 513, UF Level.
1	Single span, straight, rolled beam bridges without stiffeners, Secondary and Detail materials designed to carry tension live loads such as retrofit moment plates. Case II Loading. Quality assurance of shop drawings, material test reports, and inspection according to Item 513, Levels 1 through 5.
2	Multiple span, straight, rolled beam bridges without stiffeners. Case II loading. Quality assurance of shop drawings, material test reports, and inspection according to Item 513, Levels 1 through 5.
3	Single or multiple span, straight, dog legged, or curved, rolled beam bridges including stiffeners. Case I or II Loading. Quality assurance of shop drawings, material test reports, and inspection according to Item 513, Levels 1 through 5.
4	Straight or bent welded plate girder bridges. Case I or II loading. Quality assurance of shop drawings, material test reports, and inspection according to Item 513, Levels 1 through 5.
5	Straight, curved, haunched, or tapered welded plate girder bridges. Case I or II loading. Quality assurance of shop drawings, material test reports, and inspection according to Item 513, Levels 1 through 5.
6	Truss bridges, fracture critical bridges, fracture critical members, or fracture critical components new or retrofitted. Case I or II loading. Quality assurance of shop drawings, material test reports, and inspection according to Item 513, Level 6.

513.04 General. Item 501 includes general information pertaining to structural steel fabrication and erection. Shop painting shall conform to Item 514.

Perform all steel fabrication including the shop application of coatings in a pre-qualified structural steel fabricating shop consisting of adequately sized permanent buildings with equipment, heat and light, and experienced personnel to satisfactorily perform all necessary operations. Perform flame cutting, air carbon-arc gouging,

cambering, welding, cleaning, and painting inside permanent buildings that are maintained at the required environmental conditions. The fabricator may perform shop assembly of large pieces for fit-up of field connections outdoors. These provisions will not apply to steel requiring fabrication at the bridge site in the repair, alteration or extension of an existing structure.

If repairing, extending, or altering existing structures, take measurements of the existing structure as required to accurately join old and new work. Include these measurements on shop drawings. Measurements shown on the plans that indicate the extent and nature of repair, alterations or extension shall not relieve the Contractor of this responsibility.

At least two weeks before starting shop fabrication, the fabricator shall notify the Engineer and furnish a proposed fabrication schedule for the work.

Unless the Engineer provides a written waiver of a hold or witness point inspection, the fabricator shall store members completed during the inspector's absence in a manner that allows the inspector to completely and safely inspect the finished work.

The fabricator shall not ship fabricated members performed under Item 513, UF Level or Levels 1 through 6 from the shop without prior hold point inspections unless the Engineer waives the inspection. The Engineer will not conduct the scheduled final inspection until the fabricator completes and inspects with documentation, final fabrication and shop coatings and the Contractor documents approval of shop drawings and material test reports.

The Engineer will not conduct a final fabrication inspection of SF Level members. Instead, the Engineer will conduct random inspections during the fabricator's work.

The fabricator shall provide an office with the following attributes:

A. A minimum floor area of 120 square feet (11 m^2).

B. A minimum ceiling height of 7 feet (2.1 m).

C. Adequate working and storage facilities with one locking file cabinet for the exclusive use of the City's inspector, lighting, and electrical outlets.

D. Provisions for heating to a minimum temperature of 68 °F (20 °C) and adequately ventilated.

E. A telephone with direct access to an outside trunk line for the exclusive use of the inspector.

If using steel stamps for identification purposes, use the "mini-stress" or "stressless" type.

513.05 Fabricator Documentation Responsibility. The fabricator shall keep and maintain documentation records as specified in ODOT Supplement 1078.

At the City's request, provide access to the above documents for audit, inspection, and copying.

513.06 Shop Drawing. Provide shop drawings conforming to 501.04 and the following requirements:

Include details, dimensions, size of materials, match mark diagrams for field connections, a diagram identifying, by some unique mark, each area of a welded splice to be covered by a single radiograph, and other information necessary for the complete fabrication and erection of the metal work.

For multiple span beam and girder bridges, include an overall layout with dimensions showing the relative unloaded vertical and horizontal position of beam or girder segments with respect to a full length base or work line. Account for camber and horizontal curvature of the beams or girders, and the effect of deck surface profile in this layout. Show required offsets for vertical and horizontal curvature at approximately each one-fourth of span length, at field splices, and at bearing points. For horizontally curved members, show the offset to a baseline strung from end to end of the member, every 10 feet (3 m) of length.

Identify the grade (ASTM designation), CVN, fracture critical, or any special testing requirements for each piece of steel. Identify pieces made of different grades of steel with different assembling or erecting marks, even if the pieces have identical dimensions and detail.

Identify the welding procedure by the WPS number at each joint and the location and identification numbers of all radiograph tests.

Detail structural steel to fit under full steel dead load and prior to deck placement with the webs of primary members plumb.

513.07 Levels 1 through 6, Pre-Fabrication Meeting. After providing the notice and schedule required by 513.04 and at least 7 days after the City receives shop drawings, conduct a pre-fabrication meeting at the fabricator's facilities, or another location agreed to by all parties. The fabricator and its quality control specialists for fabrication and painting, the inspector, and the Contractor, or its designated representative, shall attend the meeting. The purpose of this meeting is to review any fabrication issues, including information on shop drawings, inspection, hold or witness points, unique fabrication items, special processes, and both the fabrication and project schedule. The fabrication quality control specialist shall conduct the meeting and record and distribute meeting minutes that document all issues discussed. Fabrication may begin after the pre-fabrication meeting is complete.

513.08 Materials. Furnish materials conforming to 501.06.

513.09 Material Control. Identify and mark each piece of steel according to the shop drawings and the following requirements.

Immediately after removing steel that is furnished in tagged lifts or bundles, mark the individual pieces of steel with the ASTM A 6/A 6M specification identification color code and heat number.

The fabricator may furnish material from stock that is marked with the heat number and mill test report.

If separated from the full-size piece furnished by the supplier, mark excess material placed in stock for later use with the heat number and, if provided, with the ASTM A 6/A 6M specification identification color code.

During fabrication, clearly and legibly mark the specification identification color code and heat number on each piece of steel.

Before cutting steel into smaller size pieces, clearly and legibly mark each smaller size piece with the ASTM A 6/A 6M specification identification color code and heat number.

Unless otherwise approved by the inspector, mark pieces of steel that will be subject to fabricating operations such as blast cleaning, galvanizing, heating for forming, or other operations that may obliterate paint color code and heat number markings with steel stamps or with a substantial tag firmly attached to the piece of steel. At locations acceptable to the Engineer, stamp the heat numbers into main material tested for CVN.

Issue cutting instructions by cross-referencing the assembly marks shown on the shop drawings with the corresponding item covered on the mill purchase order. The fabricator's system of assembly-marking individual pieces of steel and issuing cutting instructions shall provide a direct reference to the appropriate mill test report.

The fabrication quality control specialist shall provide the Engineer with a letter documenting that the fabricator performed material control according to this specification.

513.10 Care of Material. Store structural material at the shop or field above the ground, upon platforms, skids, or other supports. Use straight structural steel with clean and dry surfaces before working it in the shop. Before using, clean all rusted or corroded material. Only use this material if it conforms to ASTM A 6/A 6M thickness tolerances after cleaning.

513.11 Workmanship and Straightening. If necessary to straighten rolled material, use methods that will not damage the member. If carefully planned and supervised, apply localized heat for straightening. Do not allow the temperature of the heated area to exceed 1150 °F (620 °C) as controlled by pyrometric stick or thermometers. Do not quench to accelerate cooling. Do not kink or offset the material if using mechanic or hydraulic force to camber or strengthen material. Do not cold bend fracture critical materials.

Camber rolled beams as shown on the plans in the pre-qualified fabricating shop using heat or hydraulic jacks. Control heating as specified above and follow a formal shop heating procedure. Camber plate girders by trimming web plates before assembly. During fabrication, shipping, and erection, support and handle members to maintain camber.

Fabricate structural steel to within the dimensional tolerances specified by Articles 3.5 of the AASHTO/AWS *Bridge Welding Code*, with the following modifications:

A. Waviness, the deviation of the top or bottom surface of a flange from a straight line or plan curvature, shall not exceed 1/8 inch (3 mm) when the number of waves in a 10-foot (3 m) length is four or less, or 1/16 inch (1.6 mm) when more than four, but sharp kinks or bends shall be cause for rejection.

B. For the measurement of camber during lay down, position the bearing points both horizontally and vertically to plan dimensions ±1/8 inch (±3 mm).

C. Measure camber as the vertical offset between the steel and the common base line extending from abutment bearing to abutment bearing. The maximum camber tolerance at mid-span shall be 0 inch (0 mm) and the greater of +3/4 inch (+19 mm) or the designed haunch height. Prorate the maximum camber tolerance at mid-span between the center of the span and each adjacent bearing to provide a smooth unbroken curve.

D. Permissible difference in horizontal curvature of top and bottom flange at any point on centerline of member, when measured as specified in 3.5.1.4, shall not exceed 3/8 inch (10 mm)

513.12 Finish. Plane sheared edges of all main material to a minimum depth of 1/4 inch (6 mm) except for ASTM A 709/A 709M, Grade 36 (250) steel having a thickness of 5/8 inch (16 mm) or less. Remove fins, tears, slivers, and burred or sharp edges from steel members by grinding. If these conditions appear during the blasting operation, re-grind and re-blast the steel members to the required surface profile.

The fabricator may flame cut structural steel. Provide a smooth surface, free from cracks and notches, and use a mechanical guide to provide an accurate profile. Roll and flame cut surfaces according to the AASHTO/AWS *Bridge Welding Code*, as amended by ODOT Supplement 1011.

Provide a surface finish for bearing and base plates and other bearing surfaces that contact each other or concrete according to ANSI B46.1, Surface Roughness, Waviness and Lay, Part I.

ANSI B46.1	
Steel slabs	2000 mil (50.0 μm)
Heavy plates in contact in shoes to be welded	1000 mil (25.0 μm)
Milled ends of compression members, milled or ground ends of stiffeners and fillers	500 mil (12.5 μm)
Bridge rollers and rockers	250 mil (6.4 μm)
Pins and pin holes	125 mil (3.2 μm)
Sliding bearings	125 mil (3.2 μm)

513.13 Stiffeners. Place the bearing end of bearing stiffeners flush and square with the web and in a manner so at least 75 percent of the area of the bearing end is in contact with the inner surface of the flange. The other end of the bearing stiffener shall have a tight fit as defined below. Position bearing stiffeners to be vertical after erection. Weld intermediate stiffeners that are not used in pairs to the compression flange, and provide a tight fit for the tension flange. Weld intermediate stiffeners connected to cross frame angles to the top and bottom flange.

A tight fit is defined as the contact between the stiffener and flange over some portion of the end of the stiffener and having no gap greater than 1/16 inch (1.6 mm).

Clip stiffeners 2 1/2 inches (65 mm) along the web and 1 inch (25 mm) along the flange to clear flange-web welds and fillet or rolled shapes.

When attaching stiffeners to the web and flanges, do not extend welds to the edge of the stiffeners or into the clip area. Terminate these welds 1/4 ± 1/8 inch at the flange connections and 1/2 ± 1/4 inch at the web connection.

513.14 Fillers. Detail the shop drawings to show fill plates that compensate for the misalignment of abutting elements due to differences in thickness of flanges and webs at the splice locations. Detail the fill plates to the nearest 1/16 inch (1.6 mm) in thickness, but not less than 1/8 inch (3 mm) thick. However, in the final shop assembly, furnish fills of sufficient thickness to compensate for misalignment of abutting elements due to standard rolling mill tolerances or due to differences in thicknesses of flanges and webs at the splice location. The actual fills used shall compensate for differences in total thickness or relative positions of more than 1/16 inch (1.6 mm) but with no fills less than 1/8 inch (3 mm) thick. Provide fill plates in bolted joints that are flush with the perimeter of the splice plates.

513.15 Horizontally Curved Beams and Girders. If members are to be heat curved, submit the detailed procedure, including necessary calculations, to the Engineer. Obtain the Engineer's acceptance of the procedure before starting this work.

Curve beams and girders using heat according to *AASHTO Standard Specifications for Highway Bridges*, except that the fabricator may cut flanges for girders to obtain the required alignment.

513.16 Joints and Splices. In bolted construction where tension or flexural members are spliced, maintain a clearance of not more than 1/4 inch (6 mm) between the abutting surfaces of spliced members. For spliced compression members, face the abutting surfaces to provide a uniform bearing when properly aligned and completely bolted.

In welded construction, prepare abutting surfaces as shown on the shop drawings. Verify the preparation for field welded butt joints in main members by a complete shop assembly according to 513.24.

513.17 Pin Holes. Bore pin holes after the member is fabricated and true to size, at right angles to the axis of the member and parallel to each other. Pin holes for up to 5-inch (127 mm) diameter pins shall not exceed the pin diameter by more than 0.020 inch (0.51 mm) and pin holes for larger pins shall not exceed the pin diameter by more than 0.031 inch (0.79 mm).

513.18 Pins and Rollers. Use pins and rollers made from cold rolled steel, accurately turned to size, straight and smooth, and entirely free from flaws. Pins over 9 inches (230 mm) in diameter shall be annealed. In pins larger than 9 inches (230 mm) in diameter, bore a hole not less than 2 inches (50 mm) in diameter the full length of the axis. Furnish one pilot and one driving nut for each size of pin.

513.19 Holes for High-Strength Bolts and Bearing Bolts. Provide cylindrical holes, perpendicular to the member, clean cut, and free of ragged edges. Remove burrs by countersinking not more than 1/16 inch (1.6 mm) or by grinding. Provide finished holes with a diameter not larger than the nominal diameter of the bolt plus 1/16 inch (1.6 mm). The hole diameter shall not vary by more than 1/32 inch (0.8 mm) from a true circle for 85 percent of the holes in a contiguous group, and not more than 1/16 inch (1.6 mm) for the remainder.

Punch holes using a die with a diameter not exceeding that of the punch by more than 1/16 inch (1.6 mm). Ream and drill holes using twist drills and twist reamers. Wherever possible, direct the reamer by mechanical means.

Sub-drill holes 3/16 inch (5 mm) less in diameter than the nominal diameter of the bolt, and ream the holes to size with the parts assembled, except:

A. The fabricator may sub-punch main material conforming to ASTM A 709/A 709M, Grade 36 (250) steel that is less than 3/4 inch (19 mm) thick, and Grade 50 (345) or 50W (345W) steel that is less than 5/8 inch (16 mm) thick.

B. The fabricator may drill full-size holes in materials assembled and adequately clamped together.

C. The fabricator may punch full-size holes in secondary and detail material conforming to ASTM A 709/A 709M, Grade 36 (250) steel that is less than 3/4 inch (19 mm) thick, and Grade 50 (345) or 50W (345W) steel that is less than 5/8 inch (16 mm) thick.

D. The fabricator may make assemblies such as floor beams connected to girders and rolled beam spans connected by diaphragms through steel templates.

Place all sub-punched or sub-drilled holes with sufficient accuracy such that after assembling (before reaming) a cylindrical pin 1/8 inch (3 mm) smaller than the nominal size of the punched hole may be entered perpendicular to the face of the member without drifting in not less than 75 percent of the contiguous holes in the same plane. All holes shall allow a pin 3/16 inch (5 mm) smaller than the nominal size of the punched holes to be inserted in the above manner.

Do not plug located holes without written approval from the Engineer.

Provide steel templates with hardened bushings in holes that are accurately located in relation to the centerline of the connection as inscribed on the template. The fabricator is not required to use hardened bushings when using a roto-broach, shell drill, or other similar tool, to make the holes.

Ream and drill holes through multiple piles only if the plies of the joint are held tightly together with bolts or clamps and if sub-punched or sub-drilled, only if the joint is pinned. Disassemble and clean the piles of burrs and shavings before final assembly.

The Contractor may drill or punch bolt holes full sized in unassembled pieces or connections, including templates for use with matching sub-sized and reamed holes, using suitable numerically controlled (N/C) drilling or punching equipment. If using N/C drilling or punching equipment, demonstrate the accuracy of the drilling or punching procedure to the inspector according to 513.24.

After holes are reamed or drilled full size, 85 percent of the holes in any contiguous groups shall have no offset greater than 1/32 inch (0.8 mm) between adjacent plies. The remainder of the holes shall not be offset more than 1/16 inch (1.6 mm) between adjacent plies.

If requested in writing, the Engineer may consider other methods of preparing holes for high-strength bolts.

513.20 High-Strength Steel Bolts, Nuts, and Washers. Provide high-strength steel bolts, nuts, and washers conforming for all bolted connections including erection bolts for cross frames and lateral bracing to 711.09.

A. General. Provide the Engineer with access to the work for observing the installation and the tightening and checking of the bolts.

Determine the required bolt length by adding the value from Table 513.20-1 to the grip. The table values include an allowance for manufacturing tolerances and provide a bolt length for threads to protrude through the nut. Add 5/32 inch (4 mm) for each hardened flat washer used and 5/16 inch (8 mm) for each beveled washer used. Adjust the length, as determined by Table 513.20-1, to the next longer 1/4 inch (6 mm); when installed, the end of the bolt shall be flush with or project several thread lengths outside the face of the nut.

TABLE 513.20-1

Bolt Size (inches)	To determine required bolt Length, add to grip[1] (inches)
1/2	11/16
5/8	7/8
3/4	1
7/8	1 1/8
1	1 1/4
1 1/8	1 1/2
1 1/4	1 5/8
1 3/8	1 3/4
1 1/2	1 7/8
[1] Total thickness of all connected material excluding washers.	

TABLE 513.20-1M

Bolt Size (mm)	To determine required bolt length, add to grip[1] (mm)
M16	24
M20	28
M22	31
M24	35
M27	38
M30	41
M36	47
[1] Total thickness of all connected material excluding washers.	

Use bolts, nuts, and washers with a residual coating of lubricant when received. Do not use bolts, nuts, and washers without their original lubrication.

B. Preparation. With the exception of metalizing, galvanizing, and both organic zinc and inorganic zinc primers, remove coatings from joint surfaces, including surfaces adjacent to the bolt heads, nuts, and washers. Remove lacquer, dirt, oil, loose scale, rust, burrs, pits, and other substances or defects that prevent solid seating of the parts or interfere with the development of complete frictional contact. Do not place gaskets or other yielding material between joint surfaces.

C. Installation. For each bolt, place a hardened washer under the element (nut or bolt head) turned in tightening. If an outer face of the bolted parts has a slope of more

than 1:20 with respect to a plane normal to the bolt axis, use a smooth beveled washer to compensate for the lack of parallelism.

If necessary, the Contractor may clip washers, at one location, not closer than seven-eighths of the bolt diameter from the center of the washer.

During final assembly of the parts to be bolted, first install a sufficient number of drift pins to provide and maintain accurate alignment of holes and parts, then a sufficient number of bolts tightened to a snug tight condition to bring all the parts of the joint into complete contact. Replace any bolts that were installed before installing drift pins. Before releasing the member from the hoisting equipment, fill half the holes with drift pins and bolts tightened to a snug tight condition in at least 50 percent of the holes (preferably, half pins and half bolts) but use at least two drift pines in each flange and web of each beam or girder. Install bolts starting at the most rigidly fixed or stiffest point and progress toward the free edges.

Use cylindrical drift pines that are not more than 1/32 inch (0.8 mm) smaller than the hole diameter.

Bolts are snug tight when an impact wrench begins to impact the nut or when a man applies full effort using an ordinary spud wrench.

Install bolts in the remaining open holes and tighten the bolts to a snug tight fit, after which all bolts shall be tightened completely by the turn-of-nut method.

Where difficulty is experienced with the fit of the connection and the bolts are used to draw the elements into contact, check all bolts in the affected portion of the connection for a sustained snug tight condition.

Replace drift pins with completely tightened bolts only after all the remaining holes are filled with completely tightened bolts.

Do not field ream holes drilled full size during fabrication.

After bolts are snug tight, the wrench operator shall match-mark the outer face of the nut with the flush or protruding portion of the bolt using a crayon or paint. The Engineer will use the match-marks to determine the relative rotation between the bolt and nut during final tightening using the turn-of-the-nut method.

Commence tightening at the most rigidly fixed or stiffest point and progress toward the free edges, both in the initial snugging up and in the final tightening. If required because of wrench operation clearances, tightening may be done by turning the bolt. If used, provide impact wrenches of adequate capacity to perform the required tightening each bolt in approximately 10 seconds.

Do not reuse galvanized A 325 bolts. Re-tightening previously tightened bolts that became loose by tightening adjacent bolts is not reuse.

Follow the additional bolting requirements in 513.26.

D. Bolt Tension. When all bolts in the joint are tight, the minimum bolt tension for each bolt size is shown in Table 513.20-2.

TABLE 513.20-2

Bolt Size (inches)	Bolt Tension[1] (kips), minimum A 325
1/2	12
5/8	19
3/4	28
7/8	39
1	51
1 1/8	56
1 1/4	71
1 3/8	85
1 1/2	103

[1] Equal to 70 percent of specified minimum tensile strengths of bolts, rounded off to the nearest kip.

TABLE 513.20-2M

Bolt Size (mm)	Bolt Tension[1] (kN), minimum A 325M
M16	91
M20	142
M22	176
M24	206
M27	267
M30	327
M36	475

[1] Equal to 70 percent of specified minimum tensile strengths of bolts, rounded off to the nearest kN.

TABLE 513.20-3 NUT ROTATION FROM SNUG TIGHT CONDITION

	Disposition of Outer Faces of Bolted Parts		
Bolt Length (as measured from underside of head to extreme end of point)	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)	Both faces sloped not more than 1:20 from normal to bolt axis (bevel washer not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn

Attain the bolt tension specified in Table 513.20-2 by tightening all bolts, the applicable amount of nut rotation specified in Table 513.20-3 by the turn-of-nut method.

Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. Tighten bolts requiring 1/2 turn and less within ±30 degrees and tighten bolts requiring 2/3 turn and more within ±45 degrees.

E. Inspection.

1. The Engineer will inspect the first completed connection of each bridge according to 513.20.E.2 below and subsequent connections the Engineer deems necessary. Thereafter, where the Engineer has approved the joint compactness and snug-tight condition of bolts prior to bolt tightening by the turn-of-nut method, the bolt tension as required in Table 513.20-2 shall be considered as attained if the amount of nut rotation specified by Table 513.20-3 is verified by the required match-marking.

2. Furnish and use manual torque wrenches to inspect bolts. Perform test to the satisfaction of the Engineer. Calibrate the inspection torque wrenches at least once each workday using a device, approved by the Engineer, and capable of indicating bolt tension. Use three bolts, placed and tensioned individually, representative of the grade, size, length, and condition used in the structure to determine the job inspection torque according to 513.20.E.3. Place a washer under the part being turned.

3. Tighten each of the three representative bolts, using any convenient manner, to the tension shown in Table 513.20-2. Then, using the inspection wrench, apply a slow steady pull to the tightened bolt and measure the torque required to turn the nut or head 5 degrees, approximately 1 inch (25 mm) at a 12-inch (300 mm) radius in the tightening direction. Use the average torque measured in the tensioning of the three bolts as the job inspection torque.

4. With the Engineer present, randomly select for inspection two bolts or 10 percent of the bolts, whichever is greater, from each connection represented by the 3-bolt sample described in 513.20.E.2. Using the inspection wrench, apply the job inspection torque in the tightening direction. The Engineer will accept the connection if the job inspection torque does not turn the nut or bolt head. If the job inspection torque turns a nut or bolt head, apply the job inspection torque to all the bolts in the connection and reinspect the connection as described above.

F. Calibration Devices. The manufacturer of the calibration device or a qualified testing laboratory shall periodically examine each calibration device at least once each year and other times if requested by the Engineer. After calibration, the manufacturer or testing laboratory shall certify that each calibration device accurately indicates the actual bolt tension.

513.21 Welding. Perform welding by the shielded metal-arc, submerged arc, flux cored arc, or stud welding process. Only shielded metal arc (stick) welding is prequalified. All other welding processes require testing and approval by the Engineer. Consideration will be given to other methods of metal-arc welding if a written request is submitted to the Engineer.

In other respects, the AASHTO/AWS *Bridge Welding Code*, as amended by ODOT Supplement 1011, shall govern the work.

Post copies of the shop welding procedures at each welding location.

Weld only fracture critical and main members when the fabrication quality control specialist and inspectors are physically at the facility. The fabricator shall not perform

fracture critical welding without prior scheduling with the fabrication quality control specialist and the inspector. The fabrication quality control specialist shall witness the minimum percentages specified in ODOT Supplement 1078 and shall check all welding processes.

For non-fracture critical welds, the fabrication quality control specialist shall perform frequent inspections, and check all welding processes.

513.22 Stud Shear Connectors. Perform stud welding according to the AASHTO/AWS *Bridge Welding Code*, as amended by ODOT Supplement 1011, and this subsection.

In addition to the stud bend tests of Article 7.6.6.1 of the AASHTO/AWS *Bridge Welding Code*, perform bend tests of stud shear connectors at the start of each workday, when welding has been interrupted for an hour or more, when changing grounds, when changing weld settings, and when changing cable loop due to arc blow. Do not weld more than 500 studs without the welds being field bend tested in accordance with the specified procedure. The Contractor may leave in the bent position tested studs that show no sign of failure, as determined by the Engineer.

Weld stud shear connectors to the top flanges of beams or girders after the steel has been erected and suitable scaffolding or deck forming has been provided. Studs may be welded to beam or girder webs, end dams, bearing plates, or to other secondary members and detail material in the shop.

513.23 Threads for Bolts and Pins. Threads for pins shall conform to the Unified Standard Series ANSI B1.1-UNC (ANSI B1.13M) Class 2A (6g) for external threads and Class 2B (6H) for internal threads, except that pin ends having a diameter of 1 3/8 inches (35 mm) or more shall be threaded 6 threads to the inch (4.23 mm/thread).

513.24 Shop Assembly. Remove paint, grease, oil, rust, loose mill scale, and protruding edges or burrs from all contact surfaces. Unless waived by the Engineer, do not assemble and weld flanges and webs to form girders or other similar members and do not accomplish fabrication or assembly that interferes with the repair of a butt weld until the fabrication quality control specialist for the A rated fabricators or the inspector for B and C rated fabricators examines and approves radiographs of all butt welds in the component parts.

Perform fit-up work with the members assembled in unloaded positions as shown on the shop drawing layout required by 513.06. During shop assembly, adequately support members, especially at joints, to prevent misalignment or deflection and designate supports that prevent settlement during the fit-up, reaming or drilling of connections. The fabrication quality control specialist shall maintain records of the actual horizontal and vertical dimensions and relative positions of each assembly for each offset required by 513.06 and, upon request, furnish a copy to the inspector. Reposition members that become a part of two assemblies for the second assembly to the dimensions recorded for the first assembly.

Using steel stamps, match-mark all connecting parts assembled in the shop for the purpose of reaming or drilling of holes for field connections or for fit-up of field welded connections before disassembly. Punch mark bearing centerlines.

Continuous beam and plate girders, including sections adjacent to hinged, pin connected, sliding, or rocker bearing joints, shall have at least three adjacent segments

assembled, and holes reamed or drilled while assembled. Check the fit-up of field welded connections by similar shop assembly.

Shop assemble longitudinal or transverse beams and girders that are either framed or connected by diaphragms and floor beams to check fit-up of connections to be field welded, or to ream or drill holes for bolted connections. Assemble trusses in lengths of at least three abutting panels before drilling or reaming field connections.

Include deck plates in the final shop assembly of bridges that involve railroad deck plates, even if welding of these deck plates takes place in the field.

If the fabricator elects to use numerically controlled drilling or punching, the required assembly shall be performed as specified above. The Engineer will consider the Contractor's written request to use other methods of checking hole alignment and match marking. If the Engineer does not consider, or disapproves the fabricator's proposed methods of assembly, perform the work according to 513.19 and 513.24.

After fabrication, shop assemble deck expansion devices to check fit-up, straightness, and roadway cross-slope changes. Full width assembly is required with phased construction if expansion devices have interlocking fingers or have mechanical devices that require exact field alignment.

The fabricator may fabricate part-width deck segments without the required shop assembly under the following conditions:

A. The plans require a phased construction sequence.

B. Shop drawings incorporate a lay down, similar to 513.06, defining vertical offset dimensions from a full length common baseline to all roadway changes including sidewalks, rounding, crowns, and field splice points of the expansion device.

Secure parts not completely assembled in the shop with temporary bolts to prevent damage in handling and shipping. In the shop, bolt field splice plates into final position shift the splice plates laterally with respect to their final position so that the ends of the plates are flush with the ends of the member. Without the Engineer's written acceptance, do not weld or tack-weld to bolted assemblies. Perform authorized welding according to 513.21.

513.25 Nondestructive Testing. Nondestructive testing shall conform to the AASHTO/AWS *Bridge Welding Code*, as amended by ODOT Supplement 1011 and as specified below.

As the Engineer directs, perform ultrasonic or radiographic inspection of field welded repairs in main members for thick scabs, deep kerfs or nicks, and similar gross flaws. Ensure that all examined welds and base metal adjacent to a welded joint conform to the quality requirements specified in 513.21. Submit radiographs, field sketches showing specific locations, lengths and depths of the repair, and two copies of the radiographic or ultrasonic technical reports to the Engineer for acceptance. Receive the Engineer's acceptance before performing construction activities making welds inaccessible for repair.

The Contractor or fabricator shall notify the City at least 48 hours before performing nondestructive testing. Provide this notice even if specific hold or witness point inspections are not required by ODOT Supplement 1078.

The Engineer has the final authority to accept welds and will resolve controversies regarding the interpretation of radiographs, magnetic particle indications, or the acceptability of welds.

A. Radiographic Inspection of Welds. Before inspection, grind welds smooth. Grind web splices only where radiographed, except grind outside fascia surfaces the full length. Inspect the following welds:

1. The full length of all butt welds in flange material of plate girders or rolled beams. One hundred percent of butt welds in back up bars that remain in the structure.

2. The top and bottom one-third of transverse web splices in plate girders or rolled beams and show any cope holes. If an unacceptable weld occurs, radiograph an adjoining 12-inch (300 mm) length of weld not previously inspected. If unacceptable flaws are found in this adjoining segment, radiograph the remainder of the weld.

3. Butt welds in longitudinal stiffeners attached to tension areas of webs.

4. Twenty-five percent of each longitudinal web splice as selected by the inspector.

5. Full length of field flange cut repairs.

6. Other welds specified in the Contract or AASHTO/AWS *Bridge Welding Code*.

Use a steel stamp to make the radiograph identification mark shown on the shop drawing layout in the area marked "Weld Identification" of Figures 6.1A through 6.1D of the AASHTO/AWS *Bridge Welding Code* in a manner to make it visible in the radiograph of the area without resorting to superimposed like markings. Place steel stamped identification marks on flange plates so that after girder assembly the marks are on the inside of flange and outside the area fastened to the web. Identify films of repaired welds by the letter "R". Do not place steel stamped identification numbers within the weld area. Use superimposed characters to make other required markings.

Use film locations or a technique employed that will show the top and bottom images of the plate edge. Use films 4 1/2 × 17 inches (114 × 432 mm) where practical and a minimum film size of 4 1/2 × 10 inches (114 × 254 mm).

Supply a technical report for the RT testing similar to Annex III Form III-5 of the AASHTO/AWS *Bridge Welding Code*, and include the following: Project identification, member piece mark, description of the repairs made, and the qualification level of the technician.

The City will take ownership of contact films. For main material repairs, provide sketches that clearly show specific locations, lengths and depths of field cuts, or damages repaired by field welding.

B. Magnetic Particle Inspection of Welds. Before magnetic particle inspection (MPI), complete welding required to fabricate each beam or girder, correct all visual defects, and clean the weld. If the fabricator's quality control plan is acceptable to the City and additional processing does not produce a potential for cracking, the City may allow the Contractor to perform MPI before complete welding.

Inspect welds using the procedure and techniques for the dry powder magnetic-particle examination of welds using the prod or the yoke method according to AWS 6.7.6. The prod test equipment shall have a functioning ammeter. Provide a prod magnetizing current of 100 amperes per inch (25 mm) of prod spacing but not less than 400 amperes. Use only aluminum prods.

Inspect at least 1 foot (0.3 m) for every 10 feet (3 m), or fraction thereof, for each size of weld in the following:

1. Flange-to-web welds, including ends of girder after trimming.
2. Moment plate to flange welds.
3. Bearing stiffener welds.
4. Other welds specified in the Contract or AASHTO/AWS *Bridge Welding Code*.
5. Field weld repairs as directed by the Engineer.

The inspector or the fabrication quality control specialist will select random test sections. Unless waived by the Engineer, the inspector will observe inspection by C-rated fabricators. Position test sections as necessary for the inspection and after considering the safety and convenience to the inspecting personnel.

If a test section contains unacceptable defects, test 5-foot (1.5 m) segments on both sides of the test section, or, if less than 5-foot (1.5 m) segments are on both sides of the test section, test the full length of the weld. Retest welds requiring repair after repairs are complete. If the fabricator's quality control plan is acceptable to the City and additional processing does not produce a potential for cracking, the Engineer may allow the Contractor to perform MPI before complete welding.

MPI will not locate all surface defects of Article 9.21 of the AASHTO/AWS *Bridge Welding Code*. Unacceptable welds have MPI results that indicate defects exceed the above quality standards.

For each unacceptable defect, the fabricator shall record the piece mark, the location of the defect on the member, the defect description, and the proposed repairs.

C. Ultrasonic Testing of Welds. Perform ultrasonic inspection of the following welds:

1. Complete joint penetration flange-to-web, T, or corner joint welds: 25 percent for non-FCM, 25 percent compression or shear FCM, and 100 percent tension FCM.
2. Complete penetration butt welds: 100 percent tension FCM and 25 percent compression FCM.
3. Other welds: as specified in the Contract or AASHTO/AWS *Bridge Welding Code*.

The fabrication quality control specialist shall provide the Engineer with specified certification, sketches, technician reports, and a letter documenting that the Contractor performed nondestructive testing according to this specification.

513.26 Shipping, Storage, and Erection. Repair or replace, at the discretion of the Engineer, members damaged by improper handling, storing, or erection.

During transportation, place adequate blocking between members to prevent movement and facilitate unloading. Unless reinforced by additional plates, angles, or other material bolted in place, do not use field connection holes for tie-down. Band together bearing components.

Place material stored in the fabricating shop or in the field on skids or blocks to prevent the metal from contacting the ground. Place and shore girders and beams in an upright position for shipping, and field and shop storage. Bolt field splice plates using temporary bolts, and remove and replace temporary bolts when field splice plates are placed in their final position or shifted laterally with respect to their final position. Keep material clean and properly drained. Install bearing devices and anchorages according to Item 516.

Thoroughly clean bearing surfaces and surfaces to be in permanent contact before the members are assembled in the field.

Before erecting structural steel, completely bolt up field splices and connections that started before steel erection.

During erection, the Engineer will allow drifting to draw the parts into position, but do not enlarge the holes or distort the metal. Install drift pins and bolts according to 513.20. Fill at least three-fourths of the holes with completely tightened bolts in splices and connections subject to construction loads during erection. Complete permanent fastening of steel truss tension chord members before removing falsework. Permanently fasten compression chord members after the span is released sufficiently from the falsework to bring the compression chord joints into full bearing. Properly regulate and maintain elevations of panel points and ends of floor beams until the falsework is removed.

Do not enlarge the holes of splices and connections between segments or elements of main members without approval by the Engineer.

Adjust structures to the correct alignment and to the marked bearing centerlines before beginning permanent fastening. Do not permanently fasten cross frames and lateral bracing in continuous beam or girder spans until completing main connections in adjacent spans; however, install sufficient bracing to maintain structural stability. For erection bolts used to fasten cross frames, use not less than 5/8-inch (16 mm) diameter, and fully tighten bolts according to 513.20.

Erect end cross frames and end dams in a manner that ensures bearing parts remain in bearing contact.

Permanently fasten all intermediate cross frames before deck placement begins.

The webs of primary members shall be plumb before deck placement begins.

513.27 Shop Coating. For steel surfaces specified to be coated according to Item 514, apply a prime coat in the shop.

513.28 Cleaning ASTM A 709/A 709M, Grade 50W (345W) Steel. Before the new steel is shipped, solvent clean, where necessary, all surfaces of ASTM A 709/A 709M, and Grade 50W (345W) steel that are to be left unpainted to remove all traces of

asphalt cement, oil, grease, diesel fuel deposits, chalk, paint marks, and other soluble contaminants according to SSPC-SP 1 Solvent Cleaning. QCP #1 and QCP #2 shall apply according to Item 514.

Shop blast unpainted Grade 50W material to SSPC-SP 6, commercial blast. QCP #3 shall apply according to Item 514.

After placing superstructure concrete, clean, where necessary, the exterior surface and bottom flanges of all fascia beams or girders that are to be left unpainted to remove all traces of asphalt cement, oil, grease, diesel fuel or petroleum deposits, concrete, and other contaminants.

Do not use acid for cleaning.

513.29 Method of Measurement. The City will measure Structural Steel Members on a lump sum basis or by the number of pounds (kilograms).

If payment is per pound (kilograms), submit weight computations to the Engineer based upon the accepted shop drawings. Deduct waste material, removed by burning, cutting, machining, holes, etc., but include groove weld bevels. Include the weight of all permanent fasteners, shop fillet welds, other metals and preformed bearing pads. Exclude the weight of paint or galvanized coatings. Exclude thickness or weight of members exceeding the plan requirements (due to overweight or other cause), unless authorized by the City. As an option, measure and record the weight of structural members before painting in the presence of the inspector. Use the following unit weights for computations.

	lb/ft^3 (kg/m^3)
Steel, cast steel, and deposited weld metal	490 (7850)
Cast iron	450 (7210)
Phosphor or leaded bronze	550 (8810)
Lead	710 (11370)
Preformed bearing pads	710 (11370)

The City will measure Welded Stud Shear Connectors by the number of each installed and accepted.

513.30 Basis of Payment. If the fabricator's proposed methods of assembly with numerically controlled drilling or punching fail to produce specified results and the Engineer directs the Contractor to perform work, as per 513.19 and 513.24, the City will not pay for this work.

For steel surfaces specified to be coated according to Item 514, the cost of applying a prime coat in the shop is incidental to the bid for structural steel.

The City will not pay for repairing or replacing members damaged by improper handling, storing, transportation, or erection.

The City will pay for the accepted quantities at the contract prices as follows:

Item	**Unit**	**Description**
513	Lump Sum	Structural Steel Members, Level UF
513	Lump Sum	Structural Steel Members, Level 1
513	Lump Sum	Structural Steel Members, Level 2

513	Lump Sum	Structural Steel Members, Level 3
513	Lump Sum	Structural Steel Members, Level 4
513	Lump Sum	Structural Steel Members, Level 5
513	Lump Sum	Structural Steel Members, Level 6
513	Pound (Kilogram)	Structural Steel Members, Level UF
513	Pound (Kilogram)	Structural Steel Members, Level 1
513	Pound (Kilogram)	Structural Steel Members, Level 2
513	Pound (Kilogram)	Structural Steel Members, Level 3
513	Pound (Kilogram)	Structural Steel Members, Level 4
513	Pound (Kilogram)	Structural Steel Members, Level 5
513	Pound (Kilogram)	Structural Steel Members, Level 6
513	Each	Welded Stud Shear Connectors