SECTION 460
STRUCTURAL STEEL AND MISCELLANEOUS METALS

460-1 Description.

Prepare, fabricate, assemble, erect, and paint structural steel, shear connectors, castings and forgings, plates and bolts, and certain special metals for structures or portions of structures.

460-2 Materials.

460-2.1 General: Meet the material requirements of Section 502 and Division III, with specific reference to Sections 961 through 964.

Except where otherwise shown in the plans, use structural steel for all major members, and rivet steel for all rivets. Use either cast steel or cast iron for castings, as shown in the plans.

For paint, meet the requirements of Section 971.

460-2.2 Weathering Steel: When the plans call for weathering steel to be used, meet the requirements of ASTM A709 Grade 50W [ASTM A709M, Grade 345W], unless otherwise noted on the plans. Fabricate all unpainted structural elements with steel with weathering characteristics. For bolts, nuts and washers, meet the physical and chemical requirements of ASTM A325 Type 3 [ASTM A325M Type 3], ASTM A563 Grade C3 [ASTM A563M Grade 8S3] and ASTM F436 Type 3 [ASTM F436M Type 3], respectively.

The Engineer will not allow the use of marking materials which leave behind residual material which may affect the weathering process of the steel (grease sticks, crayons, etc.). Store the girders as required for non-weathering steels; except fabricated weathering steel girders shall be stored exposed to the elements.

Prior to erection, blast clean all surfaces to meet SSPC-SP6 criteria. Blast clean the exposed fascia of the exterior girders to meet SSPC-SP10 criteria.

Prior to erection of the girders, wrap all exposed substructure concrete surfaces with polyethylene sheeting to protect against staining from the girders. Leave the sheeting in place and keep the sheeting free of tears or separations until the application of the Class V finish. Do not, in any case, remove the sheeting prior to placement of the deck.

Upon completion of construction, remove all oil, grease, dirt or other foreign material from the steel. Solvent cleaning (SSPC-SP1) may be used to remove oil, grease and other compounds. Hand cleaning (SSPC-SP2) or power cleaning (SSPC-SP3) may be used to remove deposits of excess rust scale, paint or other foreign matter. Do not use acids for cleaning steel surfaces. Clean all concrete stains in areas without a Class V finish by sandblasting, cleaning with a stain remover or commercial cleaner after completion of the structure.

460-2.3 Fracture Critical Members: When the plans designate fracture critical members, submit to the Engineer evidence of fabricator certification for Major Steel Bridges with Fracture Critical Rating under the AISC Quality Certification Program before beginning fabrication.

460-3 Drawings.

460-3.1 General: Furnish working, shop, and erection drawings showing details, dimensions, sizes of materials, and other information and data necessary for the complete fabrication and erection of metal work. Submit drawings to the Department as specified in Section 5 for review and approval.

460-3.2 Changes: Do not make changes in any drawing after it has been approved, except by written consent or direction of the Engineer. The Contractor may substitute sections having dimensions different from those shown in the plans only when approved in writing by the Engineer.

460-4 Storage of Materials.

Store structural steel materials above the ground on platforms, skids, or other supports, and protect the materials as is necessary and practicable from exposure to conditions producing rust or other

surface deterioration. Keep materials free from accumulations of dirt, oil or other foreign matter. Place girders and beams in an upright and normal position, and support them to prevent undue stress or stresses.

460-5 Straightening Material.

Use rolled material, before being laid off or worked, that is straight. If straightening is necessary, use methods that will not injure the metal. Do not heat straighten ASTM A 514 [ASTM A 514M] or ASTM A 517 [ASTM A 517M] steel. The Engineer will consider sharp kinks and bends cause for rejection of the material.

460-6 Welds.

Where shown in the plans, make connections by electric arc welding. Proportion weld details and weld in accordance with the AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges, and the referenced AWS Structural Welding Code. The following additional provisions apply:

(1) The Department will use radiographic inspection in lieu of ultrasonic inspection wherever ultrasonic inspection is specified or permitted as an alternate.

(2) The Department will perform the initial radiographic examinations, testing, and inspections required by the Contract Documents, exclusive of the qualifying of welders and welding procedures. The actual cost of any additional radiographic examinations, tests and inspections made by the Department to determine the extent of defects and to ascertain that all flaws so detected are corrected will be charged to the Contractor.

(3) Electro-slag welding will not be permitted.

(4) Documentation of their qualifications to perform the specific welding task in accordance with the appropriate code governing the work will be required prior to permitting welders, welding operators, or tackers to perform construction or maintenance welding on Department structures.

460-7 Rivets.

460-7.1 General Requirements: The diameter of the rivets as indicated in the plans designates their diameter prior to heating. Form heads of driven rivets of approved shape, concentric with the shanks, true to size, full, neatly formed, free from fins, and in full contact with the surface of the member. Use rivets free from furnace scale on their shanks and from fins on the underside of the machine-formed heads.

460-7.2 Field Rivets: Supply field rivets, for each size and length, in excess of the actual number to be driven, to allow for losses due to misuse, improper driving, or other contingencies.

460-8 Bolts and Bolted Connections.

460-8.1 High-Strength Bolts:

460-8.1.1 General: Where bolted connections are shown in the plans, unless otherwise specifically stated, make the connections using the turn-of-nut method with fastener assemblies consisting of Type 1 steel bolts meeting the physical and chemical requirements designated in ASTM A 325, Grade DH or 2H [ASTM A 325M, Class 8S or 8S3] plain finish nuts meeting the physical and chemical requirements as designated in ASTM A 563 or ASTM A 194 [ASTM A 563M or ASTM A 194M], respectively, and hardened steel washers meeting all requirements designated in ASTM F 436 [ASTM F 436M]. Use galvanized fastener assemblies in the top flanges of main girders, stringers and floorbeams in bascule spans. Do not use galvanizing on other fastener assemblies unless otherwise shown in the plans. Provide nuts that are free running the full length of the bolt threads. When galvanizing is required, galvanize all components of the fastener assemblies by the same process. To document compliance with these Specifications, secure and provide to the Department certified reports of all test results from representative samples of fastener components selected from LOTs to be used on the project. Provide a statement with the certified reports including:

(a) The name and location of the facility where each test was performed.

(b) Number of samples in LOT and LOT size.

(c) A certificate that all test results show compliance with these Specifications.

(d) Corresponding LOT numbers which appear on the shipping package.

(e) Facsimilies of markings which appear on each LOT of fastener components delivered.

(f) A table of test requirements and actual test results.

Maintain and document the integrity of this LOT audit system during any intermediate or subsequent operations (plating, heat treating, warehousing, resale, etc.). If the Contractor fails to maintain and document at any point, the Engineer may reject the LOT or require additional sampling and testing of the LOT at a frequency suitable to the Department to accept the LOT. Perform all such additional sampling and testing to reinstate audit integrity at no expense to the Department.

Provided that the integrity of the LOT audit system has been maintained, perform sampling and testing for the purpose of verifying chemical and physical properties of the fastener components as specified in the ASTM standards governing individual fastener components. For the purpose of verifying properties of galvanizing, sample and test the fastener assembly components in accordance with ASTM B 602 Table 2 for nondestructive tests or Table 4 for destructive tests unless otherwise designated in the plans.

The Department reserves the right to independently select and test fastener components and assemblies.

460-8.1.2 Additional Material Requirements: Ensure that the maximum hardness for AASHTO M 164 (ASTM A 325) [ASHTO M164 M (ASTM A 325M)] bolts is: 34 Rc for bolts M16 to M36, 33 Rc for bolts 1/2 to 1 inch [12.7 to 25.4 mm] in diameter, and 30 Rc for bolts 1 1/8 to 1 1/2 inch [28.6 to 38.1 mm] in diameter.

Provide Grade 2H or DH [Class 8S or 8S3] nuts for black or galvanized fasteners. For coated fasteners, overtap the nuts to the minimum amount required for the fastener assembly. Provide all nuts, bolts, and washers with manufacturer's markings on them.

When zinc coating is required, furnish either hot-dip galvanizing (Class C of ASTM A 153) or mechanically deposited zinc (Class 50 of ASTM B 695) products unless the specific process is called for in the plans. Coat the bolt, nut and washer used in the fastener assembly by the same zinc process, i.e. hot-dip or mechanically deposited.

460-8.1.3 Additional Test Requirements: Perform the rotational-capacity tests indicated below on a minimum of two units of each combination of the LOTs of bolts, nuts, and washers supplied. Test and report zinc coating thickness when galvanized fasteners are required. The manufacturer or distributor who combines the bolts, nut, and washer into assembly will perform these tests.

For high strength fastener assemblies (bolt, nut, and washer), black and galvanized, perform a rotational-capacity test (AASHTO M 64, Section 8.5 [ASHTO M 164M, Section 8.2]), and meet the following requirements:

(a) Perform twice the required number of turns (from snug tight conditions) indicated in the 1988 Interim AASHTO Bridge Specification, Table 10.17B, in a Skidmore-Wilhelm Calibrator, or equivalent tension measuring device, without stripping or failure.

(b) After making the required number of turns, achieve a recorded tension equal to or greater than 1.15 times the Required Fastener Tension, AASHTO Standard Specifications for Highway Bridges, Division II, Table 11.5A.

(c) When measuring the torque to produce the Required Fastener Tension, do not exceed the value obtained by the following equation:

$$Torque = 0.25\ PD$$

Where:

Torque = Measured Torque in foot-pounds [newton meters]
P = Measured Bolt Tension in pounds [newtons]
D = Nominal Diameter in feet [meters]

Perform proof load tests (ASTM F 606 [ASTM F 606M], Method 1) for the bolts. Perform wedge tests of full size bolts in accordance with Section 8.3 of AASHTO M 164 [Section 8.1 of AASHTO M 164M]. Wedge test galvanized bolts after galvanizing. Perform proof load tests (AASHTO M 291 [AASHTO M 291M]) for the nuts. Perform the proof load tests for nuts to be used with galvanized bolts after galvanizing, overtapping and lubricating.

460-8.1.4 Lubricant: Coat fastener assembly components with a lubricant commercially produced for lubricating high strength fastener assemblies. Use a lubricant of a visually obvious color. Use a lubricant that is clean and dry to the touch, and apply it prior to testing and packaging for shipment to the job site. Lubricate all nuts. Lubricate the face of the bolt head when the bolt is the element to be turned in the tightening process. Prior to lubrication, clean fastener elements of dirt, rust, and other deleterious substances. Clean and relubricate fastener elements which are weathered or rusted after lubrication.

460-8.1.5 Packaging for Shipment: Ship fastener assembly components in sealed, watertight containers, each labeled on the side of the container with the supplier's name and LOT identification number, and marked to identify the contents and size of the component, i.e. bolt, nut, or washer. Lubricate all surfaces of the nuts prior to placing in watertight containers. Provide containers for fastener assembly components that are capable of protecting the components from moisture and other deleterious materials until they are opened for use at the job site. The Engineer may reject containers of fastener assemblies received at the job site when there is visible damage to the fastener components.

460-8.1.6 Handling and Storage: Store containers of fastener assembly components at the job site in a weatherproof storage enclosure. Take only as many containers of fastener assembly components as are anticipated to be installed and tightened during a work shift from protected storage, and leave the containers unopened until needed for erection. Return fastener assembly components not used to protected storage at the end of the work shift for use on the next succeeding work shift. Protect opened containers of fastener assembly components from the elements, such as precipitation, debris, dust, and contaminants, with removable covers at all times until emptied.

460-8.1.7 Procedure and Demonstration: Submit in writing for approval proposed methods for removal of lubricant from the exposed surfaces of the installed fastener assemblies in preparation for application of required coats of paint. Perform surface preparation, including the removal of lubricant, in accordance with the paint manufacturer's surface preparation requirements prior to paint application.

Demonstrate procedures for surface preparation prior to painting, and obtain the Engineer's approval prior to installation of fastener assemblies.

460-8.1.8 Installation:

460-8.1.8.1 General: Perform the rotational-capacity test described in 460-8.1.3 on each rotational capacity LOT prior to the start of bolt installation and at any other time the Engineer orders the test to be performed. Proceed with installation upon obtaining satisfactory test results. Tighten a bolt, nut, and washer fastener assembly to provide at least the minimum bolt tension shown in Table A below for the size used when all fastener assemblies in the joint are tight:

Table A Bolt Tension Non SI Bolts		
	Minimum Bolt Tension* (lbs.)	
Bolt Size (in.)	AASHTO M 164 (ASTM A 325) Bolts	AASHTO M 253 (ASTM A 490) Bolts
1/2	12,050	14,900
5/8	19,200	23,700
3/4	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1 1/8	56,450	80,100
1 1/4	71,700	101,800
1 3/8	85,450	121,300
1 1/2	104,000	147,500
*Equal to 70% of specified minimum tensile strength of bolts.		

Table A Bolt Tension SI Bolts		
	Minimum Bolt Tension* (kN)	
Bolt Size mm	AASHTO M 164M (ASTM A 325M) Bolts	AASHTO M 253M (ASTM A 490M) Bolts
M16	94.2	130
M20	147	203
M22	182	251
M24	212	293
M27	275	381
M30	337	466
M36	490	678
*Equal to 70% of specified minimum tensile strength of bolts.		

If required, because of bolt entering and wrench operational clearances, the Contractor may perform tightening by the required procedure by turning the bolt while the nut is prevented from rotating. Remember that normally the nut is turned while the bolt is held stationary. When it is necessary to turn the bolt instead of the nut, lubricate the face of the bolt head prior to installation of the fastener assembly.

The Contractor may reuse AASHTO M 164 (ASTM A 325) [AASHTO M 164M (ASTM A 325M)] bolts if approved by the Engineer, but not more than once. Consider a fastener assembly as used when the required turn has been made after achieving "snug tight". Do not retighten previously tightened bolts which may have been loosened by the tightening of adjacent bolts as reuse.

Provide all fastener assemblies with a hardened washer under the element (bolt head or nut) turned in tightening. Where an outer face of the bolted parts has a slope 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.

Use the turn-of-nut method to tighten a bolt, nut, and washer assembly.

In the turn-of-nut method, first bring all the fastener assemblies (bolts, nuts, and washers) of a steel connection to a "snug tight" condition to ensure that all parts of the connection are brought into full contact with each other. Regard "snug tight" as the tightness obtained by an impact wrench producing a torque and corresponding bolt tension, which produces at least the minimum required bolt tension when applying further rotations in accordance with Table B. In all cases, the final test for approval of "snug tight" condition is the visual observation by the inspector that all parts in the joint have been brought into full contact in the faying surface areas with no fasteners loose in the connection. After all of the connection fastener assemblies are in "snug tight" condition, additionally tighten all fastener assemblies in the joint by the applicable amount of nut rotation specified in Table B below:

Table B

Nut Rotation* From Snug Tight Condition

Bolt Length Measured From Underside of Head to Extreme End of Point	Disposition of Outer Faces of Bolted Parts		
	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 four diameters	1/3 turn	1/2 turn	2/3 turn
Over four diameters but not exceeding eight diameters	1/2 turn	2/3 turn	5/6 turn
Over eight diameters but not exceeding 12 diameters**	2/3 turn	5/6 turn	1 turn

*Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, maintain a tolerance of ±30 degrees; for bolts installed by 2/3 turn and more, maintain a tolerance of ±45 degrees.
**No research work has been performed by the Research Council on Riveted and Bolted Structural Joints to establish the turn-of-nut procedure when bolt lengths exceed 12 diameters. Therefore, determine the required rotation by actual tests in a suitable tension device simulating the actual condition.

Furnish calibrated torque wrenches with dial faces to be used by the Engineer for inspection of fastener assemblies in bolted connections which have been installed and brought to "snug tight" condition. If impact wrenches are used to obtain "snug tight" condition, calibrate and check them at appropriate intervals as suggested by the manufacturer to ensure that all bolt assemblies are installed correctly.

Furnish a Skidmore-Wilhelm calibrator or other acceptable bolt tension indicating device at each job site for use during bolt installation. Confirm the accuracy of the tension measuring device through calibration by an approved testing agency at least once a year. The Engineer will perform and witness daily testing to ensure the installed bolt/nut/washer assembly meets the above requirements. Make daily tests of a representative sample of five bolt assemblies from each combination of nut/bolt being tightened on that day. Tighten with the tension measuring device by the same method used for the field bolt installation process to a "snug tight" tension and corresponding torque, which, when the additional turns required in Table B are added, will result in a least 1.05 times the minimum required bolt installation tension. Place a washer under the part turned in tightening the bolt. Consider the job inspection "snug tight" torque as the average of three test values determined after rejecting the high and low test values.

460-8.1.8.2 Snugging: When tightening, systematically progress from the most rigid part of the connection (usually the center area of the fastener assemblies group) to the free edges. During this operation, do not allow rotation of the part of the fastener assembly not turned by the wrench.

After all of the fastener assemblies in any structural steel connection are tightened to the "snug tight" condition, and all parts in the joint have been brought into full contact with

the faying surface areas, the Engineer will check no less than three bolts and a minimum of 10% of the fastener assemblies in that connection with the torque wrench prior to final tightening by the turn-of-the-nut method. Tighten any fastener failing to produce the torque required to achieve the "snug tight" condition, as established with the Skidmore-Wilhelm Calibrator, as required, and perform torque wrench testing on all remaining untested fasteners in the connection.

460-8.1.8.3 Final Tightening: After the "snug tight" condition of the fasteners of a structural steel connection is verified by the Engineer, the inspector will matchmark the fastener assemblies on the bolt thread end and the nut. Thereafter, turn the nut with respect to the bolt the prescribed amount shown in Table B. Once all scribe marks indicate the amount of nut rotation with respect to the bolt as being equal to or more than the minimum rotation required in Table B, the Engineer will accept the structural steel connection.

460-8.2 Other Types of Bolts:

460-8.2.1 Use of Other Types of Bolts: Except for connections made with high-strength bolts, do not use bolted connections unless authorized by the Engineer.

460-8.2.2 Bolts: Where bolted connections are permitted, furnish unfinished bolts (ordinary rough or machine bolts) or turned bolts, as specified or directed by the Engineer. Provide unfinished bolts that are standard bolts with square or hexagonal heads and nuts. Do not use "button head" bolts. Use bolts transmitting shear that are threaded to such length that not more than one thread will be within the grip of the metal. Provide bolts of lengths which will extend entirely through their nuts but not more than 1/4 inch [5 mm] beyond them.

460-8.2.3 Bolt Holes: Make the diameter of the bolt holes 1/16 inch [2 mm] greater than the diameter of the bolts used. Carefully ream or drill holes for turned bolts, and turn the bolts to a driving fit by giving them a finishing cut. Ensure that the threads for turn bolts are entirely outside of the holes, and the heads and nuts are hexagonal.

460-8.2.4 Nutlocks: The Contractor shall use approved nutlocks on all bolts unless he obtains permission to the contrary from the Engineer. Where nutlocks are not used, place round washers having a thickness of 1/8 inch [3 mm] under the nuts.

460-9 Shop Assembly of Main Members.

Subpunch holes for field connections in all main members, including trusses, portal bracing, girders, continuous I-beams, rigid frames, bents, towers, etc. Ream holes to full size while shop-assembling the parts. Ream floor beams and stringer connections to a metal template not less than 1 inch [25 mm] thick.

Fit and line trunnion and racks to the main girders in the shop. Set the pitch lines of racks at exact radial distances from the trunnion centers. Place the face of rack teeth exactly normal to the plane of the girders.

Fit trunnion journals to their bearings in the shop, and matchmark corresponding parts.

Assemble all parts of the gear trains for span operations, except the racks, with parts in correct relative positions, and anchor them to supports.

With all parts thus placed and anchored, perform a power-driven test run of not less than four hours on the machinery. Correct any irregularities or defects which may develop or are exposed by such test run before shipping of the machinery to the project.

460-10 Holes for Rivets and Bolts.

460-10.1 General Requirements: Except for main members, as provided above, and where general reaming is not specified in the plans, the Contractor may punch full-size holes in material 3/4 inch [20 mm] or less in thickness. For material more than 3/4 inch [20 mm] in thickness, subpunch and ream, or drill holes.

460-10.2 Punched Holes:

460-10.2.1 Size of Holes: Punch full-size holes 1/16 inch [2 mm] larger than the nominal diameter of the rivet or bolt. Do not allow the diameter of the die to exceed the diameter of the punch by more than 3/32 inch [2.5 mm]. Provide holes that are clean-cut without torn or ragged edges. Ream holes that must be enlarged to admit the rivets or bolts.

460-10.2.2 Accuracy of Punching: Punch holes so that, after assembling the component parts of a member, a cylindrical pin 1/8 inch [3 mm] smaller than the nominal diameter of the punched hole may be passed through at least 75% of any group of contiguous holes in the same plane. The Engineer will reject the improperly punched pieces if this requirement is not met. The Engineer may reject the member if any hole will not pass a pin 3/16 inch [5 mm] smaller than the nominal diameter of the punched hole.

460-10.3 Drilled Holes: Drill holes 1/16 inch [2 mm] larger than the nominal diameter of the rivet or bolt. Remove burrs on the outside surface.

460-10.4 Subpunched and Reamed Holes: For subpunched and reamed holes for rivets having diameters greater than 3/4 inch [20 mm], punch holes 3/16 inch [5 mm] smaller than the nominal diameter of the rivet, and for rivets and bolts having diameters 3/4 inch [20 mm] or less, punch holes 1/16 inch [2 mm] less than the nominal diameter of the rivet or bolt. Use a punch and die having the same relative size as specified for full-size punched holes. After the punching, ream the holes to a diameter 1/16 inch [2 mm] larger than the nominal diameter of the rivet or bolt. Remove burrs resulting from reaming. Ream rivet holes with twist drills or with short taper reamers.

460-10.5 Accuracy of Reamed and Drilled Holes: Ensure that reamed or drilled holes are cylindrical and perpendicular to the member and that their accuracy is the same as specified for punched holes, except that, after reaming or drilling, ensure that 85% of any group of contiguous holes in the same plane does not show an offset greater than 1/32 inch [1 mm] between adjacent thicknesses of metal.

460-10.6 Drifting of Holes: Allow only enough drifting during assembling to bring the parts into position but not sufficient enough to enlarge the holes or distort the metal.

460-10.7 General Reaming: The Engineer may require general reaming, in which case it will be shown in the plans. Where general reaming is required, subpunch and ream all holes in material forming a part of the section of main members if the thickness of the material is not greater than the nominal diameter of the rivet or bolt. The Contractor may punch holes full size in material used for lateral, longitudinal, and sway bracing, lacing bars, stay plates, and diaphragms not forming a part of the section of main members, if the thickness of the material is not greater than the nominal diameter of the rivet or bolt. Drill holes in material of a greater thickness than the nominal diameter of the rivet or bolt.

Perform reaming after the pieces forming a built member are assembled and firmly bolted together. Do not interchange reamed parts.

Ream or drill holes for field connections, except those in lateral, longitudinal and sway bracing, with the connected parts assembled, or else ream or drill to a metal template not less than 1 inch [25 mm] thick.

460-10.8 Holes in Bearing Plates: The Contractor may form holes in bearing plates by drilling, punching or oxygen cutting. Remove all burrs by grinding. Unless plans establish different requirements, the Engineer will use the following criteria to judge the acceptability of holes in bearing plates:

Centering and alignment is within a tolerance of 1/16 inch [2 mm].

Cut faces are perpendicular to the plane of the plate.

Holes do not exceed a uniform excess of 1/16 inch [2 mm] in size.

Notches or gouges do not exceed 1/8 inch [3 mm] in depth.

460-11 Riveting.

460-11.1 General: Uniformly heat rivets to a light cherry red color, and drive while hot. Do not heat the points of rivets more than the remainder. When ready for driving, use rivets that are free from slag, scale, and other adhering matter, and that completely fill the holes when driven. Do not drive burned, burred, or otherwise defective rivets, and rivets which throw off sparks when taken from the

furnace or forge. Drive rivets using power tools. Do not use hand tools for riveting unless authorized in writing by the Engineer.

460-11.2 Defective Rivets: Cut out rivets which are loose, burned, badly formed, or otherwise defective. Do not perform caulking and re-cupping of rivet heads. When cutting out defective rivets, take care not to injure the adjacent metal and, if necessary, remove the rivet shanks by drilling.

460-11.3 Countersinking: Neatly countersink rivets to completely fill the holes.

460-12 Shop Assembly.

460-12.1 General: Ensure that the component parts of a built member are assembled, drift-pinned to prevent lateral movement, and firmly bolted to draw the parts into close contact before reaming, drilling or beginning riveting. Take apart assembled parts, if necessary, for removal of burrs and shavings produced by the reaming operation. Ensure that members are free from twists, bends, or other deformations. In preparation for shop-connecting full-size punched material, clear the rivet or bolt holes by reaming.

460-12.2 End Connection and Stiffener Angles: Carefully adjust end connection angles, stiffener angles, etc., to correct locations, and rigidly bolt, clamp, or otherwise firmly hold them in place until connected.

460-12.3 Riveting: Drive shop rivets by direct-acting rivet machines where practicable.

460-12.4 Matchmarking: Matchmark connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections. Furnish a diagram showing such marks to the Engineer.

460-13 Planing.

460-13.1 Edge Planing: When required by the Engineer, plane sheared edges of material more than 5/8 inch [16 mm] in thickness to a depth of not less than 1/8 inch [3 mm]. Fillet re-entrant cuts before cutting.

460-13.2 Planing of Bearing Surfaces:

460-13.2.1 Columns Bearing on Base and Cap Plates: Mill ends of columns that are bearing upon base and cap plates to true surfaces and correct bevels after the main section of these members and the end connection angles have been fully riveted or bolted.

460-13.2.2 Caps and Base and Sole Plates: Ensure that caps and base plates of columns, and the sole plates of girders and trusses, have full contact when assembled. If the plates are warped or deformed, hot-straighten, plane, or otherwise treat them to secure an accurate, uniform contact. After riveting in place, chip the excess metal of counter-sunk rivet heads smooth and flush with the surrounding metal, and plane or mill the surfaces which are to come in contact with other metal surfaces, if necessary, to secure proper contact. Rough-finish surfaces of base and sole plates which are to come in contact with masonry so that they are free from warps and other deformities.

460-13.2.3 Cast Pedestals, Shoes, and Bearing Plates: Plane surfaces of cast pedestals and shoes which are to come in contact with metal surfaces, and rough-finish surfaces which will bear upon the masonry. Plane the surfaces of expansion bearings in the direction of expansion. Carefully mill and polish-finish surfaces of bronze bearing plates intended for sliding contact.

460-13.3 Abutting Joints:

460-13.3.1 Compression Members: Accurately face abutting ends of compression members, after riveting or bolting the members, to secure an even bearing when assembled in the structure.

460-13.3.2 Tension Members: Rough-finish ends of tension members at splices to secure close and neat, but not contact, fitting joints.

460-14 End Connection Angles.

Locate end connection angles of floor beams and stringers flush with each other and accurately set as to position and length of member. In general, do not finish end connection angles unless so shown

in the plans. However, faulty assembling and riveting may be cause for requiring end connection angles to be milled, in which case reduce their thickness, but do not exceed 1/16 inch [2 mm], or reduce their rivet bearing value below design requirements.

460-15 Built Members.

Make several pieces forming one straight and close fitting built member. Use members that are true to detailed dimensions and free from twists, bends, open joints, and other defects resulting from faulty fabrication and workmanship.

460-16 Lacing Bars.

Neatly round the ends of lacing bars unless otherwise indicated in the plans.

460-17 Plate Girders.

460-17.1 Web Plates: The Contractor may use web plates of girders having no cover plates that are detailed with the top edge of the web flush with the backs of the angles. Chip web plates of girders having cover plates beyond the angles flush with the backs of the angles. The Contractor may use web plates of girders having cover plates that are 1/2 inch [13 mm] less in width than the distance, back to back, of flange angles.

460-17.2 Splicing: Where splicing web plates, ensure that there is not more than 3/8 inch [10 mm] clearance between ends of plates.

460-17.3 Stiffener Angles: Mill or grind end stiffener angles of girders and stiffener angles intended as supports for concentrated loads to secure a uniform, even bearing against the flange angles. Provide intermediate stiffener angles with a sufficiently tight fit to exclude water after being painted.

460-17.4 Splice Plates and Fillers: Ensure that web splice plates and fillers under stiffeners fit within 1/8 inch [3 mm] at each end.

460-17.5 Field Bolted Splices - Fillers: When fillers for field bolted splices are shown on the plans to be less than 3/16 inch [5 mm thick], the Contractor may provide fillers from low-alloy sheet material as specified in 962-2. Do not subject fillers to CVN testing, but paint them as specified in 560-11.2.

460-18 Pins and Rollers.

Use pins and rollers accurately turned to detailed dimensions that are smooth, straight, and free from flaws. Produce the final surface by a finishing cut.

Use pins and rollers with diameters greater than 6 inches [150 mm] that are forged and annealed.

Ensure that pins and rollers larger than 8 inches [200 mm] in diameter have a hole not less than 2 inches [50 mm] in diameter bored longitudinally through their centers. Bore the hole after forging and before annealing. The Engineer will reject pins and rollers showing defective interior conditions.

460-19 Boring Pin Holes.

460-19.1 General: Bore pin holes true to detailed dimensions, smooth and straight, at right angles with the axis of the member and parallel with each. Always make a finishing cut. Perform boring of holes in built-up members after completing riveting.

460-19.2 Dimensional Tolerance: Ensure that the length outside-to-outside of holes in tension members and inside-to-inside of holes in compression members does not vary from detailed dimensions more than 1/32 inch [1 mm].

460-20 Pin Clearances.

Ensure that the difference in diameter between the pin and the pin holes is not more than 1/32 inch [1 mm].

460-21 Screw Threads for Pins.

Make screw threads as shown in the plans, and make close fits in the nuts.

460-22 Pilot and Driving Nuts.

Furnish two pilot nuts and two driving nuts for each size pin, unless otherwise shown in the plans.

460-23 Notice of Rolling and Fabrication.

Give ample advance notice to the Engineer of the beginning of work at the mill and shop, so that the Engineer may inspect the work. After placing the order, do not roll or fabricate any material before notifying the Engineer.

460-24 Facilities for Inspection.

Furnish all facilities for the inspection of materials and workmanship in the mill and shop, and allow inspectors free access to the necessary parts of the premises.

460-25 Inspector's Authority.

460-25.1 Right of Rejection: The inspector has the authority to reject materials or workmanship which do not fulfill the requirements of these Specifications, but in case of dispute, the Contractor may appeal to the Engineer. The Engineer will make the final decision.

460-25.2 Subsequent Rejection of Materials Previously Approved: Although previously accepted, the inspector may reject materials or furnished members if they are later found defective. Promptly replace or make good rejected material and workmanship.

460-25.3 Mill and Shop Inspection: Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors; however, the Contractor is fully responsible in regard to imperfect material or workmanship and the necessity for replacement, as might be required by later inspections.

460-26 Rejection of Fabricated Work at Site.

The Engineer may waive shop inspection and make complete inspection of all fabricated work upon its delivery at the site of the structure. Whether or not shop inspection is made, the Engineer may reject fabricated steel at any time he might find it does not conform to the Contract Documents.

460-27 Marking and Shipping.

460-27.1 General: Mark the weight on members weighing more than 3 tons [3 metric tons]. Pack bolts and rivets of one length and diameter, and loose nuts or washers of each size, separately. Ship pins, small parts, and small packages of bolts, rivets, washers, and nuts in boxes, crates, kegs, or barrels of convenient sizes. Plainly display a list and description of the contained material on the outside of each shipping container. Keep the weight of all tools and erection material separate.

The Engineer will allow metal die stamping in the fabrication of structural steel in conformance with the requirements specified herein. Do not use die stamps on fracture-critical members, or near the edges of plate members subject to tensile stresses. The Engineer will accept numbers, letters, or combinations thereof impressed into steel components for the purpose of identifying the fabricated member in lieu of paint, metal tags, or other methods of identification.

The Contractor may accomplish marking of fabricated structural steel as required herein and in 460-12.4 by the use of paint, attached metal tags, or low stress dies with blunt-nosed continuous or blunt-nosed interrupted dot die stamps (i.e., dies manufactured to produce impressions that are rounded at the bottom of the impression).

The maximum allowed depth of the impression is 0.010 inch [0.3 mm]. Use die stamping tools that make character sizes with corresponding face radii as shown in the following table:

Size of Steel Die Stamp Markings	
Character Size inch [mm]	Minimum Face Radii inch [mm]
0.125 [3]	0.007 [0.2]
0.1,875 [5]	0.004 [0.1]
0.250 [6]	0.010 [0.3]

In all cases, ensure that shop drawings submitted by the fabricator indicate proposed location of all low stress metal die stamping.

For bridge members, the Contractor may apply the low stress metal die stamping at the following locations:

(1) Girder field splices or beam ends:

a. Outer fourth of top flange splice plates.

b. Middle third of web splice plates.

c. Outer half of girder flange bolt hole pattern at splice.

d. Within 6 inches [150 mm] of bearing stiffeners in the top flange areas at end of girder.

(2) Diaphragms:

a. The preferred location is the middle portion of a top horizontal diaphragm bracing member.

b. In lieu of the above, the middle of the bottom horizontal diaphragm bracing member.

(3) Other members: Clearly indicate the location on shop drawings submitted for approval.

Make any marking to be done at the mill, as required by AASHTO M 160 (ASTM A 6) [AASHTO M 160M (ASTM A 6M)], in no more than one place on each piece. The Contractor may use die stamping, using low-stress blunt-nosed continuous or low-stress blunt-nosed interrupted dot steel dies.

460-27.2 Anchor Bolts and Grillage Materials: Ship anchor bolts, washers, and other anchorage or grillage materials to suit the requirements of the masonry construction.

460-27.3 Handling and Transportation: Conduct the loading, transportation, and unloading of structural material so that the metal will be kept clean and free from injury by rough handling.

460-28 Mill Orders and Shipping Statements.

Furnish the Engineer with six copies of mill orders and shipping statements. Show the weights of the individual members.

460-29 Field Inspection.

The Engineer will inspect all work of erection. Provide the Engineer with all facilities required for a thorough inspection of workmanship. The Engineer will inspect material and workmanship not previously inspected after its delivery to the construction site.

460-30 Furnishing and Setting Anchor Bolts.

460-30.1 General: Fabricate anchor bolts with the material specified on the plans, and galvanize them in accordance with ASTM A 153, except that apply electroplated zinc coating SC 3, Type II in accordance with ASTM B 633 for anchor bolts fabricated of a material having a yield strength greater than 80,000 psi [550 MPa]. Treat the coated bolts, nuts, and washers with chromate after coating in a

water solution containing 0.2% sodium dichromate 3 oz/10 gal [(2.2 g/L)]. Store the quenched chromated bolts, nuts, and washers in a dry area protected from the weather. After erection, clean the bolts, nuts, and washers of all oil and deleterious material and coat with a primer recommended by the paint manufacturer for coating galvanized surfaces.

460-30.2 Responsibilities of Substructure and Superstructure Contractors: Where the substructure and superstructure are built by different contractors, the substructure contractor shall set anchor bolts. The superstructure contractor is responsible, however, to provide the substructure contractor with anchor bolts and correct plans for their setting, and he shall cause the substructure contractor no delay in such work. In any case the superstructure contractor is responsible to inspect the setting of anchor bolts at the time the substructure contractor is working and to check the placing of them. The superstructure contractor shall bear any expense incurred because of any error in setting anchor bolts.

460-30.3 Adjustments for Temperature: Vary the location of the anchor bolts in relation to the slotted holes in expansion shoes with the prevailing temperature. Install nuts on anchor bolts at the expansion ends of spans to permit the free movement of the span.

460-30.4 Methods of Setting:

460-30.4.1 General: Set anchor bolts by a method specified below. The Contractor may use either of these methods unless the Engineer designates the method to be used in any particular case.

460-30.4.2 Setting Bolts in Drilled Holes: Drill anchor bolt holes, in correct locations, vertically to the plane of the bridge seat, and set the anchor bolts in portland cement mortar. Provide mortar consisting of one part cement to one part clean, fine-grained sand, mixed sufficiently wet to flow freely. Drop anchor bolts into the dry holes to ensure their proper fit after setting. Set bolts as follows: Fill the hole about 2/3 full of mortar. Force the bolt down the hole using a uniform, even pressure or by light blows with a hammer (without flogging or ramming) until the mortar rises to the top of the hole and the anchor bolt nut rests firmly against the metal shoe or pedestal. Remove all excess mortar which may have flushed out of the hole, to permit proper field painting of the metal surfaces.

460-30.4.3 Setting Bolts in Formed Holes: The Contractor may form bolt holes in concrete masonry by the insertion in the fresh concrete of plastic or metal pipe sleeves, which are withdrawn after the concrete has partially set. When forming the holes by this method, ensure that they are not less than 4 inches [100 mm] in diameter, to allow for horizontal adjustment of the bolts.

460-31 Preparation of Bearing Areas, and Setting Shoes and Pedestals.

Ensure that column bases, truss and girder pedestals, and shoes have full and uniform bearing on the substructure masonry. Do not place masonry bearing plates on the bridge seat area of piers or abutments that are irregular. Rigidly and permanently locate the shoes and pedestals of truss and girder spans and of I-beam spans and the bases of columns to correct alignments and elevations. Place the shoes or pedestals on bearing pads of the type and size shown on the plans.

In setting the trunnion bearings, machinery supports and principal machinery, use the following procedure:

Pour and finish the concrete supports at least 1 inch [25 mm] below grade. After these have set for not less than 72 hours, set the machinery parts thereon and accurately position them in all directions by the use of steel shim supports and the anchor bolts. With the parts thus set, dampen the top of the concrete and pack the space between concrete and bearing base with a dry grout containing a nonshrink admixture.

Mix grout in the following proportions by volume:

(a) One part cement

(b) One part fine aggregate

(c) Proportion nonshrink admixture as recommended by the manufacturer.

First, thoroughly mix the dry elements to form a uniform mixture. Add only enough water to give a mealy, slightly adhesive mix.

Ram or hammer the mixture into position to produce complete contact between the bearing base and the supporting concrete. Generally do this by ramming from the edges toward the center. After this grout has set for at least 24 hours, remove the steel shim supports, patch the resulting holes with grout, and finish the edge areas around the bearing as shown in the plans.

460-32 Handling Members.

Complete the field assembling of the component parts of a structure by the use of methods and appliances not likely to produce injury by twisting, bending, or otherwise deforming the metal. Do not put any member slightly bent or twisted in place until correcting its defects. The Engineer will reject any members seriously damaged in handling.

460-33 Alignment.

Before the beginning of the field riveting or bolting, adjust the structure to correct grade and alignment and properly regulate the elevations of panel points (ends of floor beams). For truss spans the Engineer will allow a slight excess camber while riveting or bolting the bottom chords, but secure the correct camber and relative elevations of panel points before riveting or bolting the top chord joints, top lateral system, and sway bracing.

460-34 Field Assembly.

For field assembling and connecting of members, generally meet the requirements for shop assembly as specified in 460-12, and the following additional requirements: Securely drift-pin and bolt all field connections and splices before riveting or bolting. Fill at least 50% of the holes of important connections in trusses, girders, floor systems, etc. Do not paint field-driven rivets and high-strength bolts until the Engineer has inspected and accepted them. For field riveting and high-strength bolting, meet the requirements of 460-11 and 460-8.1, respectively. Use pneumatic tools for field riveting.

460-35 Adjustment of Pin Nuts.

Thoroughly tighten all nuts on pins and locate the pins in the holes so that the members will take full and even bearing upon them.

460-36 Movable Bridges.

Fabricate and erect the machinery and other operating parts of movable bridges in accordance with the requirements of Section 465 and the AASHTO Specifications for Movable Highway Bridges. Generally erect movable bridges in the open position. Keep the navigable channel unobstructed during construction.

460-37 Painting.

Meet the painting requirements of Section 560 or Section 561, as specified.

460-38 Method of Measurement.

460-38.1 General: The quantities to be paid for will be the items covered by this Section, completed and accepted, and may include the following:

460-38.2 Structural Steel: The quantity of structural steel entering into and becoming a part of the completed structure, and accepted by the Engineer, to be paid for will be at the plan quantity, in pounds [kilograms], or at the lump sum price for Structural Steel, as specified.

460-38.3 Structural Steel Weights:

460-38.3.1 Table: Structural steel weights will be the computed weights, assuming the weight per cubic foot [cubic meter] of the various metals to be as follows:

Structural and Rivet Steel	490 lbs [7,850 kg]
Steel Castings and Forgings	490 lbs [7,850 kg]

Gray-Iron Castings.....450 lbs [7,210 kg]
Malleable Iron.....480 lbs [7,690 kg]
Phosphor Bronze.....562 lbs [9,000 kg]
Wrought Iron .....485 lbs [7,770 kg]
Lead .....706 lbs [11,310 kg]

460-38.3.2 Rolled Shapes, Bars, Plates, and Pipe Railings: The weights of rolled shapes, bars, plates, and pipe railings will be computed on the basis of the nominal weights as given in manufacturers' handbooks, using the dimensions shown in the plans. The weight of shims shown in the plans will be included in the quantity of Structural Steel.

460-38.3.3 Deductions and Allowances: No deductions from the computed weight of rolled steel will be made for copes, clips, sheared edges, punchings, borings, drillings, milling, or planing, and no allowance will be made for the weight of weld metal or for overrun in weight.

460-38.3.4 Rivets and High-Strength Bolts: The weights of shop and field rivets and of high-strength bolts, including nuts and washers, all as installed and accepted, will be computed on the basis of average lengths in accordance with the following table:

Diameter of Rivet or Bolt	3/4 inch [M20]	7/8 inch [M22]	1 inch [M24]
Weight per 100 lbs [kg]	50 [24]	100 [45]	150 [61]

460-38.4 Ladders and Platforms: Where so shown in the proposal, ladders and platforms will be paid for as a separate item. The quantity to be paid for will be at the lump sum price or as plan quantity, in pounds [kilograms], for Ladders and Platforms, whether aluminum or steel is used.

460-38.5 Endwall Grates: The quantity to be paid for will be at the unit price per pound [kilogram] for Endwall Grate.

460-38.6 Expansion Joint Seals: The quantity to be paid for will be the length, in feet [meters], of Expansion Joint Seal measured in place, along the centerline of the seal, completed and accepted.

460-38.7 Machinery and Castings: The quantity to be paid for will be at the Contract lump sum price.

460-38.8 Aluminum Railings: The quantity to be paid for will be the plan quantity, in feet [meters], of Aluminum Railings installed in accordance with Structures Standard Indexes 710 and 720, and accepted.

460-39 Basis of Payment.

460-39.1 General: Prices and payments will be full compensation for all work specified in this Section, including welding and all paint materials and painting. No separate payment will be made for falsework or other erection expense.

460-39.2 Items Included Under Structural Steel: For the purpose of payment, shear connectors, shoes, rockers, pins, masonry plates, anchor bolts, and lead bearing plates for fixed spans will be classified as Structural Steel. Structural Steel will also include all parts of rolled or cast steel which can be fabricated by the ordinary structural shop methods usual for fixed structures, and all bolts and anchors used to fasten machinery to structural parts or to masonry. Where aluminum ladders and platforms are shown in the plans as alternates to steel ladders and platforms which are specified to be included in the lump sum item for Structural Steel, the aluminum ladders and platforms, if used, will be included in such payment as Structural Steel. When the furnishing and installation of welded shear connectors is required by the plans, the quantities will be determined in the same manner as required for the accompanying Item of Structural Steel. Payment for shear connectors will be included in the accompanying Item of Structural Steel.

460-39.3 Machinery and Castings: Machinery and Castings will include winding drums, tread plates, pistons and cylinders, eccentrics, pivots, trunnions and their cast supports, shafts, spools, gears, racks, bearings, couplings, clutches, brakes (unless part of the prime mover), discs, cast sheaves and

wheels, rollers, valves, pins about whose axis the connecting parts rotate, screws, wedges, toggles, bridge locks, cranks, axles, hooks, wrenches, turned bolts attaching machinery parts, and similar parts which require machine shop work and which are not included in any other class.

460-39.4 Payment Items: Payment will be made under:

Item No. 460- 1-	Structural Steel - per pound.
Item No. 2460- 1-	Structural Steel - per kilogram.
Item No. 460- 2-	Structural Steel - lump sum.
Item No. 2460- 2-	Structural Steel - lump sum.
Item No. 460- 3-	Machinery and Castings - lump sum.
Item No. 2460- 3-	Machinery and Castings - lump sum.
Item No. 460- 4-	Ladders and Platforms - lump sum.
Item No. 2460- 4-	Ladders and Platforms - lump sum.
Item No. 460- 5-	Endwall Grate - per pound.
Item No. 2460- 5-	Endwall Grate - per kilogram.
Item No. 460- 6-	Ladders and Platforms - per pound.
Item No. 2460- 6-	Ladders and Platforms - per kilogram.
Item No. 460- 7-	Expansion Joint Seal - per foot.
Item No. 2460- 7-	Expansion Joint Seal - per meter.
Item No. 460- 70-	Aluminum Railings - per foot.
Item No. 2460- 70-	Aluminum Railings - per meter.