Section 501—Steel Structures

501.1 General Description

This work includes furnishing and building with structural steel and miscellaneous metals to the lines, grades, and dimensions shown on the Plans or established by the Engineer.

The work does not include bearing devices for prestressed concrete bridge members, utility installation hardware, or any metal covered under another Pay Item.

501.1.01 Definitions

HTS Bolts: High Tensile-Strength bolts.

501.1.02 Related References

A. Standard Specifications

Section 109—Measurement and Payment

Section 500—Concrete Structures

Section 512—Shear Connectors

Section 535—Painting Structures

Section 851—Structural Steel

Section 852—Miscellaneous Steel Materials

Section 854—Castings and Forgings

Section 857—Bronze Bushings, Bearings, and Expansion Plates

Section 870—Paint

Section 881—Fabrics

Section 885—Elastomeric Bearing Pads

B. Referenced Documents

ANSI/AASHTO/AWS D 1.5

AISC Manual of Steel Construction

ANSI B1.13 Class 2A

ANSI 2.5, 3.2, 6.3, 12.5, 25, 46, 46.1 Part 1, 50

ASTM A 6/A 6M

ASTM A153/A 153M

ASTM A 325 (A 325M)

ASTM A 490 (A490M)

ASTM A 919

ASTM F 568M Class 4.6

501.1.03 Submittals

A. Pre-Inspection Documentation

Furnish documentation required by the latest ANSI/AASHTO/AWS D 1.5 under radiographic, ultrasonic, and magnetic particle testing and reporting to the State's inspector before the quality assurance inspection.

B. Shop Drawings

Prepare Shop Drawings for structural steel and other metal materials to be fabricated. Show the details necessary for shop fabrication and field erection.

1. **Description.** Use the standard sheet size of the Department's Bridge Office. Submit at least two complete sets of preliminary prints marked "NOT FOR FIELD USE" to the Department's Bridge and Structural Design Engineer (the Bridge Engineer) for review before fabricating materials.
2. **Review Process.** After the preliminary prints have been reviewed and revisions have been made, submit 5 or more complete sets of the final drawings to the Bridge Engineer. The Bridge Engineer will mark each drawing with a conditional approval stamp and return one stamped set to the fabricator. Furnish the Bridge Engineer with as many additional sets of final prints as required.

   The Bridge Engineer's review and conditional approval of Shop Drawings is a service for the Contractor. The Department assumes no responsibility for the accuracy of the drawings, and the Contractor will not be relieved of any responsibility for conforming to the Specifications and Plans.
3. **Railway Structures.** For structures carrying railway traffic and for other structures when specifically designated, furnish the Bridge Engineer a full set of permanent reproducibles of the final Shop Drawings.
4. **Welded Construction.** On Shop Drawings for welded construction, use the standard welding symbols of the American Welding Society. Explain special conditions in notes or details. Show the sequence and techniques for areas where shrinkage stress and distortion control is necessary.
5. **Changes and Substitutions.** Do not change a Shop Drawing after it has been conditionally approved unless the Bridge Engineer gives written consent. List and symbolize revisions on each drawing.

   Obtain written consent from the Bridge Engineer before substituting materials with dimensions and weights other than those shown on the Plans. Make changes associated with an approved substitution at no expense to the Department.
6. **Alternate Locations of Splices and Connections.** If splices or connections are desired at locations other than those shown on the Plans, submit a proposal and Shop Drawings to the Bridge Engineer to get written approval before proceeding.
7. **Steel Identification.** Upon request, furnish an affidavit certifying the identification of steel is maintained throughout fabrication.

   On the Shop Drawings, show the grade of steel to be used and identify each piece. Give pieces made of different types or grades of steel different assembly or erection marks.

   Maintain the identity of the mill test report number when assembly-marking individual pieces and when giving cutting instructions to the shop.

C. Fabrication Schedule

Ensure that the fabricator submits a proposed fabrication schedule to the State Materials and Research Engineer that includes the following:

- Correct project number, including county
- Bridge number
- Starting date
- Estimated completion date

D. Quality Control Program

Before fabrication begins, submit the fabricator's written Quality Control program to the Office of Materials and Research for approval. This program and its personnel will be subject to verification when the Department's Materials and Research Engineer deems necessary.

Even with a State inspection, continue to perform Quality Control (QC) on all nonfracture-critical and fracture-critical members and components.

E. Mill Orders and Shipping Statements

Furnish the number of copies of mill orders and shipping statements covering fabricated materials and related miscellaneous materials the Engineer directs. Show the weights of individual members on the statements.

F. Mill Test Reports

Furnish the Engineer two certified, legible copies of mill test reports that show the results of physical tests and complete ladle analyses for each heat and grade of steel ordered. Refer to the ASTM designation of tests used. Furnish mill test reports at no expense to the Department.

G. Welding Procedures

Before structural steel fabrication begins, submit welding procedures to the Engineer for review and approval.

H. Electrode Testing

Furnish a manufacturer's certification showing that the material requirements used for manufacturing the tested electrodes and furnished electrodes were the same for each lot of electrodes on the Project.

I. Falsework

If required, prepare and submit falsework plans for the Engineer's review. Continue to assume the responsibility to produce safe falsework. When erection is completed, remove falsework to the Engineer's satisfaction.

J. Camber Diagram

Furnish the Engineer a diagram showing the camber at each splice point for each girder. Base the diagram on measurements taken during shop assembly. In the case of partial shop assembly, base the camber diagram on theoretical calculated values.

501.2 Materials

Ensure that materials meet the requirements of the following Specifications:

Material	Section
Structural Steel	851.2.01
Cold-Finish Carbon Shafting	854.2.06
Steel Castings	854.2.07
Paints	870
Steel Bolts, Nuts, and Washers	852.2.01
Anchor Bolts	852.2.02
High Tensile-Strength Bolts, Nuts, and Washers	852.2.03
Shear Connectors	512
Elastomeric Pads	885.2.01

Material	Section
Plain Cotton Duck	881.2.01
Rubber-Impregnated Cotton Duck	881.2.02
Self-Lubricating Bronze Bearing and Expansion Plates Galvanizing and Bushings	857.2.03 ASTM A 153/A 153M

1. **Fasteners.** Use fasteners in their lubricated, as-delivered condition. Use black bolts oily to the touch. With galvanized assemblies, use nuts with a clean, dry lubricant that contrasts with the color of the zinc coating.
2. **Self-Lubricating Bronze Plates.** Use cast-bronze plates of the type shown on the Shop Drawings, unless otherwise shown on the Plans.

501.2.01 Delivery, Storage, and Handling

A. Fasteners

Store fasteners to protect them from dirt and moisture. Take from storage only enough fasteners to install and tighten during a work shift. Return unused fasteners to protective storage at the end of the shift.

B. Structural Steel Members

1. Delivery

   Load, transport, and unload girders without excessive stress or damage.

   The Engineer will observe the delivery of beams or girders and will immediately notify the Contractor of damaged or unsatisfactory material before the material is unloaded or as soon as the damage is discovered.

   If members are improperly handled, the Inspector may withhold or remove the final stamp of approval.

   Use Figure 1, Figure 2, and the following loading specifications and shipping details for truck, rail, or barge transportation.

   a. Use chains and chain binders to secure beams and girders during shipping only if using a protective shield to prevent gouging flanges and if providing adequate bracing to prevent bending the top flanges.

   b. Keep the center of gravity of beams, girders, and heavy haunch sections as low as possible.

   c. Use access roads to safely deliver beams and girders to the site.

C = 0.2L min.
C = 0.3L max.

For short beams or girders supported on a flat bed the min. C may be disregarded.

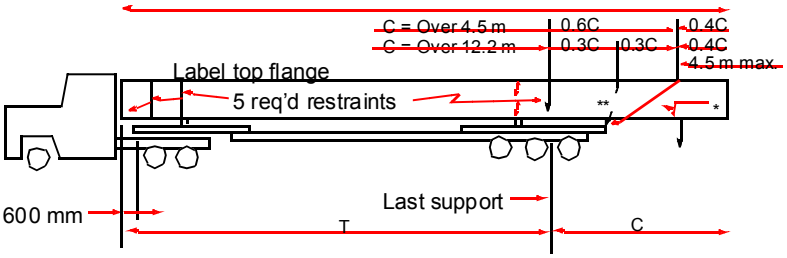
* If C = over 15 ft use additional restraint here.

** If C = over 40 ft use another restraint here.

0.4C may be increased to 15 ft to cut down or restraint length, or where angle is too flat.

Beam of overhang ends shall be restrained against flapping horizontally and vertically.

Figure 1



C = 0.2L min.
C = 0.3L max.

For short beams or girders supported on a flat bed the min. C may be disregarded.

* If C = over 4.5 m use additional restraint here.

** If C = over 12.2 m use another restraint here.

0.4C may be increased to 4.5 m to cut-down or restraint length, or where angle is too flat.

Beam of overhang ends shall be restrained against flapping horizontally and vertically.

Figure 1 (metric)

Table of Dimensions—Feet

1	Min. C & T		Remarks	Max. C & T	
75	15	60		22.5	16.0
80	16	64		24	17.0
85	17	68		25.5	18.1
90	18	72	Max C for 30 in WF →	27	19.2
95	19	76	Max C for 33 in WF →	28.5	20.3
100	20	80	Max C for 36 in WF →	30	21.3
105	21	84		31.5	22.4
110	22	88		33	23.5
115	23	92		34.5	24.5
120	24	96	Preferred Max C for PLG →	36	25.6
125	25	100		37.5	26.7
126	26	100		37.8	88.2
127	27	100		38.1	88.9
128	28	100		38.4	89.6
129	29	100		38.7	90.3

Figure 2

Table of Dimensions—Meters					
1	Min. C & T		Remarks	Max. C & T	
23.0	4.5	18.2		6.9	16.0
24.0	4.9	19.5		7.3	17.0
26.0	5.2	20.7		7.8	18.1
27.0	5.5	21.9	Max C for 760 mm WF →	8.2	19.2
29.0	5.8	23.2	Max C for 838 mm WF →	8.7	20.3
30.0	6.1	24.3	Max C for 914 mm WF →	9.1	21.3
32.0	6.4	25.6		9.6	22.4
34.0	6.7	26.8		10.0	23.5
35.0	7.0	28.0		10.5	24.5
37.0	7.3	29.3	Preferred Max C for PLG →	11.0	25.6
38.0	7.6	30.0		11.4	26.7
38.4	7.9	30.0		11.5	26.9
38.7	8.2	30.0		11.6	27.1
39.0	8.5	30.0		11.7	27.3
39.3	8.8	30.0		11.8	27.5
39.6	9.1	30.0		11.9	27.7
39.9	9.4	30.0		12.0	28.0

Figure 2 (metric)

2. Storage

   Handle structural steel during storage in the same manner as during fabrication. See Subsection 501.2.01.B.2.a, "General" and Subsection 501.2.01.B.3, "Handling."

   a. General

      Place beams and girders with their webs vertical. Shore, brace, or clamp beams and girders to resist lateral forces during storage. Keep steel free from dirt, oil, grease, or other contaminants and protect it from corrosion. Pitch trough sections to provide water drainage.

      Do not stack beams and girders on each other.

      Place long members on supports close together to prevent damage from deflection.

      The Engineer will observe the storage and handling of beams or girders and ensure that they are satisfactory before erection.

   b. Supports

      The material on which the beams and girder supports are placed shall be firm, well-drained, unyielding, and not allow excessive or uneven settlement when the supports are loaded.

      Store beams and girders on platforms, skids, or other supports on the ground above high-water elevation.

Shore supports with firm, well-drained unyielding material. Use material that settles evenly when the supports are loaded.

Support beams and girders adjacent to the bearings and at intervals of no more than 25 ft (7.5 m). Use enough intermediate supports to prevent damage from deflection.

3. Handling

Handle steel members with clamps, plate hooks, or devices to avoid nicks, gouges, or depressions. Do not use chains and chokers to handle steel members unless using a protective shield between the chain or choker and the member.

a. Beam and Girder Pick Up

Use spreader bars to lift beams and girders over 50 ft (15 m) in length.

- One-point pick ups are allowed for beams and girders less than 50 ft (15 m) long.
- Use two-point pick ups so the amount of overhang and distance between hooks does not exceed the distances in the following table:

Beam Size	30 in (760 mm) WF	33 in (840 mm) WF	36 in (920 mm) WF	Plate Girders
2-point pick-up distance between hooks linear feet (meters) maximum	74 (22)	80 (24)	85 (26)	100(30)
2-point pick-up overhang linear feet (meters) maximum	25 (7)	28 (8)	30 (9)	35 (10)
WF = Wide Flange				

If using pick-ups that cause long overhangs, attach lines at beam ends to control movement.

b. Beam and Girder Protection

Keep webs of beams and girders vertical while handling. Never drop, throw, or drag beams and girders.

Do not allow beams or girders to bend about the weak axis, even under their own weight. When shipping beams or girders upside-down, use caution when turning them over for shipment and turning them right-side up at their destination. Use enough blocking and pick-up points to prevent excess stress on the girder.

501.3 Construction Requirements

501.3.01 Personnel

A. Fabricators

Employ structural steel fabricators certified under the AISC Certification Program, Category III—Major Steel Bridges.

B. Welders

Qualify field welders according to ANSI/AASHTO/AWS D 1.5. Employ certified welders who possess a current welding certification card issued by the Department's Office of Materials and Research.

501.3.02 Equipment

A. Tension Measuring Device

Have a tension measuring device at all job sites where High Tensile-Strength bolts are installed and tightened. Use the tension-measuring device to:

- Confirm the proper snug tight and final installation bolt tension
- Calibrate wrenches properly
- Ensure the bolting crew understands the importance of proper bolt tensioning

At least once a year, have an approved testing agency calibrate the tension-measuring device to confirm its accuracy.

B. Wrenches

If using the calibrated wrench method to tighten HTS bolts, calibrate the wrench at least once each working day for each diameter, length, and grade of bolt to be installed. Recalibrate the wrench when adding or deleting the air hose, changing compressors, or performing similar tasks.

Use the wrench in job-site tightening under the exact conditions that it was calibrated. Recalibrate wrenches if a significant difference is noted in the surface condition or level of lubrication of the bolt threads, nuts, or washers.

C. Ovens

Use electric drying ovens approved by the Engineer to dry electrodes according to ANSI/AASHTO/ AWS D 1.5.

D. Lifting Equipment

Use proper lifting equipment that can carefully handle steel members without bending, twisting, damaging, or excessively stressing parts. Use cranes that have at least a two-part line for lifting.

The Department will terminate shop inspection if lifting equipment is operated or maintained in a hazardous manner.

E. Erection Equipment

Proposed erection equipment is subject to the Engineer's review. Even with this review, assume responsibility for providing adequate and safe equipment and for carrying out the work according to the Plans and Specifications. Begin erection only after the Engineer's review.

501.3.03 Preparation

A. Installation Method Testing for Bolted Construction

Before beginning the bolting operation, the Engineer will verify the Contractor's installation method. Verification will determine if the method used (calibrated wrench or turn-of-nut) will produce the correct bolt tension in the HTS structural bolts of the completed connection.

If the method is successful, the total clamping force of bolts will be transferred to the connected members and will resist slipping through friction.

Do not use bolts tightened during installation method tests or use other previously used HTS structural bolts in the work.

1. Verification Procedures for Both Methods

   Test both methods of tightening (calibrated wrench or turn-of-nut) with the following procedures:

   a. Select three assemblies (bolt, nut, and washer) from each diameter, length, and grade to be installed.
   b. Install each bolt, nut, and washer into the tension-measuring device.
   c. Install enough spacers or washers so that at least 3 but not more than 5 full threads are between the nut face and the underside of the bolt head.
   d. Use the same type of element (nut or bolt head) as will be used in the work. Place a hardened washer under the turned element.
   e. Snug tighten each assembly using the procedure that will be used in the work.
   f. After snug tightening, place appropriate marks on the end of the bolt stick out and nut, bolt head and tension calibrator, or drive socket and tension calibrator.

2. Calibrated Wrench Method Verification

   a. Impact Wrench

      When using an impact wrench:

1) Tighten each of the three assemblies beyond snug tight.
2) Adjust the wrench to cut out at a tension no less than 5 to 10 percent higher than the appropriate tension shown in Table A: Required Fastener Tension.

   Bolts tightened to this cut-out point should consistently develop the required minimum tension. This cut-out point shall be the actual job-site setting.

b. Manual Torque Wrench

When using a manual torque wrench:

1) Tighten each of the three assemblies beyond snug tight.
2) Note the torque required to induce a bolt tension 5 to 10 percent higher than the appropriate tension shown in Table A: Required Fastener Tension.
3) Measure torque with the nut in rotation.
4) Average the three tests to find the minimum torque to use for job-site installation tightening.
5) If the torque wrench produces erratic results, do not use that wrench.

3. Turn-of-Nut Method Verification

When using the turn-of-nut method, tighten the three assemblies beyond snug tight to the appropriate rotation shown in Table B: Nut Rotation from Snug Tight. Ensure that at this rotation, the minimum bolt tension is 5 to 10 percent higher than the appropriate tension shown in Table A: Required Fastener Tension.

Table A: Required Fastener Tension

Nominal Bolt Diameter and Thread Pitch	Minimum Tension (1) in kips (kN)	
	ASTM A325 (A 325M)Bolts	ASTM A490 (A 490M) Bolts
1/2	12	15
5/8 (M 16 x 2)	19 (91)	24 (114)
3/4 (M20 x 2.5)	28 (142)	35 (179)
7/8 (M22 x 2.5)	39 (176)	49 (221)
1 (M24 x 3)	51(205)	64 (257)
1-1/8 (M27 x 3)	56 (267)	80 (334)
1-1/4 (M30 x 3.5)	71(326)	102(408)
1-3/8	85	121
1-1/2 (M36 x 4)	103 (475)	148 (495)

(1) Equal to 70 percent of specified minimum tensile strengths of bolts (as specified in ASTM Specifications for tests of full-size A 325 (A 325M) and A 490 (A 490M) bolts with UNC (metric) threads loaded in axial tension) rounded to the nearest kip (kN).

Table B: Nut Rotation(1) from Snug Tight

Bolt Length (measured from underside of head	Both faces normal to bolt axis	One face normal, one faced sloped not more than 1:20	Both faces sloped not more than 1:20

to end of bolt)			
4 x bolt diameter or less	1/3 turn	1/2 turn	2/3 turn
Greater than 4 but no more than 8 x bolt diameter	1/2 turn	2/3 turn	5/6 turn
Greater than 8 but no more than 12 x bolt diameter	2/3 turn	5/6 turn	1 turn
(1) Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn or less, the tolerance of plus 30 degrees, minus 0 degrees applies. For bolts installed by 2/3 turn and more, a tolerance of plus 45 degrees, minus 30 degrees applies.			

501.3.04 Fabrication

A. Straightening Material

Ensure that rolled material is straight to the mill tolerances provided in ASTM A 6/A 6M before it is laid off or worked. Use straightening methods that do not injure the metal. Sharp kinks and bends will be cause for rejection the material.

B. Using Stock Material

The fabricator may use stock materials for minor Items whose quantity for the Project is less than the minimum required for mill rolling if the following requirements are met:

1. Mill test reports show that the stock material meets the requirements of the Specifications.
2. The stock material is identifiable by heat number and mill test report so the Inspector can determine if the material meets the required Specification.

Instead of these requirements, the Engineer may take representative stock samples and test them at the Contractor's expense.

C. Identifying Steel

Provide a system of assembly-marking individual pieces and the issuance of cutting instructions to the shop that will maintaining identity of the mill test report number.

Before cutting or placing individual pieces of steel in stock for later use, mark the pieces with the following:

- Mill test report number
- Heat number
- Color code, if any

Transfer heat numbers and color codes only in the presence of the Inspector.

Color code steel pieces according to ASTM A 6/A 6M Specification identification. Establish and record an individual color code for steels not included in the A 6/A 6M Specification.

If steel is subject to fabrication that might erase a painted color code mark before assembly, stamp it with a steel die or attach a tag.

D. General Procedures

1. **Marking Steel.** Mark finished beams or girders with the following:
    - Erection mark or match mark according to the erection diagram on the shop drawings.
    - Weight, if a member weighs more than 3 tons (3 Mg).
2. **Edge Planing.** Plane sheared edges of plates more than 5/8 in (16 mm) thick to a depth of 1/4 in (6 mm).
3. **Re-Entrant Cuts.** Fillet re-entrant cuts, notch free, to a radius of at least 3/4 in (19 mm).

4. **Oxygen Cutting.** Steel may be oxygen-cut if the following is obtained:
   - Smooth surface free of notches and cracks
   - Accurate profile using a mechanical guide

   Ensure that oxygen cutting conforms with AWS D 1.5. Oxygen-cut by hand only where approved.

   After cutting, round the corners of oxygen-cut surfaces to a 1/16 in (2 mm) radius by grinding.
5. **Cambering.** The camber shown on the Plans is that required after completely fabricating the member, including attaching cover plates and shear connectors. Do not use cambering methods that will induce stresses that may impair the service life of the member.
   a. Obtain camber for plate girders by cutting both edges of the web after the shop web splices are complete and have been inspected.
   b. Apply heat no hotter than 1,150 °F (620 °C) to adjust deviations from the camber ordinates (shown on the Shop Drawings) caused by web distortion from either of the following:
      - Oxygen cutting
      - Weld metal shrinkage

   c. Obtain camber for rolled beams with approved heat-cambering methods.
6. **Finishing Bearing Surfaces**

   Ensure that the surface finish of bearings, base plates, and other bearing surfaces in contact with each other or with concrete meets the ANSI surface roughness requirements, defined in ANSI B 46.1 Part 1, as follows:

Surface	Finish Requirement
Steel slabs	ANSI 2,000 (50 µm)
Heavy plates in contact in shoes to be welded	ANSI 1,000 (25 µm)
Milled ends of compression members and milled or ground ends of stiffeners and fillers	ANSI 500 (12.5 µm)
Bridge rollers and rockers	ANSI 250 (6.3 µm)
Pins and pin holes	ANSI 125 (3.2 µm)
Sliding bearings	ANSI 125 (125 µm)

   Finish surfaces that contact metal or masonry as specified below.

   a. **Sole and Bearing Plates.** Ensure that sole and bearing plates have full contact when assembled. Straighten warped or deformed plates before machining; then do one of the following to the surfaces of plates contacting masonry:
      1) Machine the surfaces to an ANSI 2,000 (50 µm) surface roughness rating value.
      2) Straighten the surfaces so that the maximum clearance under a straightedge placed across the bearing surface in any direction is 1/16 in. (2 mm)

   b. **Cast Pedestals and Shoes.** Machine the surfaces of cast pedestals and shoes that contact metal surfaces.
   c. **Bearing Assemblies.** Finish fabricated bearing assemblies according to Subsection 501.3.04.D.6, "Finish Bearing Surfaces."

      Perform final machining after the assembly is completely fabricated. If the completed assembly must be heat-treated, perform final machining after the heat treatment.
   d. **Plates in Contact with Elastomeric Pads.** Ensure that the plates are straight and free of loose mill scale. Do not machine-finish the surface in contact with the elastomeric pad.

e. **Direction of Cut.** Machine the faces of movable surfaces and their opposing contact surfaces so that the finish cut is in the direction of the expected movement, unless using non directional finishing equipment.

f. **Abutting Joints**. In compression members (and tension members when specified on the Plans), face the abutting joints and bring them to even bearings. When facing joints is not required, ensure an opening of 1/4 in (6 mm) or less.

7. **Annealing and Stress Relieving**

After heat treatment, machine-finish, bore, and straighten the structural members required by the Plans to be annealed or normalized. Perform full annealing and normalizing according to ASTM A 919 and the following:

a. During heating and cooling, keep the furnace temperature uniform so the temperature difference between any two points on a member does not exceed 100 °F (40 °C).

b. Record each furnace charge to identify the pieces in the charge and show the temperatures and schedule used.

The method of recording the treatment operation procedures is subject to the Inspector's approval.

c. Provide proper instruments, including recording pyrometers, to determine member temperatures in the furnace.

d. When the Contract requires, stress-relieve welded bridge shoes, pedestals, and other similar weldments according to AWS Specifications.

8. **Component Fabrication**

a. Beam and Girder Ends

Fabricate the ends of beams and girders to be vertical in the final erected position, unless otherwise shown on the Plans.

b. End Connection Angles

Build end connection angles to the exact length shown on the Plans, measured between the heels of the connection angles. The allowed tolerance is plus 0 to minus 1/16 in (plus 0 to minus 2 mm).

Where continuity is required, face end connections. Ensure that the connection angle thickness after facing is no less than 3/8 in (10 mm) or the amount shown on the Plans.

c. Steel Joints

At the shop, shape the plates, angles, or other structural shapes to conform to the section of the concrete deck. Ensure that painting and other fabrication requirements conform to the Specifications for these Items.

d. Bent Plates

Ensure that unwelded, cold-bent, load-carrying, rolled steel plates meet the following requirements:

1) The bend lines are at right angles to the rolling direction.

2) The plate will not crack during bending.

Minimum bend radii, measured to the concave face of the metal, for all grades of steel used in this specification, are shown in the following table:

Thickness "T" in Inches (Millimeters)	Minimum Bend Radii
Up to ½ (12)	2 T
Over 1/2 to 1 (12 to 25)	2-1/2 T
Over 1 to 1-1/2 (25 to 38)	3 T
Over 1-1/2 to 2-1/2 (38 to 60)	3-1/2 T
Over 2-1/2 to 4 (60 to 100)	4 T

Low-alloy steel in thicknesses over 1/2 in (12 mm) may require hot bending for small radii. If a shorter radius is essential, bend plates hot at 1,200 °F (650 °C) or less. Ensure that hot-bent plates have bend lines at right angles to the rolling direction.

3) Round the corners of plates to a radius of 1/16 in (2 mm) before bending.

e. Stiffeners

Ensure that bearing stiffeners and stiffeners used as supports for concentrated loads have full bearing on the flanges they transmit load to or the flanges they receive load from. Mill or grind the bearing surfaces of stiffeners.

On weldable steel in flange compression areas, the Contractor may weld stiffeners as shown on the Plans.

Ensure that stiffeners not located at points of concentrated loads fit tightly enough to keep water out after painting, unless otherwise shown.

f. Pins

Turn pins accurately to the dimensions shown on the Shop Drawings. Ensure that pins are straight, smooth, and flawless. The pins may be forged and annealed or of cold-finished, carbon steel shafting.

Furnish two pilot nuts and two driving nuts for each size of pin, unless otherwise specified.

g. Pin Holes

Bore pin holes in members so they are:

- True to the specified diameter
- Smooth
- Straight
- At right angles to the axis of the members
- Parallel with each other, unless otherwise required

Produce the final surface with a finishing cut. Bore holes in built-up members after completing bolting or welding.

Ensure that pin hole diameters meet the following requirements:

Pin Diameter	Pin Hole Diameter
5 in (125 mm) or less	Must not exceed pin diameter by more than 1/50 in (0.50 mm)
Larger than 5 in (125 mm)	Must not exceed pin diameter by more than 1/32 in (0.75 mm)

h. Threads

For structural steel construction, use threads for bolts and pins that conform to the Unified Screw Threads ANSI B1.13 (Metric Screw Threads, ANSI B 1.13M), Class 2A for external threads, and Class 2B for internal threads except pin ends with a diameter of 1 3/8 in (35 mm).

i. Unfinished and Turned Bolts

1) Bolts

Do not use ribbed bolts. Use unfinished bolts or turned bolts that conform to ASTM F 568M Class 4.6. Use bolts with single self-locking nuts or double nuts unless otherwise shown.

Use turned bolts with an ANSI surface roughness rating of 125 (3.2 µm).

2) Washers

Use beveled washers when bearing faces have a slope of more than 1 to 20 with respect to a plane normal to the bolt axis.

3) Heads and Nuts

Use hexagonal heads and nuts with standard dimensions for bolts of nominal size specified or of the next larger size. Provide a washer under the nut.

Use threads with a diameter equal to the body or nominal diameter of the bolt specified. For turned bolts, threads shall be entirely outside of the holes.

j. Anchor Bolts

Use anchor bolts of the size and shape specified on the Plans.

9. **Coating Machine-Finished Steel Surfaces**

Coat the following with rust-inhibiting grease or with other approved corrosion-preventive compounds:

- Opposing surfaces of sliding bearings
- Mating convex and concave surfaces of curved plates and rocker bearing assemblies
- Sliding surfaces opposite self-lubricating bronze surfaces
- Pins and pinholes

Coat other machined surfaces with one coat of the shop primer specified on the Plans. Include convex faces of rockers and sole plates at fixed bearings of spans that have line bearings on steel plates.

10. **Shop Painting**

Perform shop painting according to Section 535, especially Subsection 535.3.05.C, "Paint New Steel Structures," step 5.

E. Bolt Holes

Produce bolt holes as follows:

1. Full-Size Punched Holes

The Contractor may use full-size punched holes if these conditions exist:

- A member is composed of 5 or less separate thicknesses of metal, and
- The metal thickness of any one part is 3/4 in (19 mm) or less for structural steel, or 5/ 8 in (16 mm) or less for high-strength steel.

Poor hole matching will be cause for rejection. Punch holes as follows:

a. Punch holes 1/16 in (2 mm) larger than the nominal diameter of the bolts.

b. Do not punch full-sized holes on field connections of main members.

c. Ensure that the die diameter for punched or subpunched holes does not exceed the punch diameter by more than 1/16 in (2 mm).

d. Cut holes clean to avoid torn, ragged edges.

e. Enlarge holes by reaming.

2. Subpunched and Subdrilled Holes

Subdrill holes 3/16 in (5 mm) smaller than the nominal diameter of the bolts.

After assembly, ream the holes if any one of the conditions exists:

- A member is composed of more than 5 separate thicknesses of metal.
- The metal thickness of any one main part is greater than 3/4 in (20 mm) for structural steel or 5/8 in (16 mm) for high-strength steel.
- When required according to Subsection 501.3.05.E.1, "Normal Assembly," step b.

Instead of subpunching and subdrilling, the Contractor may drill holes from the solid after assembly. However, whether drilling from the solid or subdrilling and subpunching, ensure the following:

a. Holes are no more than 1/16 in (2 mm) larger than the nominal diameter of the bolts.

b. Holes for turned bolts are subpunched or subdrilled.

c. Holes are carefully reamed after assembly to provide a light-driving fit with the bolt.

3. Accuracy of Punched, Subpunched, and Subdrilled Holes

   Accurately full-size punch, subpunch, or subdrill holes so that after assembly but before reaming, holes meet the following requirements:

   - A cylindrical pin 1/8 in (3 mm) smaller than the nominal diameter of the punched hole can enter perpendicular to the face of the member in at least 75 percent of the adjacent holes in the same plane without drifting.
   - A pin 3/16 in (5 mm) smaller than the nominal diameter of the hole can pass through the hole.

   If either of these requirements is not met, the faulty pieces will be rejected.

4. Reamed and Drilled Holes

   Ensure that reamed and full-sized drilled holes are cylindrical, perpendicular to the member, and 1/16 in (2 mm) larger than the nominal diameter of the bolts. Ream and drill holes as follows:

   a. Direct reamers using mechanical means when practical.

   b. Ream and drill with twist drills.

   c. Remove burrs on outside surfaces. Disassemble parts, if required, to remove burrs caused by drilling or reaming.

   d. For connecting parts that require reamed or drilled holes, do the following:

      1) Assemble the connecting parts.

      2) Hold them securely while reaming or drilling.

      3) Match-mark them before disassembling.

5. Accuracy of Reamed and Drilled Holes

   After drilling and reaming holes, ensure that at least 85 percent of the holes in any group have no offset greater than 1/32 in (0.75 mm) between adjacent thicknesses of metal. Make sure the remaining holes are not elongated or show an offset greater than 1/16 in (2 mm) between the adjacent thicknesses of metal.

6. Fitting Up

   Before reaming, drilling, or bolting, ensure that the pieces forming built-up members are:

   - Straight
   - Close-fitting
   - Clean
   - True to the required dimensions
   - Free from twists, bends, open joints, burrs, and other defects resulting from faulty fabrication or workmanship
   - Well-pinned
   - Firmly drawn together

   Before shop bolting material with full-size punched holes:

   a. Ensure that holes are no more than 1/16 in (2 mm) larger than the nominal diameter of the bolt.

      Holes may be spear-reamed if necessary to clear and clean them for entering bolts.

   b. Carefully adjust end connection angles and similar parts to the correct position and firmly hold them in place until bolted.

   c. Fit up connections securely before placing bolts.

d. Ream or drill unfair holes (holes that prevent the bolt from entering).

F. High Tensile-Strength Bolt Connections

This section covers the shop and field connections of structural joints using High Tensile-Strength bolts tightened to a specified tension. Use HTS structural bolts that meet the requirements of Subsection 852.2.03, "High Tensile-Strength Bolts." Furnish the bolts, nuts, and washers according to Subsection 852.2.03.

To seat parts solidly, keep joint surfaces (including those adjacent to the bolt heads, nut, or washers) free of scale (except tight mill scale), dirt, burrs, metal spatters, and other defects. Ensure that joint contact surfaces are free of oil, grease, paint, lacquer, galvanizing, rust, and other matter. Refer to the requirements of Subsection 535.3.05.C, "Paint New Steel Structures" step 5.

Install fasteners with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

- When the slope of the bolted-part surfaces contacting the bolt head and nut do not exceed 1:20 (with respect to a plane normal to the bolt axis), use a flat washer.
- When the slope of an outer face of the bolted parts exceeds 1:20, use a smooth, beveled washer.
- If necessary, clip washers on one side to a point no closer than 85 percent of the bolt diameter from the center of the washer.

When a joint assembly is complete, ensure that each bolt has a tension 5 to 10 percent above the required minimum value shown in Table A: Required Fastener Tension.

G. High Tensile-Strength Bolt Tightening Methods

Tighten HTS bolts with either the Calibrated Wrench Method or the Turn-of-Nut Method. For both methods, conduct the final rotation of the nut or bolt (whichever is the turned element) from a snug-tight condition according to Table B: Nut Rotation from Snug Tight.

Snug tight is the tightness achieved when the plies of the joint are in firm contact. Obtain this with a few impacts of an impact wrench or with full effort using an ordinary spud wrench. Ensure that the snug tightening procedure produces 10 to 30 percent of the required fastener tension shown in Table A: Required Fastener Tension.

1. Calibrated Wrench Method

   Install bolts in the connection holes with a hardened washer under the turned element and bring the bolts up to snug tight (described above) as follows:

   a. Snug tighten systematically from the most rigid part of the connection to the free edges as follows:
      1) Start the tightening pattern at the center of the pattern near the end of each member being spliced.
      2) Work toward the edges of the splice plate.
   b. After the initial snug tightening, systematically tighten the bolts again as necessary using a similar tightening pattern until all bolts are simultaneously snug tight and the connection is fully compacted.
   c. Following snug tightening, tighten the bolts in the connection using a calibrated wrench (either air impact or manual torque). Systematically tighten from the most rigid part of the joint to its free edges.
   d. After the first pass, systematically tighten the bolts again to ensure that bolts that may have relaxed from tightening adjacent bolts are tightened to the prescribed amount.
   e. Operate impact wrenches until the wrench cuts out at the setting established by calibration.

      If using a manual torque wrench, measure the target torque with the turned element in motion.
   f. During installation in the assembled steel work, verify that the wrench adjustment selected by the calibration does not rotate the nut or bolt head from snug tight more or less than that permitted in Table B: Nut Rotation from Snug Tight.

2. Turn-of-Nut Method

When bolts are too short to fit in the tension calibrating device, use the Turn-of-Nut Method in the actual work.

Install bolt connection holes with a hardened washer under the turned element and bring the bolts up to snug tight (described above) as follows:

a. Snug tighten the bolts using steps a and b of the Calibrated Wrench Method.

b. Following snug tightening, tighten the bolts in the connection by the applicable amount of rotation specified in Table B: Nut Rotation from Snug Tight.

c. During the tightening operation, do not rotate the part not turned by the wrench.

d. Tighten systematically from the most rigid part of the joint to its free edges as follows

   1) Start the tightening pattern at the center of the pattern near the end of each member being spliced.

   2) Work toward the edges of the splice plate.

H. Welded Construction

Ensure that welded construction conforms to the requirements below. Electroslag or electragas welding is prohibited.

1. **Insufficient Welds.** Repair, remove, or replace welds that do not meet the requirements of the Specifications using methods permitted by 3.7 of ANSI/AASHTO/AWS D 1.5 Specifications. If the weld is unacceptable, the Engineer will reject the entire piece.

   After welding repairs are made, the Engineer will have the repaired areas retested to determine if the repairs meet Specification requirements.

2. **Unauthorized Welds.** Obtain the Engineer's approval before making temporary or permanent welds not shown on the Plans or permitted by the Specifications.

I. Alterations to AASHTO Paragraphs

Ensure that welded construction conforms to the American Welding Society (AWS) "Bridge Welding Code" ANSI/AASHTO/AWS D 1.5 (including revisions) except as modified by these Specifications and AASHTO. Exceptions to the ANSI/AASHTO/AWS specifications are noted below.

1. **Paragraph 3.5.2.** Instead of Paragraph 3.5.2, apply the following requirements:

   a. Before cutting ends to length, shop assemble ends of members to be field connected by welding in the laydown position (placed to grade from bearing to bearing).

   b. To align field splices vertically, match-cut adjoining ends while in the laydown position and matchmark the ends at the center point of the web section.

   c. Check rolled shapes with ends to be field welded before beginning fabrication in order to take into consideration allowed mill tolerances on web-center-line-to-flange measurements. Pair shapes to provide the best possible alignment.

2. **Paragraph 3.10.1.** Instead of Paragraph 3.10.1, apply the following requirements:

   a. Remove slag from welds immediately after completing each weld. Do not further clean or paint welds to be encased in concrete.

   b. For welds connecting swaybracing members to steel piling that are to be painted according to Subsection 535.3.05.E, "Paint Steel H-Piling, Metal Shell Piling, and Steel Swaybracing" and Subsection 535.3.05.F, "Apply Special Protective Coatings to Steel Piling, Steel Swaybracing, and Concrete Piling," remove the slag and do not clean any further.

   c. Clean and paint other welds as specified below.

   d. After removing slag and after completing visual, ultrasonic, or magnetic particle inspection, either blast-clean or scrub welds with water and a stiff brush. Ensure that weld areas are clean and free of spatter, rust, loose scale, oil, and dirt.

e. Prime welds on the same day they are cleaned, using the prime coat specified on the Plans or in the Special Provisions. When using water to clean, ensure that the surface is dry before painting. Clean and prime welds as soon as practical after the weld is accepted and before the weld area rusts.

3. **Paragraph 4.30.1.** Instead of Paragraph 4.30.1, apply the following requirements:

After welding studs to beams, visually inspect the studs and give a random number of them a light blow with a hammer. Strike the following with a hammer and bend them 15 degrees from the correct installation axis:

- Studs that do not show a full 360-degree weld fillet.
- Studs that do not ring when given a light blow with a hammer.
- Studs that have been repaired by welding.

In case of a defective or repaired weld, bend the stud 15 degrees in the direction that places the defective portion of the weld in the greatest tension.

Replace studs that crack (either in the weld, base metal, or the shank) during inspection or subsequent straightening. See paragraph 4.30.4.

On studs that must be replaced, the Contractor may manually weld the stud with the following fillet welds:

Stud Size	Fillet Weld
3/4 in (19 mm)	Full 360 degrees–1/4 in (6 mm)
7/8 in (22 mm)	Full 360 degrees–5/16 in (8 mm)
1 in (25 mm)	Full 360 degrees–5/16 in (8 mm)

501.3.05 Construction

A. Straightening Material

The Engineer may permit straightening of plates, angles, other shapes, and built-up members if the straightening is minor and can be accomplished in the field. Use only methods that do not injure the metal.

1. **Heat Straightening.** When the Engineer allows it, heat-straighten metal as follows:
   a. Ensure that parts to be heat-straightened are free of stress and external forces. The exception is stresses from the mechanical means used to apply the heat.
   b. Carefully apply a limited amount of localized heat under supervision:
      1) Heat the area to no more than 1150 °F (620 °C) as measured by temperature-indicating crayons, liquids, or bimetal thermometers.
      2) Cool the metal slowly after heating.

         After the metal cools naturally to 600 °F (315 °C), the Contractor may use air-mist spray cooling.
   c. After straightening a bend or knuckle, have the Engineer carefully inspect the metal surface for evidence of fracture and for general acceptability.

B. Erection

Proposed erection methods are subject to the Engineer's review. Even with this review, assume responsibility for providing adequate and safe methods and for carrying out the work according to the Plans and Specifications. Begin erection only after the Engineer's review.

1. Assemble Parts in the Field

   Before assembly, clean surfaces that will permanently contact each other.

   Assemble parts accurately, following the match marks, according to the Plans and the erection diagram shown in the Shop Drawings.

Do not hammer if it will injure or distort the members.

Ensure that fitting-up and drifting done during field assembly and connection meet the requirements of Subsection 501.3.04.E.6, "Fitting Up."

2. Erect Beam and Girder

   Before making field connections (bolting or welding) on continuous beams or girders, adjust splice joints to the correct elevations and slopes and properly align the beams.

   The Contractor may make beam and girder splices on the ground if using the proper blocking to give adjoining sections the correct relative slopes.

3. Place Anchor Bolts and Adjust Nuts

   Unless otherwise shown on the Plans, provide formed holes for anchor bolts. Set the bolts using an approved nonshrinking mortar. Place anchor bolts as follows:

   a. After erecting structural steel, drop the bolt into the dry hole to ensure that it fits properly.
   b. Remove the bolt and fill the hole approximately two-thirds full with an approved nonshrinking mortar the consistency of thick paint.
   c. With even pressure or light hammer blows, force the bolt down until:
      1) Mortar rises to the top of the hole.
      2) The anchor bolt nut and washer rest firmly against the metal flange, plate, shoe, or pedestal.
      3) The bolt has the correct projection above the top of the concrete bearing area.
   d. Remove excess mortar flushed from the hole down to the concrete bearing area.
   e. Clean holes or slots and metal surfaces in order to field paint surfaces properly and to allow moving parts to expand and contract without restraint.
   f. Tighten nuts on anchor bolts that pass through beam and girder flanges or through sole plates attached to flanges as follows:
      1) At both fixed and expansion ends, tighten nuts and bolts to bear on the washer and then back off one full turn.
      2) Draw nuts on other anchor bolts down to a tight fit.
      3) Do not burr anchor bolt threads.
   g. Adjust the horizontal locations of the anchor bolts relative to the midpoint of slotted holes in bottom beam flanges according to the ambient temperature at bolt placement. This allows the beam and its attached bearing components to expand or contract in the future.
   h. Do not grout anchor bolts within a complete unit until beam splicing within the unit is complete.

4. Erect Steel Joints

   Erect steel joints so that the surface in the finish grade plane (laterally and longitudinally) is true and free of warping.

   Keep joints from moving out of their correct position during concrete placement.

   Cut loose temporary connections as soon as possible to avoid restraining expansion and contraction.

   Note that openings shown on the Plans are based on an erection temperature of 60 °F (15 °C). Make corrections in the opening size for the actual erection temperature, and maintain the required opening.

5. Connect Pins

   Furnish pilot and driving nuts at no additional cost to the Department. Drive pins so that members take full bearing. Provide pin nuts and run them up tight. Burr the threads at the face of the nut.

6. Misfits

Correct misfits by reaming, cutting, and chipping during erection.

Immediately report to the Engineer errors that occur in shop fabrication or deformations from handling and transportation that prevent assembling and fitting up parts properly. The Engineer must approve the correction method.

Assume responsibility for misfits, errors in fabrication, and damage. Make corrections or replace parts at no additional cost to the Department.

C. Finishing Bearing Areas

1. Steel on Concrete

   Unless otherwise required, level and finish bearing areas with a Type IV—Floated Surface Finish according to Subsection 500.3.05.AB.5, "Type IV—Floated Surface Finish."

   a. Finish so that steel joint members, shoes, and bearing plates have full and uniform bearing.
   b. Correct improperly finished areas by approved means.
   c. Ensure that shoes and plates are on the correct alignment and elevation.
   d. Unless otherwise provided, place shoes and plates on layers of canvas (cotton duck) and red primer that conforms with Subsection 870.2.01.A.1, "No. 1A, Red Primer" as follows:
      1) Coat the bearing area surface with red primer.
      2) Place three layers of at least 8 oz (227 g) duck and coat each layer's top surface with red primer.
      3) Position shoes or plates on the top layer of duck while red primer is still plastic.
      4) Instead of red primer—saturated duck, the Contractor may substitute thin pads of an approved type and thickness.

2. Steel on Steel

   Prepare bearing areas as follows:

   a. Ensure that sole and bearing plates, rockers, and shoes that are designed to bear on one another fit with full bearing.
   b. Keep contact areas free of dirt, grit, and other foreign matter.
   c. Prepare machined surfaces that have been shop-coated according to Subsection 501.3.04.D.9, "Coating Machine-Finished Steel Surfaces" and that will be exposed after erection as follows:
      1) Remove the shop coating.
      2) Replace the coating with the same paint system used on structural steel components.

3. Steel on Self-Lubricating Bronze Plates

   Prepare machined surfaces that have been shop-coated according to Subsection 501.3.04.D.9, "Coating Machine-Finished Steel Surfaces" and that will be in contact with self-lubricating bronze plates or bushings as follows:

   a. Remove the shop coating.
   b. Coat the surface with stick lubricant or liquid furnished by the manufacturer of the self-lubricating bronze material.

4. Steel on Elastomeric Pads

   Place elastomeric pads on concrete bearing areas that have the Type IV—Floated Surface Finish specified in Subsection 500.3.05.AB.5, "Type IV—Floated Surface Finish," unless otherwise required.

   Ensure that plates that will contact elastomeric pads meet the "no paint" requirements of Subsection 535.3.05.C.5.e, "Plates That Touch Elastomeric Pads."

D. Field Painting

Field paint according to Section 535 using the paint system required by the Plans or Special Provisions. See also Subsections 501.3.05.C.2, "Steel on Steel," and 501.3.05.C.4, "Steel on Elastomeric Pads."

E. Assembly

Allow only enough drifting during assembly or field connections to bring the parts into position. Ensure that drifting does not enlarge or distort holes.

Follow these requirements when shop assembling components.

1. Normal Assembly

   Do normal shop assembly as follows:

   a. Unless otherwise specified, and before reaming, assemble each individual, full-length continuous beam, tower face, bent, rigid frame, or plate girder in the shop.

   b. Subpunch or subdrill and ream bolt holes in field connections and splices according to Subsection 501.3.04.E.1, "Full-Size Punched Holes," and Subsection 501.3.04.E.2, "Subpunched and Subdrilled Holes," while assembled in the shop.

   c. Obtain approval of the assembly, including the camber, alignment, accuracy of holes, and faced joints.

   d. On holes for the field connections of the ends of floor beams and stringers, do one of the following while members are assembled:

      - Subpunch and ream the holes
      - Ream to a steel template

2. Complete Assembly

   When the Contract requires, make the complete shop assembly of an entire structure or a portion of it, including the floor system.

3. Partial Assembly

   When authorized by the Engineer or Inspector, modify the shop assembly requirements above to permit partial shop assembly as follows:

   a. For plate girders, continuous beams, rigid frames, and columns of bents and towers, assemble at least three abutting sections.

   b. When the Plans require that the ends of compression members be faced, assemble these members with faced ends in full bearing.

4. Reaming and Drilling Through Templates

   Ream and drill through templates as follows:

   a. Use steel templates with hardened steel bushings in holes accurately dimensioned from the center lines of the connection (inscribed on the template) and from the finished end of the template.

   b. Use center lines to accurately locate the template from the milled or scribed ends of members.

   c. Use exact duplicate templates to ream matching members or the opposite faces of any one member.

   d. Accurately locate templates for connections on like members so that like members are duplicates and require no match-marking.

   e. Full-size ream or drill field connections through templates after locating the templates by position and angle and bolting the templates firmly in place.

   f. When using templates to ream field connections of web members of a bent, tower, or girder, do the following:

      1) Face or scribe at least one end of each web member normal to the long axis of the member.

2) Accurately set the templates at both ends from the faced or scribed end.

5. Match-Marking

According to the erection diagram, match-mark connecting parts assembled in the shop to ream holes in field connections.

501.3.06 Quality Acceptance

A. Testing and Inspection

1. Heat Number Testing

The Department will sample and test each heat number that structural steel is furnished from to fabricate main members.

To facilitate this testing, ship one piece from each heat of main member structural steel to the fabrication site. Provide pieces long enough to take a properly oriented, representative, 4 x 12 in (100 x 300 mm) sample. This may require that the extra length pieces be 4 or 12 in (100 or 300 mm) longer, depending on testing orientation requirements.

2. Fastener Assembly Testing

Upon receiving HTS fastener assemblies (bolts, nuts, and washers), notify the Inspection Services Branch of the Office of Materials and Research. The branch will verify that the Contractor has the documentation required by Subsection 852.2.03, "High Tensile-Strength Bolts" and sample the assemblies as necessary.

3. Bolted Construction Inspection

The Inspector will check the following before or during the bolting operation. Provide the Inspector easy access to the areas of the member to be inspected.

The Inspector will:

a. Verify that bolt tension calibrators have been calibrated within the last year. Ensure that the manual torque wrenches have been calibrated at least daily for each diameter, length, and grade as shown in this Specification.

b. Ensure that bolts are routinely installed to the proper tensions. After inspection, no further evidence of proper bolt tension is necessary.

If installation tension verification is necessary subsequent to installation and tightening of bolts, notify the Inspection Services of the Office of Materials and Research.

c. Monitor the surface condition and storage of bolts, nuts, and washers. See Subsection 501.2.01.A, "Fasteners," for storage requirements.

d. Ensure that each bolting crew member understands the procedure for snug-tightening the joint and can demonstrate this knowledge by tightening a fastener in a bolt-tension calibrator.

e. Witness the installation method verification procedure and ensure that the same conditions exist during the job-site tightening.

f. Witness fastener installation to ensure proper tightening. This monitoring will verify that plies of connected material are drawn together and that the procedure for snug tightening is followed.

g. Witness the final tightening procedure and mark at least two bolts in each connection to verify that further tightening (from the snug tight position) produces the rotation specified in Table B: Nut Rotation from Snug Tight.

4. Material Application and Traceability Verification

In addition to the requirements specified in Subsection 501.3.04.C, "Identifying Steel," the fabricator shall demonstrate by written procedures and by actual practice a material application and traceability method for the main stress-carrying elements of a shipping piece. The method must be visible at least through the fit-up operation.

The traceability method shall verify proper material application as it relates to the following:

- Material specification designation
- Heat number
- Material test reports for special requirements

5. Mill and Shop Inspection

   Give two weeks' notice to the Department's State Materials and Research Engineer (the Materials Engineer) before beginning mill or shop work so that inspection arrangements can be made. Inspection at the mill or shop is intended to facilitate work and avoid errors and does not relieve the Contractor of the responsibility for imperfect material or work quality.

   Do not roll or fabricate material until:

   - You inform the Materials Engineer where the orders have been placed.
   - The inspection is arranged or waived.

   Furnish the facilities necessary for the inspection of materials and work quality in the mill and shop. Allow Inspectors free access to the necessary mill and shop locations, and cooperate with the Inspector during inspection.

   Shop inspection is required for steel and other metal materials being fabricated.

   Inspectors will do the following:

   a. Determine if steel members, member components, or other fabricated steel components meet the Plans and Specifications.
   b. Identify the steel by color code and correlate its heat numbers obtained from certified mill test reports

   NOTE: Do not cut steel or apply prime paint until the Inspector completes this step.

   c. Check fabrication, especially the grade of steel, dimensions, welding, and bolting
   d. Perform necessary non-destructive testing to determine conformance with the Specifications and Plans.
   e. Reject materials or work that does not meet the Specifications.

   NOTE: Even if the Inspector accepts materials or members, they can be rejected later if found defective. Promptly replace or repair rejected material or members at no additional cost to the Department.

B. Quality of Work and Finish

Provide quality work and finish on shop work. Ensure that shearing, flame cutting, and chipping are neat and accurate. Neatly finish all parts of the work.

C. Welded Construction

1. Inspection

   An Inspector will be assigned to the fabrication shop for as much time as the State Materials and Research Engineer deems necessary. The State's Inspector or authorized representative will inspect fabrication phases that include, but are not limited to, the following:

   - Certification and transfer of heat numbers and grade steel
   - Dimensions and assembly
   - Inspection and testing of shop welds
   - Non-destructive testing
   - Painting
   - Random sampling

- Stamp of shop inspection

2. Quality Control

   Assume the following quality control responsibilities for non-fracture critical and fracture critical members and their components:

   a. Perform 100-percent nondestructive radiographic or ultrasonic testing of full penetration welds before offering the welds to the State for quality assurance inspection.

   b. Perform magnetic particle testing of fillet welds according to ANSI/AASHTO/AWS D 1.5.

3. Qualification

   Qualify shop weld procedures and welders according to ANSI/AASHTO/AWS D 1.5. The Engineer may accept tests conducted by other states as evidence of qualification. In the absence of approved shop weld procedures, welding operator and welder qualifications, qualify with the State Materials and Research Engineer as follows:

   a. In the presence of the Engineer's representative, prepare test plates according to ANSI/AASHTO/AWS D 1.5.

   b. Requalify according to ANSI/AASHTO/AWS D 1.5 or whenever the Engineer requires. A new welding procedure qualification is not needed at the start of each new Project.

4. Testing

   Furnish labor and equipment to do the following:

   - Position welds for magnetic particle testing
   - Help transport ultrasonic equipment
   - Provide the Inspector easy access to testing areas

   The Inspector's access to work in the shop and field is top priority.

   The Department of Transportation, in its routine quality assurance inspection, will ultrasonic or magnetic-particle test approximately 25 percent of the welds.

   If testing indicates faulty work, the Inspector will immediately notify the Contractor of the necessary corrective work. Ensure that welders are available to repair faulty work as soon as practical.

   a. **Non-destructive Testing.** If weld cracking occurs, non-destructive testing for Final Acceptance of fillet and groove welds may be delayed to:

      - Within 24 hours after welding has been completed for material 2 in (50 mm) or less
      - Within 48 hours after welding has been completed for material over 2 in (50 mm).

      The fabricator may use, at its expense, nondestructive testing methods other than those specified to examine weld passes or completed welds. Refer to ANSI/AASHTO/AWS D 1.5.

   b. **Ultrasonic Testing.** Unless otherwise specified on the Plans or in Special Provisions, test butt welds in main members by the ultrasonic method.

      In addition to the testing requirements of the Plans, Specification, and Special Provisions, the Engineer may require ultrasonic testing if the quality of the work warrants it.

5. Walkways for Field Testing

   When field testing, provide a continuous walkway between the center-most line of stringers from one of the approach fills to the farthest row of splices as follows:

   a. Provide crosswalks connecting with the center line walkway at each butt-welded splice or bolted connection on each row of stringers.

   b. Rest working platforms on the top side of the bottom flange with supporting braces fitting flush against the web.

   c. Provide at least 18 in (450 mm) of clearance on each side of the welded splice or bolted connection. Ensure that the top of the working platform is no more than 3 in (75 mm) above the top side of the bottom flange.

d. Construct walkways and working platforms of sound materials. If constructing with wood, use wood free of excessive knots or knots that could cause an unsafe condition.

e. Construct walkways at least 20 in (500 mm) wide and long enough to permit each end to rest on a fixed part or member of the bridge.

f. Ensure that walkways have a vertical support at least every 10 ft (3 m).

g. Construct working platforms at least 36 in (900 mm) wide and long enough to permit each end to rest on a fixed part or member of the bridge.

h. When a deck already exists from the end bent out to the splices, do not construct a separate walkway unless the deck reinforcement steel has been put in place.

i. Do not allow deck forms to be placed within 18 in (450 mm) of splices until the welds or bolted connections have been inspected and accepted.

6. Tolerances

   For built-up members, the requirements of paragraph 3.5.1.7 of ANSI/AASHTO/AWS D 1.5, as modified, apply except at ends to be field connected by welding. The combined warpage and tilt tolerances shall be one-half that specified.

   For rolled shapes, apply mill practice tolerances (ASTM A 6/A 6M) except at ends to be field connected by welding. The combined warpage and tilt tolerances shall be one-half that specified.

   Use the above tolerances unless there are deviations that are additive when measured at the toe. In this case, ensure that the maximum offset between adjoining flanges does not exceed 1/4 in (6 mm).

501.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

501.4 Measurement

Structural steel will be measured either per pound (kilogram) or per Lump Sum.

- **Per pound (kilogram) basis.** The quantity of structural steel to be measured for payment will be the net weight of metal in the completed and accepted structure.

  A unit weight of 490 lbs/ft³ (7850 kg/m^3) will be used to calculate the net weight of steel. The weights of rolled shapes or plates will be computed based on their nominal weight per foot (meter) as listed in standard handbooks such as the AISC Manual of Steel Construction.

- **Lump sum basis.** When the Plans specify a Lump Sum basis, this work will be measured as an accepted Lump Sum quantity, complete in place. Tabulated quantities are shown on the Plans as a service, but they do not relieve the Contractor of conforming to Plan details. If the Plan details and tabulated quantities differ, the Plan details will govern. The Contractor shall determine the actual quantities required before submitting a bid.

501.4.01 Limits

A. Qualification

Assume the cost of qualification tests and test sample preparation required under these Specifications. This cost is considered incidental to The Work.

B. Testing

Ultrasonic or magnetic-particle testing by the Department of Transportation under its quality assurance inspection rate of approximately 25 percent of welds will be performed at no cost to the Contractor.

The Contractor shall assume the cost of additional ultrasonic or magnetic-particle testing above the 25 percent rate to determine the extent of weld defects and to check corrected work. The rate for this extra testing will be $75 per hour for the Inspector, equipment, travel, and subsistence.

If the Contractor is equipped with satisfactory ultrasonic or magnetic-particle inspection equipment, the Contractor may test the Work corrected in the shop at no additional expense to the Department, but the Engineer will interpret the ultrasonic and magnetic-particle inspection.

501.5 Payment

This work will be paid for at the Contract Price per pound (kilogram) of structural steel or per Lump Sum, each complete in place. The Contract Price for structural steel includes the costs of labor and equipment and the direct or incidental costs of furnishing easy access for inspection and testing.

Payment will be made under:

Item No. 501	Structural steel, Bridge No._____	Per lump sum
Item No. 501	Structural steel	Per lb (kg)
Item No. 501	Structural steel-swaybracing	Per lb (kg

501.5.01 Adjustments

A. Payment Conditions

The cost of steel joints and metal bearing assemblies used in structures with no structural steel Pay Item shall be included in the Contract Price for superstructure concrete, unless otherwise shown on the Plans.

When authorized changes are made, the Lump Sum payment will be adjusted on a negotiated basis.

On projects with multiple bridges, payments will be applied on an individual bridge basis.

Upon satisfactory completion of the erecting, bolting, and welding of structural steel for the bridge, 95 percent of the Contract Price, either per Lump Sum Basis or per pound (kilogram) basis, will be included for payment on the next statement.

Steel spans are considered satisfactorily erected when they are placed in their final positions on the substructure, properly spaced, and anchored down. Bolting is considered satisfactorily complete when defective welds are repaired and found satisfactory by additional inspection.

Upon satisfactory completion of field painting, the remaining 5 percent of the Contract Price will be included for payment on the next statement.

Material allowance payments of structural steel will be determined and paid for in accordance with the requirements of Section 109.