




STRUCTURAL STEEL INSPECTION

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Bridge Division Construction and Maintenance

Structural Steel

- Welded Field Splices
- Diaphragm Welding
- Shear Connectors
- Bolted Splices
- Steel Beam Repair
- Bearing Assemblies
- Steel Girder Erection

Concerns for Structural Steel Inspection

- Repairs on Field Weld Splices
- Issues with T-O-N bolting crews
- CEI companies not employing CWI
- Availability of Revised Plan Sheets
- Bearing Seats not properly finished, texture and slope
- Girders out of plumb due to bearing seat elevations
- Steel Member Repairs – Having Proper Equipment

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Welder Qualification. Provide Department certification papers for each welder and for each welding process to be used before welding, except for miscellaneous welds described in Section 448.4.2.1.1., "Miscellaneous Welding Applications." Certification is issued by the Department as described in Section 448.4.2.2., "Certified Steel Structures Welder."

Miscellaneous Welding. A qualified welder is an experienced welder who is capable of making welds of sound quality but does not have Department certification papers. The Engineer will check the welder's ability by conducting a jobsite test in accordance with Section 448.4.2.1.2., "Miscellaneous Weld Qualification Test," before welding begins. Furnish all materials and equipment necessary for this test.

Miscellaneous Welding Applications. A welder certified for structural or reinforcing steel or a qualified welder may make miscellaneous welds of the following types:

- splicing reinforcing steel to extend bars in the bottom of a drilled shaft;
- attaching chairs to the reinforcing steel cage of a drilled shaft;
- armor joints and their supports;
- screed rail and form hanger supports where permitted on steel units;
- reinforcing steel to R-bars for lateral stability between prestressed beams, spirals, or bands to reinforcing bars in drilled shaft cages;
- permanent metal deck forms;
- additional steel added in railing when slip-form construction is used; and
- other similar miscellaneous members that have no load-carrying capacity in the completed structure.

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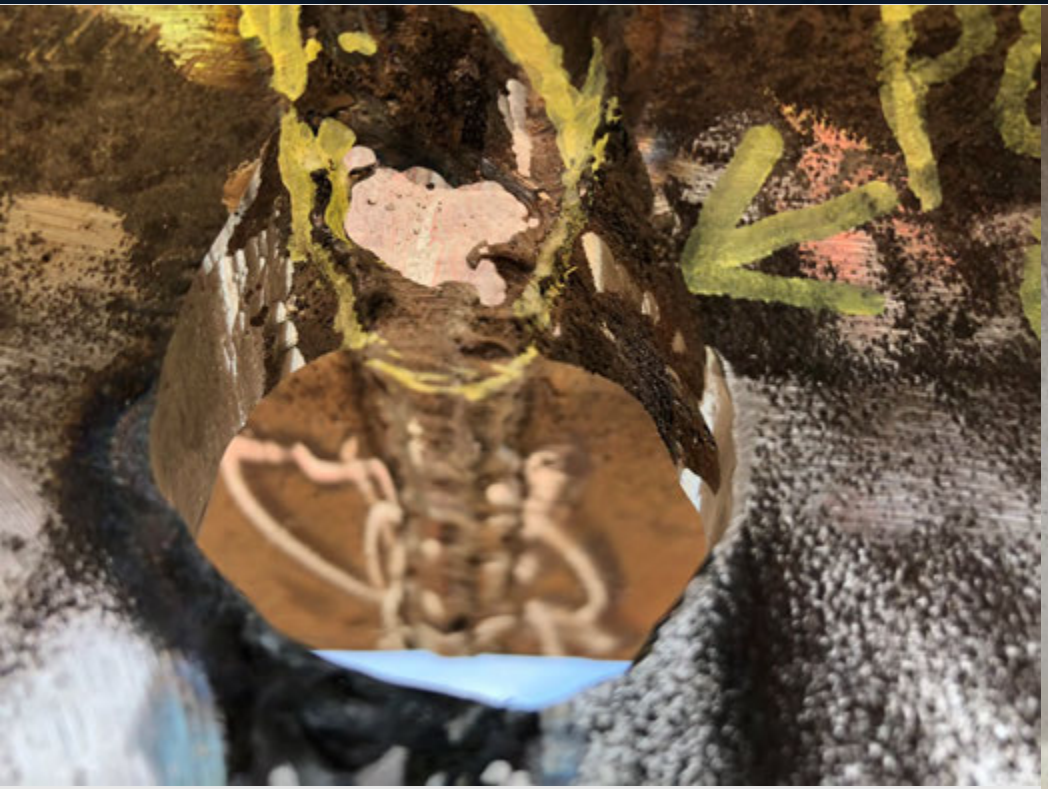

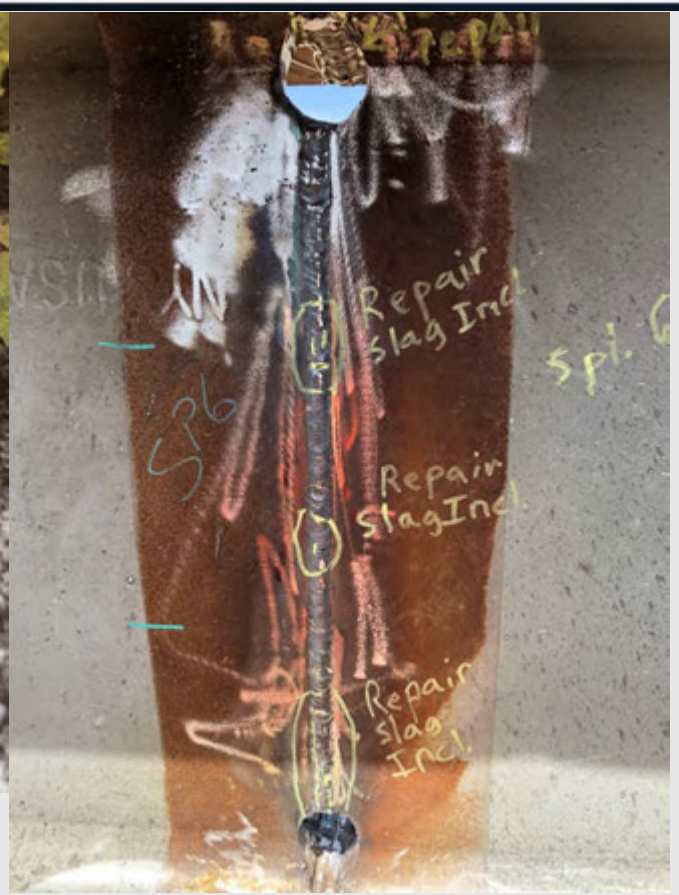

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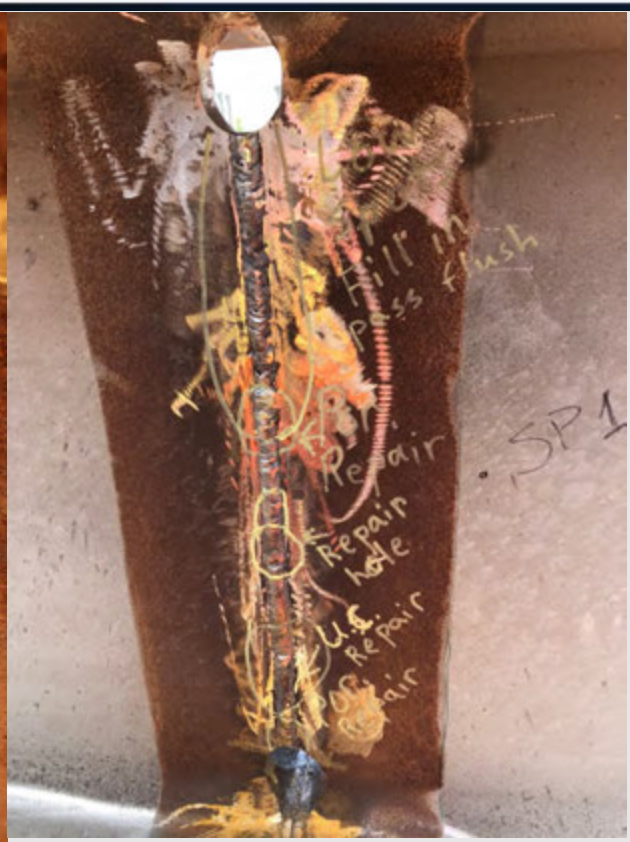

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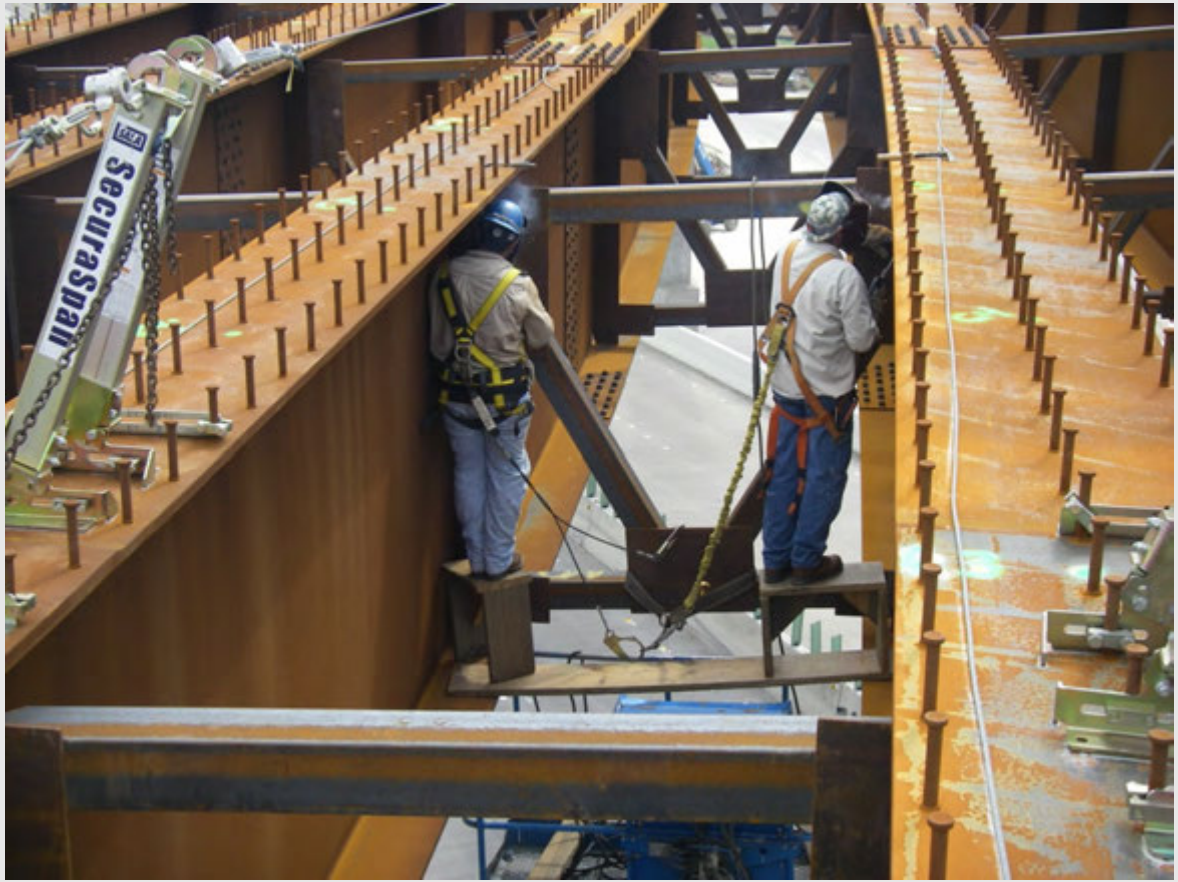

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Testing Equipment. Provide a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent), calibrated torque wrench, and other accessories necessary to perform the installation verification test and the R-C test and to calibrate hydraulic or electric torque wrenches.

Wrenches. Furnish either of the following types of wrenches.

Air-Driven Impact Wrenches. Furnish air-driven impact wrenches, air compressors, and related accessories of sufficient capacity to properly tension high-strength bolts. Impact wrenches should be of sufficient size and capacity to be able to tension fully a bolt in less than 15 sec. Repair or replace any wrenches that are unable to apply full tension to a bolt within this time.

Calibrated Torque Wrenches. Furnish calibrated hydraulic or electric torque wrench and related accessories capable of properly tensioning high-strength bolts. Calibrate the wrench to stall out or cut out completely when the bolt tension reaches 1.05 times the tension specified in Table 2. Calibrate the wrench by tensioning 3 bolts of each size in a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent). Mark each bolt and verify the rotation from snug-tight when calibrating the wrench as specified in Section 447.4.5.3.1., "Turn-of-the-Nut Method." Calibrate the wrench at least once each working day or as directed. Recalibrate the wrench for changes in bolt diameter; changes in bolt length greater than 2 bolt diameters; significant differences in the surface condition of the bolts, threads, nuts, or washers; or changes in the equipment or hose length.

CONSTRUCTION

Verification Testing. Have each member of the bolting crew that will perform the actual work complete an acceptable pre-installation verification test in the presence of the Engineer. Only crewmembers that have demonstrated proper workmanship via verification testing may perform production bolting work.

Air-Driven Impact Wrench. Perform an installation verification test on 3 complete fastener assemblies of each combination of diameter, length, grade, and lot to be installed before beginning bolting. Follow the bolt-tensioning procedures in Section 447.4.5.3., "Tension Bolts." Use a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent) to verify and demonstrate that the method for estimating the snug-tight condition and controlling the turns from snug-tight develops a tension greater than 1.05 times the tension specified in Table 2. The snug-tight condition is defined as the tightness that exists when the plies of the joint are in firm contact.

Calibrated Torque Wrench. Calibrate the wrench before beginning bolting in accordance with Section 447.3.2.2., "Calibrated Torque Wrenches." Use the bolting crew that will perform the actual work for the calibration and calibrate the wrench in the presence of the Engineer. Follow the bolt-tensioning procedures in Section 447.4.5.3., "Tension Bolts."

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Storage. Protect all bolts and nuts from dirt and moisture at the jobsite. Remove from protected storage only those bolts and nuts anticipated to be installed during a workday. Return unused fasteners to protected storage at the end of the day. Do not clean fasteners of lubricant present in the as-delivered condition. Perform a field R-C test at the Contractor's expense in accordance with Tex-452-A on any lot of fasteners that shows signs of rust, dirt, or loss of lubrication as directed. Apply additional lubrication and rerun the R-C test before installing bolts if the fasteners fail the R-C test. Replace any fasteners that cannot be re-lubricated to pass the field R-C test. Tension control bolts may only be re-lubricated by the manufacturer.

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Bolt Reuse. Do not reuse ASTM A490 or galvanized ASTM A325 bolts. Ungalvanized ASTM A325 bolts may be reused one time if the threads have not been damaged. Re-tensioning previously tensioned bolts loosened by the tensioning of adjacent bolts is not considered to be reuse.

Tension all bolts in a connection within 10 days of installation. Bolts not tensioned within 10 days of installation are subject to field R-C testing. Re-lubricate or replace any installed bolts that do not have sufficient lubrication as determined by the field R-C test.

Table 2
Bolt Tension

Nominal Bolt Size, in.	Minimum Tension (kips)	
	ASTM A325 Bolts	ASTM A490 Bolts
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1-1/8	56	80
1-1/4	71	102
1-3/8	85	121
1-1/2	103	148

Table 3
Nut Rotation from Snug-Tight Condition[1]

Bolt length (underside of head to end of bolt)	Disposition of Outer Face of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped less than 1:20 (beveled washer not used)	Both faces sloped less than 1:20 from bolt axis (beveled washer not used)
Up to and including 4 bolt diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 bolt diameters up to and including 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 bolt diameters up to and including 12 diameters[2]	2/3 turn	5/6 turn	1 turn

1. Nut rotation is relative regardless of the element (nut or bolt) being turned. The tolerance is –0°, +30° for bolts installed by 1/2 turn or less and –0°, +45° for bolts installed by 2/3 turn or more.
2. Determine the required rotation for bolt lengths greater than 12 diameters using the installation verification test in a simulated connection of solidly fitted steel.

- Long Bolts

The following table describes steps used in rotational capacity testing of long bolts.

Rotational Capacity of Long Bolts	
Step	**Action**
1	Attach the tension-measuring device to a convenient steel section.
2	Measure and record the bolt length (see 'Bolt Diagram').
3	Thread the nut on the bolt, and measure and record the stick out of the bolt when 3 to 5 full threads of the bolt are located within the grip length (see 'Bolt Diagram').
4	Mark off a vertical line, plus lines at 1/3 of a turn (120°) and 2/3 of a turn (240°), measured in a clockwise direction, from vertical on the face plate of the tension measuring device.
5	Install the bolt into the tension-measuring device. Include the required number of shim plates and/or washers (always use at least one washer under the nut) to produce the stick out measured in Step 3.
6	Using a spud wrench or equivalent, tighten the bolt to the snug tension listed below and to within a tolerance of -0, +9 kN (-0, +2 kips). Snug tension will be indicated on the tension indicator. (Refer to 'Table 1, Values for Fasteners with ASTM A 490 Bolts' table.)

U. S. BOLTS (A 325)									
Bolt Diameter (In.)	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Snug Tension (kips)	1	2	3	4	5	6	7	9	10

7	Match mark the nut at the vertical line marked in Step 4 on the faceplate of the tension-measuring device.
8	Using the calibrated manual torque wrench, tighten the bolt to at least the tension listed below. Record the torque required to reach the tension and the value of the corresponding bolt tension. Torque must be measured with the nut in motion. (Refer to 'Table 2, Values for Fasteners with ASTM A 490 Bolts' table.)

U. S. BOLTS (A 325)

Bolt Diameter (in.)	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Tension (kips)	12	19	28	39	51	56	71	85	103

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9	Further tighten the bolt to the rotation listed below. The rotation is measured from the initial marking in Step 7. Record the bolt tension after achieving this rotation. Assemblies which fail prior to this rotation either by stripping of the threads or fracture of the bolt fail the test.
10	The bolt tension measured in Step 9, after the required rotation, must equal or exceed the values in the table shown below. Assemblies which do not meet this tension have failed the test. (Refer to the 'Table 3, Values of Fasteners with ASTM A 490 Bolts' table.)

Bolt Length (measured in Step 2)	4 x Bolt Diameter or Less	Greater than 4 but no more than 8 x Bolt Diameter	Greater than 8 x Bolt Diameter
Required Rotation (turns)	2/3	1	1-1/3

U. S. BOLTS (A 325)

Bolt Diameter (in.)	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Tension (kips)	14	22	32	45	59	64	82	98	118

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11	Loosen and remove the nut; examine the threads on the nut and bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt should be evident. Assemblies that have evidence of stripping have failed the test. (Elongation of the bolt, in the threads between the nut and bolt head, is to be expected at the required rotation and is not to be classified as a failure).
12	Calculate and record the torque value as shown under 'Calculations.'

Calculation

The following calculation determines the torque value:

$$Torque \leq 0.25 \times P \times D$$

Where:

- Torque = torque, N-M (ft.-lbs.) measured with the calibrated torque wrench and recorded in Step 8.
- P = measured bolt tension, in N (lbs.) from the direct tension indicator and recorded in Step 8.
- D = bolt diameter, in m (ft.) (diameter in m = mm/1000; diameter in feet = diameter in inches/12).

The torque measured and recorded in Step 8 must be equal to or less than this calculated value. Assemblies with torque values exceeding this calculated value fail the test.

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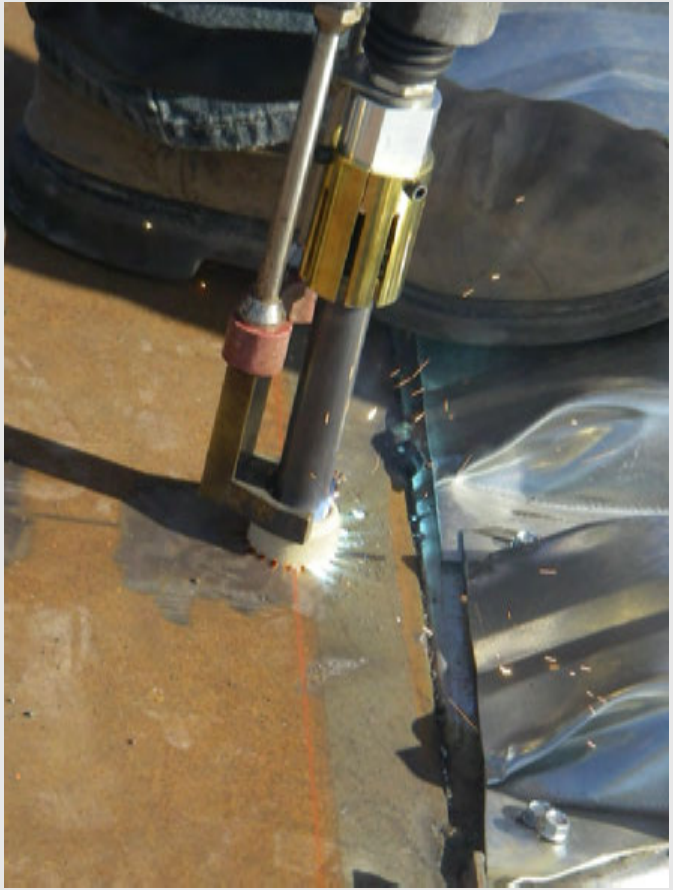

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GENERAL

Repair or replace steel bridge members in accordance with the plans. Submit a plan that includes the repair method, application of heat and restraint, material, temporary bracing or shoring, and equipment. Obtain approval of the plan before beginning work. Field-weld in accordance with Item 448, "Structural Field Welding." Perform heat straightening using welding personnel certified for unlimited thickness and all positions in accordance with Item 448, "Structural Field Welding." Perform shop fabrication in accordance with Item 441, "Steel Structures."

Only welders certified or working directly under the supervision of a welder certified in accordance with Item 448, "Structural Field Welding," may handle torches when applying heat to steel members.

Use drills to place holes in steel members. Ensure torches are not used to place holes unless authorized or permitted on the plans.

Do not fill holes with weld metal.

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Heat Straightening. Return all distorted members to their original section, tilt, and straightness by heat straightening. Use approved mechanical devices to restrain the member while applying heat to straighten the distorted metal. Ensure mechanical forces are not used to straighten or bend the metal. Ensure impact loads such as hammer blows are not applied. Repair cracks as shown on the plans before straightening. Repair minor dents, nicks, and gouges by grinding the defect to an acceptable contour and appearance with all corners rounded to a 1/16-in. radius. Grind so the finished grinding marks run in the direction of the applied stresses. Straighten steel members to the tolerances of Table 1.

Table 1
Straightening Tolerances

Greatest Cross-Section Dimension	Maximum Cross-Section Displacement	Maximum Departure from Straightness (per foot of length)
Over 36"	0.5"	0.05"
12–36"	0.375"	0.0375"
Under 12"	0.25"	0.025"

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Restraining Force. Apply and lock-off load before applying heat when jacks are used. Limit restraining forces applied before heating to the values shown on the plans or as approved. Ensure the member is not loaded in a manner that causes material to yield without the application of heat.

Heating process. Heat steel and maintain temperature above 700°F while straightening, but no greater than 1,200°F for typical steel grades, and 1,100°F for Q&T, HPS 70W, or 100/100W grade steel.

Use only multi-flame heating tips unless approved otherwise, and proportion tip size to the thickness of the material. Manipulate heating torches to guard against overheating. When vee or rectangular heat patterns are used, mark the patterns on the steel before heating. Bring steel within the planned temperature as rapidly as possible without overheating. Guard against buckling when heating relatively thin, wide plates. Closely monitor temperatures with temperature-sensitive crayons, pyrometers, or infrared non-contact thermometers. Measure the temperature 5–10 sec. after the heating flame leaves the area to be tested.

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Cooling. Use dry compressed air for cooling after the steel has cooled to below 600°F. Ensure the steel is not cooled with water or mist. Allow the steel to cool below 250°F before applying another set of heating patterns.

Section Replacement. Replace sections of steel members as shown on the plans or as approved. Use steel backing plates in accordance with AASHTO/AWS D1.5 when placing complete joint penetration groove welds from one side only. Remove backing plates after completing welding operations.

Bearing Establishment. Repair areas of incomplete bearing between the slab and the beam by epoxy injection in accordance with Item 780, "Concrete Crack Repair," or placement of a grout mixture in accordance with Item 421, "Hydraulic Cement Concrete," as directed.

Painting. Complete repairs before painting. Paint repaired area only, unless otherwise shown on the plans, in accordance with Item 446, "Field Cleaning and Painting Steel." Match the color of the existing appearance coating.

MEASUREMENT

This Item will be measured by each repaired member or lump sum for the entire bridge. A member is defined as one of the following individual components:

- steel beam or girder over the length of one span, unless otherwise shown on the plans;
- diaphragm and its connecting hardware between adjacent steel beams;
- truss vertical;
- truss diagonal;
- truss sway brace;
- piling; or
- other elements shown on the plans.

PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Steel Member Repair" of the component specified

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Bearing Assemblies are covered in Items 420, 434, 441

Slope the tops of caps and piers between bearing areas from the center slightly toward the edge, and slope the tops of abutment and transition bent caps from the backwall to the edge, as directed, so water drains from the surface. Give the concrete a smooth trowel finish. Construct bearing areas for steel units in accordance with Section 441.3.11.6., "Bearing and Anchorage Devices." Give the bearing area under the expansion ends of concrete slabs and slab and girder spans a steel-trowel finish to the exact grades required. Give bearing areas under elastomeric bearing pads or nonreinforced bearing seat buildups a textured, wood float finish. Do not allow the bearing area to vary from a level plane more than 1/16 in. in all directions.

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Items 420, 434, 441

Bearing and Anchorage Devices. Place all bearing devices such as elastomeric pads, castings, bearing plates, or shoes on properly finished bearing areas with full and even bearing on the concrete. Place metallic bearing devices on 1/4 in.-thick preformed fabric pads manufactured in accordance with DMS-6160, "Water Stops, Nylon-Reinforced Neoprene Sheet, and Elastomeric Pads," to the dimensions shown on the plans. Provide holes in the pad that are no more than 1/4 in. larger than the bolt diameter.

Build the concrete bearing area up to the correct elevation once it has been placed below grade using mortar that meets Item 420, "Concrete Substructures," and provide adequate curing. Use only mortar for build-ups between 1/8 in. and 3/8 in. thick. Use galvanized steel shims or other approved shim materials in conjunction with mortar if the bearing area must be raised more than 3/8 in.

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Items 420, 434, 441

Provide at least 75% contact of flange to shoe with no separation greater than 1/32 in. for beams and girders. Make corrections using heat or pressure in accordance with S2.1, or with galvanized shims. Correct small irregularities by grinding.

Provide at least 85% contact between the rocker plate and the base plate. Adjust the location of slotted holes in expansion bearings for the prevailing temperature. Adjust the nuts on the anchor bolts at the expansion ends of spans to permit free movement of the span. Provide lock nuts or burr the threads.

Remove all foreign matter from sliding or machine-finished surfaces before placing them in the structure.

Restore distorted bearing pads or expansion bearings to an equivalent 70°F position after completion of all welded or bolted splices, using an approved method of relieving the load on the bearing devices.

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Item 441 – “Steel Structures”, Section 3.1.6.1

- Requires Erection Drawings for RR Underpasses, Field-spliced Girders, Horizontally curved girders, etc.
- Does not require Erection Drawings for rolled I-beams.
- Specifies to prepare drawings in accordance with AASHTO/NSBA Steel Bridge Collaboration S10.1 (Section 2.2) and Lists the minimum required information.
- Specifies to perform girder erection analyses using TxDOT provided software UT-Lift and UT-Bridge when applicable, or use other suitable commercial software.
- Clarifies that any changes to previously approved erection drawings/procedures requires re-approval.

Steel Beams – MEBR(S)

- To be used a guide for Erection Drawings
- Shows minimum Bracing Requirements
- Specifies minimum amount of supplement support based on beam curvature
- Does not dictate lifting points

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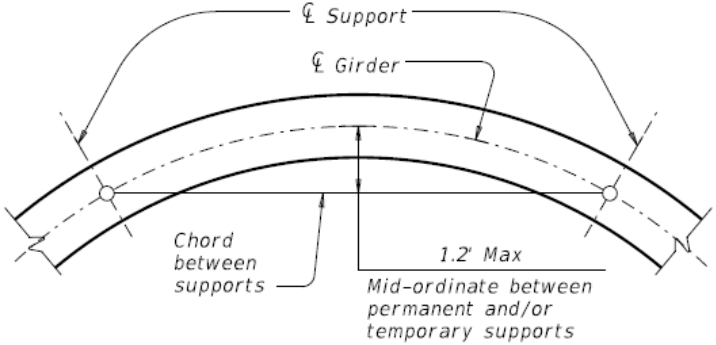
GENERAL NOTES:

This standard is to be used as a guide in preparing the required erection drawings (see Item 441). The contractor is responsible for the adequacy of bracing and shoring at all times.



CURVED GIRDER ERECTION SUPPORT DETAIL

On the erection drawings, indicate the following:

1. Assumed loads (dead, live, wind, etc.) used to design the brace and shoring members.
2. Timber species, grade, and moisture content.
3. Grade and size of steel sections used for bracing or shoring members
4. Grade and size of all threaded hardware (bolts, lag screws, concrete anchors, etc.) required for bracing and shoring.
5. Minimum embedment of concrete anchors.
6. Required weld sizes and lengths.
7. Manufacturer's name and model number of manufactured shoring or bracing.

HORIZONTALLY CURVED I-GIRDERS:

Unless shown otherwise on the erection drawings, support girder sections such that the mid-ordinate of the girder does not exceed 1.2' between support points. See "Curved Girder Erection Support Detail". Brace girders at all supports. Do not remove temporary supports until continuous girders are supported by at least three permanent supports, cross-frames or diaphragms are fully installed, and splices are completed.

When using the support plate details shown on this standard, as a minimum, use a support near the center of the girder section until the splice is completed.


Texas Department of Transportation
Bridge Division Standard
MINIMUM ERECTION AND BRACING REQUIREMENTS
STEEL GIRDERS AND BEAMS
MEBR(S)

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Safety

- Has a PE designed a plan that will not put public safety at risk?
- Has lateral loading been considered?
- Are traffic control issues clearly defined?
- Site conditions have an influence on the thoroughness of our review.
- Is the plan being followed?

Member Integrity

- Does the plan seem reasonable (past experience of similar work) to avoid issues
- Do the analysis results verify no permanent distortion
- Is the plan in accordance with plans and specifications
- We factor in that the erector/contractor are not out to have a problem

Inspection

- Does the plan include step by step procedures?
- Are temporary supports clearly documented?
- Are the intermediate steps described (i.e. % of fasteners in splices, number of diaphragms installed, etc.)

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On-Going Issues

- Geometry Tolerances for Web Tilt
- Survey Control on Bearing Seats
- Beam Camber – Too Much or Too Little

QUESTIONS?

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