SECTION 1050—STEEL BRIDGE SUPERSTRUCTURE

1050.1 DESCRIPTION—This work is the construction of a steel bridge superstructure.

1050.2 MATERIAL—

(a) Deck and Barriers.

- Cement Concrete Structures—Section 1001.2
- Preformed Neoprene Compression Joint Seal—Section 1008.2
- Pedestrian Railing—Section 1012.2
- Aluminum Bridge Hand Railing—Section 1023.2
- Steel Bridge Hand Railing—Section 1022.2
- Protective Barrier—Section 1015.2
- Protective Fence—Section 1016.2
- Protective Coating for Reinforced Concrete Surfaces—Section 1019.2(a)
- Armored Preformed Neoprene Compression Dam—Section 1021.2
- Tooth Expansion Dam with Drain Trough—Section 1020.2
- Reinforcement Bars—Section 1002.2
- Neoprene Strip Seal Dam—Section 1026.2

(b) Fabricated Structural Steel. Section 1105

(c) Paint. Section 1060.2

(d) Neoprene Bearing Pads. Sections 1113.02 and 1113.03(g)

(e) High-Load Multi-Rotational Bearings. Section 1111

(f) Polymer Modified Mortar for Beam Seat Leveling. Section 1080.2(e)

1050.3 CONSTRUCTION—

(a) General. The superstructure consists of all indicated portions of the bridge above the bridge seat and includes bearings, bearings and anchors set in the substructure, abutment backwalls, cheekwalls, bridge drainage down to but not including the drain box, and portions of wings and appurtenances above the horizontal construction joint nearest the bridge seat. Do not ship fabricated materials without approved shop drawings marked “Accepted”.

(b) Superstructure. Construct the superstructure, as indicated, as shown on the Standard Drawings, and as follows:

- Fabricated Structural Steel—Section 1105
1. Handling and Storing Materials. Place material stored at the job site on skids. Keep it clean and properly drained. Place girders and beams upright and shore them. Support long members, such as columns and chords, on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, check material turned over against the shipping lists and promptly report in writing any shortage or injury discovered. The Contractor is responsible for the loss of any material while in the Contractor's care, or for any damage caused to it after being received by the Contractor.

2. Falsework Design and Construction. Design and construct falsework according to AASHTO 11.2.2, 11.6.1, AASHTO Publications (Guide Design Specifications for Bridge Temporary Works and Construction Handbook for Bridge Temporary Works) and as specified in Section 105.03(c).

2.a General. Provide all tools, machinery, and equipment necessary to erect the falsework. Falsework is considered to be any temporary structure that supports structural elements of concrete, steel, masonry, or other materials during their construction or erection. Form travelers, as used in segmental cantilever construction, are considered to be a combination of falsework and forms. Have a Professional Engineer registered in the State sign and seal the working drawings for the falsework if the height of falsework exceeds 14 feet or if traffic, other than workmen involved in constructing the bridge, will travel under the bridge. Furnish falsework of sufficient rigidity and strength to safely support all forces imposed, and to produce, in the finished structure, the lines and grades indicated.

2.b Design Loads. Ensure that the design load for falsework consists of the sum of dead and live vertical loads, and any horizontal loads. As a minimum, include in the dead loads the gravitational force of the falsework and all construction material to be supported. Assume the combined density of concrete, reinforcing and prestressing steel, and forms to be not less than 160 pounds per cubic foot of normal density concrete or 130 pounds per cubic foot of low-density concrete that is supported.

For live loads, include the actual force of any equipment to be supported, applied as concentrated forces at the points of contact and a uniform force of not less than 20 pounds per square foot applied over the area supported, plus 75 pounds per linear foot applied at the outside edge of deck overhangs.

For the design of the falsework bracing system, use the sum of the horizontal forces due to equipment, construction sequence, including unbalanced hydrostatic forces from fluid concrete, stream flow when applicable, and
an allowance for wind. However, do not allow the horizontal force to be resisted in any direction to be less than 2% of the total dead load.

Do not exceed the load-carrying capacity of the structure, or portion of structure, as computed using AASHTO LRFD Specifications Article 3.4.2 by imposing forces on existing, new, or partially completed portions of structures due to construction operations. For the compressive strength of concrete, f′c, in computations of the load-carrying capacity, use the lesser of the actual compressive strength at the time of loading or the specified compressive strength of the concrete.

2.c Clearances. Unless otherwise provided for roadways that are to remain open to traffic, supply minimum dimensions for clear openings through falsework at least 5 feet wider than the width of the approach traveled way, measured between barriers when used, and 14 feet high, except over interstate routes and freeways use 14.4 feet for the minimum vertical clearance.

2.d Erection Drawings. Submit drawings illustrating the proposed method of erection. Show details on the drawings of all falsework bents, bracing, guys, dead-men, lifting devices, and attachments to the bridge members. Show the sequence of erection, location of cranes and barges, crane capacities, location of lifting points on the bridge members, and masses weights of the members. Supply plans and drawings complete in detail for all anticipated phases and conditions during erection. If required, furnish calculations to demonstrate that allowable stresses are not exceeded and that member capacities and final geometry will be correct. Do not proceed with erection until the drawings have been accepted.

2.e Construction. Construct falsework and set it to grades that allow for its anticipated settlement and deflection, and for the vertical alignment and camber indicated or ordered by the Representative for the permanent structure. Use variable depth camber strips between falsework beams and soffit forms to accomplish this, if directed.

Use suitable screw jacks, pairs of wedges or other devices at each post to adjust falsework to grade, to allow minor adjustments during the placement of concrete or structural steel should observed settlements deviate from those anticipated, and to allow for the gradual release of the falsework. Provide tell-tales attached to the forms and extending to the ground, or other means, for accurate measurement of falsework settlement during the placing and curing of the concrete.

Support falsework or formwork for deck slabs on girder bridges directly on the girders so that there will be no appreciable differential settlement during placing of the concrete. Brace and tie girders to resist any forces that would cause rotation or torsion in the girders caused by the placing of concrete for diaphragms or deck. Do not weld falsework support brackets or braces to structural steel members or reinforcing steel unless specifically allowed.

2.f Removal. Section 1001.3(q)


3.a Conformance to Drawings. Ensure that the erection procedure conforms to the erection drawings. Have a Professional Engineer registered in the State sign and seal these drawings. For falsework drawings, submit as specified in Section 1050.3(c)2.d. Any modification to or deviations from this erection procedure will require revised drawings and verification of stresses and geometry.

3.b Erection Stresses. Account for any erection stresses that are induced in the structure as a result of the use of a method of erection or equipment which differs from that indicated or specified, and which will remain in the finished structure as locked-in stresses. Provide additional material, at no additional cost to the Department, to keep both temporary and final stresses within the allowable limits used in design.

Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.

3.c Maintaining Alignment and Camber. During erection, support segments of the structure in a manner that will produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing, as necessary during the erection process, to provide stability and ensure correct geometry. Provide temporary bracing, if necessary, at any stage of erection.

4.a General. This work consists of furnishing and installing bridge bearings. Bearing types include, but are not limited to, elastomeric pad, rocker, roller, pot, spherical, disk, and sliding plate bearings. Included as components of bearings are masonry, sole and shim plates, bronze or copper-alloyed bearing and expansion plates, anchor bolts, PTFE sheets or surfacing, lubricants and adhesives. The furnishing and installation of bedding materials used under masonry plates is also included in this work.

Construct bearings according to the indicated details. If complete details are not provided, furnish bearings that conform to the limited, indicated details and provide the design capacities for loads and movements shown or specified and the performance characteristics specified.

4.a.1 Working Drawings. If complete details for bearings and their anchorages are not indicated, prepare and submit working drawings for the bearings. Show all details of the bearings and of the materials proposed for use on such drawings, and have the drawings approved before fabrication of the bearings is begun.

4.a.2 Packaging, Handling, and Storage. Before shipment from the point of manufacture, package bearings in such a manner to ensure that during shipment and storage the bearings will be protected against damage from handling, weather, or any normal hazard. Clearly identify each completed bearing’s components; securely bolt, strap, or otherwise fasten its components to prevent any relative movement; and mark on its top its location and orientation in each structure in the project, in conformity with the plans. Do not dismantle bearings at the site unless absolutely necessary for inspection or installation.

Store all bearing devices and components at the work site in an area that provides protection from environmental and physical damage. Ensure that bearings are clean and free of all foreign substances when installed.

4.a.3 Manufacture or Fabrication. Unless otherwise specified or indicated, furnish the surface finish of bearing components that come into contact with each other or with concrete, but are not embedded in concrete, as specified in Section 1105.03(q).

4.a.4 Construction and Installation. Install bearings to the positions indicated. At the time of installation, set bearings to the dimensions prescribed by the manufacturer, the Representative, or as indicated. Adjust bearings as necessary to take into account the temperature and future movements of the bridge.

Set bridge bearings level, in exact position, and to have full and even bearing on all bearing planes.

For bearing surfaces located at improper elevations or set not level and true to plane, either grind the surface, grout pack bearings, or modify the bearing such that intended bearing placement is as originally designed with the least amount of bearing modification.

Use a filler or fabric material as specified in Section 1113.03(h) to bed on the concrete metallic bearing assemblies not embedded in the concrete.

Set elastomeric bearing pads directly on properly prepared concrete surfaces without bedding material.

For bearings seated directly on steel work, machine the supporting surface so as to provide a level and planar surface to place the bearing.

4.b Preparation of Bearing Areas. Prepare bearing areas as specified in Section 1001.3(k)9 and furnish bedding material as specified in Section 1113.03(h).

4.c Elastomeric Bearings. Elastomeric bearings include unreinforced pads (consisting of neoprene only) and reinforced pads with steel or fabric laminates. Furnish bearings with the dimensions, material properties, neoprene grade and type of laminates indicated.

4.c.1 Setting Bearing Pads. Set bearing pads as specified in Section 1080.3(c)2 and as indicated. Where elastomeric bearings are used at piers of continuous bridges, provide full contact between the beam, the bearing pad, and the beam seat, unless the plans indicate that a lift-off condition is expected when the beam is initially set on the pad.

4.c.2 Resetting Bearing Pads. If indicated, reset expansion bearings after all dead loads have been placed. Submit a plan showing and describing the jacking procedure for review and acceptance at least 2 weeks before proceeding with the jacking operations. Provide calculations showing actual and allowable bearing stresses in the bearing plates and bearing areas at the jacking locations. Have the plans and calculations sealed and signed by a
Professional Engineer registered in the State.

Before resetting, truck mixers and slip-forming equipment, necessary for placement of barriers and sidewalks, will be allowed on the structure. Do not allow other construction equipment or traffic on the structure until the bearings are reset. Coordinate the resetting operation with the installation of on-bridge hardware, including conduits, utilities, expansion dams, and drainage, to prevent damage to these components when the beams are jacked and lowered.

Furnish jacks with a working capacity at least equal to the jacking forces indicated. Jack beams at expansion bearings to achieve a 1/16-inch gap between the bottom of beam or sole plate and the top of the entire bearing pad. Place jacks at jacking points indicated. Unless indicated otherwise, jack all beams simultaneously. Limit the differential rise between all beams to 1/8 inch during jacking. After jacking, center the pad beneath the sole plate or beam bearing area as indicated. Lower the beams onto the bearings in the same manner as they were jacked.

Reset bearings when the ambient temperature is above 20F and below 85F.

4.d Anchor Bolts.

4.d.1 Fabrication. Furnish swedged or threaded and headed anchor bolts to secure a satisfactory grip upon the material used to embed them in the holes.

4.d.2 Setting Anchor Bolts. Set by template to the indicated elevation and alignment. As an alternate, set in preformed holes 32 inches larger than the bolt diameter. Clean the holes, set and fix the bolts, and fill the holes with nonshrink grout, as specified in Section 1001.2(e). Use drilled holes, as a substitute for preformed holes, in abutments and solid piers only. Protect the holes against water entry during freezing periods.

Limit the threaded projection above the nut to between 3/16 inch and 1 inch.

4.e Setting Bearings. As shown on the Standard Drawings and as follows:
 Align masonry plates and set them so they will be centered with the rockers, rollers, sole plates, and bearing plates, at 68F and under full dead load. Make adjustment for the difference in temperature, from 68F, at time of erection. Compensate for the change in length of the bottom chord, or flange, due to the later addition of dead loads.

Maximum deviation of the top of rockers from a vertical position, and maximum eccentricity of the parts of sliding bearings, is 0.0001(L) + 0.25 inch, where L, in inches, is the horizontal distance between the expansion bearing and the fixed bearing.

4.f Spherical Bearings. Fabricate, test, and install spherical bearings as indicated.

4.g Separate Contracts for Substructure and Superstructure. If the substructure and superstructure are built under separate contracts, proceed as follows:

4.g.1 Substructure Contractor. Accurately place the anchor bolts and grind the bearing areas to the correct plane and elevation.

At the completion of the substructure, make an as-built survey to accurately show the as-built versus the plan location of all substructure centerlines, girder centerlines, anchor bolt group centerlines, anchor bolts, bearing elevations, and any other elements or items that may affect the layout or placement of the work to be furnished by the superstructure contractor. Show all of the pertinent as-built survey information, including dimensions, elevations, and angles on suitable drawings, as specified for shop drawings, together with the corresponding design drawing information for direct comparison. Submit the original drawings, or equal, to the Department as soon as practical after completion of the survey. Conduct the survey and have the survey drawings signed by a Surveyor or Professional Engineer registered in the State.

Provide documented evidence to show that the bearings can be set properly within the tolerances specified in Section 1050.3(c)4.d.

4.g.2 Superstructure Contractor. Use the as-built survey information, furnished by the substructure contractor, for the accurate layout of the connecting parts of the work.

Verify location, level, and elevation of all bearing seats and anchor bolts as soon as possible. Verify, before the fabrication of any metal work, in cases where the substructure is completed before award of the superstructure contract, or before erection of the metal work, in cases where fabrication has been started before completion of the substructure.
Furnish and install bedding, bearings, and nuts and washers for anchor bolts.

4.h High-Load Multi-Rotational Bearings. If required, construct as follows:
Provide complete erection and installation procedures for acceptance before installation.
Evenly support bearings over their upper and lower surfaces under all erection and service conditions.
Lift bearings by undersides only or by specially designed lifting lugs.
Take care to avoid damage to and contamination of bearing surfaces during installation.
Align the centerlines of the bearing assembly with those of the substructure and superstructure. On guided bearings take special care to properly align the guiding mechanism with the designated expansion direction of the structure.
Leave bearing straps or retaining clamps in place as long as possible to ensure parts of bearing are not inadvertently displaced relative to each other. Take care to remove straps or clamps before any normal structural movement takes place, such as post-tensioning.
Set offsets of upper and lower bearing parts as indicated. Under dead load, the distance between the upper and lower bearing plates will be not to be out of parallel by more than 1/8 inch measured from edge to edge.
Make the mating surface of the superstructure level within a slope of 100:1. Have no local irregularities exceeding 1/16 inch.
During welding of sole plates to girders, limit the temperature of the metal adjacent to neoprene and PTFE to a maximum of 300F. Use temperature indicating markers.

4.h.1 Bearing Seats. Provide bedding material for steel bearings as specified in Section 1113.03(h).

5. Straightening Material. If allowed, straighten plates, angles, other shapes, and built-up members. Use methods that will not produce fracture or other injury to the metal. Straighten distorted non-fracture critical members by mechanical means or, if allowed, by carefully planned procedures and supervised application of a limited amount of localized heat. Heat-straighten Grades HPS 70W, HPS 100, and HPS 100W steel members only under rigidly controlled procedures, each application subject to approval. Do not allow the maximum temperature to exceed the following values:

<table>
<thead>
<tr>
<th>Steel Grade</th>
<th>Distance from Weld</th>
<th>Max. Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS 70W</td>
<td>&gt; 6 inches</td>
<td>1,050F</td>
</tr>
<tr>
<td>HPS 70W</td>
<td>&lt; 6 inches</td>
<td>900F</td>
</tr>
<tr>
<td>HPS 100 or 100W</td>
<td>&gt; 6 inches</td>
<td>1,100F</td>
</tr>
<tr>
<td>HPS 100 or 100W</td>
<td>&lt; 6 inches</td>
<td>950F</td>
</tr>
</tbody>
</table>

In all other steels, do not allow the temperature of the heated area to exceed 1,150F as controlled by temperature indicating crayons, liquids, or other approved methods, such as bimetal thermometers.
Ensure that parts to be heat-straightened are substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.
Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

6. Field Assembly. Accurately assemble the parts as indicated or shown on the erection drawings, and follow any match-marks. Carefully handle the material so that no parts will be bent, broken, or otherwise damaged. Do not hammer members if it will injure or distort them. Clean bearing surfaces and surfaces to be in permanent contact before the members are assembled. Fill one-half of the holes of splices and field connections with bolts and cylindrical erection pins (half bolts and half pins) before installing and tightening the balance of high-strength bolts. Fill three-fourths of the holes of splices and connections carrying traffic during erection before installing and tightening the balance of high-strength bolts.
Fitting-up bolts may be the same high-strength bolts used in the installation. If other fitting-up bolts are used, supply fitting-up bolts of the same nominal diameter as the high-strength bolts, but supply cylindrical erection pins 1/32 inch larger.

7. Connections Using High-Strength Bolts. Make connections as specified in Section 1105.03(j) and as follows: (Note Do not use ASTM F 3125 Grade 490 bolts unless approved for use by the Chief Bridge Engineer

Change No. 2
or his designee, on a project by project basis.)

7.a General. Obtain the “snug tight” condition as defined in Section 1050.3(c)7.d for any method of final tightening except direct-tension-indicator (DTI) tightening or tightening of alternate design fasteners.

Assemble fasteners of appropriately assigned lot numbers together when installed. Protect such fasteners from dirt and moisture at the job site. Take only as many fasteners as are anticipated to be installed and tightened during a work shift from protected storage. Return fasteners not used to protected storage at the end of the shift. Do not clean lubricant from fasteners that is required to be present in as-delivered condition. Before installation, clean and relubricate fasteners for slip-critical connections, which accumulate rust or dirt resulting from job site conditions. If relubrication is required, use a lubricant recommended by the fastener manufacturer.

Provide a Skidmore-Wilhelm Calibrator, or other equivalent bolt tension measuring device, at each job site, during erection. Perform periodic testing (at least once each working day if calibrated wrench method is used) to ensure compliance with the installation test procedures specified herein for turn-of-the-nut tightening, calibrated wrench tightening, installation of alternate design bolts, and direct tension indicator tightening. Bolts that are too short for the Skidmore-Wilhelm Calibrator may be tested using DTI devices. In that case, calibrate the DTI devices in the Skidmore-Wilhelm Calibrator using longer bolts, in accordance with the latest edition of PTM No. 429 as applicable.

Install fasteners together with washers of size and quality specified, located as required below, in properly aligned holes, and tighten by any of the methods specified in Sections 1050.3(c)7.d through 1050.3(c)7.g to at least the minimum tension specified in Table A, when all the fasteners are tight. When it is impractical to turn the nut, tighten the fastener by turning the bolt while the nut is prevented from rotating. If impact wrenches are used, ensure greater rotation, including the tolerance, than that required by Table B.

Do not reuse ASTM F 3125 Grade A 490 fasteners or galvanized ASTM F 3125 Grade A 325A325 fasteners. Reuse other ASTM F 3125 Grade A 325 fastenersA325 bolts only if approved by Department Representative. Do not consider as reuse touching up or retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance, than that required by Table B.

7.b Rotational-Capacity Tests. Perform the rotational capacity test on each bolt/nut/washer assembly lot, as specified in Section 1105.02(d)7.d, immediately before the start of bolt installation in the fabrication shop or at the job site. Document test results according to PTM No. 427. If testing and installation is performed in the fabrication shop, submit test results to CMDMDOLTS. If testing and installation is performed at the job site, submit test results to the Representative. All job-site rotational capacity tests are to be performed by the fabricator or Contractor, as applicable at the site of bolt installation, and witnessed by the Inspector.

Hardened steel washers are required under the turned element or as directed by the Department Representative, as part of the test, although they may not be required in the actual installation. Mark fastener containers for each assembly lot after testing to indicate their acceptance.

7.c Requirement for Washers. Where the outer face of the bolted parts has a slope greater than 20:1 with respect to a plane normal to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

For American Standard Beams and Channels use hardened beveled washers that are square or rectangular, that conform to ASTM F 436M, and that taper in thickness.

Where necessary, clip washers on one side to a point not closer than 7/8 of the bolt diameter from the center of the washer.

Hardened washers or plate washers are not required for all connections using ASTM F 3125 Grade A 325 and ASTM F 3125 Grade A 490A325 bolts unless noted on the drawings, except as follows:

Use hardened washers under the element turned in tightening when the tightening is to be performed by turn-of-the-nut method and calibrated wrench method.

Hardened steel washers are required under the turned element as part of rotational-capacity tests, even if they are not required in the actual installation.

- Where ASTM F 3125 Grade A 325A325 bolts of any diameter bolts equal to or less than 1.0 inch in diameter, are to be installed in oversize or short slotted holes in an outer ply, a hardened washer conforming to ASTM F 436 will be used.
Where (ASTM F 3125 Grade A 325) bolts of any diameter bolts equal to or less than 1.0 inch in diameter, are to be installed in a long slotted holes in an outer ply, provide a single plate washer or continuous bar of at least (5/16-inch) thickness with standard holes. Furnish washers or bars of sufficient size to completely cover the slot after installation. Use a single hardened washer conforming to ASTM F 436 but with a minimum thickness of (5/16 inch), or use of washers or bars of structural grade material but need not be hardened. Do not use multiple hardened washers or bars to achieve a thickness of (5/16 inch).

As an alternate satisfying the requirements for washers, use alternate design fasteners conforming to the requirements specified in Section 1050.3(c)7.c, if approved, with a geometry that provides a bearing circle on the head or nut with a diameter equal to or greater than the diameter of hardened washers conforming to the requirements of ASTM F 436. Such fasteners may be used in standard size round holes without washers.

7.1 Alternate Fasteners. If alternate fasteners are allowed, proceed as specified in Section 1050.3(c)7.fh and as follows:

If allowed, use other fasteners or fastener assemblies that conform to the materials, manufacturing, and chemical composition requirements of ASTM F 3125 Grade A 325 and that conform to the mechanical property requirements of the same specifications in full-size tests, and that have body diameter and bearing areas under the head and nut, or their equivalent, not less than those provided by a bolt and nut of the same nominal dimensions specified in Section 1105.02(d). Such alternate fasteners may differ in other dimensions from those of the specified bolts and nuts.

7.d Turn-of-the-Nut Tightening. Immediately prior to the start of bolting operations, perform pre-installation verification testing. If turn of nut tightening is used, hardened washers are not required except as specified in accordance with the latest edition of PTM No. 429, and as follows: Check a representative sample of not less than three of each fastener assembly rotational-capacity lot combination of bolt, nut and washer(bolt and nut assemblies of each diameter, length and grade to be used in the work at the start of work) in a device capable of indicating bolt tension.

Using the test, demonstrate that the method for achieving estimating the snug tight condition and for controlling the turns from snug tight to be used by the bolting crew develops a tension not less than 5% greater than the tension required by Table A. Perform periodic retesting if ordered by the Representative.

Following successful pre-installation testing, perform bolt installation as follows: Install bolts in all holes of the connection and bring them to a snug tight condition. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. Use a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench to attain the snug tight condition (use the same method that was used for pre-installation verification).

Snug tighten the bolts of the connection by progressing systematically from the most rigid part of the connection to the free edges, and then retighten the bolts in a similar systematic manner as necessary until all bolts are simultaneously snug tight and the connection is fully compacted. Following this initial operation further tighten all bolts in the connection by the applicable amount of rotation specified in Table B. During the tightening operation, do not allow rotation of the part not turned by the wrench. Systematically tighten the bolts progressing from the most rigid part of the joint to its free edges.

7.e Calibrated-Wrench Tightening. Prior to the start of bolting operations, perform pre-installation torque calibration as stipulated in the latest edition of PTM No. 429 and as follows. Use calibrated wrench tightening only if installation procedures are calibrated on a daily basis and if a hardened washer is used under the element turned in tightening. Standard torques determined from tables or from formulas, which are assumed to relate torque to tension, are not acceptable.

When calibrated wrenches are used for installation, set them to deliver a torque which has been calibrated to produce a tension not less than 5% in excess of the minimum tension specified in Table A. Calibrate the installation procedures at least once each working day for each bolt diameter, length, and grade, using fastener assembly rotational-capacity lot combination assemblies that are being installed in the work that day. Perform
calibration in a device capable of indicating actual bolt tension by tightening three typical fastener assemblies from each rotational-capacity lot, bolts of each diameter, length, and grade, from the bolts being installed and with a hardened washer, from the washers being used in the work, under the element turned in tightening. Recalibrate wrenches if significant difference is noted in the surface condition of the bolts, threads, nuts, and washers. Verify during actual installation in the assembled steel work that the wrench adjustment selected by the calibration does not produce a nut or bolt head rotation from snug tight greater than that specified in Table B. If manual torque wrenches are used, turn nuts in the tightening direction while torque is measured.

When calibrated wrenches are used to install and tension bolts in a connection, install bolts and nuts, with hardened washers under the element turned in tightening bolts in all holes of the connection and bring them to a snug tight condition. Following this initial tightening operation, tighten the connection using the calibrated wrench. Tighten the bolts by progressing systematically from the most rigid part of the joint to its free edges. Use the wrench to again tighten previously tightened bolts that may have been relaxed as a result of the subsequent tightening of adjacent bolts, until all bolts are tightened to the prescribed amount.

7.f Installation of Alternate Design Bolts. When fasteners that incorporate a design feature intended to indirectly indicate the bolt tension or to automatically provide the tension specified in Table A and that have been qualified under Section 1050.3(c)7.c.1 are to be installed, check a representative sample of not less than three bolts of each diameter, length, and grade, at the job site in a device capable of indicating bolt tension. Include flat, hardened washers in the test assembly, if required in the actual connection, arranged as those in the actual connections to be tensioned. Use the calibration test to demonstrate that each bolt develops a tension not less than 5% greater than the tension specified in Table A. Follow the manufacturer’s installation procedure for installation of bolts in the calibration device and in all connections. Perform periodic retesting when ordered by the Representative.

When alternate design fasteners that are intended to control or indicate bolt tension of the fasteners are used, install bolts in all holes of the connection and initially tighten them sufficiently to bring all plies of the joint into firm contact but without yielding or fracturing the control or indicator element of the fasteners. Then further tighten all fasteners, progressing systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. In some cases, to properly tension the bolts, perform more than a single cycle of systematic partial tightening before final twist-off of the control or indicator element of individual fasteners. Replace any individual fastener assembly if twist off occurs before the final tensioning cycle.

7.g Direct Tension Indicator Tightening. Furnish direct tension indicators (DTIs) conforming to the requirements stipulated in Section 1105.02(d)6, and in sufficient numbers to allow for all required testing. When fastener assemblies using DTIs are proposed for use, perform pre-installation verification testing and subsequent fastener installation in accordance with the testing and installation procedures in PTM No. 429 as applicable. Three verification tests are required for each combination of fastener assembly rotational-capacity lot, DTI lot, and DTI position relative to the turned element to be used on the project. Unless otherwise approved, install the DTI under the head of the bolt, and turn the nut to tension the bolt.

7.g Direct Tension Indicator Tightening. When tightening of bolts using DTI devices is used, assemble a representative sample of not less than three devices, for each diameter and grade of fastener to be used in the work, in a calibration device capable of indicating bolt tension. Include flat hardened washers in the test assembly, if required in the actual connection, arranged as those in the actual connections to be tensioned. Use the calibration test to demonstrate that the device indicates a tension not less than 5% greater than that specified in Table A.

After tightening in the calibrating device, use a torque wrench to verify the torque required for proper tightening. Tighten the nut of each assembly five degrees past the initial required tension, record the respective load reading on the torque wrench dial, and determine the average of the sample assemblies. This average torque will be the inspection torque used on completed connections and is to be determined each day that inspection of completed connections is performed.

Follow manufacturer’s installation procedure for installation of bolts in the calibration device and in all connections. Give special attention to proper installation of flat hardened washers when DTI devices are used with bolts installed in oversize or slotted holes and when the load indicating devices are used under the turned element.

When bolts are installed using DTIs conforming to the requirements of ASTM F959, install bolts in all holes of the connection and bring them to snug tight conditions. Snug tight is indicated by partial compression of the direct
tension indicator protrusions. Provide a maximum gap of 0.005 inch after installation. Then tighten all fasteners, progressing systematically from the most rigid part of the connection to the free edges, in a manner that will minimize relaxation of previously tightened fasteners.
### TABLE A
Required Fastener Tension
Minimum Bolt Tension in Pounds*

<table>
<thead>
<tr>
<th>Bolt Size inches</th>
<th>ASTM F 3125 Grade A 325</th>
<th>ASTM F 3125 Grade A 490</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>12,000</td>
<td>15,000</td>
</tr>
<tr>
<td>5/8</td>
<td>19,000</td>
<td>24,000</td>
</tr>
<tr>
<td>3/4</td>
<td>28,000</td>
<td>35,000</td>
</tr>
<tr>
<td>7/8</td>
<td>39,000</td>
<td>49,000</td>
</tr>
<tr>
<td>1</td>
<td>51,000</td>
<td>64,000</td>
</tr>
<tr>
<td>1-1/8</td>
<td>56,000</td>
<td>80,000</td>
</tr>
<tr>
<td>1-1/4</td>
<td>71,000</td>
<td>102,000</td>
</tr>
<tr>
<td>1-3/8</td>
<td>85,000</td>
<td>121,000</td>
</tr>
<tr>
<td>1-1/2</td>
<td>103,000</td>
<td>148,000</td>
</tr>
</tbody>
</table>

* Equal to 70% of specified minimum tensile strength of bolts (according to ASTM Specifications for tests of full-size ASTM F 3125 Grade A 325 and ASTM F 3125 Grade A 490 bolts with UNC profile threads loaded in axial tension) rounded to the nearest kip.

### TABLE B
Nut Rotation from the Snug-Tight Condition\(^{(1)(2)}\) Geometry of Outer Faces of Bolted Parts

<table>
<thead>
<tr>
<th>Bolt length measured from underside of head to end of bolt</th>
<th>Both faces normal to bolt axis</th>
<th>One face normal to bolt axis and other face sloped not more than 20:1. Bevel washer not used.</th>
<th>Both faces sloped not more than 20:1 from normal to bolt axis. Bevel washers not used.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to and including 4 diameters</td>
<td>1/3 turn</td>
<td>1/2 turn</td>
<td>2/3 turn</td>
</tr>
<tr>
<td>Over 4 diameters but not exceeding 8 diameters</td>
<td>1/2 turn</td>
<td>2/3 turn</td>
<td>5/6 turn</td>
</tr>
<tr>
<td>Over 8 diameters but not exceeding 12 diameters(^{(3)})</td>
<td>2/3 turn</td>
<td>5/6 turn</td>
<td>1 turn</td>
</tr>
</tbody>
</table>

(1) Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance should be ±30 degrees; for bolts installed by 2/3 turn and more, the tolerance should be plus or minus 45 degrees.

(2) Applicable only to connections in which all material within grip of the bolt is steel.

(3) No research work has been performed by the Research Council Riveted and Bolted Structural Joints to establish the turn-of-nut procedure if bolt lengths exceed 12 diameters. Therefore, the required rotation must be determined by actual tests, in a suitable tension device, simulating the actual conditions.

In some cases, proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final tightening to deform the protrusion to the specified gap.

7.h **Lock-Pin and Collar Fasteners.** If approved for use, test and install lock-pin and collar fasteners using approved methods and procedures, and in accordance with Section 1050.3(c).7.f. Meet the requirements of Section 1105.02(d)2 for the shank and head of high-strength steel lock-pin and collar fasteners.
fasteners. Provide each fastener with a solid-shank body of sufficient diameter to provide tensile and shear strength equivalent to or greater than that of the bolt specified in the contract documents and a cold-forged head on one end, of type and dimensions as approved by the Department; a shank length suitable for the material thickness fastened; locking grooves; breakneck groove; and pull grooves (all annular grooves) on the opposite end. Provide each fastener with a steel locking collar of proper size for the shank diameter used which, by means of suitable installation tools, is cold-swaged into the locking grooves forming a head for the grooved end of the fastener after the pull groove section has been removed. Provide a steel locking collar with a standard product of an established manufacturer of lock-pin and collar fasteners, as approved by the Department.

7.i Inspection. In the presence of the Inspector, inspect the tightened bolts using a 1000 ft-lb manual dial calibrated torque wrench, in accordance with the procedures specified in the latest edition of PTM No. 429 and as follows, unless alternate fasteners or direct tension indicator devices are used, allowing verification by other methods: At the Representative's option, this inspection can be performed either by the Inspector or the Contractor. Inspection tests must be conducted daily.

Individually place three fastener assemblies of the same lot size, grade, size, configuration and condition as those under inspection in a device calibrated to measure bolt tension. Perform this calibration operation at least once each inspection day. Provide a washer under the part turned in tightening each bolt, if washers are used on the structure. If washers are not used on the structure, furnish the material used in the tension measuring device which abuts the part turned of the same specification as that used on the structure. In the calibrated device, tighten each bolt to the specified tension by any convenient means. Apply the calibrated torque wrench to the tightened bolt to determine the torque required to turn the nut or head five degrees (approximately 1 inch at a 12-inch radius) in the tightening direction. Take the average of the torque required for all three assemblies as the job-inspection torque.

For final acceptance of connections installed using high-strength bolts, inspect 10% (2 minimum) of the bolts in the connection using a calibrated torque wrench. Select bolts to be inspected according to PTM No. 1. Then apply the job-inspection torque to each with the calibrated torque wrench turned in the tightening direction. If this torque turns no bolt head or nut, the bolts in the connection will be considered to be properly tightened. But if the torque turns one or more bolt heads or nuts, apply the job-inspection torque to all bolts in the connection. Tighten and reinspect any bolt whose head or nut turns at this stage, or retighten all the bolts in the connection and resubmit it for inspection.

8. Pin Connections. Use pilot and driving nuts in driving pins. Drive pins so that the members will take full bearing on them. Screw pin nuts up tight and burr the threads at the face of the nut with a pointed tool.

9. Misfits. The correction of minor misfits involving minor amounts of reaming, cutting, and chipping will be considered a legitimate part of the erection. However, errors in the shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

The Contractor is responsible for all misfits, errors, and damage. Make the necessary corrections and replacements to correct misfits, errors, and damage.

(d) Painting. Apply intermediate and finish coats of paint, as specified in Section 1060.3.

1050.4 MEASUREMENT AND PAYMENT—Lump Sum. The price includes the following component items.

- **Fabricated Structural Steel.** Pound
  The cost of welds in excess of those indicated and allowed by the Chief Bridge Engineer, due to the Contractor's request, is incidental to the other fabricated structural steel work. The cost of all nondestructive testing, including equipment, supplies, and technicians is also incidental to the other fabricated structural steel work.

- **Cement Concrete Structures.** Section 1001.4

- **Preformed Neoprene Compression Joint Seal.** Section 1008.4
• Pedestrian Railing. Section 1012.4
• Aluminum Bridge Hand Railing. Section 1023.4
• Steel Bridge Hand Railing. Section 1022.4
• Protective Barrier. Section 1015.4
• Protective Fence. Section 1016.4
• Protective Coating for Reinforced Concrete Surfaces. Section 1019.4
• Armored Preformed Neoprene Compression Dam. Section 1021.4
• Tooth Expansion Dam with Drain Trough. Section 1020.4
• Reinforcement Bars. Section 1002.4
• Neoprene Strip Seal Dam. Section 1026.4
• High Load Multi-Rotational Bearings. Each
  For the type indicated.
• Neoprene Bearing Pads. Each
  For the type indicated.
• Reset Expansion Bearings, Steel Superstructure. Each