SECTION 605 STEEL STRUCTURES

605.01 Description. This work consists of furnishing, field fabricating, erecting, and painting structural steel for bolted and welded construction.

This work also consists of recoating a portion of or the entire existing steel structure.

605.02 Materials. Materials for steel structures shall conform to the following Subsections:

Coatings	820.02
Structural Steel	826.02
Fasteners	826.03
Shear Connectors	826.04
Forgings and Castings	826.05
Bearing Materials	826.06
Galvanizing	826.07
Sheet Zinc	826.08

605.03 Storage of Materials. Structural material shall be stored above the ground on platforms, skids, or other supports. It shall be kept free from dirt, grease, and other foreign matter, and shall be protected as far as practicable from corrosion.

FABRICATION.

605.04 Straightening Material. Rolled material, before being laid out or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends shall be cause for rejection of the material.

605.05 Finish. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately and result in square and true edges.

605.06 Holes.

1. *High Strength Bolts.* All holes for high strength bolts shall be either punched or reamed or drilled. When there are more than five layers of metal to be bolted or when any of the material is thicker than 3/40 (19 mm) for carbon steel, or 5/80 (16 mm) for high-strength steel, all holes shall be either subpunched or subdrilled 3/160 (5 mm) smaller than the diameter of the bolts. After preliminary assembling, the holes shall be reamed 1/160 (2 mm) larger or drilled from the solid to 1/160 (2 mm) larger than the diameter of the bolts.

   Material forming parts of a member composed of not more than five layers of metal may be punched 1/160 (2 mm) larger than the diameter of the bolts whenever the thickness of the metal is not greater than 3/40 (19 mm) for structural steel or 5/80 (16 mm) for high-strength steel.

2. *Ribbed Bolts, Turned Bolts, or other Approved Bearing Type Bolts.* All holes for ribbed bolts, turned bolts, or other approved bearing type bolts shall be either subpunched or subdrilled 3/160 (5 mm) smaller than the diameter of the bolt and reamed assembled to a steel template or, after assembling, drilled from the solid at the option of the fabricator. In any case the finished holes shall provide a driving fit as specified on the Plans or in the Special Provisions.

605.07 Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 1/160 (2 mm). All holes to be enlarged to admit the bolts must be reamed. Holes must be cut clean without torn or ragged edges. Poor matching of holes will be cause for rejection.

605.08 Reamed or Drilled Bolt Holes. Reamed or drilled holes shall be cylindrical and perpendicular to the member. Where practicable, reamers shall be directed by mechanical means. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required by the Engineer, assembled members shall be taken apart for removal of burrs caused by drilling. Connecting members requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match-marked before disassembling.

605.09 Subpunching or Subdrilling and Reaming Field Connections. Unless otherwise specified in the Special Provisions or on the Plans, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames shall be subpunched or subdrilled and reamed while assembled to a steel template. Drilling full size holes, in lieu of assembly reaming or template reaming undersized holes, will be permitted upon approval of the procedures by the Engineer.

All holes for floor beam and stringer field end connections shall be subpunched or subdrilled and reamed to a steel template or reamed while assembled. Reaming or drilling full size field connection holes through a steel template shall be done after the template has been located with respect to position and angle and firmly bolted in place. Templates used for reaming matching members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts or members shall be located so that the parts or members are duplicates and require no match-marking.

If additional subpunching or subdrilling and reaming is required, it shall be specified in the Special Provisions or on the Plans.

605.10 Accuracy of Punched, Subpunched, and Drilled Holes. All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling and before any reaming is done, cylindrical pins 1/80 (3 mm) smaller in diameter than the size of the punched, subpunched, and subdrilled holes may be entered perpendicular to the face of the member without drifting, in at least 75% of the contiguous holes in the same plane. If this requirement is not fulfilled, the members will be rejected. If any hole will not pass a pin 3/160 (5 mm) smaller in diameter than the size of the punched hole, this will be cause for rejection.

605.11 Accuracy of Reamed and Drilled Holes. When holes are reamed or drilled, 85% of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/320 (1 mm) between adjacent thicknesses of metal.

All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. The centerlines shall be used in locating accurately the template from the milled or scribed ends of the members.

605.12 Fitting for Bolting. Surfaces of metal in contact shall be cleaned before assembling. The members shall be assembled, well pinned, and firmly drawn together with bolts before reaming is commenced. Assembled members shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. All members shall be free from twists, bends, and other deformations.

605.13 Drifting of Holes. The drifting during assembling shall only be to bring the members into position for bolting. The drifting shall not enlarge the holes or distort the metal. All holes to be enlarged must be reamed.

605.14 Connections Using Non-High-Strength Bolts. Non-high-strength bolts shall be unfinished, turned, or ribbed bolts conforming to the requirements for Grade A bolts of ASTM A 307. Bolted connections shall be used only as indicated by the Plans or Special Provisions. Bolts shall have single, self-locking nuts or double nuts unless otherwise shown on the Plans or in the Special Provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

a. *Unfinished Bolts.* Unfinished bolts shall be furnished unless other types are specified.

b. *Turned Bolts.* The surface finish of the body of turned bolts shall meet the ANSI B 46.1 roughness rating value of 125 (3.2 ìm). Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed for the bolts furnished to provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

c. *Ribbed Bolts.* The body of ribbed bolts shall be of any approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/640 (2 mm) greater than the nominal diameter specified for the bolts.

   Ribbed bolts shall be furnished with round heads conforming to ANSI/ASME B18.5.2.2M unless otherwise specified. Nuts shall be hexagonal. The nuts shall be recessed or installed using washers of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the holes shall be carefully reamed and an oversized bolt used as a replacement.

605.15 High Strength Bolts. This Subsection covers the assembly of structural joints using AASHTO M 164 (M 164M) high-strength carbon steel bolts and AASHTO M 253 (M 253M) quenched and tempered alloy steel bolts or equivalent fasteners, tightened to a high tension. Holes for high-strength bolt connections shall conform to the requirements of Subsections 605.06, 605.07, and 605.08.

a. *Bolts, Nuts, and Washers.* Bolts manufactured to AASHTO M 164 (M 164M) shall be marked on the top of the head with three radial lines and the symbol **A325** (**A 325M)**.

   All galvanized nuts shall be lubricated with a water soluble lubricant containing a visible dye so a visual check can be made for the lubricant at the time of field installation. Nuts shall be marked according to the requirements of ASTM A563 (A 563M).

   Bolts, nuts, and washers shall be kept protected from the weather or any other adverse environments. Weathered or rusted fasteners or fasteners which have lost their lubricant or protective coating will be rejected for use.

   Bolt and nut dimensions shall conform to the dimensions shown in Table 605-A.

Table 605-A

Bolt and Nut Dimensions, U.S. Customary

Heavy Hex Structural Bolts (Inches)				**Heavy Hex Nuts (Inches)**	
Nominal Bolt Diameter, D	**Width Across Flats, F**	**Height, H**	**Thread Length**	**Width Across Flats, W**	**Height, H**
1/2	7/8	5/16	1	7/8	31/64
5/8	1 1/6	25/64	1 1/4	1 1/6	39/64
3/4	1 1/4	15/32	1 3/8	1 1/4	47/64
7/8	1 7/16	35/64	1 1/2	1 7/16	55/64
1	1 5/8	39/64	1 3/4	1 5/8	63/64
1 1/8	1 13/16	11/16	2	1 13/16	1 7/64
1 1/4	2	25/32	2	2	1 7/32
1 3/8	2 3/16	27/32	2 1/4	2 3/16	1 11/32
1 1/2	2 3/8	15/16	2 1/4	2 3/8	1 15/32

Table 605-A

Bolt and Nut Dimensions Metric

Nominal Bolt Diameter and Thread Pitch [1]	*Heavy Hexagon Structural Bolt Dimensions [1] (mm)*						*Nut Dimensions [2] (mm)*			
	Body Diameter (D)		*Width Across Flats (S)*		*Head Height (K)*		*Width Across Flats (S)*		*Thickness (M)*	
	max.	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*
M16 H 2	16.70	15.30	27.00	26.16	10.75	9.25	27.00	26.16	17.10	16.40
M20 H 2.5	20.84	19.16	34.00	33.00	13.40	11.60	34.00	33.00	20.70	19.40
M22 H 2.5	22.84	21.16	36.00	35.00	14.90	13.10	36.00	35.00	23.60	22.30
M24 H 3	24.84	23.16	41.00	40.00	15.90	14.10	41.00	40.00	24.20	22.90
M27 H 3	27.84	26.16	46.00	45.00	17.90	16.10	46.00	45.00	27.60	26.30

M30 H 3.5	30.84	29.16	50.00	49.00	19.75	17.65	50.00	49.00	30.70	29.10
M36 H 4	37.00	35.00	60.00	58.80	23.55	21.45	60.00	58.80	36.60	35.00

Note 1: From ANSI B18.2.3.7M - 1979. Pitch = the distance in millimeters from the crest of one thread to the crest of the next thread.

Note 2: From ANSI B18.2.4.6M - 1979.

b. *Bolted Members.* The slope of surfaces of bolted members in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted members shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

When assembled, all faying surfaces including the outside surfaces adjacent to the bolt heads, nuts, or washers shall be free of scale, except for tight mill scale. The faying surfaces shall also be free of dirt, loose scale, burrs, other foreign material, and other defects that would prevent solid seating of the members.

c. *Surface Preparation of Contact Surfaces.* Contact surfaces of high strength bolted connections which are considered within friction-type joints shall be free of oil, paint, lacquer, rust inhibitor, or galvanizing unless specifically modified by the Plans or Special Provisions.

d. *Bolt Tension.* During installation each fastener shall be tightened to provide a tension which is greater than 70% of the tensile strength given in AASHTO M164 for A325 (AASHTO M 164M for A 325M) bolts and between 70% of the minimum and maximum tensile strength given in AASHTO M253 for A490 (AASHTO M 253M for A 490M) bolts.

Table 605-B, US Customary

Minimum Bolt Tension (pounds)

Bolt Size (in.)	**AASHTO M164 (ASTM A325) Bolts**	**AASHTO M253 (ASTM A490) Bolts**
1/2	12,050	14,900
5/8	19,200	23,700
3/4	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1 1/8	56,450	80,100
1 1/4	71,700	101,800
1 3/8	85,450	121,300
1 1/2	104,000	147,500

Table 605-B Metric

Minimum Bolt Tension [1], kilonewtons

Nominal Bolt Diameter and Thread Pitch	*AASHTO M 164M*	*AASHTO M 253M*	
		min.	*max.*
M16 H 2	91	114	132
M20 H 2.5	142	179	206
M22 H 2.5	176	221	255
M24 H 3	205	257	297
M27 H 3	267	334	386
M30 H 3.5	326	408	471
M36 H 4	475	595	686

Note 1: Equal to 70% of specified minimum tensile strength of bolts.

Threaded bolts shall be tightened by the turn-of-nut method. If required because of bolt-entering and wrench-operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating. Impact wrenches, if used, shall be of adequate capacity and supplied with sufficient air to perform the required tightening of each bolt in approximately ten seconds.

e. *Washers.* All fasteners shall have a hardened washer under the element (nut or bolt head) turned in tightening. Hardened washers shall be used under both the head and nut regardless of the element turned when using AASHTO M253 (ASTM 490) [AASHTO M 253M (ASTM A 490M)] bolts, if the material against which it bears has a specified yield strength of less than 40,000 psi (276 MPa).

Where an outer face of the bolted members has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth, beveled washer shall be used to compensate for the lack of parallelism.

f. *Calibrated Wrench Testing.* To check the correct calibration of a wrench, the Skidmore-Wilhelm Bolt Tension Calibrator or equivalent tension measuring device shall be furnished.

g. *Turn-of-Nut Tightening.* When the turn-of-nut method is used to provide the bolt tension specified under (d) above, there shall first be enough bolts brought to a "snug tight" condition to ensure that all members of the connection are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a construction worker using an ordinary spud wrench. Following this initial operation, bolts shall be placed in all remaining holes in the connection and brought to snug tightness. All bolts in the connection shall then be tightened by the applicable amount of nut rotation specified in Table 605-C. Tightening shall progress systematically from the most rigid part of the connection to its free edges. During this operation there shall be no rotation of the element not turned by the wrench.

h. *Tightening by Use of a Load Indicating Fastener System.* Tightening by this means is permitted provided it can be demonstrated, by an accurate, direct measurement procedure, that the bolt has been tightened in accordance with Table 605-C. Tightening shall be by methods and procedures approved by the Engineer.

Table 605-C

Nut Rotation from Snug Tight Condition [1]

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

Note 1: Nut rotation is relative to the 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 "45 degrees.

Note 2: No research work has been performed by the Research Council on Riveted and Bolted Structural Joints to establish the turn-of-nut procedures when bolt lengths exceed 12 diameters. Therefore, the required rotation must be determined by actual tests in a suitable tension device simulating the actual conditions.

i. *Inspection.*

1. The Engineer will determine when the requirements of (3)b. and (3)c. below are met. When the calibrated-wrench method of tightening is used, the Engineer will have full opportunity to witness the calibration tests prescribed under (f) above.
2. The Engineer will observe the installation and tightening of bolts to determine if the selected tightening procedure is properly used and will determine when all bolts are tightened.
3. The following inspection procedure shall be used unless a more extensive or different inspection procedure is specified:

   a. Either the Engineer will or the Contractor in the presence of the Engineer, at the Engineer's option, shall perform the inspection using an inspection wrench. The inspection wrench may be either a torque wrench or a power wrench that can be accurately adjusted in accordance with the requirements under (f) above.
   b. Three bolts of the same grade, size*, and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. There shall be a washer under the element turned. (* Length may be any length representative of bolts used in the structure.)
   c. When the inspection wrench is a torque wrench, each of the three bolts shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size under (d) above. The inspection wrench shall then be applied to the tightened bolt, and the torque necessary to turn the nut or head five degrees

[approximately 10 (25 mm) at a 120 (300 mm) radius] in the tightening direction shall be determined. The average torque measured in the tests of the three bolts shall be taken as the job inspecting torque to be used as specified in (3)e. below.

d. When the inspection wrench is a power wrench, it shall be adjusted so that it tightens each of the three bolts to a tension at least 5% but not more than 10% greater than the minimum tension specified for its size under (d) above. This tension setting of the power wrench shall be taken as the job inspecting torque to be used in the manner specified in (3)e. below.

e. Bolts represented by the three-bolt sample that have been tightened in the structure shall be inspected by applying in the tightening direction, the inspection wrench to its job inspecting torque on 10% of the bolts, but not less than two bolts, selected at random in each connection. If no nut or bolt is turned by this application of the job inspecting torque, the connection shall be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection. All bolts whose nut or head is turned by the job inspecting torque shall be tightened and re-inspected. Alternatively, the Contractor has the option to retighten all of the bolts in the connection and then resubmit the connection for inspection.

605.16 Plate Cut Edges.

1. *Edge Planing.* Sheared edges of plates more than 5/80 (16 mm) in thickness and carrying calculated stress shall be planed, milled, ground, or thermal cut to a depth of **3**0 (6 mm). Re-entrant cuts shall be filleted to a minimum radius of 3/40 (19 mm) before cutting.

2. *Visual Inspection and Repair of Plate Cut Edges.* In the repair and determination of limits of internal defects visually observed on sheared or flame-cut edges and caused by entrapping slag or refractory, deoxidation products, gas pockets, or blow holes, the amount of metal removed shall be the minimum necessary to remove the defect or to determine that the permissible unit is not exceeded. Plate edges may be at any angle with respect to the rolling direction. All repairs of defects made by welding shall conform to the applicable provisions of ANSI/AASHTO/AWS D1.5, *Bridge Welding Code* as modified in this Section.

The limits of acceptability and the repair of visually observed edge defects in plates 40 (100 mm) and under in thickness shall be in accordance with Table 605-D.

Table 605-D

Required Repairs for Discontinuity

Description of Discontinuity	*Repair Required*
Any discontinuity 10 (25 mm) in length or less and 1/80 (3 mm) maximum depth.	None; need not be explored.
Any discontinuity over 10 (25 mm) in length and	None; depth should be explored by random spot

1/80 (3 mm) maximum depth.	grinding
Any discontinuity over 10 (25 mm) in length with depth over 1/80 (3 mm) but not greater than **3**0 (6 mm) .	Remove discontinuity; need not fill area with weld material.
Any discontinuity over 10 (25 mm) length with depth over **3**0 (6 mm) but not greater than 10 (25 mm).	Completely remove and weld. Aggregate length of welding shall not exceed 20% of plate edge length being repaired.
Any discontinuity over 10 (25 mm) in length with depth greater than 10 (25 mm).	Subject to approval by the Engineer. Repair to be made in accordance with Section 3.2 of the AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.

Note 1: The length of defect is the visible long dimension on the plate cut edge, and the depth is the distance that the defect extends into the plate from the cut edge.
Note 2: This table does not apply to fracture critical members.

Steel plate, bar, or shapes containing any discontinuity, regardless of length or depth, will not be permitted for use in any member or component in a tension area.

605.17 Welding and Oxygen Cutting. All welding and oxygen cutting shall conform to the requirements of Subsection 826.12.

605.18 Joints. Abutting joints in compression members and girder flanges, and in tension members where so specified on the drawings, shall be faced and brought to an even bearing. Wheel joints are not faced and the opening shall not exceed **3**0 (6 mm).

605.19 End Connection Angles. Floorbeams, stringers, and girders having end connection angles shall be built to the exact length shown on the Plans measured between the heels of the connection angles with a permissible tolerance of +0 to -1/160 (+0 to -2 mm). Where continuity is required, end connections shall be faced. The thickness of the connection angles shall be not less than 3/80 (10 mm) and not less than that shown on the detail drawings, after facing.

605.20 Web Plates. For girders having no cover plates and not encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than 1/80 (3 mm) below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles.

At web splices, the clearance between the ends of the web plates shall not exceed 3/80 (10 mm). The clearance at the top and bottom ends of the web splice plates shall not exceed **3**0 (6 mm).

605.21 Bent Plates. Cold-bent, load-carrying, rolled-steel plates shall conform to the following:

1. They shall be taken from the stock plates so that the bend-line will be at right angles to the direction of rolling.
2. The radius of bends shall be such that no cracking of the plate occurs. Generally accepted minimum radii, measured to the concave face of the metal, are shown in Table 605-E:

Table 605-E

Minimum Radii for Cold Bent Steel Plates

radii and t (thickness) in millimeters

All Grades of Structural Steel in this Section	Up to 20 (13 mm)	Over 20 (13 mm) to 10 (25 mm)	Over 10 (25mm) to 120 (38 mm)	Over 120 (38 mm) to 220 (64 mm)	Over 220 (64 mm)
Bend Radius	2t	2.5t	3t	3.5t	4t

Note: Low alloy steel in thickness over 20 (13 mm) may require hot bending for small radii. If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1150 ºF (620 ºC). Hot-bent plates shall conform to (a) above.

3. Before bending, the corners of the plates shall be rounded to a radius of 1/160 (2 mm) throughout that portion of the plates at which the bending is to occur.

605.22 Eyebars. Pin holes may be flame-cut at least 20 (50 mm) smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together so that they will be placed on the pin and bored at both ends while clamped. Eyebars shall be packed and match-marked for shipment and erection. All identifying marks shall be stamped with steel stencils on the edge of one head of each member after fabrication is completed so that the markings will be visible when the bars are nested in place on the structure. The eyebars shall be straight and free from twists, and the pin holes shall be accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/160 to a foot (1 in 200 mm).

The edges of eyebars lying between the transverse centerline of their pin shall be cut simultaneously with two mechanically operated torches abreast of each other guided by a substantial template in such a manner as to prevent distortion of the plates.

605.23 Testing Requirements. Testing of fabricated structural members shall be according to Subsection 826.26.

FIELD ERECTION.

605.24 Erection of Structure. The Contractor shall set the steel according to the lines and elevations as provided in the Contract, remove the temporary construction, and do all the work required to complete the bridge or bridges as covered by the Contract, all in accordance with the Plans and this Section.

605.25 Erection Material. The Contractor shall provide the falsework and all tools, machinery, and appliances, including drift pins and fitting-up bolts, necessary to complete the work.

605.26 Handling and Storing Fabricated Materials. Stored material shall be placed on skids above the ground. It shall be kept clean and shall be properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent permanent deflections.

605.27 Falsework. The Contractor shall engage a Professional Engineer registered in Delaware to design the falsework separately for steel structures and for necessary changes in existing steel structures on the Project. The Professional Engineer's signature and seal shall be affixed to the working drawings. Working falsework drawings shall be submitted in accordance with

Subsection 105.04. The falsework shall be properly designed, constructed, and maintained for the loads that it will carry. It is the Contractor's responsibility to obtain approval of the working drawings from the Department prior to the construction of the falsework. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility. After placement of the falsework, the Contractor's Professional Engineer shall certify that the falsework system has been assembled according to the approved falsework drawing prior to placing loads on the falsework.

605.28 Methods and Equipment. Before starting the work of erection, the Contractor shall inform the Engineer as to the method of erection it proposes to follow and the number and type of equipment it proposes to use. The Contractor's methods and equipment shall be subject to the approval of the Engineer. The Engineer's approval does not relieve the Contractor of its responsibility for the safe performance of the work or from carrying out the work in full accordance with the Plans and the requirements of this Section. No work shall be done until the Engineer's approval has been obtained.

605.29 Anchorages.

1. *Bearings.* Bridge bearings shall be set level in the exact position indicated and shall have full and even bearing on the masonry. Prior to assembly in place, the steel surface bearing on the self-lubricating bearing plate shall be thoroughly lubricated with additional antioxidant lubricant furnished by the manufacturer.

   The sliding surface shall be planed parallel to the movement of the spans.
2. *Anchor Bolts.* Anchor bolts, when required, including hex nuts and washers, shall conform to the requirements of AASHTO M 314 unless otherwise specified on the Plans. The exposed portion of the anchor bolt shall be either galvanized or painted, unless otherwise specified.

   When the anchor bolt passes through the sole plate, the nut is to be **3**0 (6 mm) clear. The threads shall be burred at face of nut. Anchor bolts shall be swedged and may be cast-in-place or grouted in preformed (sleeved or drilled) holes. If the Contractor elects to drill, it shall not cut through the bar reinforcement in the masonry. All slots and holes in the masonry plates surrounding the anchor bolts shall be filled with an approved, non-hardening caulking compound or elastic joint sealer.

605.30 Straightening Bent Material. The straightening of plates, angles, other shapes, and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fractures or other injuries. Distorted members shall be straightened using mechanical means or, if approved by the Engineer, using a limited amount of localized heat. The temperature of the heated area shall not exceed 1150 EF (620 EC) (a dull red) as monitored by temperature indicating crayons, liquids, or bimetal thermometers. Members to be heat-straightened shall be substantially free of stress and external forces, except stresses resulting from the mechanical means used in conjunction with the application of heat.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

605.31 Assembling Steel. The members shall be accurately assembled as shown on the Plans and all match-marks shall be followed. The material shall be carefully handled so that no members are bent, broken, or otherwise damaged. Hammering which injures or distorts the members shall not be done. Bearing surfaces and surfaces in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so to give the trusses proper camber. The blocking shall be left in place until the tension chord

splices are fully bolted and all other truss connections are pinned and bolted. Permanent bolts in splices of butt joints of compression members and permanent bolts in railings shall not be tightened until the span has been swung. One-half of the holes in splices and field connections shall be filled with bolts and cylindrical erection pins (half bolts and half pins) before bolting with high-strength bolts. All splices and connections during erection shall have three-fourths of the holes filled.

Filling-up bolts shall be of the same nominal diameter as the high strength bolts. Cylindrical erection pins shall be 1/320 (1 mm) larger.

605.32 Pin Connections. Pilot and driving nuts shall be used for driving pins. They shall be furnished by the Contractor. Pins shall be driven so that the members take full bearing on them. Pin nuts shall be securely fastened, and the threads shall be burred at the face of the nut using a pointed tool.

605.33 Misfits. The correction of minor misfits involving harmless amounts of reaming, cutting, and chipping will be considered a legitimate part of the erection. However, all errors in the shop fabrication, or deformations resulting from handling and transportation, that prevent the proper assembly and fitting up of members by the moderate use of drift pins, or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the inspector to obtain approval of the proposed correction method. All corrections shall be made in the inspector's presence.

605.34 Cleaning and Restoration. Upon completion of the erection and before final acceptance, the Contractor shall remove all falsework, excavated or useless materials, rubbish, and temporary buildings. The Contractor shall also replace or renew any damaged fences, restore in an acceptable manner all property, both public and private, damaged during the prosecution of this work, and leave the structure site and adjacent highway in a neat and presentable condition satisfactory to the Engineer. All excavated material or falsework placed in the stream channel during construction shall be removed by the Contractor before final acceptance.

FIELD PAINTING.

605.35 Field Painting. All structural steel members, railings, fascia, downspouts, and other miscellaneous steel items that have been previously painted shall be cleaned, and primed and painted by applying two full coats of paint, the intermediate coat and the finish coat. The coating system to be used shall meet the requirements of moisture-cured urethane system as specified in Subsection 820.02.

605.36 Surface Preparation. Surfaces identified to be painted shall be cleaned in the following manner:

1. Surfaces specified to be recoated shall be cleaned to bare metal in accordance with SSPC-SP 11.

   The perimeter or edge of intact paint adjoining the cleaned surface shall be feathered back, and the adjoining paint shall be tightly adhered. Ragged edges on intact paint will not be allowed. Adherence will only be considered satisfactory if the adjoining remaining paint is smoothly feathered back and cannot be removed by lifting with a dull putty knife. After power tool cleaning operations are completed, all residue generated by the cleaning work shall be removed by vacuuming using HEPA filtered vacuums.

   Surfaces shall be accepted by visual comparison to a prepared Project standard. The

Contractor shall prepare the Project standard by power tool cleaning a representative area on the structure that is being prepared for painting. The prepared standard shall generally conform to SSPC-Vis 3, E SP 11, F SP 11, and G SP 11, as applicable, and shall be approved by the Engineer before the start of general cleaning work. At least one standard shall be prepared for each structure that is being specified for cleaning. More than one standard may be necessary if the cleaned steel differs significantly from the photographic standards due to surface conditions or other factors. Each standard shall be at least 12 by 120 (300 by 300 mm) in size and shall be located in an area of the structure that is accessible to and approved by the Engineer.

The Contractor shall protect the Project standard from corrosion and contamination throughout the duration of work. Protection shall be by applying a clear coat of polyurethane, or other means. At the completion of cleaning work, the Project standard shall be re-cleaned and painted in accordance with this Section. If in the opinion of the Engineer the Project standard becomes deteriorated, or otherwise ineffective, it shall be re-established in accordance with this Subsection.

2. Surfaces specified to be over-coated shall be solvent cleaned after water blasting.

605.37 Painting.

a. *Manufacturer's Instructions.* At least five working days prior to the start of work, the Contractor shall provide the Engineer with one copy of the paint manufacturer's current Technical Data and Material Safety Data Sheets for the paint materials being furnished. Instructions, suggestions, and precautions contained in the data sheets shall be followed to the extent that they do not contradict the provisions of this Section. In the case of a contradiction, the more stringent requirements shall be followed.
b. *Specifications and Inspection Equipment.* Prior to the start of and throughout the duration of work, the Contractor shall supply the Engineer with the following:

1. One bound copy each of the SSPC surface preparation specifications, SSPC-SP 1 and SSPC-SP 11;
2. One bound copy of the SSPC pictorial standard, SSPC-Vis 3;
3. One bound copy of the SSPC paint application specification, SSPC-PA 2;
4. One air thermometer, pocket type, ranging from 0 to 200 EF (-17 to 93 EC);
5. One surface thermometer, ranging from 0 to 300 EF (-18 to 149 EC); and
6. One magnetic dry film thickness gage, Type 2 (fixed probe);

c. *Atmospheric Conditions.* Painting shall not be performed unless all of the following conditions are met:

1. The receiving surface is clean and free of rust back, condensation, and visible moisture. Rustback occurs when freshly exposed bare steel is exposed to conditions of high humidity, moisture, or a corrosive atmosphere. The time interval from blast cleaning to rust back varies from minutes to weeks depending on the environment.
2. The receiving surface and ambient air temperature are as recommended by the paint manufacturer, except that in no case shall painting work be performed when the surface and ambient temperatures are less than 36 or greater than 100 EF (2 or greater than 38 EC).
3. *Mixing Paint.* All paints shall be thoroughly mixed with mechanical mixers in accordance with the manufacturer's recommendations.

4. *Solvent Restrictions.* The Contractor may thin the paint only with approved manufacturer's thinner. Thinning will be allowed only in strict accordance with manufacturer's recommendations and State VOC regulations. Unauthorized use of solvents shall result in re-cleaning and repainting of the surface in accordance with this Section.
5. *Paint Application.* Paint coatings may be applied using brush, roller, or spray methods unless prohibited by the Contract. When spray painting is prohibited, paint shall be applied using brushes or rollers only.

   Stripe painting with primer will be required on the following surfaces cleaned to bare metal. All welds, rivets, bolts, nuts, and edges of plates, angles, lattice, pieces, or other shapes, and corners and crevices shall be "striped" with primer before the general prime coat is applied. All stripe painting shall be performed using a brush only. No other method of paint application will be allowed for stripe painting.

   Complete protection against paint spatter, spillage, overspray, wind blown paint, or similar releases of paint shall be provided. Covers, tarps, mesh, and similar materials shall be placed around the work area to protect public and private property; pedestrian, vehicular, marine, or other traffic; all portions of the bridge, highway appurtenances, waterways, and similar surrounding areas; and property upon, beneath, or adjacent to the structure.

d. *Number of Coats.* Areas cleaned to bare metal and specified to be recoated shall be painted with one coat of primer. After the primer has dried, all surfaces shall be painted with two full coats of paint: the intermediate coat and the finish coat.
e. *Film Thickness.* Paint shall be applied in sufficient quantity to produce the minimum dry film thickness specified in Section 820 for the type of paint specified.
f. *Painting Schedule.* Primer shall be applied on the same day of the cleaning operation and before rust back occurs. Failure to apply primer to a cleaned surface within eight hours shall result in recleaning the surface in accordance with this Section.

   The intermediate coat of paint shall be applied to the receiving surface within 14 days of the application of the previous coating (primer), or within the manufacturer's recommended schedule for recoating, whichever is less.

   The finish coat of paint shall be applied to the receiving surface within 14 days of the application of the previous (intermediate) coating, or within the manufacturer's recommended schedule for recoating, whichever is less.

   Areas failing to meet the specified minimum dry film thickness shall be recoated with the same type of paint to produce at least the total dry film thickness required. Paint applied containing thinners, paint applied to contaminated surfaces, and paint applied contrary to this Section shall result in recleaning and repainting the surface. The work of recleaning and repainting, if required, shall be done by the Contractor to the satisfaction of the Engineer.
g. *Material Storage.* Paint in storage shall be protected from damage and maintained between 40 and 85 °F (5 and 29 °C). Paint not used before the expiration shall be immediately removed from the Project.

605.38 Painting of Galvanized Steel. All galvanized surfaces (downspouts, etc.) shall be painted with a moisture-cured aluminum paint that is designed to adhere to galvanized steel surfaces.

605.39 Stenciling Requirement. At the completion of the painting work, the completion date (month and year) and the bridge number, shall be stenciled on the structure in 3" (75 mm) high

numbers. The paint used for this marking shall be the same as the topcoat except the color shall be black. The numbers shall be stenciled on the outside of each fascia beam at the approaching traffic end of the structure, on a location designated by the Engineer. The Contractor shall paint the month and year of the existing stenciling after the existing stenciling area is cleaned and painted if so required in case of partial painting of the structure.

605.40 Method of Measurement. The quantity of steel structures will not be measured if payment is on a lump sum basis. If payment is based on the Contract unit price per pound (kilogram), then the quantity of steel structures will be measured in pounds (kilograms). Unless measurement by the scale weight is specified, the quantity of steel will be computed on the following basis:

a. Unit weights, lb/ft; (kg/m;)

Aluminum, cast or wrought	173 (2770)
Bronze, cast	536 (8590)
Copper-alloy	536 (8590)
Copper sheet	558 (8940)
Iron, cast	445 (7130)
Iron, malleable	470 (7530)
Iron, wrought	487 (7800)
Lead, sheet	707 (11 330)
Steel, rolled, cast, copper bearings, silicon, nickel, and stainless	490 (7850)
Zinc	450 (7210)

b. The weights of rolled shapes shall be computed on the basis of their nominal weights per foot (meter) as shown on the drawings, or listed in the AISC Manual of Steel Construction.

   The weights of plates shall be computed on the basis of the nominal weight of their width and thickness, as shown in the drawings, plus an estimated over-run computed as one-half the permissible variation in thickness and weight as tabulated in AASHTO M 160/M 160M.

c. The weight of castings shall be computed from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight shall be added 5% allowance for fillets and overruns. Scale weights may be substituted for computed weights in the case of castings or of small complex parts for which accurate computations of weight would be difficult.

d. The weight of temporary erection bolts; shop and field paint; boxes, crates, and other containers used for shipping; and materials used for supporting members during transportation and erection shall not be included.

e. When computing the pay weight on the basis of computed net weight the following stipulations in addition to those in (a) through (d) above shall apply:

   1. The weight shall be computed on the basis of the net finished dimensions of the members as shown on the approved shop drawings, deducting for copes, cuts, clips, and all open holes.

2. The aggregate weight of heads, nuts, single washers, and the threaded stick-through of all high strength shop bolts shall be included on the basis of the following weights:

Table 605F

U.S. Customary

Diameter of Bolt **Inches**	**Weights per 100** **Bolts, pounds**
1/2	19.7
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1 1/8	165.1
1 1/4	212.0
1 3/8	280.0
1 1/2	340.0

Table 605-F

Weights of Metric High-Strength Structural Bolts [1]

approximate weight of 100 steel bolts in kilograms

Bolt Length (mm)	*Nominal Bolt Diameter and Thread Pitch*						
	M16 H 2	*M20 H 2.5*	*M22 H 2.5*	*M24 H 3*	*M27 H 3*	*M30 H 3.5*	*M36 H 4*
45	10.8	---	---	---	---	---	---
50	11.6	19.8	---	---	---	---	---
55	12.3	21.0	26.0	---	---	---	---
60	13.1	22.3	27.5	35.4	---	---	---
65	13.9	23.5	29.0	37.1	50.5	---	---
70	14.7	24.7	30.5	38.9	52.7	64.0	---
75	15.5	26.0	32.0	40.7	55.0	66.8	---

80	16.3	27.2	33.5	42.4	57.2	69.6	108
85	17.1	28.4	34.9	44.2	59.5	72.4	112
90	17.9	29.7	36.4	46.0	61.7	75.1	116
95	18.6	30.9	37.9	47.8	63.9	77.9	120
100	19.4	32.1	39.4	49.5	66.2	80.1	124
110	20.8	34.3	42.1	52.7	70.4	85.6	132
120	22.4	36.8	45.0	56.2	74.9	91.1	140
130	24.0	39.2	48.0	59.7	79.4	96.7	148
140	25.6	41.7	51.0	63.3	83.9	102	155
150	27.1	44.1	54.0	66.8	88.4	108	163
160	28.7	46.6	57.0	70.4	92.8	113	171
170	30.3	49.1	59.9	73.9	97.3	119	179
180	31.8	51.5	62.9	77.5	102	124	187
190	33.4	54.0	65.9	81.0	106	130	195
200	35.0	56.4	68.9	84.6	111	135	203
210	36.6	58.9	71.8	88.1	115	141	211
220	38.2	61.4	74.8	91.6	120	146	219
230	39.7	63.8	77.8	95.2	124	152	227
240	41.3	66.2	80.8	98.7	129	158	235
250	42.9	68.7	83.8	102	133	163	243
260	44.5	71.2	86.7	106	138	169	251
270	46.0	73.7	89.7	109	142	174	259
280	47.6	76.1	92.7	113	147	180	267
290	49.2	78.6	95.7	116	151	185	275
300	50.8	81.1	98.6	120	156	191	283

Note 1: From ANSI B18.2.3.7M, Table 3.

3. The weight of weld metal shall be computed on the basis of the theoretical volume from dimensions of the welds.

f. When computing the pay weight on the basis of scale weight, the pay quantity of structural steel will be the shop scale weight of the fabricated members, weighed on satisfactory scales in the presence of the inspector. If the shop paint has been applied to the completed member when weighed, 0.4% of the weight of the member shall be deducted from the scale weight to compensate for the weight of shop paint.

The quantity of recoating will either be measured by the square foot (square meter) of area recoated or will not be measured.

605.41 Basis of Payment.

a. *Steel.* The quantity of steel structures will be paid for either at the Contract unit price per pound (kilogram) or on a lump sum basis. Price and payment will constitute full compensation for all labor, materials, equipment, and transportation required for furnishing, fabricating, transporting, erecting, and shop and field painting to complete the work. The quantity of recoating will be paid for either at the Contract unit price per square foot (square meter) or at the Contract lump sum price.

The Contract price for steel structures shall also include, when applicable, taking field elevations along the tops of the existing beams; removal of existing blast plates; and modifications to existing beams for widening except those specifically paid for under the applicable Section. Also included are all additional costs for stage construction for all the work on the Project. The cost of painting of all new structural steel includes all material, labor, tools and equipment, and surface preparation, spatter protection, and cleanup.

When tests of fabricated members are required by the Contract, the cost of testing, including equipment, handling, supervision, and incidentals including but not limited to temperature indicating crayons, liquids, or bimetal thermometers for making the test, will be included in the Contract unit price per pound (kilogram) of structural steel, unless otherwise specified.

All metal parts such as anchor bolts and nuts, shoes, rockers, rollers, bearing and slab plates, pins and pilot and driving nuts, expansion dams, roadway drains and scuppers, weld metal, bolts embedded in concrete, cradles and brackets, blast plates, and waterstops shall be paid for as structural steel unless otherwise stipulated. Steel reinforcement for concrete is not included in this Section and will be paid separately under the appropriate Section.

Payment will be made on a lump sum or price per pound (kilogram) basis as required by the terms of the Contract. When payment is to be based on price per pound (kilogram), the finished work shall be weighed in the presence of the inspector, if practicable. The Contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various members.

If payment is made on a lump sum basis the Contractor should note that the approximate weight of structural steel is stated in the proposal. It shall be the responsibility of the Contractor, however, to estimate and determine for itself the amount of metal work required as the quantity given is not guaranteed to be absolutely correct.

If payment is made on a price per pound (kilogram) basis, the payment shall be based on the computed net weight of metal in the fabricated and erected structures unless the Contract provides that payment shall be based on the scale weight. No payment will be

made for any weight in excess of 1.5% above the computed net weight of the whole item.

b. *Painting.* The quantity of recoating all existing structural steel, unless specified elsewhere, will be paid for at the Contract unit price per square foot (square meter) or lump sum price. Price and payment will constitute full compensation for all material, labor, tools and equipment, surface preparation, spatter protection, and cleanup.

Price and payment for the moisture-cured urethane paint system will constitute full compensation for furnishing all materials; for providing protection against damage during paint application; for re-establishing Project standards, if necessary; for re-cleaning when primer is not applied within eight hours of initial cleaning; for re-cleaning and repainting surfaces when unauthorized solvents are used, when paint containing thinners is applied, when paint is applied to contaminated surfaces, and when paint is applied contrary to the requirements of this Section; and for all labor, equipment, tools, and incidentals required to complete the work.

Progress payments will be made based on the percentage of the structure primed and painted with two full coats of paint in accordance with the specification. The percentage will be computed as the ratio of the length of structure primed to the total length of structure. The percentage of payments to be paid to the Contractor will be 25%, 50%, 75%, and 100% after the completion of the work.