SECTION 712

STRUCTURAL STEEL CONSTRUCTION

712.1 Description. This work shall consist of the field construction of bridges and structures made of structural steel and miscellaneous metals.

712.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Shear Connectors	1037
Paint for Structural Steel	1045
Structural Steel Fabrication	1080
Coating of Structural Steel	1081

712.3 Handling, Transporting, Storing and Erecting. Fabricated material shall be properly braced and supported at all times to prevent damage from torsional, vertical and lateral deflections. Members or shipped material showing possible damage during handling, transporting, storing or erecting will be subjected to nondestructive tests as directed by the engineer. The costs of these tests will be at the contractor's expense. Fabricated structural steel shall be stored on suitable supports. Trough sections shall be stored in a manner to provide drainage. Any material that has become bent shall be straightened before being assembled or shall be replaced, if necessary. Material intended for use in the finished structure shall not be used by the contractor for erection or temporary purposes unless such use is provided for in the contract, or with written approval from the engineer.

712.4 Falsework. Staging and falsework necessary for the erection of the structure shall be furnished and placed and, upon completion of the erection, removed by the contractor. If required, plans for falsework shall be submitted to the engineer before starting the work, but the engineer's acceptance of the plans will not relieve the contractor of the responsibility for obtaining satisfactory results.

712.5 Erection. Erection of all parts of the structure shall be in accordance with the erection diagram or working drawings. Surfaces to be in permanent contact shall have all burrs and loose scale removed. Before erection, machine finished surfaces shall be cleaned of the protective coating, other than the primer permitted by the contract, and contact surfaces shall be given a heavy coat of graphite and oil. Connections match-marked in the shop shall be erected in accordance with those match marks. Interchange or reversal of match-marked connections will not be permitted. Any damage or distortion of members will not be permitted.

712.5.1 Fit-up and Drifting. Truss spans, plate girders and continuous I-beams shall be supported to maintain required camber during erection. High-strength bolted field splices and primary connections, except for trusses and structures carrying live load erection stresses, shall have no less than one-half of the holes filled with a combination of fitting-up bolts and cylindrical drift pins. No more than 50 percent of this combination shall be fitting-up bolts. Splices and primary connections carrying erection traffic during erection or truss connections shall have no less than three-fourths of the holes filled with drift pins and bolts with no more than 50 percent of being fitting-up bolts. The specified ratio of pins to bolts shall apply to

each element of the splice, for example, top flange, web and bottom flange of girders. Fitting up bolts shall be the same diameter as the high-strength bolts. High strength bolts may be used for fitting-up bolts, and may be left in place, as long as they are not damaged during erection. High strength bolts will be considered damaged and shall be replaced if they are tensioned past snug tight, used to draw two members together, driven into place with a hammer, or have any deformation of the threads. Drift pins shall be sized to provide a driving, tight fit that maintains structure geometry during erection. Reaming of the holes to aid in drifting the connections will not be permitted. Fitting-up bolts shall be placed uniformly to draw the entire splice tight. All fitting-up bolts and drift pins shall be properly installed before beginning high strength bolt installation. Holes that do not match shall be reamed only with approval from the engineer. Drifting that would distort the metal will not be permitted.

712.5.2 Bearings. The lead plates or preformed rubber and fabric pads shall be approximately 1/8 inch thick and 1/2 inch greater in length and width than the bottom bearing plates under which the plates are to be placed. Lead plates shall weigh approximately 8 psf. Preformed rubber and fabric pads shall be in accordance with Sec 1038. Shop drawings will not be required for lead plates or preformed rubber and fabric pads. Lead plates or preformed rubber and fabric pads will be considered incidental to bearings, and payment will be considered as covered under the contract unit price for bearings.

712.5.3 Anchor Bolts. Anchor bolt wells for superstructures shall be formed in the substructure units in accordance with the details shown on the plans utilizing permanently placed galvanized corrugated steel pipe in accordance with AASHTO M36 Type 1 avoiding direct metallic contact with other reinforcement. Other removable forming material may be used and shall not be left in place. Where permitted or required, the anchor bolt wells may be omitted, and in lieu thereof, holes drilled into the substructure without cutting any reinforcments. The anchor bolt holes shall be drilled in the exact location shown, to the required depth and perpendicular to the plane of the bridge seat. The drilled holes shall be at least 1 inch larger than the bolt diameter. When the anchor bolts are set in wells or holes, the wells hole shall be clean and dry prior to grouting with an expansive mortar in accordance with Sec 1066. Excess mortar forced out of the holes shall be removed. The location of anchor bolts in relation to the center of slotted holes provided in movable plates and shoes shall be varied to compensate for the movement of spans due temperatures above or below 60 F. Nuts on anchor bolts through moving parts of expansion bearings shall be adjusted to provide ample clearance for free movement of the span.

712.5.4 Grouting. Grouting under bearing plates and castings to build the bearing plates and castings to the proper grade will not be permitted. Steel shims the full size of the plate of the bearing device may be used for this purpose. Shims shall be placed between the bottom of the stringers and the top of bearing plates, if practical, and shall be straightened to a plane surface.

712.6 Field Welding. All field welding shall be performed in accordance with Sec 1080.

712.6.1 Certification. All field welders shall be certified to weld on all steel products incorporated in MoDOT projects.

712.6.2 Testing. Field welders shall be qualified by a test facility with an established accredited AWS Certified Welder Program as defined in AWS Standard QC 4-89 or by an independent testing laboratory furnished by the contractor. If specimens are to be tested at an independent testing laboratory, the tests shall be witnessed and properly documented by the engineer. All tested specimens and radiographs, including the laboratory's test report certifying the test results, shall be delivered to the engineer for final acceptance or rejection. If the field welder was tested and certified by a facility with an established accredited AWS Certified Welder Program, as defined in AWS Standard QC 4-89, the tested specimens and

radiographs will not be subject to the engineer's review. A copy of the welder's certification from the AWS test facility shall be delivered to the engineer.

712.6.3 Issuance of Cards. Qualification cards will be issued by the engineer for field welders working on MoDOT projects. No individual may weld on a MoDOT project unless the engineer can confirm the individual has continued to weld on MoDOT projects with the processes and in the positions for which the individual was initially certified, without an interruption exceeding 12 months. The engineer may require recertification if there is specific reason to question the welder's ability.

712.6.4 Welding Procedures. Welding procedures shall be submitted for review prior to welding, at the engineer's request.

712.7 High-Strength Bolt Installation.

712.7.1 Bolted Parts. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed one in 20 with respect to a plane normal to the bolt axis. All bolted parts, including underhead bearing areas and joint surfaces within the grip of the bolt, shall fit solidly together when assembled in the snug tight condition, and shall not be separated by gaskets or any other interposed compressible material. When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts or washers, shall be free of scale, dirt, burrs, other foreign material and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil and paint, except in accordance with Sec 1081.3.9, lacquer, rust inhibitor and galvanizing. All bolts, nuts and washers shall be free of rust, burrs, dirt, other foreign material and other defects that would prevent proper tensioning. All nuts for coated high-strength bolts shall be properly lubricated with a visible water-soluble lubricant. All nuts for uncoated high-strength bolts shall be properly lubricated with a water-soluble lubricant that is oily to the touch.

712.7.2 Snug Tightness of Connections. Regardless of the method of final tightening used to install the fasteners, the joint and all fasteners shall first be brought to the snug tight condition. Snug tight will be defined as the tightness where all faying surfaces of the joint are in firm contact as attained by a few impacts of an impact wrench or the full effort of a person using an ordinary spud wrench. Following the initial snug tightening of the fitting-up bolts, the remaining holes shall be filled with high strength bolts and tightened to a snug tight condition. All final bolts completing the connection shall be high strength and required nominal diameter. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. Bolts shall be retightened in a similar manner as necessary until all bolts are simultaneously snug tight, and the section is fully compacted with the bolted parts of the joint in full contact. For Type 3 and Type 1 bolts that will be field coated, if a connection is not completely tightened within five days of snug tightening, the contractor shall remove five percent or five bolts (whichever is less) of a given connection and conduct rotational capacity testing in accordance with Sec 1080 to verify nut lubrication. For bolted field splices, the amount of bolts specified for bolt removal shall apply to each element of the splice (top flange, web and bottom flange). If the rotational capacity test is unacceptable, all bolts shall be removed, inspected, relubricated and may then may be reinstalled. For galvanized bolts, the above condition shall be met as well as the threads of the bolts and nuts shall be inspected for galling prior to final tensioning. Any bolts or nuts with threads that are galled shall be removed and replaced.

712.7.3 Bolt Tension. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown below for the size and grade of fastener used. Threaded bolts shall be tightened by methods described in Secs 712.7.5, 712.7.6 or 712.7.7. 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. On non-

parallel abutting surfaces where bevel washers will not be required, the nut shall be torqued against the non-sloping surface. Nuts shall be placed on the inside face of exterior girders, the top of girder flanges or in other situations the least exposed position, except if inaccessible for turning, on a sloping surface or otherwise approved by the engineer. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds. Bolts or nuts, once tensioned and subsequently loosened (turned), shall not be used as permanent bolts or nuts. Bolt tension calibration devices shall be calibrated and certified as to accuracy by a private testing lab within one year before usage, or at any time the tensioning process indicates that the calibration is in error.

Bolt Tension		
English		
Bolt Size (in.)	**Minimum Bolt Tension (lb x 1000)**	
	A 325	A 490
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1 1/8	56	80
1 1/4	71	102
1 3/8	85	121
1 1/2	103	148

712.7.4 Washers. All fasteners shall have a hardened washer under the nut or bolt head, whichever is turned in tightening. All fasteners over all oversized or slotted holes shall also have a hardened washer under the non-turned element. Where an outer face of the bolted parts has a slope of more than one in 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.

712.7.5 Calibrated Wrench Method. When calibrated wrenches are used to provide the bolt tension specified in Sec 712.7.3, the wrench setting shall be such as to induce a bolt tension 5 to 10 percent in excess of the specified value. Wrenches shall be calibrated at least once each working day by tightening in a device capable of indicating actual bolt tension no less than three typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to stall or cut out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the selected tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in tightening motion when torque is measured. After the joint has been brought to a snug tight condition, all bolts in the joint shall be tightened by progressing systematically from the most rigid part of the joint to the free edges. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the selected tension. During tightening, there shall be no rotation of the part not turned by the wrench.

712.7.6 Turn-of-Nut Method. When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a snug tight condition as defined in Sec 712.7.2 to ensure that the parts of the joint are brought into full contact with each other. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable nut rotation specified below, with tightening progressing systematically from the

most rigid part of the joint to the free edges. During this operation, there shall be no rotation of the part not turned by the wrench.

Nut[a] Rotation from Snug Tight Condition			
Disposition of Outer Faces of Bolted Parts			
Bolt length measured from underside of head to extreme end of point	**Bolt 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	2/3 turn	5/6 turn	1 turn

[a]Nut rotation shall be relative to bolts, regardless of the element (nut or bolt) being turned. For bolts installed by one-half of a turn and less, the tolerance will be ± 30 degrees. For bolts installed by two-thirds of a turn and more, the tolerance will be ± 45 degrees.

712.7.7 Load Indicating Bolt Method. Tightening by this method will be permitted, provided it can be demonstrated by the following procedure that the bolt has been tightened, at a minimum, to the bolt tension indicated in Sec 712.7.3. Three bolts of a representative length and of the same grade, diameter 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 part turned in tightening each bolt. Each bolt specified shall be tightened in the calibration device until the spline drive has sheared off. When this method is used to provide the bolt tension, all bolts in the joint shall be tightened in stages to prevent or minimize slackening of the installed bolts. The first stage shall be to tighten all bolts to a snug tight condition at which point all of the faying surfaces of the joint shall be firmly in contact. The final stage of tightening to full tension shall be accomplished by progressing systematically from the most rigid part of the joint to the free edges.

712.7.8 Bolt Length. When snug tight, the beginning of the bolt threads shall be even with or project slightly beyond the nut. When properly tensioned, the bolt projections beyond the nut shall be as such to prevent the nut from engaging the thread runout.

712.7.9 Bolt Tension Calibration Device. A Skidmore-Wilhelm Calibrator or an acceptable equivalent tension measuring device will be required at each job site during erection. Periodic testing, at least once each working day when the calibrated wrench method is used, shall be performed to assure compliance with the installation test procedures required for the tightening method used, and to perform pre-installation job site rotational-capacity testing. Bolts too short for the Skidmore-Wilhelm Calibrator may be tested using direct tension indicators (DTI). The DTI shall be calibrated in the Skidmore-Wilhelm Calibrator using longer bolts. Bolt tension calibration devices shall be calibrated and certified as to accuracy by a private testing laboratory within one year before usage or at any time the accuracy is questionable.

712.7.10 Rotational-Capacity Testing. The rotational-capacity test shall be performed on each rotational-capacity lot prior to the start of bolt installation. Hardened steel washers shall be part of the test, regardless if washers will not be required as part of the installation procedure. Bolt, nut, and washer when required, combinations as installed shall be only from the established and tested rotational-capacity lot.

712.7.11 Weathered Bolts. Weathered or rusted bolts or nuts not in accordance with Secs 712.7.1, 712.7.3 and 712.7.10 shall be cleaned and relubricated prior to installation. Recleaned or relubricated bolt, nut and washer assemblies shall be retested in accordance with Sec 712.7.10 prior to installation.

712.7.12 Inspection. The engineer will observe the installation and tightening of bolt assemblies to determine that the selected tightening procedure is properly used, and will determine that all bolt assemblies are tightened. The following verification inspection will be used:

(a) Either the engineer, or the contractor in the presence of the engineer, will use an inspecting torque wrench and bolt tension calibration device furnished by the contractor.

(b) Five bolt assemblies of a representative length, and of the same grade, diameter and condition as those under inspection will be placed individually in a calibration device capable of indicating bolt tension. There will be a washer under the part turned in tightening each bolt. Each bolt specified will be tightened in the device by any convenient means to the minimum tension specified in Sec 712.7.3. The inspecting torque wrench then will be applied to the tightened bolt, and the torque necessary to turn the nut or head 5 degrees, approximately one inch at 12-inch radius, in the tightening direction will be determined. Of the five values obtained, the highest and the lowest values will be disregarded, with the average of the remaining three being taken as the job inspecting torque to be used in the manner specified in Sec 712.7.12. The inspecting torque will be re-established at intervals of no more than 30 calendar days or at any time appreciable changes are encountered.

(c) Bolts represented by the sample prescribed in Sec 712.7.12 that have been tightened in the structure will be inspected by applying, in the tightening direction, the inspecting wrench and the wrench's job inspecting torque to 10 percent of the bolts, but no less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection will 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 was turned by the job inspecting torque shall be tightened and re-inspected.

(d) Calibrated wrench tightening will be verified during actual installation in the assembled steel work. The wrench adjustment selected by the calibration shall not produce a bolt or nut rotation from snug tight greater than permitted in Sec 712.7.6.

712.8 Field Coating. Field coating of structural steel shall be in accordance with Sec 1081.

712.9 Steel Bar Dams. Steel bar dams placed at expansion devices on existing bridges to serve as headers for surfacing material shall be installed in a manner that will not interfere with the movement of the expansion devices.

712.10 Method of Measurement.

712.10.1 Steel and Iron. Payment for structural steel and wrought iron weights will be based on contract plan quantities. The theoretical weight of the various sections will be used to compute the contract plan quantities of the material incorporated in the completed structure. No allowance will be made for overrun in scale weights or for erection bolts, excess field bolts or similar items, or the weight of any coating, galvanizing or weld material.

712.10.2 Bolts. The weight of steel bolts for steel-to-steel connections will be included in the contract plan quantities for fabricated structural steel on the basis of following weights per 100 bolts:

Bolt Weights[a]	
Bolt Size (in.)	**Weight (lb)**
5/8	40
3/4	65
7/8	95
1	135

[a]These specified weights will be considered to cover the head, nut, any required washers and only that part of the bolt extending outside the grip of steel.

712.10.3 Connection to Concrete or Timber. The weight of bolts connecting steel to concrete or timber will be included for payment as fabricated structural steel, and the full weight of the bolts will be computed.

712.10.4 Castings. Castings will be computed on the basis of the theoretical weight of the material in the completed structure, and no allowance will be made for overrun in scale weights or for the weight of any coating material, galvanizing material or other protective coatings.

712.10.5 Accuracy of Weights. Weights of structural steel, wrought iron and castings will be computed to the nearest 10 pounds of the total weight of each class of material in the completed structure.

712.10.6 Coatings. For recoating or overcoating, the contract documents will indicate the estimated number of tons to be coated for informational purposes.

712.10.6.1 Weight Measurement. If the contract specifies a unit of measurement of coating steel structures in tons, the weight of the steel to be cleaned and coated will be based on plan quantities to the nearest 1/10-ton. The weight will not vary with the number of coats applied.

712.10.6.2 Surface Area Measurement. If the contract specifies a unit of measurement of coating steel structures in square feet, the area of the girders or stringers to have surface preparation performed or to be coated will be computed to the nearest 100 square feet. The bearings, diaphragms, stiffeners and all other miscellaneous steel within the limits of surface preparation or of the field coatings will not have the area computed and will be considered completely covered by the area computations of the girders or stringers. The area will not vary with the number of coats applied. Final measurement will not be made.

712.10.6.3 Lump Sum Measurement. Measurement will not be made when the contract specifies units of measurement per lump sum.

712.10.7 Bar Dams. A steel bar dam shall consist of the complete assembly on both sides of the expansion joint and will be considered a unit.

712.10.8 Shear Connectors. The weight of shear connectors will be based on the theoretical weight and will be included for payment in the weight of material to which the connectors are attached.

712.11 Basis of Payment.

712.11.1 Fabricated Steel. Payment for fabricated structural steel, fabricated wrought iron, steel castings and gray iron castings will be based on the contract plan quantities. Any change in the contract plan quantities based on approved change orders will be paid for at the contract unit price. Payment for the shop prime coat, including inaccessible areas, will be included in

the cost of fabricated structural steel, and no direct payment will be made. No direct payment will be made for coating bolted field connections, touch-up, galvanizing, applying protective coating to machined surfaces or for cleaning coatings and rust streaks from finished concrete.

712.11.2 Hardware. Bolts for attaching timber members to any part of a structure will be classified as hardware and no direct payment will be made.

712.11.3 Coatings. Payment for surface preparation and applying field coatings to the structural steel, if specified as a contract item, will be based on the contract plan quantities. Any change in the contract plan quantities, based on approved change orders, will be paid for at the contract unit price. If no contract item is specified for surface preparation or applying field coatings, no direct payment will be made. Payment for the shop applied coatings, including inaccessible areas, will be considered completely covered by the cost of the fabricated structural steel. No direct payment will be made for the surface preparation or applying field coatings to the bearings, diaphragms, stiffeners and all other miscellaneous steel within the limits of surface preparation or of the field coatings. No direct payment will be made for stencils, paint and painting specified in Sec 1081. No direct payment will be made for field touch-ups specified in Sec 1081.

712.11.4 Bar Dams. The accepted number of steel bar dams will be paid for at the contract unit price.