

## **SECTION 6.03 STRUCTURAL STEEL**

**6.03.01--Description:** This item shall consist of furnishing, fabricating, transporting, erecting, surface preparation and painting structural steel, rivet and eyebar steel, steel forgings, wrought iron, steel castings, gray iron castings, malleable castings and phosphor bronze of the kind and size designated, in conformity with the requirements of the plans or as ordered and in accordance with these specifications.

Structural steel, regardless of its source, will be fabricated in the United States.

**6.03.02--Materials:** The materials for this work shall conform to the requirements of Section M.06 and Article M.07.02.

### **6.03.03--Construction Methods:**

**1--Shop Drawings:** Before fabricating any material, with the exception of structural steel for side-mounted sign supports, the Contractor shall submit shop drawings to the Engineer for approval in accordance with Article 1.05.02-3. These drawings shall include erection plans, material lists and material designations.

**2--Camber for Stringer Spans and Floor Beam-Girder Systems:** Camber shall be interpreted as the convexity induced into a member to provide for vertical curvature of grade and to offset the anticipated deflections indicated on the plans when the member is in its erected position in the structure. Cambers shall be measured in this erected position, and failure to meet the required amount of camber may be cause for rejection of the member. Unless otherwise noted on the plans, the camber shall approximate a smooth circular curve for the length of the member or between designated points. Compound or reverse cambers may be required for special designs as shown on the plans.

Rolled, plated-rolled and fabricated sections shall be cambered to the total amount specified on the plans and within the camber deviation tolerances permitted for welded beams and girders, as indicated in the ANSI/AASHTO/AWS D1.5 Bridge Welding Code.

Additional camber required to compensate for loss of camber caused by shrinkage due to welding of the members and shear connectors shall be determined by the fabricator.

Camber for rolled and plated-rolled sections shall be produced by local heating. Rolled sections requiring shop welding shall be heat-cambered to the total amount required after such welding has been completed. Improper heating or cooling which might affect the grain structure, strength or ductility of the metal may be cause for rejecting the member.

Correction of errors in camber in welded beams and girders of A514M/A517M material shall be done only under rigidly controlled procedures, each application subject to approval of the Engineer.

**3--Workmanship and Finish:** The workmanship and finish shall be equal to the best general practice in modern bridge shops.

Weathering steel, particularly within the limits designated on the plans or in the specifications to be blast-cleaned, requires a higher than normal degree of workmanship and finish. Mismatched sections, gouges, scratches, dents and grinding marks other than those permitted by ASTM A6M will be cause for rejection by the Engineer. The repair of defects, as permitted by ASTM A6M, shall be performed by qualified welders using low hydrogen electrodes which provide deposited weld metal meeting the special requirements of the base metal for chemistry, oxide color and atmospheric corrosion resistance in conformity with Article M.06.04.

Where a choice of plates is available for the various weathering steel girders, the best plates shall be reserved for the fascia girders.

**4--Storage of Materials:** Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon 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.

Weathering steel shall be stored in such a manner as to allow free drainage and promote the development of the oxide coating in order to develop an early uniform appearance.

**5--Fabrication:** Unless otherwise shown on the plans or indicated in the Special Provisions, Structural Steel shall be fabricated in accordance with the latest edition (including interim specifications) of AASHTO Standard Specifications for Highway Bridges, Division II, Section 11.

**6--Welding:** Unless otherwise shown on the plans or indicated in the special provisions, welding of structural steel shall be done in accordance with "ANSI/AASHTO/AWS D1.5 Bridge Welding Code, latest edition."

(a) Qualification testing of welders, welding operators and tackers shall be carried out under the supervision of the Engineer except that at his discretion, he may approve qualification under other supervision satisfactory to him.

If a welder, welding operator or tacker on any project has not been engaged in welding operations on a Department project or a project acceptable to the Department for a period of six months or more, or if he cannot produce a suitably approved welding certificate dated not more than twelve months previously from a welding agency acceptable to the Engineer, he shall be required to requalify through examination.

Updating of Department welder certification cards shall be performed by personnel from the Division of Materials Testing.

The Department will maintain a listing of approved agencies that are authorized by the State of Connecticut to administer Welder Certification tests. The cost of these tests shall be borne by the Contractor. The Contractor shall furnish without cost all welding appurtenances necessary to perform the test, welding protective equipment, and filler metal for the test welding.

When the coupons or welded specimens pass all the required tests, the welder, welding operator or tacker will be issued a dated certificate of qualifications specifying the weld position and type of weld for which he has been certified; and he shall perform only those operations for which he is certified. The welding certificate shall be valid for a period of two years, after which time the welder may apply for a new certificate. This renewal shall be issued at no cost to the welder if the welder certificate has been properly maintained in accordance with the requirements contained herein. Any discrepancies in the proper maintenance and use of this welder certificate shall be grounds for immediate revocation. If the coupons or welded specimens fail to pass any or all of the required tests, the welder, welding operator or tacker will be so notified; and he may apply for reexamination at any time without prejudice.

The Engineer shall require requalification in the case of those welders, welding operators or tackers whose quality of work he has specific reason to question.

(b) Inspection and Testing of Shop Welds: Magnetic particle, radiographic or ultrasonic testing inspection, whichever, is specified, shall be made of all shop weld areas designated on the plans, special provisions or by the Engineer. Such inspection shall be made for the fabricator by an established and approved laboratory whose equipment shall have a rated capacity sufficient for the work to be done.

Each test shall be witnessed by an authorized representative of the Department. Three copies of certified reports of these inspections shall be sent by the Contractor to the Assistant Manager, Materials Testing Section, Department of Transportation, Materials Testing Laboratory, Rocky Hill, Connecticut for his examination. Each certified report shall be identified as to structure, member and location of weld or welds and shall also list all the defective welds, the number of times defective welds were corrected, and the amount of additional inspection required.

The member will be accepted for placement in the structure only when all corrections have been made, and the copies of the certified report shall state that the welds have been inspected and are free from any type of imperfection hereinafter noted for the type of inspection specified, or the entire piece shall be rejected as determined by the Engineer. Upon completion of the work, the Contractor shall send to the Assistant Manager, Materials Testing Section, all radiographs or magnetic particle plates or transfers properly identified. These records shall be one of the documents required under Article 1.08.14--Acceptance of Contract.

**Inspection of Weld Areas not Designated in the Contract:** The Engineer shall have the right to require radiographic inspection, magnetic particle inspection or ultrasonic testing inspection of shop weld areas not designated in the contract. In such cases, if the inspection shows the shop weld to be defective, the cost of such inspection shall be borne by the Contractor; but if the inspection shows the weld to be satisfactory, the Contractor will be paid by the Department for the actual cost of the inspection.

Visual inspection and nondestructive testing of welds (shop and field welds) in all steels other than ASTM A514M/517M may begin immediately after they are completed. Welds in A514M/517M steel shall be visually inspected and nondestructively tested not less than 48 hours after they are completed.

**Cost of Inspection:** Except as stated herein above, there will be no direct payment made for any work required in connection with the inspection of shop welds, but the cost thereof shall be included in the contract lump sum price for "Structural Steel (Site No. )" as identified by number or at the contract unit price per kilogram for "Structural Steel" or "Structural Steel (Low Alloy)," whichever is indicated on the proposal form. The payment for tests as stated in Articles 1.05.10 and 1.06.02 shall not apply to the inspection of shop welds for "Structural Steel (Site No. )," "Structural Steel," "Structural Steel (Low Alloy)," or "Structural Steel (Quenched or Tempered)."

**7--General:** If the substructure and superstructures are built under separate contracts, the Department will provide the substructure, constructed to correct lines, dimensions and elevations and properly finished and will establish the lines and elevations required for setting steel.

The Contractor shall erect the structural steel, remove the temporary construction, and do all work required to complete the construction included in the contract in accordance with the plans, and specifications.

The Contractor shall take the reasonable precautions to protect all components of the substructure from stains due to rusting. Stains caused by rusting shall be removed by the Contractor at his own expense.

**8--Plans:** The Contractor shall submit erection plans prepared by the fabricator, showing a method and procedure of erection compatible with the details of fabrication.

If the fabrication and erection of the structure are done under separate contracts, the Department will furnish detail plans for the bridge or bridges to be erected, including the shop details, camber diagrams, erection diagrams, list of field rivets and bolts and copy of shipping statements showing a list of parts and their masses.

**9--Plant:** The Contractor shall provide the falsework and all tools, machinery and appliances, including drift pins and fitting-up bolts necessary for the expeditious handling of the work.

**10--Delivery of Materials:** The Contractor shall make all arrangements necessary to unload, handle and store all material and shall unload promptly upon delivery any material which he is required to unload. He shall be responsible for the payment of all demurrage charges.

**11--Handling and Storage:** Material to be stored shall be placed on skids above the ground. It shall be kept clean and 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 injury from deflection. If the contract is for erection only, the Contractor shall check the material turned over to him against the shipping lists and shall report promptly in writing any shortage or injury discovered. The Contractor shall be held responsible for any loss of material or for any damage to it, while in his care, occurring prior to its acceptance by the Engineer.

If surfaces which are to be connected by field bolting or that are subject to field welding become rusted or contaminated with any foreign material that would make these connecting procedures unacceptable, the Contractor shall restore these surfaces at no additional cost to the State by scraping, grinding or wire brushing as necessary to remove all foreign material and rust that will interfere with welding and bolting.

**12--Falsework:** The falsework shall be properly designed and substantially constructed and maintained for the loads which will come upon it. The Contractor, if required, shall prepare and submit to the Engineer for approval, plans for falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility. Falsework shall be adequate to the needs of construction, and adjustment shall be provided so the required camber may be maintained.

**13--Methods and Equipment:** The Contractor shall be solely responsible for the adequacy of his erection scheme and for all details of plant, falsework and other equipment and material necessary to carry it out. The Contractor's responsibility includes the investigation of erection stresses. The results of this investigation, including computations, shall be submitted upon request of the Engineer for his information.

Before starting the work of erection, the Contractor shall inform the Engineer fully as to the method of erection he proposes to follow, and the amount and character of equipment he proposes to use, which shall be subject to the approval of the Engineer. The approval of the Engineer shall not serve to relieve the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done until such approval by the Engineer has been obtained.

When the correct location of any part of the structure such as railings, etc., makes it necessary, the Engineer may require that such parts shall not be placed until all floor and paving material has been placed and the structure freed from the falsework. Adequate provision shall be made for the adjustment of such parts. If necessary, all holes for the attachment of such pieces shall be drilled in the field.

If the proposed method of erection requires additional metal in the members, all such additional metal shall be provided at the expense of the Contractor.

**14--Anchorages:** Anchor bolts and similar materials which are to be placed during the erection of the superstructure shall be carefully and accurately set to the requirements of Subarticle 6.01.03-13.

When anchorage material is to be furnished by the Contractor for the superstructure and placed by the Contractor for the substructure, the necessary material shall be fabricated and delivered to the site of the work at such time as it may be required for proper inclusion in the substructure construction.

In locating anchor bolts in relation to slotted holes in expansion shoes, due consideration shall be given to the temperature at the time of erection.

**15--Placement of Bearings:** Bearing plates shall have a full and uniform bearing upon the substructure masonry. Bearing plates shall be placed upon bearing areas which are finished according to the requirements of Subarticle 6.01.03-14 "Preparation of Bearing Areas."

Prefabricated pads conforming to the requirements of Article M-12.01 shall be installed unless specifically noted otherwise on the contract plans.

Each piece shall be the same size as the bearing plate it is to support and the holes to accommodate the anchor bolts shall be clearly and accurately punched before setting the pad in place.

In placing expansion bearings, due consideration shall be given to the temperature at the time of erection. The nuts of anchor bolts at expansion bearings shall be adjusted to permit the free movement of the span.

**16--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 fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and supervised application of a limited amount of localized heat, except that heat-straightening of A514M/A517M steel members shall be done only under rigidly controlled procedures, each application subject to the approval of the Engineer. In no case shall the maximum temperature of the A514M/A517M steel exceed 607° C, nor shall the temperature exceed 510° C at the weld metal or within 150 mm of weld metal. Heat shall not be applied directly on weld metal. In all other steels, the temperature of the heated area shall not exceed 648° C (a dull red) as controlled by temperature-indicating crayons, liquids or bimetal thermometers.

Parts to be heat-straightened shall be substantially free of stress and from external forces, except stresses resulting from 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.

**17--Assembly Steel:** The parts shall be accurately assembled as shown on the plans and any matchmarks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be 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 placed as to give the proper camber. The blocking shall be left in place until the tension chord splices are fully riveted or bolted and all other truss connections pinned and bolted. Rivets, or permanent bolts in splices or butt joints of compression members, and rivets or permanent bolts in railings, shall not be driven or tightened until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before riveting or bolting with high-strength bolts. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the rivets or high-strength bolts, and cylindrical erection pins shall be 0.8 mm larger.

**18--Riveting:** Pneumatic hammers shall be used for field riveting, except when the use of hand tools is permitted by the Engineer. Rivets larger than 22 mm in diameter shall not be driven by hand. Cup-faced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be accurately and securely fitted up before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes and distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light "cherry red" color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out.

#### **19--Bolted Connections:**

**(a) General:** This subarticle covers the field assembly of structural joints using high strength bolts tightened to a specified tension.

**(b) Bolted Parts:** Bolted parts shall fit solidly together when assembled 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, except tight mill scale, and shall also be free of dirt, loose scale, burrs, other foreign material and other defects that would prevent solid seating of the parts.

Except as noted on the plans, contact surfaces within joints designated on the plans as friction type shall be free of oil, paint, lacquer, rust inhibitor, or other foreign material. If protective coating has been applied in accordance with paragraph two of Subarticle 6.03.03-37, it shall be removed prior to making the bolted connection by the use of approved methods to expose joint surfaces as specified above. Joint contact surfaces of members which have been hot-dip galvanized shall be scored by wire brushing or blasting after galvanizing and prior to assembly. The wire brushing treatment shall be a light application of manual or power brushing that marks or scores the surface but removes relatively little of the zinc coating.

The blasting treatment shall be a light "brush-off" treatment which will produce a dull gray appearance. However, neither treatment should be severe enough to produce any break or discontinuity in the zinc surface.

**(c) Installation:**

**(1) Bolt Tension:** Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in Table A for the size and grade of fastener used.

**TABLE A**  
**Minimum Bolt Tension <sup>(1)</sup> (kN)**

<b>Bolt Diameter</b> <b>mm</b>	<b>AASHTO M 164M</b> <b>(ASTM A 325M) Bolts</b>	<b>AASHTO M 253M</b> <b>(ASTM A 490M) Bolts</b>
16	91	114
20	142	179
22	176	221
24	205	257
27	267	334
30	326	408
36	475	595

<sup>(1)</sup> Equal to 70 percent of specified minimum tensile strength of the bolts rounded to the nearest kN.

Threaded bolts shall be tightened with properly calibrated wrenches or by the turn-of-nut method. If required because of bolt entering and wrench operation clearances, tightening by either procedure may be done by turning the bolt while the nut is prevented from rotating.

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.

All fasteners shall have a hardened washer under the element (nut or bolt head) turning in tightening.

**(2) Calibrated Wrench Tightening:** When calibrated wrenches are used to provide the bolt tension specified in paragraph (c) (1) above, their setting shall be such as to induce a bolt tension 5% to 10% in excess of this value. These wrenches shall be calibrated at least once each working day by tightening, in a device capable of indicating actual bolt tension, not less than three typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to install or cut-out at the selected calibrating tension. If manual torque wrenches are used, the torque indication corresponding to the calibrating 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. 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 prescribed amount.

**(3) Turn-of-Nut Tightening:** When the turn-of-nut method is used to provide the bolt tension specified in paragraph (c) (1), there shall be enough bolts brought to a "snug tight" condition to insure that the parts of the joint 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 man using an ordinary spud wrench. 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 be tightened additionally by the applicable amount of nut rotation specified in Table B with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench.

**TABLE B**  
**Nut Rotation<sup>1</sup> from Snug Tight Condition**

**Disposition of Outer Faces of Bolted Parts**

<b>Bolt Length measured from underside of head to extreme end of point</b>	<b>Both faces normal to bolt axis</b>	<b>One face normal to bolt axis &amp; other face sloped not more than 1:20 (bevel washer not used)</b>	<b>Both faces sloped not more than 1:20 from normal to bolt axis (bevel washers not used)</b>
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 <sup>2</sup>	2/3 turn	5/6 turn	1 turn

<sup>1</sup>- 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 plus or minus 30°; for bolts installed by 2/3 turn and more, the tolerance should be plus or minus 45°.

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

**(d) Inspection:** (1) The Engineer shall determine that the requirements of paragraphs (2) and (3) following are met in the work. When the calibrated wrench method of tightening is used, the Engineer shall have full opportunity to witness the calibration tests prescribed in paragraph (c) (2) above. When calibrated wrenches are used, the Contractor shall furnish a calibrated inspection wrench, including a device capable of indicating actual bolt tensions.

(2) The Engineer shall observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and shall determine that all bolts are tightened.

(3) The following inspection shall be used unless a more extensive or different inspection procedure is specified.

(A) Either the Engineer, or the Contractor in the presence of the Engineer, shall use an inspecting wrench which may be either a torque wrench or a power wrench that can be accurately adjusted in accordance with the requirements of paragraph (c) (2) 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 part turned in tightening each bolt.

(C) When the inspecting wrench is a torque wrench, each bolt specified in paragraph (d) (3) (B) shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in paragraph (c) (1). The inspecting wrench then shall be applied to the tightened bolt; and the torque necessary to turn the nut or head 5 degrees (approximately 25 mm at 305 mm radius) in the tightening direction shall be determined. The average torque measured in the test of three bolts shall be taken as the job inspecting torque to be used in the manner specified in paragraph (d) (3) (E).

\*Length may be any length representative of bolts used in the structure.

(D) When the inspecting wrench is a power wrench, it shall be adjusted so that it will tighten each bolt specified in paragraph (d) (3) (B) to a tension at least 5 but not more than 10 percent greater than the minimum tension specified for its size in paragraph (c) (1). This setting of wrench shall be taken as the job inspecting torque to be used in the manner specified in paragraph (d) (3) (E).

(E) Bolts represented by the sample prescribed in paragraph (d) (3) (B), which have been tightened in the structure, shall be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to 10 percent of the bolts, but not less than two bolts, selected at random, in each connection. If no nut or bolthead is turned by this application of the job inspecting torque, the connection shall be accepted as properly tightened. If any nut or bolthead is turned by the application of the job inspection torque, this shall be applied to all bolts in the connection; and all bolts, whose nut or head is turned by the job inspecting torque, shall be tightened and reinspected; or alternately, the fabricator or erector, at his option, may retighten all of the bolts in the connection and then resubmit the connection for the specified inspections.

**20--Pin Connections:** Pilot and driving nuts shall be used in driving pins. They shall be furnished by the Contractor without charge. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

**21--Welded Connections:** (a) General: This subarticle covers the field assembly of structural joints using welding processes conforming to the requirements of Subarticle 6.03.03-6.

**(b) Dimensional Tolerances:** Ends of members fabricated by welding which are to be field connected by welding shall be shop assembled or assembled to a template and conform to the following requirements.

Abutting parts to be joined by butt welds shall be carefully aligned. Where the parts are effectively restrained against bending due to eccentricity in alignment, an offset not exceeding 10 percent of the thickness of the thinner part joined, but in no case more than 3 mm may be permitted as a departure from the theoretical alignment. In correcting misalignment in such cases, the parts shall not be drawn in to a greater slope than 41.67 mm/m. Measurement of offset shall be based upon center line of parts unless otherwise shown on the drawing.

**(c) Requirements of Minimum Preheat and Interpass Temperature:** The minimum requirements for preheat and interpass temperature tabulated hereinafter, shall apply except that the requirements of Subarticle 6.03.03-6(b) shall take precedence.

**MINIMUM PREHEAT AND INTERPASS  
TEMPERATURE DEGREES °C (1), (3)**

**Thickness of Thickest Part at Point  
of Welding- mm**

<b>Welding Process (Base Metal)</b>	<b>To 19</b>	<b>Over 19 to 38</b>	<b>Over 38 to 63.5</b>	<b>Over 63.5</b>
Shielded Metal-Arc Welding; Submerged Arc Welding; Gas Metal-Arc Welding; or Flux Cored Arc Welding (ASTM A 36M (2); A 572M, Grade 345; A588M)	10	20	65	110
Shielded Metal-Arc Welding; Submerged Arc Welding; Gas Metal-Arc Welding; or Flux Cored Arc Welding (ASTM A514M/517M)	10	50	80	110

(1) When the base metal is below the temperature listed for the welding process being used and the thickness of material being welded, it shall be preheated (except as otherwise provided) in such manner that the surfaces of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded, but not less than 76 mm both laterally and in advance of the welding. Preheat and interpass temperatures must be sufficient to prevent crack formation. Temperature above the minimum shown may be required for highly restrained welds. For ASTM A514M/A517M steel the maximum preheat and interpass temperature shall not exceed 205° C for thicknesses up to 38 mm inclusive, and 230° C for greater thicknesses. Heat input when welding ASTM A514M/A517M steel shall not exceed the steel producer's recommendation. Welding shall be carried continuously to completion or to a point that will insure freedom from cracking before the joint is allowed to cool below the minimum specified preheat and interpass temperature.

(2) For A36M steel to 25.4 mm thickness, inclusive, when welded with other than low-hydrogen electrodes, the minimum preheat and interpass temperature shall be 65.6° C.

(3) In joints involving combinations of base metals, preheat shall be as specified for the higher strength steel being welded.

**(d) Inspection and Testing of Field Welds :** Visual inspection of welds shall be performed by the Contractor in accordance with the requirements of 6.03.03-6 prior to nondestructive testing of welds. The Department will make magnetic particle inspection, radiographic testing inspection or ultrasonic testing inspection of field welds when so required by the plans, special provisions or Engineer. Each test shall be witnessed by an authorized representative of the Department.

Welds or sections of welds containing imperfections and judged unacceptable by the Department shall be removed and rewelded by the Contractor at his expense. Welds so removed and replaced will be reinspected by the Department by the same method of inspection and judged by the same criterion, or the entire piece shall be rejected as determined by the Engineer. All costs for the reinspection of defective welds shall be at the expense of the Contractor, and these costs will be deducted from any monies due or which may become due to the Contractor.

The Engineer will schedule the inspection and testing of field welds so as to keep the number of inspection trips to a feasible minimum, and the Contractor shall plan and prosecute the work so that this inspection may be performed in an orderly and efficient manner.

The Contractor shall furnish and properly locate suitable scaffolding, platforms or other means of accessibility to the area where the testing is required. This means of access shall be in position for use by the Department or

moved by the Contractor to such position prior to the time it is needed by the Department. The cost of providing, furnishing and moving the means of access will not be paid for directly but shall be included in the structural steel item(s).

**22--Misfits:** The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts 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 and his approval of the method of correction obtained. The correction shall be made in his presence. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.

If the contract is for erection only, the inspector, with the cooperation of the Contractor, shall keep a correct record of labor and materials used; and the Contractor shall render, within 30 days, an itemized bill for the approval of the Engineer.

### SURFACE PREPARATION

**23--General:** Surface preparation shall consist of cleaning surfaces of metals in accordance with the methods listed herein. The cleaned surface shall be approved by the Engineer prior to any painting. The metal surfaces to be painted shall be painted before any rust forms. At no time shall the cleaning and painting of a structure section be done simultaneously without the approval of the Engineer.

Prior to abrasive blast cleaning, all flame cut or sheared corners shall be ground in accordance with ANSI/AASHTO/AWS Bridge Welding Code D1.5, Section 3.2.9. In addition, all rough surfaces shall be ground smooth. Flame-cut edges shall be ground over their entire surface regardless of appearance, so that any hardened surface layer will be removed and subsequent abrasive blast cleaning will produce the specified surface profile depth. All steel surfaces shall then be solvent-cleaned in accordance with SSPC-SP1 - "Solvent Cleaning" before being blast cleaned.

Unless otherwise specified, all surfaces which are to be given a first shop coat or a field prime coat shall be prepared in accordance with the requirements of Subarticle 6.03.03-24.

Surface preparation shall be done in accordance with SSPC specifications with the following exceptions:

- (a) Where U.S. Bureau of Mines helmets are specified, other approved helmets may be used.
- (b) Inspection shall be in conformance with Articles 1.05.09, 1.05.10 and 1.05.11.
- (c) Abrasive blast cleaning shall be done with 16/35 grade mesh or finer sand, or other approved abrasive which will produce a maximum height of profile of 1.9 mils. This exception applies to surfaces to be painted only.
- (d) The surface for "Near-White Blast Cleaning" shall conform to SSPC-SP 10 and SSPC-VIS 1.
- (e) All field blast cleaning shall be performed using techniques approved by the Engineer that will contain and collect all removed paint and blast debris. The collected paint and debris shall be disposed of by the Contractor in a safe and environmentally acceptable method.

When erection work is completed, including field connections and straightening of bent metal, all surfaces to be painted which are unpainted, have rusted or developed defects in the prime coat, or which are otherwise considered unsatisfactory by the Engineer, shall be cleaned in conformance with the requirements of the system used in the original surface preparation. Before any rust forms, the Contractor shall apply one coat of field touch-up repair primer.

All foreign matter such as oil, grease and cement spatter shall be cleaned from the surfaces in accordance with the requirements of SSPC-SP 1 "Solvent Cleaning" before the next field coat of paint is applied.

**24--Blast Cleaning:** All surfaces shall be blast cleaned in strict conformance with provisions of SSPC-SP 10 "Near-White Blast Cleaning." Unless otherwise noted on the plans or in the special provisions, the metal surfaces of hardware, railings, plates and other similar materials to be painted may be cleaned in conformance with the provisions of SSPC-SP 8 "Pickling" as a substitute for the requirements of "Blast Cleaning" prior to painting.

Surfaces which are to be blast cleaned before fabrication shall be given a coat of zinc silicate primer conforming to M.07.17 at a dry film thickness of .5 to 1.5 mils. Surfaces receiving this treatment may be welded without removal of the primer.

**25--Pickling for Painting:** Where noted on the plans or in the special provisions, the members to be cleaned by pickling shall be cleaned in strict conformance with the provisions of SSPC-SP 8 "Pickling."

**26--Other Methods of Surface Cleaning:** Where noted on the plans or in the special provisions or where directed by the Engineer, surfaces shall be cleaned in conformance with the provisions of SSPC-SP 2 "Hand Tool Cleaning." Cleaning in accordance with the provisions of SSPC-SP 3 "Power Tool Cleaning," SSPC-SP 4 "Flame Cleaning of New Steel" or SSPC-SP 7 "Brush-Off Blast Cleaning" may be used in lieu of SSPC-SP 2 for all or part of the surfaces to be cleaned. Where these methods of surface cleaning are specified as the primary method of cleaning, all weld areas shall be neutralized before cleaning is begun in accordance with the provisions of SSPC-SP 1 "Solvent Cleaning," Article 3.1.6.

**27--Cleaning for Weathering:** Weathering steel shall be blast-cleaned within the limits of the following areas:

1. The outside face of fascia girder including exposed surfaces of top flange; web; top, sides and bottom of bottom flange.
2. Sides and bottom of bottom flanges of all interior girders, cross frames, and horizontal connection plates.

Additional areas of weathering steel shall be blast-cleaned within the limits shown on the plans or as directed by the Engineer. At the option of the Contractor, all weathering steel may be blast-cleaned. Blast cleaning shall be executed in accordance with the requirements of SSPC-SP 6 "Commercial Blast Cleaning" before or immediately after fabrication. Areas not to be blast-cleaned shall have all foreign matter removed in accordance with the requirements of SSPC-SP 2 "Hand Tool Cleaning," SSPC-SP 3 "Power Tool Cleaning" or SSPC-SP 7 "Brush-Off Blast Cleaning."

Weathering steel shall be kept free and clean of all foreign matter. Any foreign matter which gets on the steel after it has been cleaned, such as paint, grease, oil, welding slag and spatter, chalk and crayon marks, dirt, etc., that may affect its natural oxidation shall be removed in accordance with the aforementioned specifications as soon as possible. Concrete spatter shall be washed off immediately.

Identification markings shall be on faying surfaces or the top of the top flange, and shall be stenciled with permanent ink. The use of steel die stamps, or marking with paint, will not be allowed.

All weld areas, excepting those to be blast-cleaned, shall be cleaned by power tool in accordance with the requirements of SSPC-SP 3, "Power Tool Cleaning," to remove welding flux, slag and spatter.

All weathering steel shall be fabricated and handled carefully and treated with the care and concern accorded any finished architectural product. The Contractor shall provide all necessary protection for the steel during concreting operations or other work where soiling might occur.

After the structure is completed, if the weathering steel has not developed a uniform appearance due to soiling, imperfections or improper procedures, any foreign material which gets on the steel is to be removed as soon as

possible with the proper solvent according to the requirements of the SSPC Surface Preparation Specification "No. 1 Solvent Cleaning," SSPC-SP 1. Where soilage is too severe to be removed by solvent cleaning, it shall be removed according to the requirements of the SSPC Surface Preparation Specifications "No. 2 Hand Cleaning," SSPC-SP 2. Where soilage is too severe to be removed by hand cleaning, the soiled areas shall be cleaned according to the SSPC Surface Preparation Specifications "No. 3 Power Brush Cleaning," SSPC-SP 3 or "No. 7 Brush-off Blast-cleaning," SSPC-SP 7.

**28--General:** The painting of metal structures shall include, unless otherwise provided in the contract, the preparation of the metal surfaces as specified hereinbefore the application, protection and drying of the paint coatings and the supplying of all tools, tackle, scaffolding, labor and materials necessary for the entire work. Weathering steel shall not be painted.

**29--Paint:** The paint used shall conform to the requirements as stated herein and shall be as specified on the plans or in the special provisions.

### **30--Vacant**

**31--Mixing of Paint:** Paint shall be factory mixed except as provided herein. All paint shall also be thoroughly field mixed before applying in order to keep the pigments in uniform suspension.

**32--Weather Conditions:** Paint shall not be applied when the air temperature is below 5° C or when the air is misty, or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work. It shall not be applied upon damp or frosted surfaces.

Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting shall not be done when the metal is hot enough to cause the paint to blister and produce a porous paint film.

**33--Application:** Painting shall be done in a neat and workmanlike manner. Paint shall be applied with hand brushes, except as hereinafter provided for shop painting and inaccessible surfaces. By whatever method applied, the coating of paint shall be smoothly and uniformly spread so that no excess paint will collect at any point.

(a) **Brushing:** The paint shall be so manipulated under the brush as to produce a smooth, uniform, even coating in close contact with the metal or with previously applied paint, and shall be worked into all corners and crevices.

(b) **Inaccessible Surfaces :** On all surfaces which are inaccessible for paint brushes, the paint shall be applied by spraying as hereinafter described or with sheepskin daubers to insure thorough covering.

(c) **Spraying:** Power spraying equipment shall apply the paint so as to secure uniform coverage in a fine, even spray without the addition of any thinner. In cool weather, the paint may be warmed by approved methods to reduce viscosity for use.

(d) **Rollers:** The use of rollers will be allowed only for the application of the finish coat--Provided that the completed finish coating meets all the specification requirements as to coverage, appearance and film thickness. Prior to the use of the rollers, the finish coat on edges of plates or shapes, rivet and boltheads, and on any angular or welded areas shall be applied by brushing.

(e) **Film Thickness:** The dry film thickness will be measured by means of a calibrated film thickness gage applied at such random locations as the Engineer may select. Areas found to be deficient in dry film thickness shall be corrected by the Contractor at his expense by the application of additional paint in a manner acceptable to the Engineer.

**34--Removal of Paint:** If the surface is unsatisfactory to the Engineer, the paint shall be removed by abrasive blast cleaning and the metal thoroughly cleaned and repainted.

**35--Thinning Paint:** Paint as delivered in containers is ready for use when the components are thoroughly mixed. If it is necessary to thin the paint so that it can spray or spread more freely, it shall be done up to the maximum thinning requirements of the coating manufacturer, by approved methods and only with the permission of the Engineer.

**36--Painting Galvanized Surfaces:** Galvanized surfaces which are required to be painted shall be treated as follows:

For the purpose of conditioning, the painting of galvanized surfaces shall be deferred as long as possible in order that the surfaces may weather.

Before painting galvanized surfaces, they shall be treated as follows:

In 3.785 L of soft water dissolve 59.1 ml each of copper chloride, copper nitrate and sal ammoniac, then add 59.1 ml of commercial muriatic acid. This should be done in an earthen or glass vessel, never in tin or other metal receptacle. Apply the solution to the galvanized surface with a wide flat brush when it will assume a dark almost black color which, on drying, becomes a grayish film.

**37--Shop Painting:** Unless otherwise specified, steel work shall be brushed or sprayed with one coat of approved paint after it has been accepted by the inspector and before it is shipped from the plant.

Surfaces not in contact with other steel surfaces, but inaccessible after assembly, shall be coated prior to assembly. Field contact surfaces shall be protected by an application of zinc silicate primer conforming to Article M.07.17 except application of the coating shall be within the range of 2.5 to 3.5 mils dry film thickness.

Structural steel which is to be welded shall be coated after welding is completed. If it is to be welded only in the fabricating shop and subsequently erected by bolting or riveting, it shall be fully coated after shop welding is completed, except that contact surfaces within friction-type joints shall be free of contaminants, as indicated below. Steel which is to be field welded shall receive .5 to 1.5 mils dry film thickness of zinc silicate primer conforming to Article M.07.17, after shop welding and shop fabrication are completed.

Surfaces of iron and steel casting, either milled or finished, shall be given one coat of paint.

With the exception of abutting joints and base plates, machine-finished surfaces shall be coated, as soon as practicable after being accepted, with corrosion protective compound conforming to MS MIL-C-11796B, Class 1, before removal from the shop.

Contact surfaces within friction-type joints, as indicated on the plans, shall be free of contaminants. A coat of zinc silicate primer conforming to Article M.07.17 shall be applied on contact surfaces of friction-type joints, except application of the coating shall be within the range of 2.5 to 3.5 mils dry film thickness and shall be removed prior to making the bolted connection by use of approved methods to expose the joint surfaces in accordance with Subarticle 6.03.03-19(b).

Erection marks for the field identification of members and mass marks shall be painted upon surface areas previously painted with the shop coat.

Freshly painted material shall not be loaded for shipment or be moved outside to dry during inclement weather, but shall remain in the shop until the paint is thoroughly dry and, in any case, not less than 24 hours after the paint has been applied.

**38--Field Painting:** When the erection work is completed, including all connections and straightening of bent metal, all adhering rust, scale, dirt, grease and other foreign material shall be removed as specified under "Surface Preparation."

As soon as the inspector has examined and approved all field connections and any surfaces from which the shop or first coat of paint has been worn or has otherwise become defective, these surfaces shall be cleaned and thoroughly covered with shop paint. All shipping and erection marks shall also be cleaned and thoroughly covered with shop paint.

Surfaces which will be inaccessible after erection shall be painted with such field coats as are called for on the plans or authorized, before being erected.

When the paint applied for retouching the shop coat has thoroughly dried and the field cleaning has been satisfactorily completed, such field coats as are called for on the plans or are authorized shall be applied. In no case shall a succeeding coat be applied until the previous coat has dried throughout the full thickness of the paint film.

The following provisions shall apply to the application of both field coats. To secure a maximum coating on edges of plates or shapes, rivet heads and other parts subject to special wear and attack, the edges shall first be striped with a longitudinal motion and the rivet heads with a rotary motion of the brush, followed immediately by the general painting of the whole surface, including the edges and rivet heads.

If, in the opinion of the Engineer, traffic produces an objectionable amount of dust, the Contractor shall allay the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before the paint is applied.

The application of the field coats shall be deferred until adjoining concrete work has been placed and finished. If concreting operations have damaged surfaces to be painted, they shall be thoroughly cleaned before painting is started.

The Contractor shall protect property, pedestrians, vehicular and other traffic upon, underneath, or in the vicinity of the bridge, and also all portions of the bridge superstructure and substructure against damage or disfigurement from spatters, splashes, smirches or spray of paint or paint materials.

Contact surfaces within friction-type joints as indicated on the plans shall be free of oil and other contaminants.

**6.03.04--Method of Measurement:** Payment under this item will be at the contract lump sum price per each complete bridge structure or shall be based on the net mass of metal in the fabricated structure, whichever method appears on the proposal form.

When payment is based on a lump sum basis, the work will not be measured for payment.

When payment is based on the net mass of metal in the fabricated structure, it shall include rivet heads, high tensile strength boltheads, nuts, stickthrough and washers required. This net mass shall be determined by computation as described in Subarticle 6.03.04-1, unless it is provided that it be determined by a scale, as described in Subarticle 6.03.04-2.

**1--Computed Mass:** The mass of the metal works to be paid for under the item of structural steel shall be computed on the basis of the net finished dimensions of the parts as shown on the approved shop drawings, deducting for copes, cuts, clips and all open holes, except rivet and bolt holes, and on the following basis:

(a) The mass shall be computed on the basis of the following densities:

<b>Metal</b>	<b>Density (kg/m<sup>3</sup>)</b>
Aluminum, cast or wrought	2770
Brass	8490
Bronze, cast	8590
Copper-alloy	8590
Copper, sheet	8940
Iron, cast	7130
Iron, malleable	7530
Iron, wrought	7800
Lead, sheet	11 325
Steel, cast, copper bearing, carbon silicon, nickel and stainless	7850
Zinc	7210

(b) The masses of rolled shapes be computed on the basis of their nominal masses per meter, as shown on the drawings or listed in the handbooks.

The mass of plates shall be computed on the basis of the nominal mass for their width and thickness as shown on the drawings, plus an estimated overrun computed as one-half of the "Permissible Variation in Thickness" (Table A1.1) and "Permissible Variations in Mass" (Table A1.2) as tabulated in ASTM A6M. The estimated overrun shall be applied to the net finished dimensions of the plate as shown on the approved shop drawings.

(c) The mass of castings shall be computed from the dimensions shown on the approved shop drawings, deducted for open holes. To this mass shall be added 5 percent allowance for fillets and overrun. Scale masses may be substituted for computed masses in the case of castings or small complex parts for which accurate computations of mass would be difficult.

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

(e) The mass of all rivet heads, both field and shop, and high strength boltheads, nuts, stickthrough and washers shall be included on the basis of the following masses:

<b>Mass per 100 (kg)</b>		
<b>Nominal diameter of H.S. Bolt or rivet (mm)</b>	<b>Rivet heads</b>	<b>Bolthead, nut, 1 washer and stickthrough</b>
16	2	17
20	3	26
22	5	39
24	8	50
27	12	60
30	16	73
36	22	122

(f) The mass of weld metal shall be computed on the basis of the theoretical volume from dimensions of the welds.

(g) The mass of railings shall be measured and paid for as structural steel only if so specified in the special provisions.

(h) Steel grid floor shall be measured and paid for as structural steel only if so specified in the special provisions.

(i) The mass of steel or brass shims shall be included. The mass of brass shims shall be calculated on the basis of the density of brass.

(j) No deduction shall be made for trepanned or drilled in recesses in self-lubricating bearings or bearing plates.

**2--Scale Mass:** The mass of metal in the fabricated members shall be determined on scales, approved by the Department, in the presence of the inspector. The Contractor shall supply such scales and shall perform all work involved in handling and determining the mass of the various parts. If shop paint has been applied to the completed member, 0.4 of 1 percent of the mass of the member shall be deducted from the scale mass to compensate for the mass of the paint. If galvanization has been applied to the completed member, 2 percent of the mass of the member shall be deducted from the scale mass to compensate for the mass of the galvanization. The mass of field rivets shall be based on the approved shipping list. No payment will be made for any mass in excess of 1 1/2 percent above the computed net mass of the whole item.

If the scale mass of any member is less than 97 1/2 percent of the computed mass, the member may be rejected.

**6.03.05--Basis of Payment:** The structural steel and metal of the various other types covered by this section, incorporated in the completed and accepted structure, will be paid for at the contract lump sum price for "Structural Steel (Site No. )," or at the contract unit price per kilogram for "Structural Steel," "Structural Steel (Low Alloy)" or "Structural Steel Sign Support," whichever is indicated on the proposal form.

Payment under either method shall be for structural steel, complete in place, which price shall include furnishing, fabricating, transporting, erecting, surface preparation, painting, galvanizing and all materials, equipment, tools and labor incidental thereto.

Unless otherwise provided, such items as bronze plates, castings, etc., will be paid for at the same unit price as for the structural steel, even though consisting of other materials.

Unless otherwise provided, bridge railing, if required, will be paid for as separate items as provided hereinafter.

Full size tests of eyebars and other members will be paid for as specified hereinbefore.

Wrought iron will be paid for at the contract unit price per kilogram for "Wrought Iron," incorporated in the completed structure, complete in place, which price shall include furnishing, fabricating, transporting, erecting, surface preparation, painting and all materials, equipment, tools and labor incidental thereto.

No direct payment will be made for setting anchor bolts and anchorage material, preparing bearing areas, furnishing and placing materials under shoes and setting shoes, but the cost thereof shall be included in the general cost of the work.

Anchorage materials furnished by the Contractor for the superstructure and placed by the Contractor for the substructure will be included as part of the superstructure contract.

Pay Item	Pay Unit
Structural Steel (Site No. )	L.S.
Structural Steel	kg
Structural Steel (Low Alloy)	kg
Wrought Iron	kg
Structural Steel Sign Support	kg