

**SECTION M.06
METALS**

M.06.01--Reinforcing Steel: The materials for this work shall conform to the following requirements:

1--Bar Reinforcement:

Bar reinforcement shall be deformed and conform to the following:

Uncoated bar reinforcement shall conform to the requirements of ASTM A615M, Grade 420.

Epoxy coated bar reinforcement shall conform to the requirements of ASTM A615M, Grade 420 and be epoxy coated to the requirements of ASTM D3963M.

Galvanized bar reinforcement shall conform to the requirements of ASTM A615M, Grade 420 and be galvanized, after fabrication, to the requirements of ASTM A767M, Class 1, including supplemental requirements. Dowels and tie bars for masonry facing and for granite curbing shall be galvanized, after fabrication, in accordance with ASTM A767M, Class 1.

Weldable bar reinforcement shall conform to the requirements of ASTM A706M.

Prior to incorporation into the work, samples of the uncoated, epoxy coated, galvanized and weldable bar reinforcement shall be submitted to the Engineer for destructive testing in accordance with the latest edition of the "Schedule of Minimum Requirements for Sampling Materials for Test". One sample, at least 1550 mm long, shall be submitted for each size and type of bar reinforcement.

2--Unit Mass: Listed below are the bar sizes with approximate diameters, areas and mass.

Article M.06.01-2 Unit Mass:

Bar Designation No. **	Nominal Mass, kg/m	Nominal Dimensions*		Perimeter, mm
		Diameter, mm	Cross-Sectional Area mm ²	
10	0.560	9.5	71	29.9
13	0.994	12.7	129	39.9
16	1.552	15.9	199	49.9
19	2.235	19.1	284	59.8
22	3.042	22.2	387	69.8
25	3.973	25.4	510	79.8
29	5.060	28.7	645	90.0
32	6.404	32.3	819	101.3
36	7.907	35.8	1006	112.5
43	11.38	43.0	1452	135.1
57	20.24	57.3	2581	180.1

* The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same mass per meter as the deformed bar.

**Bar designation numbers approximate the number of millimeters of the nominal diameter of the bar.

3--Wire and Welded Steel Wire Fabric: Wire shall be cold-drawn steel wire conforming to the requirements of ASTM A 82 (AASHTO M 32).

Welded steel wire fabric, when used as reinforcement in concrete, shall conform to the requirements of ASTM A 185 (AASHTO M 55). The type of welded steel wire fabric shall be approved by the Engineer.

4--Bar Mat Reinforcement: Bar mat reinforcement shall conform to the requirements of ASTM A 184 (AASHTO M 54)

5--Dowel Bar Mechanical Connections: Dowel bar mechanical connections shall develop in tension and compression at least 125 percent of the specified yield strength of the bar reinforcement being spliced.

Epoxy coated mechanical connectors shall be epoxy coated in accordance with the requirements of ASTM D3963M.

Galvanized mechanical connectors shall be galvanized, after fabrication, in accordance with the requirements of ASTM A767M, Class 1, including supplemental requirements.

Prior to incorporation into the work, samples of the uncoated, epoxy coated and galvanized dowel bar mechanical connections shall be submitted to the Engineer for destructive testing. One sample, complete with all the components, shall be submitted for each size, type and manufacturer of the dowel bar mechanical connections.

6--Deformed Steel Wire and Welded Deformed Steel Wire Fabric: Deformed steel wire shall be cold-worked, deformed steel wire conforming to the requirements of AASHTO M225 (ASTM A 496). Welded deformed steel wire fabric, when used as reinforcement in concrete, shall conform to the requirements of AASHTO M221 (ASTM A497). The type of welded deformed steel wire fabric shall be approved by the Engineer.

7--Reinforcing Steel for Pavement: Reinforcing steel for pavement shall be in accordance with the applicable standard plans.

8--Reports and Certification: Mill test reports and materials certification shall be submitted for all types of reinforcing steel and dowel bar mechanical connections confirming they meet the requirements of the applicable specifications.

Materials Certificates shall be submitted in accordance with Article 1.06.07 for all types of reinforcing steel and dowel bar mechanical connections.

M.06.02--Structural Steel and Other Structural Materials: The materials for this work shall conform to the following requirements:

1--Structural Steel: All structural steel shall conform to ASTM A 709, Grade 250 unless otherwise specified.

(a) Charpy V-notch Impact Testing: Unless otherwise shown on the plans or indicated in the Special Provisions, all structural steel used for main load carrying components shall meet the Charpy V-notch impact value requirements specified herein. Main load carrying components shall include but not necessarily be limited to the following:

Flange and web plates of welded plate and box girders; rolled beams; welded cover plates; and longitudinal stiffener plates.

Flange and web splice plates.

Cross frames and their connection plates on horizontally curved girders.

Portions of trusses, arches, and rigid frames.

Charpy V-notch sampling and testing procedures shall be in accordance with ASTM A 673 (AASHTO T 243). The H (Heat) frequency of testing shall be used for structural steels conforming to ASTM Designations A 36, A 572, and A 588; the P (Piece) frequency of testing shall be used for structural steel conforming to ASTM Designation A 514/517.

Charpy V-notch (CVN) impact values shall meet the following minimum values:

ASTM Designation	Thickness—mm	Charpy V-notch Joules (J) @ Temp. (°C)
A 36		20 @ 4
A 572*		20 @ 4
A 588*	50 and under - welded	20 @ 4
	Over 50 - welded	27 @ 4
	100 and under - mech. fastened	20 @ 4
A 514/517	64 and under - welded	34 @ -18
	Over 64 welded	48 @ -18
	100 and under - mech. fastened	34 @ -18

*If the yield point of the material exceeds 450 MPa, the temperature for acceptability shall be reduced by -10 ° C for each increment of 70 MPa above 450 MPa.

Except as otherwise noted in the Special Provisions or on the plans, Charpy V-notch tests will be required for structural repairs but will not be required for temporary structures.

(b) Ordering Weathering Steel: When placing an order for ASTM A 588 steel which is to be used as "Weathering Steel", the fabricator shall notify the manufacturer that it is "weathering steel" (structural steel for use in bare, unpainted applications) and that the steel shall not be marked with paint or steel die stamped, but identification shall be stenciled with permanent ink.

2--Anchor Bolts: Unheaded anchor bolts shall be swaged and shall conform to the requirements of ASTM A 36. Anchor bolts, nuts and washers shall be galvanized in conformance with ASTM A 153.

3--Eyebars Steel: Steel for eyebars shall conform to the requirements specified on the plans or in the contract documents.

4--Structural Rivets:

(a) Structural Rivet Steel: Unless otherwise specified, all rivets shall be made of structural rivet steel conforming to the requirements of ASTM A 502, Grade 1.

(b) High Strength Structural Rivet Steel: Where high strength structural rivets are called for on the plans or in the special provisions, rivets shall be made of high strength structural rivet steel conforming to the requirements of ASTM A 502, Grade 2.

The steel for rivets used in fastening weathering steel, conforming to ASTM A 588, shall be modified by the addition of such alloying elements as to have, while in a fully stressed condition, weathering and corrosion characteristics equal to or exceeding the requirements for weathering steel conforming to ASTM A 588. The final weathered appearance of the rivets shall be compatible with that of the structural steel.

5--High Strength Bolts: Bolts, nuts and circular washers shall conform to the requirements of the specification for High-Strength Bolts for Structural Steel Joints, including suitable Nuts and Plain Hardened Washers. Bolt and nut dimensions shall conform to the Manufacturer's dimensions and tolerances.

Subject to the approval of the Engineer, other fasteners which meet the chemical composition requirements of ASTM A 325 or ASTM A 490 and which meet the mechanical requirements of the same specifications in full size tests, and which have body diameter and bearing areas under the head and nut or their equivalent, not less than those provided by a bolt and nut of these same nominal dimensions shown in the table below, may be used. Such alternate fasteners may differ in other dimensions from those specified for ASTM 325 or ASTM A 490 bolts and nuts.

When high-strength, low-alloy steel conforming to the requirements of ASTM A 588 is specified, high strength bolts, if specified, shall conform to the requirements of ASTM A 325, Type 3.

Circular washers shall be flat and smooth, and their nominal dimensions shall conform to the dimensions given in the table below.

Beveled washers for American Standard beams and channels shall be square or rectangular, shall taper in thickness, and shall conform to the dimensions given in the table below.

Where necessary, washers may be clipped on one side to a point not closer than $7/8$ of the bolt diameter from the center of the washers.

Washer Dimensions (mm)

	Circular Washers						Square or Rectangle Beveled Washers for American Standard Beams and Channels		
Nominal Washer Size	Inside Diameter max min		Outside Diameter max min		Thickness max min		Minimum side dimension	Mean thickness	<u>Slope or taper in thickness</u>
12	14.4	14.0	27.0	25.7	4.6	3.1	42	7	1:6
14	16.4	16.0	30.0	28.7	4.6	3.1	42	7	1:6
16	18.4	18.0	34.0	32.4	4.6	3.1	42	7	1:6
20	22.5	22.0	42.0	40.4	4.6	3.1	42	7	1:6
22	24.5	24.0	44.0	42.4	4.6	3.4	42	7	1:6
24	26.5	26.0	50.0	48.4	4.6	3.4	56	7	1:6
27	30.5	30.0	56.0	54.1	4.6	3.4	56	7	1:6
30	33.6	33.0	60.0	58.1	4.6	3.4	56	7	1:6
36	39.6	39.0	72.0	70.1	4.6	3.4	56	7	1:6
42	45.6	45.0	84.0	81.8	7.2	4.6	56	7	1:6
48	52.7	52.0	95.0	92.8	7.2	4.6	—	—	—
56	62.7	62.0	107.0	104.8	8.7	6.1	—	—	—
64	70.7	70.0	118.0	115.8	8.7	6.1	—	—	—
72	78.7	78.0	130.0	127.5	8.7	6.1	—	—	—
80	86.9	86.0	142.0	139.5	8.7	6.1	—	—	—
90	96.9	96.0	159.0	156.5	8.7	6.1	—	—	—
100	107.9	107.0	176.0	173.5	8.7	6.1	—	—	—

6--Supplementary Requirements: The specification requirements stated above for the various types of steel are modified and supplemented by the following requirements:

(a) Stock Material: Stock material of a quality substantially equal to that called for by the above specifications, and free from surface imperfections, may be used to such an extent as the Engineer may permit. Mill test reports shall constitute a sufficient record as to the quality of material carried in stock.

(b) Full Size Tests: When full size tests of fabricated structural members of eyebars are required by the contract, the plans or specifications shall state the number and nature of the tests, the results to be attained, and the measurements of strength, deformation or other performance requirements that are to be made. The Contractor shall provide suitable facilities, material, supervision and labor necessary for making and recording the tests. The members tested in accordance with the contract will be paid for in accordance with paragraph (c) below.

(c) Payment for Full Size Tests: Any full sized member tested to destruction will be paid for by the Department at the same rate as for comparable members for the structure if the test proves satisfactory. If the test proves the member to be unsatisfactory, the members represented by it will be rejected; and all material so rejected will not be paid for by the Department. The expense of conducting the tests shall be borne by the Contractor unless otherwise specified. The scrap from the tests shall be the property of the Contractor.

(d) Anchor Bolts/High Strength Bolts--Certified Test Report: The Contractor shall submit a Certified Test Report and Materials Certificate in conformance with Article 1.06.07 and a sample of all anchor bolts and nuts and high strength bolts and nuts for testing prior to their installation. The Contractor shall not install any anchor bolts or high strength bolts prior to receipt of the approved test results and approval by the Engineer.

7--Steel Shaftings and Forgings: Pins and rollers, unless otherwise specified on the plans or elsewhere within the contract documents, shall conform to the following:

Rollers 508 mm or less in diameter shall conform to the requirements of ASTM A 668, Class C. Pins 102 mm or less in diameter shall conform to the requirements of ASTM A 108, Grade 1016 to 1030 inclusive. Pins having a diameter greater than 102 mm shall conform to the requirements of ASTM A 668, Class C.

Steel forgings for hangers shall conform to the requirements of ASTM A 668 Class G, annealed, modified by such alloying elements as will produce a steel suitable for the thickness of the hangers shown on the plans, and shall have a minimum comparative resistance to atmospheric corrosion of four times that of structural carbon steel.

Pins and rollers incorporated in structural steel components for weathering steel applications shall be corrosion-resisting (stainless) steel conforming to ASTM A 276, Types 410 or 414, which shall develop a minimum yield strength of 276 MPa.

8--Welded and Seamless Steel Pipe: Welded and Seamless Steel Pipe shall conform to the requirements of ASTM A 53, Type E or S, Grade A, Schedule 40 Black Finish.

9--Metal Castings: Castings shall be boldly filleted at angles, and the arrises shall be sharp and perfect.

Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and other defects in positions affecting their strength and value for the service intended.

Castings shall be sandblasted or otherwise effectively cleaned of scale and sand so as to present a smooth, clean and uniform surface.

(a) Carbon steel castings shall conform to the requirements of ASTM A 27. Grade [415-205 MPa], [450-240] or [485-250] castings shall be furnished unless otherwise specified.

(b) Chromium alloy-steel castings shall conform to the requirements of ASTM A 296. Grade 10 shall be furnished unless otherwise specified.

(c) Gray iron castings shall conform to the requirements of the specifications for gray iron castings, ASTM A 48. Unless otherwise specified, Class 207 castings shall be furnished.

(d) Malleable castings shall conform to the requirements of the specifications for malleable iron castings, ASTM A 47, Grade No. 24018. Ductile iron castings shall conform to the Specifications for Ductile Iron Castings, ASTM A 536, Grade 414-276-18 unless otherwise specified. In addition to the specified test coupons, test specimens from parts integral with the castings, such as risers, shall be tested for castings having a mass of more than 455 kg to determine that the required quality is obtained in the castings in the finished condition.

10--Bronze or Copper Alloy Bearing and Expansion Plates: Bronze bearing and expansion plates shall conform to the requirements of ASTM B 22. Alloy B shall be furnished unless otherwise specified.

Rolled copper alloy bearing expansion plates shall conform to the requirements of ASTM B 100, Alloy No. 1.

Bearing surfaces of self-lubricating bronze bearings and bearing plates shall be provided with trepanned or drilled-in recesses (not grooves) filled with a lubricating compound capable of withstanding atmospheric elements. The compound shall consist of graphite and metallic substances with a lubricating binder. The compound shall be forced into the recesses under pressure to form or retain the form of dense, nonplastic lubricating inserts. The lubricating area shall comprise not less than 25 percent of the total area. The self-lubricating bearings and bearing plates shall have a finish of 3.2 μm root mean square, and all surfaces in contact with them shall have the same degree of finish.

The lubricant to be used for the self-lubricating plates shall provide a coefficient of friction not to exceed 0.10, as determined by the following test procedure:

A self-lubricating bronze test plate measuring not less than 127 mm long by 127 mm wide shall be prepared and shall conform to all requirements of this specification.

An assembly consisting of the fixed self-lubricating test plate and a movable steel plate shall be subjected to a vertical unit loading 7 MPa. The steel plate shall then be subjected to not less than 100 cycles of horizontal movement at a speed not to exceed 30 cycles per minute. Each cycle shall consist of a forward and return movement of not more than 12.5 mm in each direction. The recorded horizontal force, divided by the recorded vertical force, shall be established as the coefficient of friction between the sliding surfaces.

The coefficient determined by the foregoing method shall not exceed 0.10, and tests indicating a coefficient of friction greater than 0.10 shall be cause for rejection of the lubricating compound.

Before such materials are incorporated into the work, the supplier, at his own expense, shall furnish a Certified Test Report Certificate that the lubricant, when tested as herein before described, shall not have coefficient of friction greater than 0.10.

Batches of the lubricating compound shall be clearly tagged or marked by the supplier for identification with the certification.

11--Aluminum Castings, Tubing and Fittings:

(a) The castings for ornamental posts shall be permanent mold aluminum alloy castings conforming to the requirements of ASTM B 108, Aluminum Alloy A 356.0-T6.

The castings for traffic rail posts shall be permanent mold aluminum alloy castings conforming to the requirements of ASTM B 108 Aluminum Alloy A 444.0-T4.

The finish of all castings shall be commercial with all gates, risers and seams finished flush. Casting tolerances will be plus or minus (\pm) 0.8 mm.

(b) The extruded aluminum for posts, bases, post connection splice bars and rails shall conform to ASTM B 221 Aluminum Alloy 6061--T6, unless 6063--T6 is indicated on the plans or in the special provisions.

(c) Aluminum for bolts and screws shall be aluminum alloy made from rod or wire conforming to ASTM B 211 Aluminum Alloy 2024--T4.

Aluminum for nuts 6.4 mm tap and under shall be aluminum alloy made from rod or wire conforming to ASTM B 211 Aluminum Alloy 2024--T4.

Aluminum for nuts 8 mm tap and over shall be aluminum alloy made from rod or wire conforming to ASTM B 211 Aluminum Alloy 6061--T6, or 6262--T9, or extruded rods conforming to ASTM B 221 Aluminum Alloy 6061--T6.

Unless otherwise noted, all nuts shall conform to American Standard Heavy Hexagon, ASA Specification B 18.2. Threads shall conform to American Standard Coarse Series, Class 2 fit, ASA Specification B-1.1. The finished bolts and nuts shall be heat-treated to the required temper and given an anodic coating at least 5 μm in thickness with dichromate or boiling water seal.

(d) Washers shall be made from aluminum alloy sheet or plate conforming to ASTM B 209 Aluminum Alloy Alclad 2024--T4. Shims shall be of aluminum alloy shim material made from sheet or plate conforming to ASTM B 209, Aluminum Alloy 1100-0.

(e) End caps shall be sand mold castings conforming to ASTM B 26 Alloy SG-70A Commercial Alloy 356--F or ASTM B 26 Alloy S-5A, Commercial Alloy 43-F or sheet and plate conforming to ASTM B 209 Aluminum Alloy 6061--T6.

(f) Rivets shall conform to ASTM B 316 Aluminum Alloy 6061-T6 or ASTM B 221 Aluminum Alloy 6061-T6.

12--Welded Stud Shear Connectors and Welded Studs : Stud shear

connectors shall be of a design suitable for electrically end-welding to steel with automatically timed stud welding equipment. The studs shall be of the sizes and dimensions noted on the plans. Flux for welding shall be furnished with each stud, either attached to the end of the stud or combined with the arc shield for automatic application in the welding operation. Each stud shall be furnished with a disposable ferrule of sufficient strength to remain intact during the welding operation and not crumble or break; it shall not be detrimental to the weld or create excessive slag.

Stud shear connectors shall conform to the requirements of ASTM A 108, cold-drawn bar, Grades 1015, 1018 or 1020, either semi- or fully-killed. If flux-retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with ASTM A 109.

Tensile properties as determined by tests of bar stock after drawing or of finished studs shall conform to the following requirements:

Tensile strength (min.)	415 MPa
Yield strength (min.) *	345 MPa
Elongation (min.)	20% in 50 mm
Reduction of area (min.)	50%

* as determined by the 0.2% offset method

Tensile properties shall be determined in accordance with the applicable sections of ASTM A 370.

Finished studs shall be of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends or other injurious defects. Finish shall be as produced by cold-drawing, cold-rolling or machining.

Studs shall be tested for weldability in accordance with the requirements of the ANSI/AASHTO/AWS D1.5 Bridge Welding Code. Certified copies of in-plant control test reports shall be furnished to the Engineer upon request.

13--Mill and Shop Inspection of Structural Steel:

(a) Notice of Beginning of Work: The Contractor shall give ample notice to the Engineer of the beginning of work at the mill and shop so that inspection may be provided. The term "mill" means any rolling mill, foundry or fabricating plant where material for the work is to be manufactured. No material shall be manufactured or work done in the shop before the Engineer has been so notified.

(b) Facilities for Inspection: The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and inspectors shall be allowed free access to the necessary parts of the premises.

(c) Inspector's Authority: The inspector shall have the authority to reject the materials or work which do not meet the requirements of these specifications. In case of dispute, the Contractor may appeal to the Engineer whose decision shall be final.

(d) Mill Orders: The Contractor shall furnish the Engineer with as many copies of mill orders as the Engineer may direct.

(e) Facilities for Testing: The contractor shall furnish without charge test specimens as specified herein, and all labor, testing machines and tools necessary to prepare the specimens and to make the full sized tests.

(f) Rejections: The acceptance of any material or finished members by the inspector shall not be a bar to their subsequent rejection if found defective. Rejected material and workmanship shall be replaced promptly or satisfactorily corrected by the Contractor.

(g) Marking and Shipping: Each member shall be painted or marked with an erection mark for identification, and an erection diagram shall be furnished with erection marks shown thereon.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements and erection diagrams as the Engineer may direct. The mass of the individual members shall be shown on the statements. Members having a mass of more than 2700 kg shall have the mass marked thereon. Structural members shall be loaded on trucks or cars in such manner that they may be transported and unloaded at their destination without being deformed, excessively stressed or otherwise damaged.

Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, small parts and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels; but the gross mass of any package shall not exceed 135 kg. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

M.06.03--Galvanizing: Unless otherwise specified on the plans or in the special provisions, the zinc coating on all iron and steel materials, other than wire, shall meet the requirements of ASTM A 123, or A 153, whichever shall apply.

When mechanical galvanizing is used it shall meet the requirements of ASTM B 695 Class 50.

M.06.04--Filler Metal for Welding: Unless otherwise shown on the plans or as indicated in the special provisions, fill metal for welding shall conform to the requirements of AWS.

The fabricator shall note on the shop plans the electrode classification number and other identification references for the electrodes and flux he proposes to use.