

SECTION 16440

REINFORCING STEEL

PART 1 DESCRIPTION

- A. Furnish and place reinforcing steel of the sizes and details shown on the plans.

PART 2 MATERIALS

2.01 APPROVED MILLS

- A. Before furnishing steel, producing mills of reinforcing steel must be pre-approved in accordance with Item 16000. Reinforcing steel obtained from unapproved sources will not be accepted.

2.02 DEFORMED BAR AND WIRE REINFORCEMENT

- A. Unless otherwise shown on the plans, reinforcing steel must be Grade 60, and bar reinforcement must be deformed. Reinforcing steel must conform to one of the following:
 - 1. ASTM A 615, Grades 40 or 60;
 - 2. ASTM A 996, Type A, Grades 40 or 60;
 - 3. ASTM A 996, Type R, Grade 60, permitted in concrete pavement only (Furnish ASTM A 996, Type R bars as straight bars only and do not bend them. Bend tests are not required.); or
 - 4. ASTM A 706.
- B. The provisions of this Item take precedence over ASTM provisions.
- C. The nominal size, area, and weight of reinforcing steel bars covered by this Item are shown in Table 1. Designate smooth bars up to No. 4 by size number and above No. 4 by diameter in inches.

Table 1
Size, Area, and Weight of Reinforcing Steel Bars

Bar Number (in.)	Bar Size Number (mm)	Diameter (in.)	Area (Sq. in.)	Weight per Ft.
3	10	0.375	0.11	0.376
4	13	0.500	0.20	0.668
5	16	0.625	0.31	1.043
6	19	0.750	0.44	1.502
7	22	0.875	0.60	2.044
8	25	1.000	0.79	2.670
9	29	1.128	1.00	3.400
10	32	1.270	1.27	4.303
11	36	1.410	1.56	5.313
14	43	1.693	2.25	7.650
18	57	2.257	4.00	13.60

Note: Bar size numbers (in.) are based on the number of eighths of an inch included in the nominal diameter of the bar. Bar size numbers (mm) approximate the number of millimeters included in the nominal diameter of the bar.

2.03 SMOOTH BAR AND SPIRAL REINFORCEMENT

- A. Smooth bars and dowels for concrete pavement must have a minimum yield strength of 60 ksi and meet ASTM A 615. For smooth bars that are larger than No. 3, provide steel conforming to ASTM A 615 or meet the physical requirements of ASTM A 36.
- B. Spiral reinforcement may be smooth or deformed bars or wire of the minimum size or gauge shown on the plans. Bars for spiral reinforcement must comply with ASTM A 615, Grade 40; ASTM A 996, Type A, Grade 40; or ASTM A 675, Grade 80, meeting dimensional requirements of ASTM A 615. Smooth wire must comply with ASTM A 82, and deformed wire must comply with ASTM A 496.

2.04 WELDABLE REINFORCING STEEL

- A. Reinforcing steel to be welded must comply with ASTM A 706 or have a carbon equivalent (C.E.) of at most 0.55%. A report of chemical analysis showing the percentages of elements necessary to establish C.E. is required for reinforcing steel that does not meet ASTM A 706 to be structurally welded. These requirements do not pertain to miscellaneous welds on reinforcing steel as defined in Section 16448.4.B.1.a, "Miscellaneous Welding Applications."
- B. Calculate C.E. using the following formula:

$$C.E. = \%C + \frac{\%Mn}{6} + \frac{\%Cu}{40} + \frac{\%Ni}{20} + \frac{\%Cr}{10} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

2.05 WELDED WIRE FABRIC

- A. For fabric reinforcement, use wire that conforms to ASTM A 82 or A 496. Use wire fabric that conforms to ASTM A 185 or A 497. Observe the relations shown in Table 2 among size number, diameter in inches, and area when ordering wire by size numbers, unless otherwise specified. Precede the size number for deformed wire with “D” and for smooth wire with “W.”
- B. Designate welded wire fabric as shown in the following example: $6 \times 12 - W16 \times W8$ (indicating 6 in. longitudinal wire spacing and 12 in. transverse wire spacing with smooth No. 16 wire longitudinally and smooth No. 8 wire transversely).

Table 2
Wire Size Number, Diameter, and Area

Size Number (in.)	Size Number (mm)	Diameter (in.)	Area (sq. in.)
31	200	0.628	0.310
30	194	0.618	0.300
28	181	0.597	0.280
26	168	0.575	0.260
24	155	0.553	0.240
22	142	0.529	0.220
20	129	0.505	0.200
18	116	0.479	0.180
16	103	0.451	0.160
14	90	0.422	0.140
12	77	0.391	0.120
10	65	0.357	0.100
8	52	0.319	0.080
7	45	0.299	0.070
6	39	0.276	0.060
5.5	35	0.265	0.055
5	32	0.252	0.050
4.5	29	0.239	0.045
4	26	0.226	0.040
3.5	23	0.211	0.035
2.9	19	0.192	0.035
2.5	16	0.178	0.025
2	13	0.160	0.020
1.4	9	0.134	0.014
1.2	8	0.124	0.012
0.5	3	0.080	0.005

Note: Size numbers (in.) are the nominal cross-sectional area of the wire in hundredths of a square inch. Size numbers (mm) are the nominal cross-sectional area of the wire in square millimeters. Fractional sizes between the sizes listed above are also available and acceptable for use.

2.06 EPOXY COATING

- A. Epoxy coating will be required as shown on the plans. Before furnishing epoxy-coated reinforcing steel, an epoxy applicator must be pre-approved in accordance with Item 16000.
- B. Coat reinforcing steel in accordance with Table 3.

Table 3
Epoxy Coating Requirements for Reinforcing Steel

Material	Specification
Bar	ASTM A 775 or A 934
Wire or fabric	ASTM A 884 Class A or B
Mechanical couplers	As shown on the plans
Hardware	As shown on the plans

- C. Use epoxy coating material and coating repair material that complies with these requirements. Do not patch more than 1/4 in. total length in any foot at the applicator’s plant.
- D. Epoxy-coated reinforcement will be sampled and tested.
- E. Maintain identification of all reinforcing throughout the coating and fabrication and until delivery to the project site.
- F. Furnish 1 copy of a written certification that the coated reinforcing steel meets the requirements of this Item and 1 copy of the manufacturer’s control tests.

2.07 MECHANICAL COUPLERS

- A. When mechanical splices in reinforcing steel bars are shown on the plans, use the following types of coupler:
 - 1. sleeve-filler,
 - 2. sleeve-threaded,
 - 3. sleeve-swaged, or
 - 4. sleeve-wedge.
- B. Furnish only couplers that have been produced by a manufacturer that has been prequalified in accordance with these requirements. Sleeve-wedge type couplers will not be permitted on coated reinforcing. Couplers for use on individual projects must be sampled and tested in accordance with these requirements. Furnish couplers only at locations shown on the plans.

PART 3 CONSTRUCTION

3.01 BENDING

- A. Cold-bend the reinforcement accurately to the shapes and dimensions shown on the plans. Fabricate in the shop if possible. Field-fabricate, if permitted, using a method approved by the Owner’s Representative. Replace improperly fabricated, damaged, or broken bars at no additional expense to the City. Repair damaged or broken bars embedded in a previous concrete placement using a method approved by the Owner’s Representative.
- B. Unless otherwise shown on the plans, the inside diameter of bar bends, in terms of the nominal bar diameter (d), must be as shown in Table 4.

**Table 4
Minimum Inside Diameter of Bar Bends**

Bend	Bar Size Number (in.)	Bar Size Number (mm)	Diameter
Bends of 90° and greater in stirrups, ties, and other secondary bars that enclose another bar in the bend	3, 4, 5	10, 13, 16	4d
	6, 7, 8	19, 22, 25	6d
Bends in main bars and in secondary bars not covered above	3 through 8	10 through 25	6d
	9, 10, 11	29, 32, 36	8d
	14, 18	43, 57	10d

Note: Bar size numbers (in.) are based on the number of eighths of an inch included in the nominal diameter of the bar. Bar size numbers (mm) approximate the number of millimeters included in the nominal diameter of the bar.

- C. Where bending No. 14 or No. 18 Grade 60 bars is required, bend-test representative specimens as described for smaller bars in the applicable ASTM specification. Make the required 90° bend around a pin with a diameter of 10 times the nominal diameter of the bar.

3.02 TOLERANCE

- A. Fabrication tolerances for bars are shown in Figure 1.

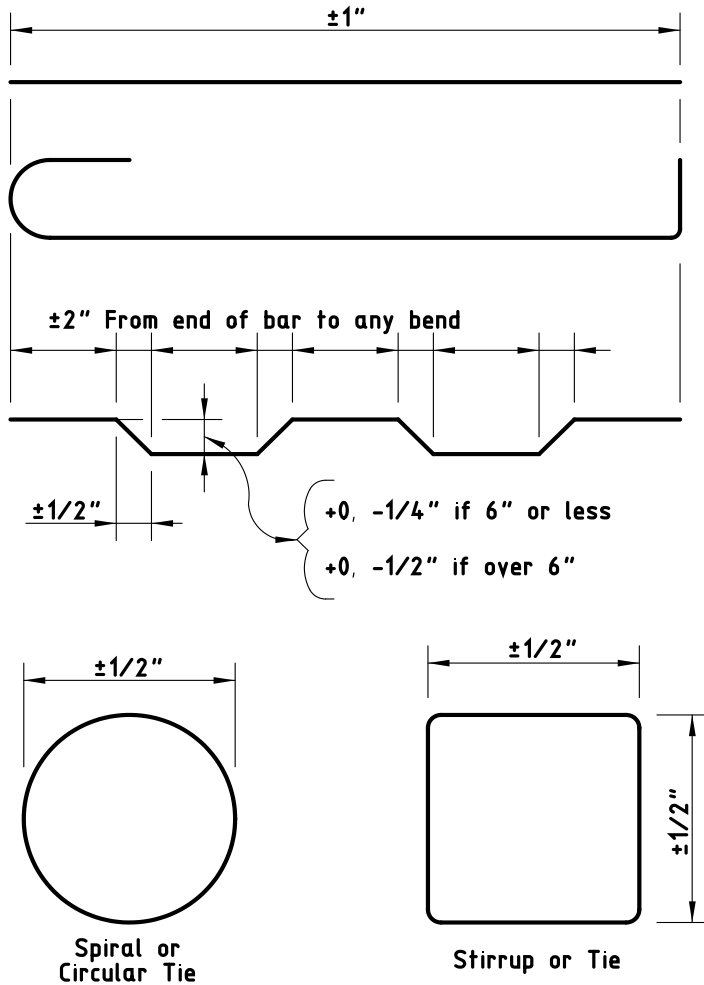


Figure 1
Fabrication tolerances for bars.

3.03 STORAGE

- A. Store steel reinforcement above the ground on platforms, skids, or other supports, and protect it from damage and deterioration. Ensure that reinforcement is free from dirt, paint, grease, oil, and other foreign materials when it is placed in the work. Use reinforcement free from defects such as cracks and delaminations. Rust, surface seams, surface irregularities, or mill scale will not be cause for rejection if the minimum cross-sectional area of a hand wire-brushed specimen meets the requirements for the size of steel specified.

3.04 SPLICES

- A. Lap-splice, weld-splice, or mechanically splice bars as shown on the plans. Additional splices not shown on the plans will require approval. Splices not shown on the plans will be permitted in slabs 15 in. or less in thickness, columns, walls, and parapets.
1. Unless otherwise approved, splices will not be permitted in bars 30 ft. or less in plan length. For bars exceeding 30 ft. in plan length, the distance center-to-center of splices must be at least 30 ft. minus 1 splice length, with no more than 1 individual bar length less than 10 ft. Make lap splices not shown on the plans, but otherwise permitted, in accordance with Table 5. Maintain the specified concrete cover and spacing at splices, and place the lap-spliced bars in contact, securely tied together.

Table 5
Minimum Lap Requirements for Bar Sizes through No. 11

Bar Number	Size (in.)	Bar Number	Size (mm)	Uncoated Lap Length	Coated Lap Length
3		10		1 ft. 4 in.	2 ft. 0 in.
4		13		1 ft. 9 in.	2 ft. 8 in.
5		16		2 ft. 2 in.	3 ft. 3 in.
6		19		2 ft. 7 in.	3 ft. 11 in.
7		22		3 ft. 5 in.	5 ft. 2 in.
8		25		4 ft. 6 in.	6 ft. 9 in.
9		29		5 ft. 8 in.	8 ft. 6 in.
10		32		7 ft. 3 in.	10 ft. 11 in.
11		36		8 ft. 11 in.	13 ft. 5 in.

Note: Bar size numbers (in.) are based on the number of eighths of an inch included in the nominal diameter of the bar. Bar size numbers (mm) approximate the number of millimeters included in the nominal diameter of the bar.

2. Do not lap No. 14 or No. 18 bars.
3. Lap spiral steel at least 1 turn.
4. Splice welded wire fabric using a lap length that includes the overlap of at least 2 cross wires plus 2 in. on each sheet or roll. Splices using bars that develop equivalent strength and are lapped in accordance with Table 5 are permitted.
5. For box culvert extensions with less than 1 ft. of fill, lap the existing longitudinal bars with the new bars as shown in Table 3. For extensions with more than 1 ft. of fill, lap at least 1 ft. 0 in.
6. Ensure that welded splices conform to the requirements of the plans and of Item 16448, "Structural Field Welding." Field-prepare ends of reinforcing bars if they will be butt-welded. Delivered bars must be long enough to permit weld preparation.

7. Install mechanical coupling devices in accordance with the manufacturer's recommendations at locations shown on the plans. Protect threaded male or female connections, and make sure the threaded connections are clean when making the connection. Do not repair damaged threads.
8. Mechanical coupler alternate equivalent strength arrangements, to be accomplished by substituting larger bar sizes or more bars, will be considered if approved in writing before fabrication of the systems.

3.05 PLACING

- A. Unless otherwise shown on the plans, dimensions shown for reinforcement are to the centers of the bars. Place reinforcement as near as possible to the position shown on the plans. In the plane of the steel parallel to the nearest surface of concrete, bars must not vary from plan placement by more than 1/12 of the spacing between bars. In the plane of the steel perpendicular to the nearest surface of concrete, bars must not vary from plan placement by more than 1/4 in. Cover of concrete to the nearest surface of steel must be at least 1 in. unless otherwise shown on the plans.
- B. For bridge slabs, the clear cover tolerance for the top mat of reinforcement is $-0, +1/2$ in.
- C. Locate the reinforcement accurately in the forms, and hold it firmly in place before and during concrete placement by means of bar supports that are adequate in strength and number to prevent displacement and to keep the steel at the proper distance from the forms. Support bars by standard bar supports with plastic tips, approved plastic bar supports, or precast mortar or concrete blocks when supports are in contact with removable or stay-in-place forms. Use bright basic bar supports to support reinforcing steel placed in slab overlays on concrete panels or on existing concrete slabs. Bar supports in contact with soil or subgrade must be approved.
- D. For bar supports with plastic tips, the plastic protection must be at least 3/32 in. thick and extend upward on the wire to a point at least 1/2 in. above the formwork.
- E. All accessories such as tie wires, bar chairs, supports, or clips used with epoxy-coated reinforcement must be of steel, fully coated with epoxy or plastic. Plastic supports approved by the Owner's Representative may also be used with epoxy-coated reinforcement.
- F. Cast mortar or concrete blocks to uniform dimensions with adequate bearing area. Provide a suitable tie wire in each block for anchoring to the steel. Cast the blocks to the thickness required in approved molds. The surface placed adjacent to the form must be a true plane, free of surface imperfections. Cure the blocks by covering them with wet burlap or mats for a period of 72 hr. Mortar for blocks should contain approximately 1 part hydraulic cement to 3 parts sand. Concrete for blocks should contain 850 lb. of hydraulic cement per cubic yard of concrete.

- G. Place individual bar supports in rows at 4 ft. maximum spacing in each direction. Place continuous type bar supports at 4 ft. maximum spacing. Use continuous bar supports with permanent metal deck forms.
- H. The exposure of the ends of longitudinals, stirrups, and spacers used to position the reinforcement in concrete pipe and in precast box culverts or storm drains is not cause for rejection.
- I. Tie reinforcing steel for bridge slabs, top slabs of direct traffic culverts, and top slabs of prestressed box beams at all intersections, except tie only alternate intersections where spacing is less than 1 ft. in each direction. For reinforcing steel cages for other structural members, tie the steel at enough intersections to provide a rigid cage of steel. Fasten mats of wire fabric securely at the ends and edges.
- J. Before concrete placement, clean mortar, mud, dirt, debris, oil, and other foreign material from the reinforcement. Do not place concrete until authorized.
- K. If reinforcement is not adequately supported or tied to resist settlement, reinforcement is floating upward, truss bars are overturning, or movement is detected in any direction during concrete placement, stop placement until corrective measures are taken.

3.06 HANDLING, PLACEMENT, AND REPAIR OF EPOXY-COATED REINFORCING STEEL

A. Handling

- 1. Provide systems for handling coated reinforcement with padded contact areas. Pad bundling bands or use suitable banding to prevent damage to the coating. Lift bundles of coated reinforcement with a strongback, spreader bar, multiple supports, or a platform bridge. Transport the bundled reinforcement carefully, and store it on protective cribbing. Do not drop or drag the coated reinforcement.

B. Construction Methods

- 1. Do not flame-cut coated reinforcement. Saw or shear-cut only when approved. Coat cut ends as specified in Section 16440, Part 3, 3.06 C. "Repair of Coating."
- 2. Do not weld or mechanically couple coated reinforcing steel except where specifically shown on the plans. Remove the epoxy coating at least 6 in. beyond the weld limits before welding and 2 in. beyond the limits of the coupler before assembly. After welding or coupling, clean the steel of oil, grease, moisture, dirt, welding contamination (slag or acid residue), and rust

to a near-white finish. Check the existing epoxy for damage. Remove any damaged or loose epoxy back to sound epoxy coating.

3. After cleaning, coat the splice area with epoxy repair material to a thickness of 7 to 17 mils after curing. Apply a second application of repair material to the bar and coupler interface to ensure complete sealing of the joint.

C. Repair of Coating

1. For repair of the coating, use material that complies with the requirements of this Item and ASTM D 3963. Make repairs in accordance with procedures recommended by the manufacturer of the epoxy coating powder. For areas to be patched, apply at least the same coating thickness as required for the original coating. Repair all visible damage to the coating.
2. Repair sawed and sheared ends, cuts, breaks, and other damage promptly before additional oxidation occurs. Clean areas to be repaired to ensure that they are free from surface contaminants. Make repairs in the shop or in the field as required.

PART 4 MEASUREMENT AND PAYMENT

- A. The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be considered subsidiary to pertinent Items.

END OF SECTION