METAL REINFORCEMENT
5-393.250

5-393.251 GENERAL

Specification 2472 describes the requirements for furnishing and placing metal reinforcing bars in concrete structures other than pavements.

Until recently, reinforcing bars were specified and marked with a number that denoted the bar diameter in eights of an inch, i.e., a 1/2" diameter bar was denoted as a #4 bar (1/2" = 4/8"). In the late 1990's the industry converted to metric designations so now the first two digits of each bar mark indicate the bar number which approximates the nominal diameter of the bar in millimeters (mm).

Specification 3301 requires that, if not otherwise specified, reinforcement bars for use in any part of a concrete bridge, box culvert, or retaining wall shall be deformed billet steel bars with a minimum yield strength of 420 MPa (60,000 psi). This strength is designated as Grade 420. Grade 420 reinforcement corresponds to Grade 60 in the inch-pound reinforcement specifications. The inspector should make certain that the proper grade of steel has been supplied as soon as it is received and before placement has started. See Figure A 5-393.261 for identification markings.

Reinforcement bars, steel fabric, and other such materials are usually sampled and tagged by the Mn/DOT Materials Office prior to shipment to the project. The inspector should look for these tags when the material arrives at the job site and record the information in his or her diary. Reinforcement bars also carry tags indicating the bar numbers and the unit for which they are intended. When bars arrive at the site without sampling tags, it will be necessary to check with the Materials Section to verify inspection and, if not previously sampled, samples must be submitted as specified in the Materials Manual.

5-393.252 CUTTING AND BENDING

Bar bending dimensions are not generally checked prior to shipment and should, therefore, be verified upon arrival. See Figure B and C 5-393.261 for bends, dimensions, etc. It is the Contractor's responsibility to furnish bars with properly made bends and of specified lengths, but an alert inspector can sometimes save time and money for both the Contractor and the State by detecting bending errors in time so that a correction can be made without delaying the progress of the work.

Bars should also be inspected at bend points, particularly the larger bars, to determine whether or not cracks or fractures have occurred at these points due to the bending operations. Galvanized or epoxy coated bars should be carefully checked at bends for damage to coating.

Occasionally, the plans will provide for some bars to be cut or bent in the field. Such field work will be permitted but bending must be done without heating if possible. Uncoated hot bent bars shall not be heated above the dull cherry-red range (a maximum of 650E C) and shall not be quenched. Bars bent in the field should be checked to see that the bends and dimensions are correct. Epoxy coated reinforcement bars shall not be heated or flame cut. After the epoxy bars are cut or bent, a field application or touch up of the coating should be made.

5-393.253 EPOXY COATED BARS

Specifications for coated bars generally require padding to protect the coating. Bar coating should be inspected for scratches, holidays and chips or other damage. Any damage should be repaired prior to long term storage. Repairs are required if damage exceeds an area 6 mm by 6 mm (1/4" x 1/4"). All bars with total damage greater than 2 percent of bar surface area shall be rejected and removed.

Field cutting of epoxy-coated reinforcing bars should be avoided and only if permitted by the engineer. If cutting is allowed it should only be done by the use of hydraulically powered cutters, friction cutting tools (chop saw) or hack saws. Never should the use of a cutting torch be allowed. When patching cut ends the coating materials shall be handled, stored and applied in accordance with the manufacturer's recommendations, or as directed by an authorized representative of the coating manufacturer. The patch compounds usually consist of a two part epoxy material that can be applied only after the surface is moisture free and cleaned of any oil, grease, dust, scale and rust.

All visible damage must be repaired before concrete is poured. If you are in doubt, repair it. Use epoxy repair material recommended by the coating manufacturer. Remove all rust and contaminants from the damaged area with a wire brush. Mix the epoxy prior to use according to the manufacturer's recommended mixing procedures. Check the pot life.

The instructions furnished by the patching material manufacturer on how patching or touch-up material is applied should be strictly followed. Be sure to allow the patch sufficient curing time as specified by the material's instructions before pouring concrete, (Some patch materials require a minimum of 8 hours to cure).

5-393.254 STORAGE AND PROTECTION

Reasonable care should be exercised by the Contractor's workers when unloading or handling reinforcement bars to avoid kinking or otherwise damaging them. Long bars should be supported at several points when being handled and should not be dragged on the ground. Epoxy coated bars should be unloaded with padded slings to prevent damage to the coating. When the bars are unloaded, they should be placed on suitable blockings, well off the ground, in an area that has been cleared of brush, tall grass, and other growth, and which will be kept drained.

It is good practice on the part of the Contractor to separate the different bar types so that they can be readily checked for bending and quantity, and so that they are readily available when needed.

Non coated bars which are to be stored for a long period of time should be protected to minimize rusting. Rust, itself, should not be cause for rejection; but rusting to the extent that the bar becomes pitted reduces its strength and is definitely cause for rejection. Normal handling of the bars will usually remove rust which is loose enough to cause loss of bond.

Reinforcement bars which have become irreparably damaged due to improper handling, storage, bending, or for any other reason, or which have become excessively rusted or pitted, should be rejected and removed from the site. Bars may be checked for loss of section by weighing.

Store epoxy-coated reinforcing bars as close as possible to the area where they will be placed in the structure to keep handling operations to a minimum. This is most easily accomplished by planning for: location, accessibility, stacking methods and duration of storage.

Schedule delivery to minimize long-term storage of epoxy-coated reinforcing bars at the job site. Coating color may fade slightly from bright sun. This does not change the corrosion protection properties of the epoxy coating. If storage in direct sunlight is expected to exceed two months, the bars should be protected. If protective sheeting is used, allow for adequate air circulation around the bars to minimize condensation under the sheeting.

5-393.255 PLACING, SUPPORTING AND TYING REINFORCEMENT BARS

The condition of the reinforcement bars should be rechecked immediately prior to placement to make certain that they are free of dirt, grease, oil, paint, heavy rust, or any other foreign matter which would tend to destroy the bond between the concrete and the reinforcement. If the forms have not already been treated with form oil (in the case of wood forms), this should be done before the reinforcement bars are placed. The bars should not be dragged across or laid directly on forms which have recently been treated with form oil.

The positioning of the bars should be in accordance with the plans. It is generally good practice on the part of the Contractor to mark off the bar spacing on the forms with chalk prior to starting placement. The inspector should be alert to such activity and check the spacing before placement is started, so errors can be detected. Alertness of this type promotes better relations with the Contractor, provided it is carried on in the proper spirit.

Attention must be given to the positioning of the various layers of bars in bridge slabs and similar sections, since a deviation of a few millimeters reduces the strength of the section. Also, adequate concrete cover must be maintained to protect the bars from exposure to air, moisture, and salt action. Check the plans for the amount of cover specified. Detailing by Bridge Designers does not always make allowances for fabrication tolerances. Therefore, in some cases, it may not be possible to obtain minimum cover even if bars meet dimensional requirements. When this occurs, placement should be accepted as "substantial compliance" and actual minimum cover noted on the "as built" plans. The strike-off should be moved over a slab section before concrete placement is started and the depth of cover carefully checked, as required in the Specifications. Figures D and E 5-393.261 show typical support systems for deck slab reinforcement.
Unless otherwise specified in the plans or special provisions, reinforcing bars should be placed within the following tolerances:

1. Tolerance for minimum clear concrete cover in flexural members (bridge decks), walls and columns should be as follows:

d=slab depth, wall thickness or column diameter	Tolerance on minimum concrete cover
d ≤ 200 mm (8 in.)	- 10 mm (3/8 in.)
d › 200 mm (8 in.)	- 12 mm (½ in.)

   Except that the tolerance for the clear distance to edge of slab should be -6 mm (1/4 in.), and the tolerance for cover should not exceed minus one-third of the minimum cover required on the plans.

2. Tolerance for the longitudinal location of bends and ends of bars should be ± 50 mm (2 in.) except at discontinuous ends of members where the tolerance should be ± 12 mm (½ in.).

3. As long as the total number of bars specified is maintained, a reasonable tolerance in spacing individual bars is ± 50 mm (2 in.), except where openings, inserts, embedded items, etc., might require some additional shifting of bars.

4. Tolerance for length of laps in lap splices should be ± 25 mm (1 in.).

The bars should be securely tied so that their position will not be changed by workers walking or climbing on them, or by placement of concrete against them. The Specifications are quite explicit in their requirements for supporting and tying reinforcement bars. A table in Specification 2472.3C shows the maximum spacing for slab bolsters and continuous type high chairs for bridge slabs, as well as maximum tie spacing. Note that additional ties are required for coated bars. For all interior bays on beam span bridges, slab bolsters and upper continuous high chairs shall be placed within 150 mm (**6 inches**) of the edge of beam flanges. The maximum spacing of all slab bolsters and upper continuous high chairs shall be 915 mm (**3 feet**) for #10 and #13 bars, and 1220 mm (**4 feet**) for #16 - #22 bars. Also, additional bar chairs or exact location may be required if a finishing screed that rides on the rebar is used. The inspector should keep in mind, however, that these spacings are the maximum permitted, and that closer spacing may be necessary in order to achieve stability in the bar mats, as well as in the individual bars. Enforcement of these Specifications will eliminate sloppily placed, inadequately supported, or poorly tied reinforcement. Coated bars must be tied with coated ties to provide protection against corrosion. Coated bar supports are also required.

The bottom layer of longitudinal reinforcement bars for slab span bridges, cast-in-place concrete girders, beams, struts, and similar sections shall be supported on beam bolsters or heavy beam bolsters commensurate with the mass to be supported. Precast concrete block or brick supports will not be permitted on formed surfaces. Subsequent layers of longitudinal bottom reinforcement, except for those bars which can be tied to vertical bars, shall be supported by upper beam bolsters or upper heavy beam bolsters.

Epoxy coated reinforcing bars require a compatible support system coated entirely with a dielectric material such as epoxy or plastic or made completely from a dielectric material such as plastic. Uncoated "black" steel reinforcing bars or other uncoated steel products or materials shall not be used to support epoxy coated reinforcing. Contractors commonly use plastic slab bolsters to support the bottom transverse bars of slabs supported on beams. Such bolsters are permissible as long as they meet the general requirements described in the Concrete Reinforcing Steel Institute (CRSI) Manual of Standard Practice.

Cases have been encountered in the past where the Contractor has been in the process of placing concrete for a bridge deck, or preparing to do so, with inadequate supporting and tying systems. This will not happen if the inspection is performed correctly and on time. Considerable emphasis has been placed on this phase of the work during Department Bridge Seminars, but enforcement can only be done on the job.

Considerable care should be exercised in the placement, alignment, projection, supporting, and fastening of dowel bars. Dowel alignment should be determined from a line of known accuracy, such as the centerline of bearing, coping line, etc., and should be maintained in proper position by substantial frame work. These bars should not be disturbed once they are in their correct position, especially after the concrete has been placed and vibrated around them. Any disturbance will tend to destroy their bond with the concrete and consequently the value of the bar itself. Inserting dowel bars after the concrete has been placed is not good practice and should be permitted only in special cases. Bars with hooked ends should never be inserted into concrete that has been placed. Dried mortar should be removed from the exposed portion of the bars before the next section of concrete is placed.

Workers often walk on reinforcement bars which have been placed for sidewalks, curbs, and medians in order to perform their work. Because these bars are relatively small, they tend to bend rather easily and are sometimes found to have shifted from their correct position. The Contractor should be required to provide plank walkways outside of or over such reinforcement, both for the protection of the work and for the safety of the workers. Walking on reinforcement bars which are partly embedded in concrete that has started to set should not be permitted. To avoid this situation, walkways should be provided which are supported directly on the forms or on the structural members.

5-393.256 SPLICING REINFORCEMENT BARS

Except when otherwise noted or shown in the plans, the bars should be lapped 36 bar diameters for bars up to #22 (#7) and 40 bar diameters for bars #25 (#8) and over. In other words, the length of lap for joining two #22 (#7) bars would be 800 mm (32 in.) and for two #25 (#8) bars would be 1020 mm (40 in.). In general, splices should not be made in reinforcement bars except as shown in the plans or as approved by the Bridge Design Engineer. (See Figure F 5-393.261 for bar lap table.)

There are times when splicing of rebar in a manner other than lapping is necessary. Examples include:

1. Complicated placement where the cage could be tied off site, in sections, and set in place

2. Reinforcement cages for drilled shafts

3. Situations where an existing rebar is not long enough to develop strength by lapping

An example might be during the removal of an existing curb on a bridge deck widening project, existing rebar is either cut with the saw or broken during concrete demolition. In this case additional demolition would be needed to provide a lap development length.

Currently, several couplers are manufactured which can be used to mechanically splice rebar. Mechanical splicing for the above conditions may be approved. Mechanical splices shall develop 125% of the reinforcing bar's yield strength. Consideration for splice usage must be initiated by the Contractor. The project engineer should review that request with the Bridge Construction Engineer.

Many mechanical coupling devices are available for use with epoxy-coated reinforcing bar. Couplers should be precoated with fusion-bonded epoxy coating. Repair any coating damage on the couplers as necessary after installation.

5-393.257 WELDING

Welding reinforcement bars should not be permitted except when required by the plans or specifically approved by the engineer. Bar steel should be of a type suitable for welding and low hydrogen weld rods such as E7016 must be used. All welds having structural significance shall be performed by a Department Certified Welder. See section 5-393.415 for information regarding welding and welder certification.

5-393.258 WELDED WIRE FABRIC

Welded wire fabric is not normally used as reinforcement for cast-in-place structures, but it is often used in precast box culverts. The special provisions and the plans will define the requirements in detail.

5-393.259 PRESTRESSING STEEL

Prestressing steel is seven wire, uncoated, stress-relieved or low relaxation strand which is used in both pretensioned and post-tensioned construction. The majority of this material is used for precast prestressed concrete beams which are inspected by the Materials Office. Placement and tensioning requirements for strands in prestressed concrete beams are given in Specification 2405. Placement and tensioning requirements for all other pretensioned and post-tensioned concrete are given in the plans and specifications.

At the time of transfer of the prestressing force from the jacks to the permanent anchors, large compressive forces must be resisted by the concrete. Concrete members will shorten due to these forces and this shortening must be taken into account in placement of the bearing plates. Final prestress forces will be less than jacking forces, due to shortening of members, slippage of anchors and friction. Temperature differences at time of tensioning and at time of concrete placement must also be considered for pretensioned concrete.

The inspector must verify the accuracy of tension forces at time of prestress transfer since the strength of the finished structure is dependent on these forces.

Precast prestressed concrete items are susceptible to damage during transportation and handling and should be carefully inspected at the project site.

5.393-260 PAY QUANTITIES

Reinforcing steel is generally a "plan quantity" item (see Specification 1901). The plan quantity is the final quantity for which payment will be made unless there is a plan revision or corrections are made due to plan errors.

Information relative to bending details and dimensions, for use in computing the total length of bent bars, is included in this section and may be used if the plans do not provide the necessary details. (See Figure B and C 5-393.261.) Also included are tables showing mass of spiral reinforcement based on diameter of the steel rod, diameter of the spiral, and the pitch. (See Figure H 5-393.261.)

5-393.261 REFERENCES AND MATERIALS INFORMATION

The Concrete Reinforcing Steel Institute (CRSI) handbook entitled "Placing Reinforcement Bars" contains an abundance of information concerning terminology, fabrication, uses, types, and methods of placing reinforcement bars. A copy of this book may be purchased for a nominal fee from the Concrete Reinforcing Steel Institute, 933 North Plum Grove Road, Schaumburg, Illinois 60173-4758.

The CRSI "Design Handbook" is also available through the sources indicated above. This handbook deals with the technical design features, but also contains numerous charts, tables and other useful construction information. www.crsi.org.

The Concrete Reinforcing Steel Institute also publishes a "Manual of Standard Practice" from which some of the information contained in this manual was obtained.

The American Concrete Institute, PO Box 9094, Farmington Hills, Michigan 48333, publishes codes for concrete structures. Their "Manual of Concrete Practice" for detailing reinforced concrete structures is referenced in Specification 2472 as ACI 315.

AMERICAN STANDARD BAR MARKS

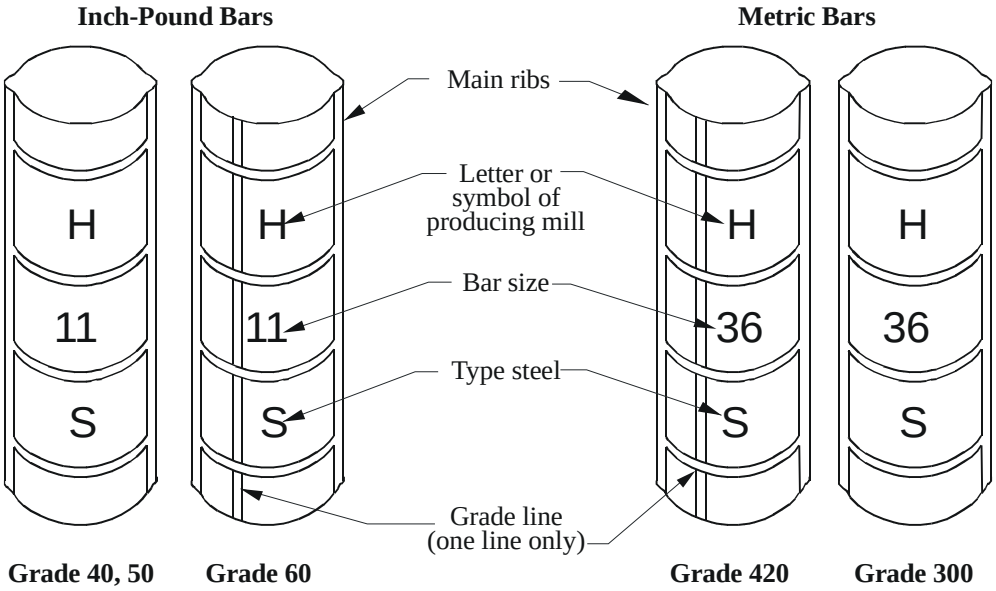
Type steel

Symbols include the following:

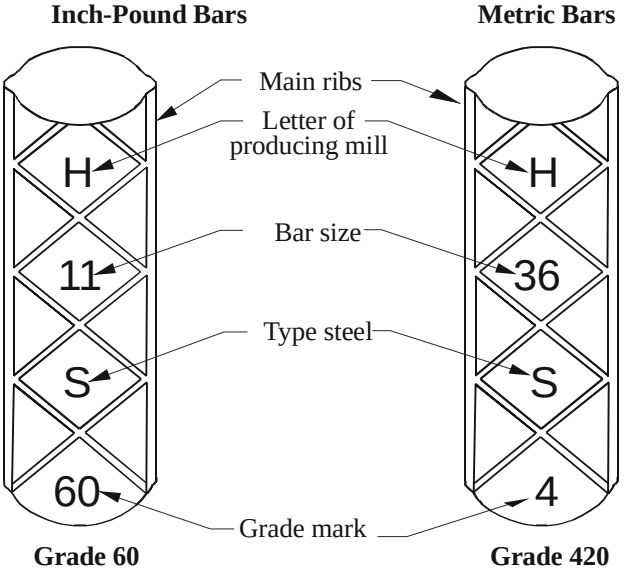
S - Billet (A615),(A615M)
I - Rail (A616),(A616M)
A - Axle (A617),(A617M)
W - Low Alloy (A706),(A706M)
IR - For rail meeting supplementary requirements S1 (A616),(A616M)

Grade mark lines are smaller and between the two main ribs which are on opposite sides of all American Bars

CONTINUOUS LINE SYSTEM - GRADE MARKS

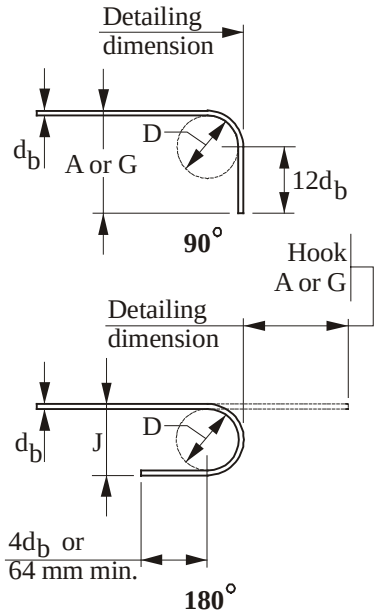


NUMBER SYSTEM - GRADE MARKS

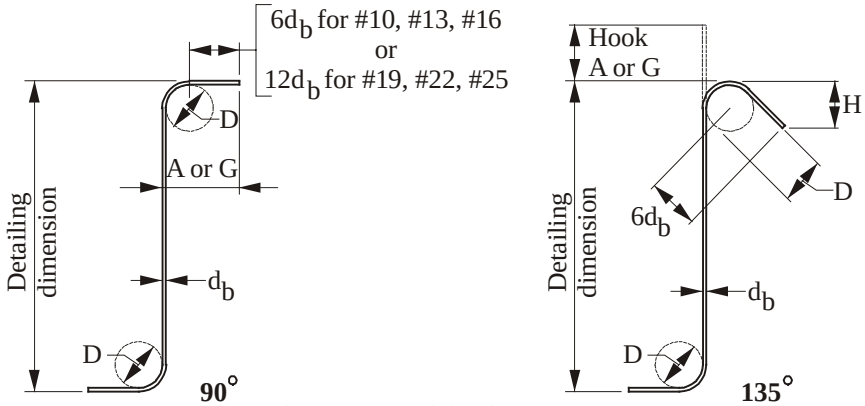


STANDARD HOOKS - All Dimensions For Metric Bar Sizes Are Shown in Millimeters

RECOMMENDED END HOOKS, ALL GRADES					
Metric Bar Size *	Inch-pound Bar Size	D	180° Hooks		90° Hooks
			A or G	J	A or G
#10	#3	60 (2 1/4")	125 (5")	80 (3")	150 (6")
#13	#4	80 (3")	150 (6")	105 (4")	200 (8")
#16	#5	95 (3 3/4")	175 (7")	130 (5")	250 (10")
#19	#6	115 (4 1/2")	200 (8")	155 (6")	300 (1'-0")
#22	#7	135 (5 1/4")	250 (10")	180 (7")	375 (1'-2")
#25	#8	155 (6")	275 (11")	205 (8")	425 (1'-4")
#29	#9	240 (9 1/2")	375 (1'-3")	300 (11 3/4")	475 (1'-7")
#32	#10	275 (10 3/4")	425 (1'-5")	335 (1'-1 1/4")	550 (1'-10")
#36	#11	305 (12")	475 (1'-7")	375 (1'-2 3/4")	600 (2'-0")
#43	#14	465 (18 1/4")	675 (2'-3")	550 (1'-9 3/4")	775 (2'-7")
#57	#18	610 (24")	925 (3'-0")	725 (2'-4 1/2")	1050 (3'-5")



STIRRUP AND TIE HOOK DIMENSIONS ALL GRADES					
		Stirrup Hooks (Tie Bends Similar)			
Metric Bar Size *	Inch-pound Bar Size	D	90°	135°	
			A or G	A or G	H
#10	#3	40 (1 1/2")	105 (4")	105 (4")	65 (2 1/2")
#13	#4	50 (2")	115 (4 1/2")	115 (4 1/2")	80 (3")
#16	#5	65 (2 1/2")	140 (6")	155 (5 1/2")	95 (3 3/4")
#19	#6	115 (4 1/2")	205 (1'-0")	305 (8")	115 (4 1/2")
#22	#7	135 (5 1/4")	230 (1'-2")	355 (9")	135 (5 1/4")
#25	#8	155 (6")	270 (1'-4")	410 (10 1/2")	155 (6")

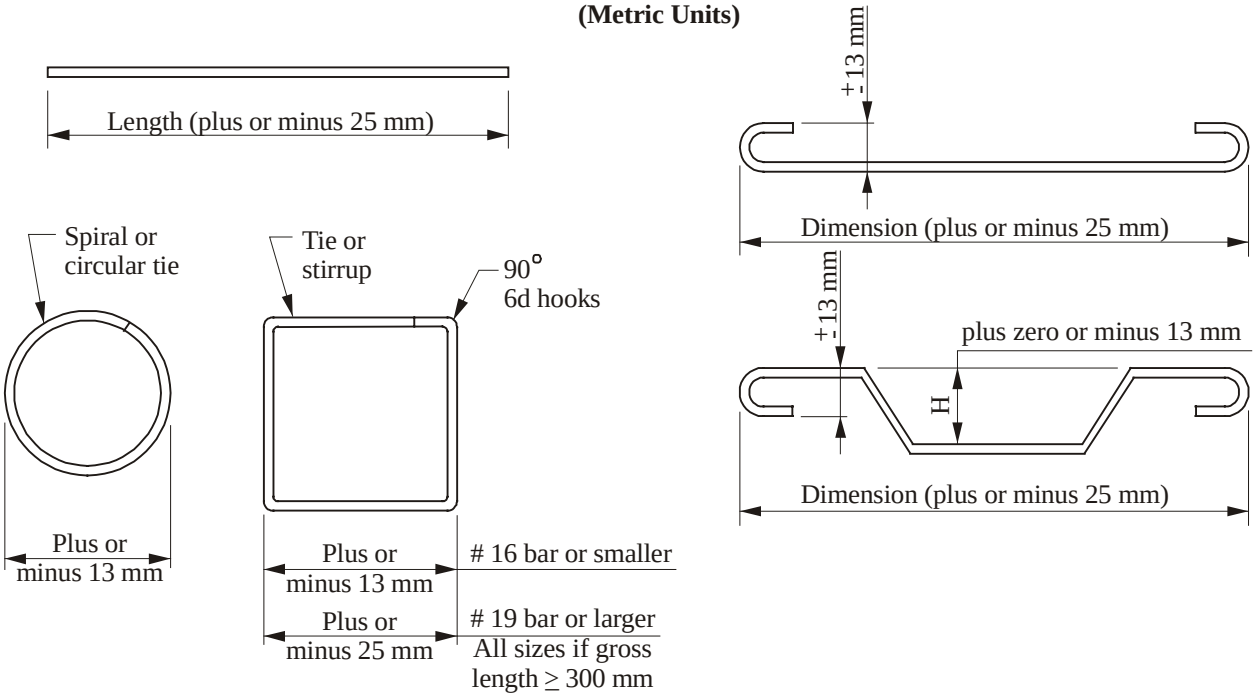


STIRRUP HOOKS (Tie Bends Similar)

*Metric information based on ASTM A615M.

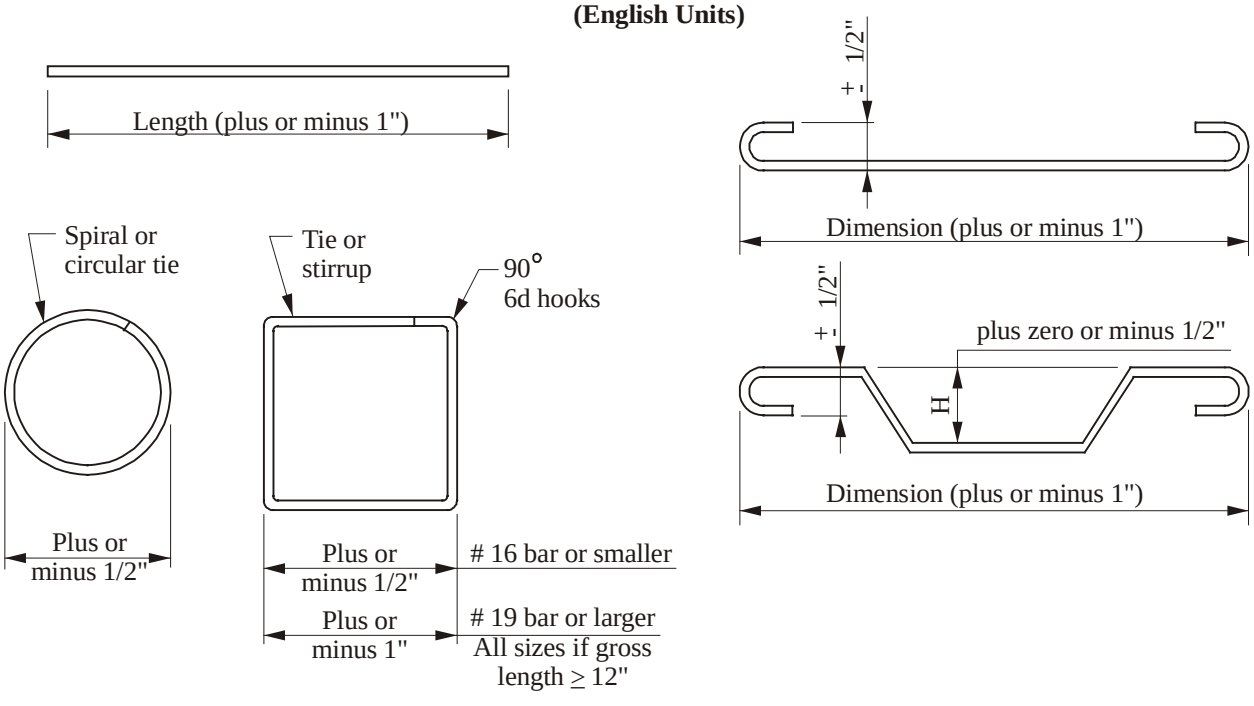
STANDARD FABRICATION - CUTTING & BENDING TOLERANCES

Bar sizes #10 through #36
(Metric Units)

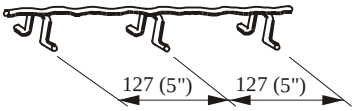
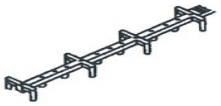
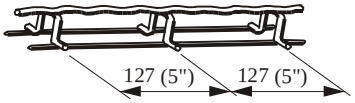
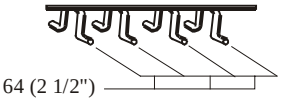
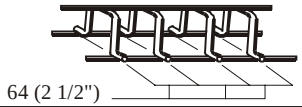
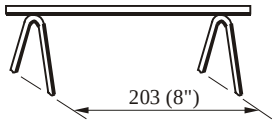
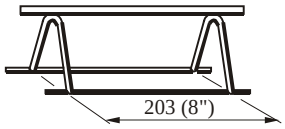
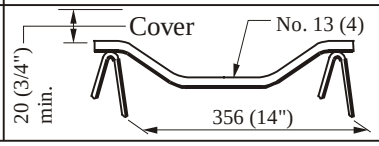


STANDARD FABRICATION - CUTTING & BENDING TOLERANCES

Bar sizes #10 through #36
(English Units)



BAR SUPPORT SPECIFICATIONS AND STANDARD NOMENCLATURE

SYMBOL	BAR SUPPORT ILLUSTRATION	TYPE OF SUPPORT	STANDARD SIZES
SB		Metal Slab Bolster (coated)	19 (3/4"), 25 (1"), 38 (1-1/2"), and 51 (2") heights in 1.5 m (5 ft) and 3 m (10 ft) lengths
SB		Slab Bolster (plastic)	Heights, 3/4 to 3 Lengths up to 32
SBU *		Slab Bolster Upper	Same as SB
BB		Beam Bolster	25 (1"), 38 (1-1/2"), 51 (2") and over 51 (2") to 127 (5") heights in increments of 6 (1/4") in lengths of 1.5 m (5 ft)
BBU *		Beam Bolster Upper	Same as BB
BC		Individual Bar Chair	19 (3/4"), 25 (1"), 38 (1-1/2") and 44 (1-3/4") heights
HC		Individual High Chair	51 (2") to 381 (15") heights in increments of 6 (1/4")
HCM *		High Chair for Metal Deck	51 (2") to 381 (15") heights in increments of 6 (1/4")
CHC		Continuous High Chair	Same as HC in 1.5 m (5 ft) and 3 m (10 ft) lengths
CHCU *		Continuous High Chair Upper	Same as CHC
CHCM *		Continuous High Chair for Metal Deck	Up to 127 (5") heights in increments of 6 (1/4")
JCU **		Joist Chair Upper	356 (14") Span Heights - 25 (1") thru +89 (3-1/2") vary in 6 (1/4") increments

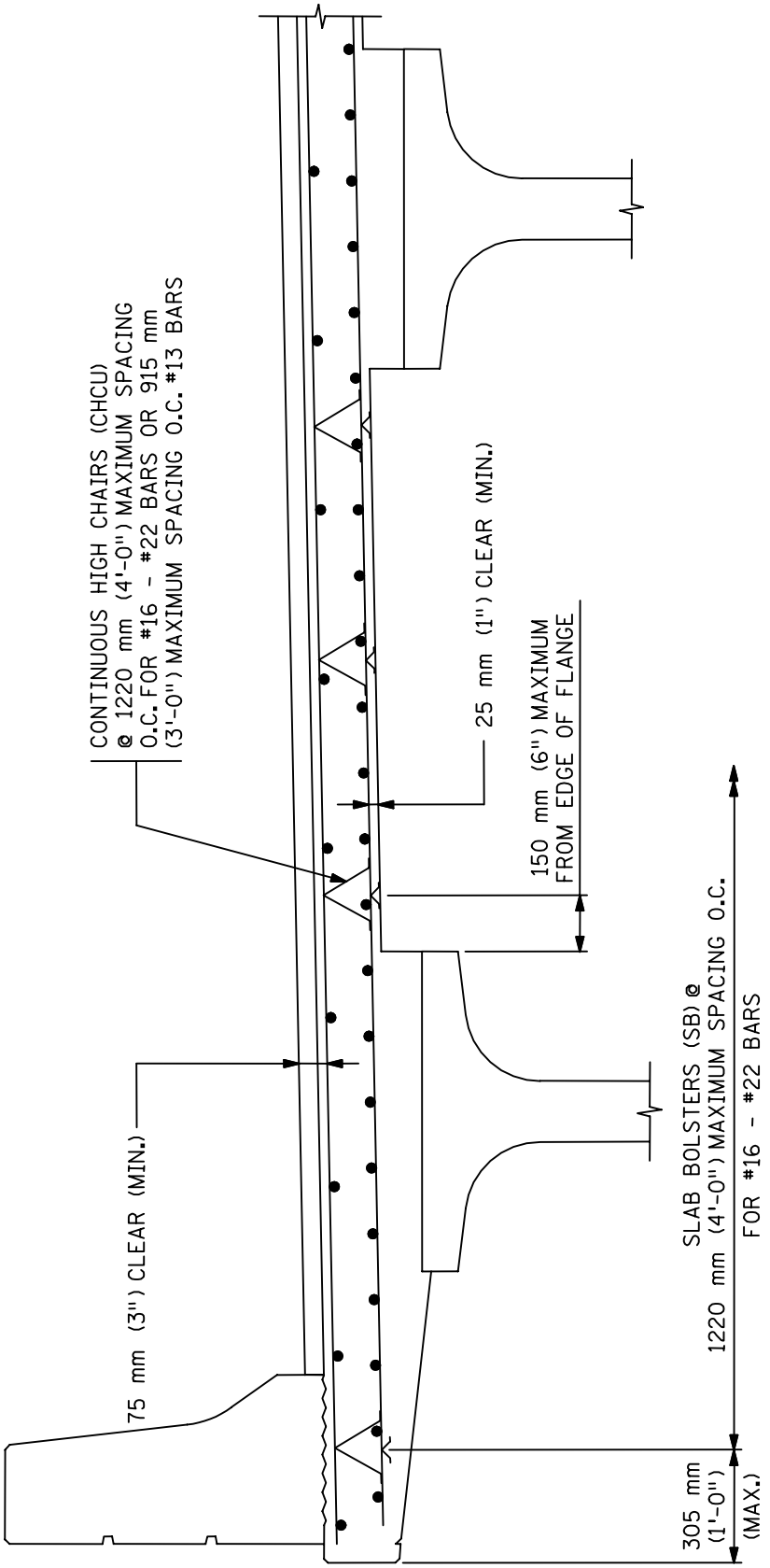
NOTES:

Class 1 are plastic protected; Class 2 are stainless steel; Class 3 are unprotected cold drawn steel wire.

* Available in Class 3 only, except on special order.

** Available in Class 3 only, with upturned or end bearing legs.

All dimensions shown in mm unless otherwise stated.



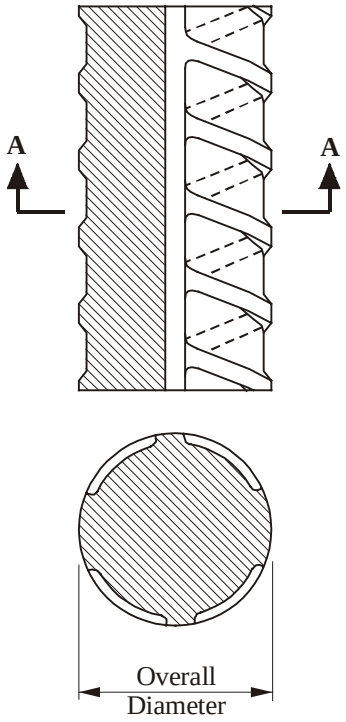
SUPPORT SYSTEM FOR DECK SLAB REINFORCEMENT

FIGURE E 5-393.261

REINFORCING BAR DIAMETERS

Diameters of deformed bars are nominal, with the actual overall diameters being somewhat greater than the nominal diameter. The overall diameter may be important when selecting the size of members of the bar support system, or when allowing for the minimum cover requirements. Approximately 2 mm for #10, #13 & #16 bars (1/16" for #3, #4 & #5 bars); 3 mm for #19, #22, #25 & #29 bars (1/8" for #6, #7, #8 & #9 bars); 5 mm for #32, #36 & #43 bars (3/16" for #10, #11 & #14 bars) and 6 mm for #57 bars (1/4" for #18 bars) should be added to the nominal bar diameter for the height of the deformations.

Metric Bar Size	Inch-pound Bar Size	Nom. Dia. (mm)	Approx. Dia. of Outside Deformations (mm)
#10	#3	10	11
#13	#4	13	14
#16	#5	16	17
#19	#6	19	22
#22	#7	22	25
#25	#8	25	29
#29	#9	29	32
#32	#10	32	37
#36	#11	35	41
#43	#14	44	48
#57	#18	57	64



Section A-A

ASTM STANDARD REINFORCING BARS							
Metric Bar Size	Inch-pound Bar Size	Nominal Mass, kg/m Nominal Weight, (lbs/ft)	Nominal Dimensions - Round Sections				
			Diameter mm	Diameter (in.)	Cross Sectional Area mm^2	Cross Sectional Area ($in.^2$)	Perimeter mm / (in.)
#10	#3	0.560 (0.376)	9.5	(0.375)	71	(0.11)	29.8 (1.178)
#13	#4	0.994 (0.668)	12.7	(0.500)	129	(0.20)	39.9 (1.571)
#16	#5	1.552 (1.043)	15.9	(0.625)	199	(0.31)	50.0 (1.963)
#19	#6	2.235 (1.502)	19.1	(0.750)	284	(0.44)	60.0 (2.356)
#22	#7	3.042 (2.044)	22.2	(0.875)	387	(0.60)	69.7 (2.749)
#25	#8	3.973 (2.670)	25.4	(1.000)	510	(0.79)	79.8 (3.142)
#29	#9	5.060 (3.400)	28.7	(1.128)	645	(1.00)	90.2 (3.544)
#32	#10	6.404 (4.303)	32.3	(1.270)	819	(1.27)	101.5 (3.990)
#36	#11	7.907 (5.313)	35.8	(1.410)	1006	(1.56)	112.5 (4.430)
#43	#14	11.38 (7.650)	43.0	(1.693)	1452	(2.25)	135.1 (5.320)
#57	#18	20.24 (13.60)	57.3	(2.257)	2581	(4.00)	180.0 (7.090)

INCHES OF LAP CORRESPONDING TO NUMBER OF BAR DIAMETERS*									
Number of Diameters	English Units								
	#10	#12	#16	#19	#22	#25	#29	#32	#36
20	----	----	13	15	18	20	23	26	29
21	----	----	14	16	19	21	24	27	30
22	----	----	14	17	20	22	25	28	31
23	----	12	15	18	21	23	26	30	33
24	----	12	15	18	21	24	27	31	34
25	----	13	16	19	22	25	29	32	36
26	----	13	17	20	23	26	30	33	37
27	----	14	17	21	24	27	31	35	38
28	----	14	18	21	25	28	32	36	40
29	----	15	19	22	26	29	33	37	41
30	12	15	19	23	27	30	34	38	43
32	12	16	20	24	28	32	36	41	46
34	13	17	22	26	30	34	39	44	48
36	14	18	23	27	32	36	41	46	51
38	15	19	24	29	34	38	43	49	54
40	15	20	25	30	35	40	45	51	57

NOTES: Minimum lap equals 12 in.
* Figured to next larger whole inch.
Lap splices not permitted for bars larger than #36.

MILLIMETERS OF LAP CORRESPONDING TO NUMBER OF BAR DIAMETERS *									
Number of Diameters	Metric Units								
	#10	#13	#16	#19	#22	#25	#29	#32	#36
20	----	----	320	390	450	510	580	650	720
21	----	----	340	400	470	540	610	680	760
22	----	----	350	420	490	560	640	710	790
23	----	310	370	440	510	590	660	750	830
24	----	310	390	460	540	610	690	780	860
25	----	320	400	480	560	640	720	810	900
26	----	330	420	500	580	660	750	840	930
27	----	350	430	520	600	690	780	880	970
28	----	360	450	540	630	720	810	910	1010
29	----	370	470	560	650	740	840	940	1040
30	310	390	480	580	670	770	870	970	1080
32	310	410	510	620	710	820	920	1040	1150
34	330	440	540	650	760	870	980	1100	1220
36	350	460	580	690	800	920	1040	1170	1290
38	360	490	610	730	850	970	1090	1230	1360
40	380	510	640	770	890	1020	1150	1300	1440

NOTES: Minimum lap equals 310 mm
* Figured to next larger ten millimeters.
Lap splices not permitted for bars larger than #36.

STANDARD STEEL WIRE GAUGES AND DIFFERENT SIZES OF WIRE

Diameter (inches)	A S & W (gauge)	Diameter mm (inches)	Area mm^2 ($in.^2$)	Mass (weight) kg/m (lbs/ft)
(1/2)	----	12.7 (.5000)	126.7 (.19635)	.9943 (.6668)
----	7/0	12.4 (.4900)	121.7 (.18857)	.9549 (.6404)
(15/32)	----	11.9 (.46875)	111.3 (.17257)	.8739 (.5861)
----	6/0	11.7 (.4615)	107.9 (.16728)	.8471 (.5681)
(7/16)	----	11.1 (.4375)	97.0 (.15033)	.7613 (.5105)
----	5/0	10.9 (.4305)	93.9 (.14556)	.7371 (.4943)
(13/32)	----	10.3 (.40625)	83.6 (.12962)	.6564 (.4402)
----	4/0	10.0 (.3938)	78.6 (.12180)	.6168 (.4136)
(3/8)	----	9.5 (.3750)	71.3 (.11045)	.5593 (.3751)
----	3/0	9.2 (.3625)	66.6 (.10321)	.5226 (.3505)
(11/32)	----	8.7 (.34375)	59.9 (.092806)	.4700 (.3152)
----	2/0	8.4 (.3310)	55.5 (.086049)	.4357 (.2922)
(5/16)	----	7.9 (.3125)	49.5 (.076699)	.3884 (.2605)
----	0	7.8 (.3065)	47.6 (.073782)	.3736 (.2506)
----	1	7.2 (.2830)	40.6 (.062902)	.3185 (.2136)
(9/32)	----	7.1 (.28125)	40.1 (.062126)	.3146 (.2110)
----	2	6.7 (.2625)	34.9 (.054119)	.2741 (.1823)
(1/4)	----	6.4 (.2500)	31.7 (.049087)	.2486 (.1667)
----	3	6.2 (.2437)	30.1 (.046645)	.2362 (.1584)
----	4	5.7 (.2253)	25.7 (.039867)	.2019 (.1354)
(7/32)	----	5.6 (.21875)	24.2 (.037583)	.1903 (.1276)
----	5	5.3 (.2070)	21.7 (.033654)	.1704 (.1143)
----	6	4.9 (.1920)	18.7 (.028953)	.1466 (.09832)
(3/16)	----	4.8 (.1875)	17.8 (.027612)	.1398 (.09377)
----	7	4.5 (.1770)	15.9 (.024606)	.1246 (.08356)
----	8	4.1 (.1620)	13.3 (.020612)	.1044 (.07000)
(5/32)	----	4.0 (.15625)	12.4 (.019175)	.0971 (.06512)
----	9	3.8 (.1483)	11.1 (.017273)	.0875 (.05866)
----	10	3.4 (.1350)	9.2 (.014314)	.0725 (.04861)
(1/8)	----	3.2 (.125)	7.9 (.012272)	.0621 (.04168)
----	11	3.1 (.1205)	7.4 (.011404)	.0577 (.03873)
----	12	2.7 (.1055)	5.6 (.0087147)	.0443 (.02969)

Weight of Spiral Reinforcement

O.D. SPIRAL (in)	WEIGHTS IN POUNDS PER FOOT OF HEIGHT			
	3/8" DIA. ROD		1/2" DIA. ROD	
	6" PITCH (lb/ft)	F (lb)	3" PITCH (lb/ft)	F (lb)
24	4.72	7.1	16.79	12.60
26	5.12	7.7	18.19	13.65
28	5.51	8.3	19.59	14.70
30	5.91	8.9	20.99	15.75
32	6.30	9.5	22.38	16.80
34	6.69	10.1	23.78	17.85
36	7.09	10.7	25.18	18.90
38	7.48	11.2	26.58	20.00
40	7.87	11.8	27.98	21.00
42	8.27	12.4	29.38	22.00
44	8.66	13.0	30.78	23.10
46	9.06	13.6	32.18	24.10
48	9.45	14.2	33.58	25.20
50	9.84	14.8	34.98	26.20
52	10.24	15.4	36.38	27.30
54	10.63	15.9	37.77	28.30
56	11.02	16.5	39.17	29.40
58	11.42	17.1	40.57	30.40
60	11.81	17.7	41.97	31.50
62	12.21	18.3	43.37	32.50
64	12.60	18.9	44.77	33.60
66	12.99	19.5	46.17	34.60
68	13.39	20.1	47.57	35.70

For more complete coverage, see *CRSI Design Handbook*.

Total weight = (wt. per ft x height) + F

F = weight to add for finishing
(this includes $1^1/_2$ turns at the top and $1^1/_2$ turns at the bottom of spiral)

For additional information see Mn/DOT 2472 and AASHTO LRFD 5.10.6.2