Safety Notes and Product Application

Dayton Superior strives to ensure that all products supplied from its manufacturing plants meet or exceed the safety requirements inherent in the proper use of its products. However, the performance of a product can be greatly affected by the manner in which the product is used. It is imperative that the user be instructed in the proper installation and use of the products displayed in this handbook prior to job application.

Product production runs are constantly sampled and tested to assure the user a high standard of quality. Samples are tested in Dayton Superior test facilities or at independent testing laboratories. The safe working loads listed in this handbook were determined from the results of the testing program and other industry sources.

Dayton Superior publishes the safe working loads and the associated minimum safety factors of its products and strongly advises that the minimum safety factors not be compromised. When there are unusual job conditions, the minimum safety factors must be increased by the user. Refer to the provisions of the American National Standards Institute (ANSI A 10.9), the Occupational Safety and Health Administration (OSHA) Act, Part 1910, and the American Concrete Institute (ACI) *Recommended Practice for Concrete Formwork* (ACI 347) and ACI 318 Building Code when considering product safety factors.

Dayton Superior Technical Services

The Dayton Superior technical departments are well staffed with trained personnel to service inquiries, take-offs and details for the users of Dayton Superior quality splicing accessories.

Eastern Technical Service Center
Telephone 800.745.3700
Fax 937.866.9768

Western Technical Service Center
Telephone 800.745.3512
Fax 562.944.2451

Chemical Technical Service Center
Telephone 800.989.2701
Fax 913.371.3332

General and Technical Information

Table 1.1 Reinforcing Bar Data

Reinforcing Bars Size Designations and Nominal Dimensions				
Bar Size Designation	Nominal Dimensions			Ultimate Minimum Capacity 1.5 f_y
	Diameter (inches)	Area (inches^2)	Weight (lbs./ft.)	pounds
#4 [#13]	0.500	0.20	0.688	18,000
#5 [#16]	0.625	0.31	1.043	27,900
#6 [#19]	0.750	0.44	1.502	39,600
#7 [#22]	0.875	0.60	2.044	54,000
#8 [#25]	1.000	0.79	2.670	71,100
#9 [#29]	1.128	1.00	3.400	90,000
#10 [#32]	1.270	1.27	4.303	114,300
#11 [#36]	1.410	1.56	5.313	140,400
#14 [#43]	1.693	2.25	7.650	202,500
#18 [#57]	2.257	4.00	13.600	360,000

*Rebar size is based on the number of eighths of an inch included in the nominal diameter of the bar.

Note: The nominal dimensions of a deformed rebar are equivalent to those of a plain, round bar having the same weight (mass) per foot (meter) as the deformed rebar.

Nearly all reinforcing bars currently produced in the USA are marked with the numbers 13, 16, etc., to designate bar sizes. These bar size numbers correspond to the traditional designations 4, 5, etc., as shown in the accompanying table.

ACI 318-02 still list the bar sizes traditionally using #3 - #18 designations. The tables in this manual are typically designated #3 [#10] or simply use the traditional designations.

Table 1.2 Mechanical Requirements For Standard ASTM Deformed Reinforcing Bars*

Type of Steel and ASTM Designation	Bar Nos. Range	Grade[1]	Minimum[2] Yield Strength, psi	Minimum Tensile Strength, psi	Minimum Percentage Elongation in 8 in.	Cool Bend Test[3] Pin Diameter (d=nominal diameter of specimen)
Billet-Steel A615	3-6	40	40,000	70,000	#3.....11 #4, #5, #6.....12	#3, #4, #5.....3-1/2d #6.....5d
	3-11, 14, 18	60	60,000	90,000	#3, #4, #5, #6.....9 #7, #8.....8 #9, #10, #11, #14, #18...7	#3, #4, #5.....3-1/2d #6, #7, #8.....5d #9, #10, #11.....7d #14, #18 (90°).....9d
	6-11, 14, 18	75	75,000	100,000	#6, #7, #8.....7 #9, #10, #11, #14, #18...6	#6, #7, #8.....5d #9, #10, #11.....7d #14, #18 (90°).....9d
Low-Alloy Steel A706	3-11, 14, 18	60	60,000[4]	80,000[5]	#3, #4, #5, #6.....14 #7, #8, #9, #10, #11....12 #14, #18.....10	#3, #4, #5.....3d #6, #7, #8.....4d #9, #10, #11.....6d #14, #18.....8d

* For the mechanical requirements of rail-steel and axle-steel bars, see ASTM specifications A616 and A617, respectively.
[1] Minimum yield designation (KSI).
[2] Yield point or yield strength. See ASTM specifications.
[3] Test bends 180°, unless noted otherwise.
[4] Maximum yield strength 78,000 psi (ASTM A706 only).
[5] Tensile Strength shall not be less than 1.25 times the actual yield strength (ASTM A706 only).

Table 1.3 Mechanical Splice ACI & ICC Code Requirements

Mechanical Splice ACI & ICC Code Requirements					
ASTM Bar Type	Bar Grade	Specified Yield, psi	Specified Ultimate, psi	Mechanical Splice Requirement - psi Type 1	Type 2
A706	60	60,000	80,000	75,000	80,000
A615	40	40,000	60,000	50,000	60,000
A615	60	60,000	90,000	75,000	90,000
A615	75	75,000	100,000	93,750	100,000

Mechanical Splice Requirement –
ACI 318 Chapters 12 and 21 state the requirements for mechanical splices. They are as follows:

Type 1 Mechanical Splice shall develop in tension and compression as required at least 125% of the specified yield of the bar.
Example: For ASTM A615 Grade 60 bar: 1.25 X 60,000psi = **75,000psi**
Therefore, a splice test exceeding 75,000 psi meets the Type 1 requirement for A615 Grade 60 ba

Type 2 Mechanical Splice shall conform to Type 1 requirements and develop 100% of the specified ultimate strength of the bar being spliced.
Example: For ASTM A615 Grade 60 bar: 1.00 X 90,000psi = **90,000psi**
Therefore, a splice test exceeding 90,000 psi meets the Type 1 and Type 2 requirement for A615 Grade 60 bar.

Table 1.4 Deformation Requirements for Standard ASTM Deformed Reinforcing Bars

Bar Size Designation	Maximum Average Spacing, in.	Maximum Average Height, in.	Maximum* Gap, in.
#3 [#10]	0.262	0.015	0.143
#4 [#13]	0.350	0.020	0.191
#5 [#16]	0.437	0.028	0.239
#6 [#19]	0.525	0.038	0.286
#7 [#22]	0.612	0.044	0.334
#8 [#25]	0.700	0.050	0.383
#9 [#29]	0.790	0.056	0.431
#10 [#32]	0.889	0.064	0.487
#11 [#36]	0.987	0.071	0.540
#14 [#43]	1.185	0.085	0.648
#18 [#57]	1.58	0.102	0.864

*Chord of 12.5% of nominal perimeter

Table 1.5 Chemical Composition Requirements for Standard ASTM Deformed Reinforcing Bars

Type of Steel and ASTM Designation	Condition*	Element									
		Carbon (C)	Manganese (Mn)	Phosphorus (P)	Sulphur (S)	Silicon (Si)	Copper (Cu)	Nickel (Ni)	Chromium (Cr)	Molybdenum (Mo)	Vanadium (V)
Billet-Steel A615	1	X	X	X	X						
	2			0.06%							
	3			0.075%							
Low-Alloy Steel A706	1	X	X	X	X	X	X	X	X	X	X
	2	0.30%	1.50%	0.035%	0.045%	0.50%					
	3	0.33%	1.56%	0.043%	0.053%	0.55%					

*CONDITION DEFINITIONS:
1. Analysis required of these elements for each heat.
2. Maximum allowable chemical content for each heat.
3. Maximum allowable chemical content for finished bar.

General and Technical Information

Table 1.6 Grade 60 Rebar

ACI Compression Development and Lap Splice Lengths for f'_c = 3,000 psi to 5,000 psi

Bar Size Designation	Compression Development Lengths per f'_c			Compression Lap Splice Length
	f'_c = 3,000 psi	f'_c = 4,000 psi	f'_c = 5,000 psi	
#3 [#10]	9	8	8	12
#4 [#13]	11	10	9	15
#5 [#16]	14	12	12	19
#6 [#19]	17	15	14	23
#7 [#22]	19	17	16	27
#8 [#25]	22	19	18	30
#9 [#29]	25	22	21	34
#10 [#32]	28	24	23	38
#11 [#36]	31	27	26	43
#14 [#43]	37	32	31	N/A
#18 [#57]	50	43	41	N/A

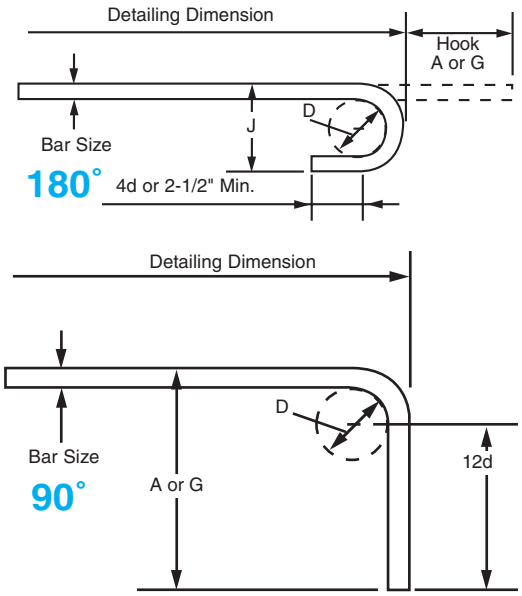
Notes:

1. Tabulated values are based on Grade 60 reinforcing bars and normal-weight concrete.
2. Compression development lengths and compression lap splice lengths are based on ACI 318-02, Sections 12.3 and 12.16, respectively. Lengths are in inches.
3. For compression development lengths, if bars are enclosed in spirals or ties conforming to ACI 318-02, Section 12.3.3(b), then a modification factor of 0.75 may be applied but the resulting length must not be less than 8 in.
4. For compression lap splice lengths:
   a. If bars are enclosed in a tied-reinforced compression member convorming to ACI 318-02, Section 12.17.2.4, then a modification factor of 0.83 may be applied but the resulting length must not be less than 12 in.
   b. If bars are enclosed in a spirally-reinforced compression member conforming to ACI 318-02, Section 12.17.2.5, then a modification factor of 0.75 may be applied but the resulting length must not be less than 12 in.
   c. The tabulated lengths are applicable for all concrete strengths of at least 3,000 psi.
5. ACI 318-02 does not allow lap splices of #14 [#43] and #18 [#57] bars.

Table 1.7 Recommended End Hooks

All Grades: D = Finished bend diameter

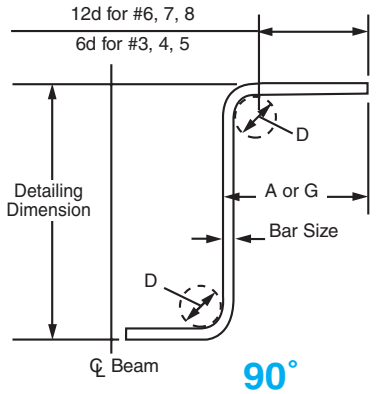
Bar Size	D (in.)	180° Hooks		90° Hooks
		A or G	J	A or G
#3 [#10]	2-1/4"	5"	3"	6"
#4 [#13]	3"	6"	4"	8"
#5 [#16]	3-3/4"	7"	5"	10"
#6 [#19]	4-1/2"	8"	6"	1'–0"
#7 [#22]	5-1/4"	10"	7"	1'–2"
#8 [#25]	6"	11"	8"	1'–4"
#9 [#29]	9-1/2"	1'–3"	11-3/4"	1'–7"
#10 [#32]	10-3/4"	1'–5"	1'–1-1/4"	1'–10"
#11 [#36]	12"	1'–7"	1'–2-3/4"	2'–0"
#14 [#43]	18-1/4"	2'–3"	1'–9-3/4"	2'–7"
#18 [#57]	24"	3'–0"	2'–4-1/2"	3'–5"



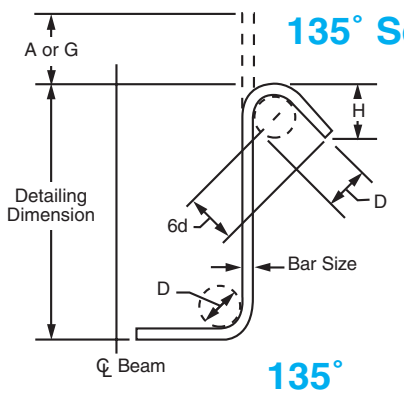
General and Technical Information

DAYTON SUPERIOR

Recommended Industry Practice for Stirrup and Tie Hooks

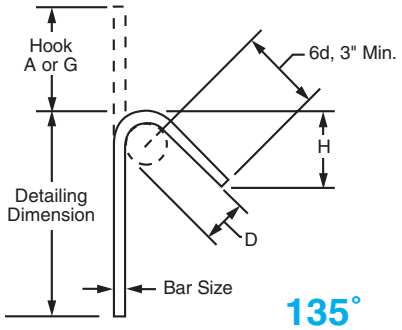


90°



135°

135° Seismic Stirrup/Tie Hooks



135°

Table 1.8 Stirrup (Ties Similar)

Stirrup and Tie Hook Dimensions All Grades:

Bar Size	D	90°	135°	
		A or G	A or G	H*
#3 [#10]	1-1/2"	4"	4"	2-1/2"
#4 [#13]	2"	4-1/2"	4-1/2"	3"
#5 [#16]	2-1/2"	6"	5-1/2"	3-3/4"
#6 [#19]	4-1/2"	1'-0"	8"	4-1/2"
#7 [#22]	5-1/4"	1'-2"	9"	5-1/4"
#8 [#25]	6"	1'-4"	10-1/2"	6"

*H dimension is approximate.

Table 1.9 135° Seismic Stirrup/Tie

Hook Dimensions All Grades:
Seismic Stirrup/Tie Hooks

Bar Size	135° Seismic Hook		
	D	A or G	H*
#3 [#10]	1-1/2"	4-1/4"	3"
#4 [#13]	2"	4-1/2"	3"
#5 [#16]	2-1/2"	5-1/2"	3-3/4"
#6 [#19]	4-1/2"	8"	4-1/2"
#7 [#22]	5-1/4"	9"	5-1/4"
#8 [#25]	6"	10-1/2"	6"

*H dimension is approximate.

Development ℓ_{dh} of Standard Hooks

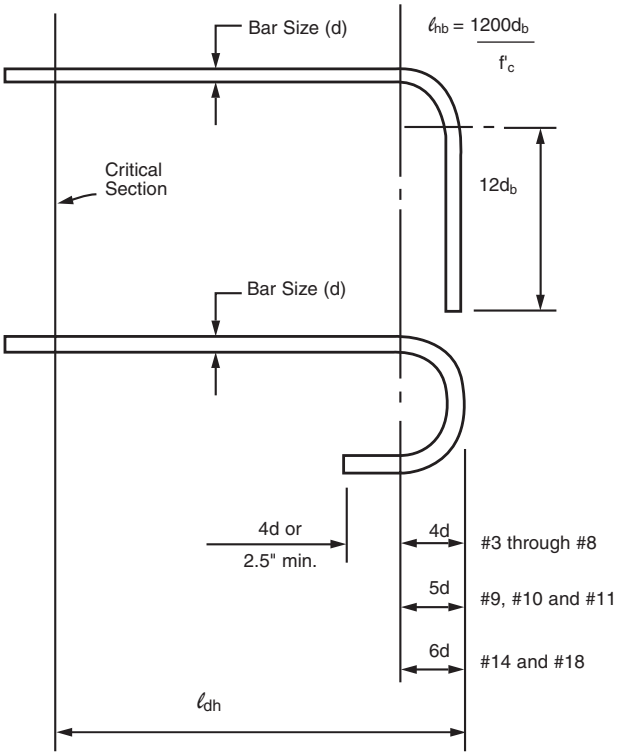


Table 1.10 ACI Hook Development Lengths for f'_c = 3,000 to 5,000 psi

Bar Size	f'_c = 3,000 psi	f'_c = 4,000 psi	f'_c = 5,000 psi
#3 [#10]	9	7	7
#4 [#13]	11	10	9
#5 [#16]	14	12	11
#6 [#19]	17	15	13
#7 [#22]	19	17	15
#8 [#25]	22	19	17
#9 [#29]	25	22	19
#10 [#32]	28	24	22
#11 [#36]	31	27	24
#14 [#43]	37	32	29
#18 [#57]	50	43	39

Notes:

1. Tabulated values are based on Grade 60 reinforcing bars and normal-weight concrete.
2. Tension development lengths of standard hooks are based on ACI 318-02, Section 12.5. Lengths are in inches.
3. For bar sizes #3 [#10] through #11 [#36] only:
   a. If concrete cover conforms to ACI 318-02, Section 12.5.3(a), then a modification factor of 0.7 may be applied but the resulting length must not be less than $8d_b$ nor 6 in.
   b. If hook is enclosed in ties or stirrups conforming to ACI 318-02, Section 12.5.3(b), then a modification factor of 0.8 may be applied but the resulting length must not be less than $8d_b$ nor 6 in.
4. For epoxy-coated hooks, multiply the tabulated values by 1.2.

Table 1.11 Tension Lap Splice Lengths – Grade 60 Uncoated Bars

f'_c = 3,000 psi or greater, Normal Weight Concrete

DESIGN AND DETAILING DATA – ACI ACI Tension Lap Splice Lengths for f'_c =3,000, 4,000, and 5,000 psi

Bar Size	Lap Class	f'_c = 3,000 psi				f'_c = 4,000 psi				f'_c = 5,000 psi			
		Top Bars		Other Bars		Top Bars		Other Bars		Top Bars		Other Bars	
		Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
#3 [#10]	A	22	32	17	25	19	28	15	22	17	25	13	19
	B	28	42	22	32	24	36	19	28	22	33	17	25
#4 [#13]	A	29	43	22	33	25	37	19	29	22	33	17	26
	B	37	56	29	43	32	48	25	37	29	43	22	33
#5 [#16]	A	36	54	28	41	31	47	24	36	28	42	22	32
	B	47	70	36	54	40	60	31	47	36	54	28	42
#6 [#19]	A	43	64	33	50	37	56	29	43	33	50	26	38
	B	56	84	43	64	48	72	37	56	43	65	33	50
#7 [#22]	A	63	94	48	72	54	81	42	63	49	73	37	56
	B	81	122	63	94	70	106	54	81	63	94	49	73
#8 [#25]	A	72	107	55	82	62	93	48	72	55	83	43	64
	B	93	139	72	107	80	121	62	93	72	108	55	83
#9 [#29]	A	81	121	62	93	70	105	54	81	63	94	48	72
	B	105	157	81	121	91	136	70	105	81	122	63	94
#10 [#32]	A	91	136	70	105	79	118	61	91	70	105	54	81
	B	118	177	91	136	102	153	79	118	91	137	70	105
#11 [#36]	A	101	151	78	116	87	131	67	101	78	117	60	90
	B	131	196	101	151	113	170	87	131	101	152	78	117
#14 [#43]	N/A	121	181	93	139	105	157	81	121	94	140	72	108
#18 [#57]	N/A	161	241	124	186	139	209	107	161	125	187	96	144

Notes:

1. Tabulated values are based on Grade 60 reinforcing bars and normal-weight concrete.

2. Tension development lengths and tension lap splice lengths are based on ACI 318-02, Sections 12.2.2 and 12.15, respectively. Tabulated values for beams or columns are based on transverse reinforcement and concrete cover meeting minimum Code requirements. Lengths are in inches.

3. Cases 1 and 2, which depend on the type of structural element, concrete cover, and the center-to-center spacing of the bars, are defined as:

Beams or Columns	Case 1	Cover at least 1d_b and c.-c. spacing at least 2d_b
	Case 2	Cover less than 1d_b or c.-c. spacing less than 2d_b
All Others	Case 1	Cover at least 1d_b and c.-c. spacing at least 3d_b
	Case 2	Cover less than 1d_b or c.-c. spacing less than 3d_b

4. Lap Class A values are the required tension development lengths, ℓ_d; lap splice lengths are multiples of tension development lengths; Class A - 1.0ℓ_d and Class B = 1.3ℓ_d (ACE 318-02, Section 12.15.1).

5. Lap splices of #14 [#43] or #18 [#57] bars are not permitted. The tabulated values for those bar sizes are the tension development lengths.

6. Top bars are horizontal bars with more than 12 inches of concrete cast below the bars.

7. For lightweight aggregate concrete, multiply the tabulated values by 1.3; or when f_{ct} is specified, the factor is $6.7\sqrt{f'_c}/f_{ct} \geq 1.0$.

8. For epoxy-coated bars, multiply the tabulated values by one of the following factors:

Concrete Cover and Spacing	Top Bars	Other Bars
Cover < 3d_b or c.-c. spacing > 7d_b	1.7 / 1.3 - 1.31	1.50
Cover ≤ 3d_b or c.-c. spacing ≤ 7d_b	1.20	1.20

Table 1.11 Metric Conversion Factors

Quantity	To Convert From…	To…	Multiply By…
Length	mile yard foot foot inch	km m m mm mm	1.609 344* 0.9144* 0.3048* 304.8* 25.4*
Area	square mile acre acre square yard square foot square inch	km^2 m^2 ha m^2 m^2 mm^2	2.589 998 4046.873 0.404 687 3 0.836 127 4* 0.092 903 04* 645.16*
Volume	acre foot cubic yard cubic foot cubic foot cubic foot 100 board feet gallon cubic inch cubic inch	m^3 m^3 m^3 cm^3 L m^3 L cm^3 mm^3	1233.489 0.764 554 9 0.028 316 85 28 316.85 28.316 85 0.235 973 7 3.785 412 16.387 06 16 387.06
Mass	pound ton (2,000 pounds) kip	kg kg t	0.453 592 4 907.184 7 0.453 592 4
Mass/ Unit Length	pound/foot	kg/m	1.488 164
Mass/Unit Area	$pound/foot^2$	kg/m^2	4.882 428
Mass Density	$pound/foot^3$	kg/m^3	16.018 46
Force	pound kip	N kN	4.448 222 4.448 222
Force/ Unit Length	pound/foot kip/foot	N/m kN/m	14.593 90 14.593 90
Pressure, Stress	$pound/foot^2$ $kip/foot^2$ $pound/inch^2$ $kip/inch^2$ $pound/inch^2$ $kip/inch^2$	Pa kPa kPa MPa N/mm^2 N/mm^2	47.880 26 47.880 26 6.894 757 6.894 757 0.006 895 6.894 757
Moment, Torque	foot-pound foot-kip	N•m kN•m	1.355 818 1.355 818
Moment of Mass	pound-foot	kg•m	0.138 255 0
Moment of Inertia	$pound\text{-}foot^2$	$kg•m^2$	0.042 140 11
Second Moment of Inertia	$inch^4$	mm^4	416 231.4
Section Modulus	$inch^3$	mm^3	16 387.06
Temperature	˚F	˚C	(˚F-32)5/9
Plane Angle	degree	rad	0.017 453 29

Note: Asterisk denotes exact number.