

Reinforcing Steel Data

**BridgeSight Solutions™
for the
AASHTO LRFD Bridge Design Specifications**

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<p>Abstract</p> <p>This installment of the BridgeSight Solutions™ Series is a design aid for reinforcing steel detailing. This design aid contains lookup tables for reinforcing steel data including bar properties, development lengths, and splice lengths.</p>			
<p>Notes</p> <p>10/10/99 - Updated development lengths for epoxy coated non-top bars.</p>			
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Introduction

This installment of the BridgeSight Solutions™ Series is a design aid for reinforcing steel detailing. This design aid contains lookup tables for reinforcing steel data including bar properties, development lengths, and splice lengths.

For convenience, the tabulated bar properties are organized first by the system of units (SI or Traditional US Units) and secondly by the LRFD article number.

This design aid is part of the BridgeSight Solutions™ series. The BridgeSight Solutions™ series is comprised of design aids and design examples to assist practicing engineers and engineering students learn and implement the AASHTO LRFD Bridge Design Specification. Visit the BridgeSight Solutions™ section of our web site at www.BridgeSight.com for more information.

General Data

Reinforcing Steel Specifications

AASHTO LRFD Bridge Construction Specification, Article 9.2.1

Uncoated Reinforcing

Description	AASHTO Designation	ASTM Designation
Deformed and Plain Billet Steel Bars for Concrete Reinforcing	M 31	A 615
Rail-Steel Deformed and Plain Bars for Concrete Reinforcing	M 42 including Supplementary Requirement S1	A 616 including Supplementary Requirement S1
Low Allow Steel Deformed Bars for Concrete Reinforcement		A 706

Epoxy-Coated Reinforcing

AASHTO LRFD Bridge Construction Specification, Article 9.2.2

When epoxy coating of reinforcing bars is required the coating materials and process, the fabrication, handling, identification of steel, and the repair of any damaged coating material that occurs during fabrication and handling shall conform to the requirements of AASHTO M 284 (ASTM D 3963).

Reinforcing Bar Properties

Bar Size No.	Nominal Mass kg/m	Nominal Diameter mm	Nominal Area mm ²	Bar Size No.	Nominal Weight lb/ft	Nominal Diameter in	Nominal Area in ²
10	0.560	9.5	71	3	0.376	0.375	0.11
13	0.994	12.7	129	4	0.668	0.500	0.20
16	1.552	15.9	199	5	1.043	0.625	0.31
19	2.235	19.1	284	6	1.502	0.750	0.44
22	3.042	22.2	387	7	2.044	0.875	0.60
25	3.973	25.4	510	8	2.670	1.000	0.79
29	5.060	28.7	645	9	3.400	1.128	1.00
32	6.404	32.3	819	10	4.303	1.270	1.27
36	7.907	35.8	1006	11	5.313	1.410	1.56
43	11.380	43.0	1452	14	7.650	1.693	2.25
57	20.240	57.3	2581	18	13.600	2.257	4.00

SI Units

Areas for Various Number of Bars and Sizes SI (mm²)

# Bars	Bar Designation										
	10	13	16	19	22	25	29	32	36	43	57
1	71	128	199	284	387	510	645	819	1006	1452	2581
2	142	256	398	568	774	1020	1290	1638	2012	2904	5162
3	213	384	597	852	1161	1530	1935	2457	3018	4356	7743
4	284	512	796	1136	1548	2040	2580	3276	4024	5808	10324
5	355	640	995	1420	1935	2550	3225	4095	5030	7260	12905
6	426	768	1194	1704	2322	3060	3870	4914	6036	8712	15486
7	497	896	1393	1988	2709	3570	4515	5733	7042	10164	18067
8	568	1024	1592	2272	3096	4080	5160	6552	8048	11616	20648
9	639	1152	1791	2556	3483	4590	5805	7371	9054	13068	23229
10	710	1280	1990	2840	3870	5100	6450	8190	10060	14520	25810
11	781	1408	2189	3124	4257	5610	7095	9009	11066	15972	28391
12	852	1536	2388	3408	4644	6120	7740	9828	12072	17424	30972
13	923	1664	2587	3692	5031	6630	8385	10647	13078	18876	33553
14	994	1792	2786	3976	5418	7140	9030	11466	14084	20328	36134
15	1065	1920	2985	4260	5805	7650	9675	12285	15090	21780	38715
16	1136	2048	3184	4544	6192	8160	10320	13104	16096	23232	41296
17	1207	2176	3383	4828	6579	8670	10965	13923	17102	24684	43877
18	1278	2304	3582	5112	6966	9180	11610	14742	18108	26136	46458
19	1349	2432	3781	5396	7353	9690	12255	15561	19114	27588	49039
20	1420	2560	3980	5680	7740	10200	12900	16380	20120	29040	51620
21	1491	2688	4179	5964	8127	10710	13545	17199	21126	30492	54201
22	1562	2816	4378	6248	8514	11220	14190	18018	22132	31944	56782
23	1633	2944	4577	6532	8901	11730	14835	18837	23138	33396	59363
24	1704	3072	4776	6816	9288	12240	15480	19656	24144	34848	61944
25	1775	3200	4975	7100	9675	12750	16125	20475	25150	36300	64525
26	1846	3328	5174	7384	10062	13260	16770	21294	26156	37752	67106
27	1917	3456	5373	7668	10449	13770	17415	22113	27162	39204	69687
28	1988	3584	5572	7952	10836	14280	18060	22932	28168	40656	72268
29	2059	3712	5771	8236	11223	14790	18705	23751	29174	42108	74849
30	2130	3840	5970	8520	11610	15300	19350	24570	30180	43560	77430

Deformed Bars In Tension - Article 5.11.2.1

Notes

1. Reinforcement is Grade 420
2. Top bars are horizontal bars so placed that more than 300 mm of fresh concrete is cast in the member below the bar
3. Double l_d if cover is not more than d_b or clear spacing is not more than $2d_b$.
4. For epoxy coated bars with cover less than $3d_b$ or with clear spacing less than $6d_b$, multiply l_d by 1.5
5. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required})/(A_s \text{ provided})$
6. Development lengths have been rounded up to the next highest 25 mm

Uncoated Straight Bars

Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5 \text{ MPa}$		$f'_c = 34.5 \text{ MPa}$		$f'_c = 41.5 \text{ MPa}$		$f'_c = 48 \text{ MPa}$	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	350	300	350	300	350	300	350	300
13	450	325	450	325	450	325	450	325
16	575	425	575	425	575	425	575	425
19	675	500	675	500	675	500	675	500
22	875	625	800	575	800	575	800	575
25	1150	825	1025	750	950	675	900	650
29	1450	1050	1300	925	1200	850	1100	800
32	1850	1325	1650	1175	1500	1075	1400	1000
36	2275	1625	2025	1450	1850	1325	1725	1225
43	2825	2025	2525	1800	2300	1650	2125	1525
57	3825	2725	3425	2450	3125	2225	2900	2075

Uncoated Straight Bars

Center-to-center spacing $\geq 150 \text{ mm}$ and clear cover $\geq 75 \text{ mm}$

Concrete	$f'_c = 27.5 \text{ MPa}$		$f'_c = 34.5 \text{ MPa}$		$f'_c = 41.5 \text{ MPa}$		$f'_c = 48 \text{ MPa}$	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	300	300	300	300	300	300	300	300
13	375	300	375	300	375	300	375	300
16	450	325	450	325	450	325	450	325
19	550	400	550	400	550	400	550	400
22	700	500	650	450	650	450	650	450
25	925	675	825	600	750	550	725	525
29	1175	850	1050	750	950	675	900	650
32	1475	1050	1325	950	1200	875	1125	800
36	1825	1300	1625	1175	1475	1050	1375	1000
43	2250	1625	2025	1450	1850	1325	1700	1225
57	3050	2200	2725	1950	2500	1775	2325	1650

Epoxy Coated Straight Bars

Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	425	300	425	300	425	300	425	300
13	550	400	550	400	550	400	550	400
16	675	500	675	500	675	500	675	500
19	825	600	825	600	825	600	825	600
22	1050	750	950	675	950	675	950	675
25	1375	1000	1250	900	1125	800	1100	775
29	1750	1250	1550	1125	1425	1025	1325	950
32	2225	1575	1975	1425	1800	1300	1675	1200
36	2725	1950	2425	1750	2225	1575	2050	1475
43	3375	2425	3025	2150	2750	1975	2550	1825
57	4575	3275	4100	2925	3725	2675	3475	2475

Epoxy Coated Straight Bars

Center-to-center spacing ³ 150 mm and clear cover ³ 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	325	300	325	300	325	300	325	300
13	450	325	450	325	450	325	450	325
16	550	400	550	400	550	400	550	400
19	650	475	650	475	650	475	650	475
22	850	600	775	550	775	550	775	550
25	1100	800	1000	725	900	650	875	625
29	1400	1000	1250	900	1150	825	1075	775
32	1775	1275	1575	1125	1450	1050	1350	975
36	2175	1550	1950	1400	1775	1275	1650	1175
43	2700	1925	2425	1725	2200	1575	2050	1475
57	3675	2625	3275	2350	3000	2150	2775	2000

Deformed Bars In Compression - Article 5.11.2.2

Notes

1. Reinforcement is Grade 420
2. Reinforcement is enclosed with a spiral composed of a bar of not less than 6mm in diameter and spaced at not more than a 100 mm pitch.
3. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required})/(A_s \text{ provided})$
4. Development lengths have been rounded up to the next highest 25 mm

Compression Development Lengths of Straight Bars

Concrete	$f'_c = 27.5 \text{ MPa}$		$f'_c = 34.5 \text{ MPa}$		$f'_c = 41.5 \text{ MPa}$		$f'_c = 48 \text{ MPa}$	
	Development Length, l_d (mm)							
Bar Size	Enclosed in Spiral	Others	Enclosed in Spiral	Others	Enclosed in Spiral	Others	Enclosed in Spiral	Others
10	200	200	200	200	200	200	200	200
13	200	250	200	250	200	250	200	250
16	250	325	225	300	225	300	225	300
19	300	375	275	375	275	375	275	375
22	325	450	325	425	325	425	325	425
25	375	500	375	475	375	475	375	475
29	425	575	400	550	400	550	400	550
32	475	625	450	600	450	600	450	600
36	525	700	500	675	500	675	500	675
43	625	850	600	800	600	800	600	800
57	850	1125	800	1075	800	1075	800	1075

Standard Hooks In Tension - Article 5.11.2.4

Notes

1. Reinforcement is Grade 420
2. Hook cover is, for a 90° hook, cover on the bar extension beyond the hook.
3. Special confinement is when the hook is enclosed vertically or horizontally within ties or stirrups which are spaced along the full development length, l_{dh} , at a spacing not exceeded $3d_b$.
4. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required})/(A_s \text{ provided})$
5. Development lengths have been rounded up to the next highest 25 mm
6. At discontinuous ends with special confinement, divide l_d by 0.8 (See LRFD 5.11.2.4.3)

Uncoated Standard 90° or 180° Hooks

Concrete	$f'_c = 27.5 \text{ Mpa}$			$f'_c = 34.5 \text{ Mpa}$		
	Development Length, l_d (mm)					
Bar Size	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm
10	200	150	150	175	150	150
13	250	175	150	225	175	150
16	325	225	175	275	200	175
19	375	275	225	350	250	200
22	425	300	250	400	275	225
25	500	350	275	450	325	250
29	550	400	325	500	350	275
32	625	450	350	550	400	325
36	700	700	700	625	625	625
43	825	825	825	750	750	750
57	1100	1100	1100	1000	1000	1000
Concrete	$f'_c = 41.5 \text{ Mpa}$			$f'_c = 48 \text{ Mpa}$		
	Development Length, l_d (mm)					
Bar Size	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm
10	150	150	150	150	150	150
13	200	150	150	200	150	150
16	250	175	150	250	175	150
19	300	225	175	300	200	175
22	350	250	200	325	225	200
25	400	300	225	375	275	225
29	450	325	250	425	300	250
32	525	375	300	475	350	275
36	575	575	575	525	525	525
43	675	675	675	625	625	625
57	900	900	900	850	850	850

Epoxy Coated Standard 90° or 180° Hooks

Concrete	$f'_c = 27.5 \text{ Mpa}$			$f'_c = 34.5 \text{ MPa}$		
	Development Length, l_d (mm)					
Bar Size	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm
10	225	175	150	200	150	150
13	300	225	175	275	200	150
16	375	275	225	325	250	200
19	450	325	250	400	275	225
22	525	375	300	475	325	275
25	600	425	350	525	375	300
29	675	475	375	600	425	350
32	750	525	425	675	475	375
36	700	700	700	625	625	625
43	825	825	825	750	750	750
57	1100	1100	1100	1000	1000	1000
Concrete	$f'_c = 41.5 \text{ Mpa}$			$f'_c = 48 \text{ MPa}$		
	Development Length, l_d (mm)					
Bar Size	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm	Side cover < 64mm and Hook cover < 50mm	Side cover \geq 64mm and Hook cover \geq 50mm	Special confinement with side cover \geq 64mm and Hook cover \geq 50mm
10	200	150	150	175	150	150
13	250	175	150	225	175	150
16	300	225	175	300	200	175
19	375	250	200	350	250	200
22	425	300	250	400	275	225
25	475	350	275	450	325	250
29	550	375	300	500	350	300
32	625	425	350	575	400	325
36	575	575	575	525	525	525
43	675	675	675	625	625	625
57	900	900	900	850	850	850

Tension Lap Splices - Article 5.11.5.3.1

Notes

1. Reinforcement is Grade 420
2. Top bars are horizontal bars so placed that more than 300 mm of fresh concrete is cast in the member below the bar
3. Double l_d if cover is not more than d_b or clear spacing is not more than $2d_b$.
4. For epoxy coated bars with cover less than $3d_b$ or with clear spacing less than $6d_b$, multiply l_d by 1.5
5. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required})/(A_s \text{ provided})$
6. Development lengths have been rounded up to the next highest 25 mm

Classes of Tension Lap Splices

Ratio of (A_s required)/(A_s provided)	Percent of A_s spliced with Required Lap Length		
	50	75	100
≥ 2	A	A	B
< 2	B	C	C

Uncoated Class A Tension Splice

Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5$ Mpa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	350	300	350	300	350	300	350	300
13	450	325	450	325	450	325	450	325
16	575	425	575	425	575	425	575	425
19	675	500	675	500	675	500	675	500
22	875	625	800	575	800	575	800	575
25	1150	825	1025	750	950	675	900	650
29	1450	1050	1300	925	1200	850	1100	800
32	1850	1325	1650	1175	1500	1075	1400	1000
36	2275	1625	2025	1450	1850	1325	1725	1225
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Uncoated Class A Tension Splice

Center-to-center spacing ≥ 150 mm and clear cover ≥ 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	300	300	300	300	300	300	300	300
13	375	300	375	300	375	300	375	300
16	450	325	450	325	450	325	450	325
19	550	400	550	400	550	400	550	400
22	700	500	650	450	650	450	650	450
25	925	675	825	600	750	550	725	525
29	1175	850	1050	750	950	675	900	650
32	1475	1050	1325	950	1200	875	1125	800
36	1825	1300	1625	1175	1475	1050	1375	1000
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class A Tension Splice
Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
Development Length, l_d (mm)								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	425	300	425	300	425	300	425	300
13	550	400	550	400	550	400	550	400
16	675	500	675	500	675	500	675	500
19	825	600	825	600	825	600	825	600
22	1050	750	950	675	950	675	950	675
25	1375	1000	1250	900	1125	800	1100	775
29	1750	1250	1550	1125	1425	1025	1325	950
32	2225	1575	1975	1425	1800	1300	1675	1200
36	2725	1950	2425	1750	2225	1575	2050	1475
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class A Tension Splice
Center-to-center spacing \geq 150 mm and clear cover \geq 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
Development Length, l_d (mm)								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	325	300	325	300	325	300	325	300
13	450	325	450	325	450	325	450	325
16	550	400	550	400	550	400	550	400
19	650	475	650	475	650	475	650	475
22	850	600	775	550	775	550	775	550
25	1100	800	1000	725	900	650	875	625
29	1400	1000	1250	900	1150	825	1075	775
32	1775	1275	1575	1125	1450	1050	1350	975
36	2175	1550	1950	1400	1775	1275	1650	1175
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Uncoated Class B Tension Splice
Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
Development Length, l_d (mm)								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	450	400	450	400	450	400	450	400
13	600	425	600	425	600	425	600	425
16	750	525	750	525	750	525	750	525
19	900	650	900	650	900	650	900	650
22	1150	825	1025	750	1025	750	1025	750
25	1500	1075	1350	950	1225	875	1175	850
29	1900	1350	1700	1200	1550	1100	1425	1025
32	2400	1725	2150	1525	1950	1400	1825	1300
36	2950	2100	2625	1875	2400	1725	2225	1600
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Uncoated Class B Tension Splice

Center-to-center spacing ³ 150 mm and clear cover ³ 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	400	400	400	400	400	400	400	400
13	475	400	475	400	475	400	475	400
16	600	425	600	425	600	425	600	425
19	725	525	725	525	725	525	725	525
22	925	650	825	600	825	600	825	600
25	1200	850	1075	775	975	700	950	675
29	1525	1075	1350	975	1225	875	1150	825
32	1925	1375	1725	1225	1575	1125	1450	1050
36	2350	1700	2100	1500	1925	1375	1800	1275
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class B Tension Splice

Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	525	400	525	400	525	400	525	400
13	700	500	700	500	700	500	700	500
16	900	650	900	650	900	650	900	650
19	1075	775	1075	775	1075	775	1075	775
22	1375	975	1225	875	1225	875	1225	875
25	1800	1275	1600	1150	1475	1050	1400	1000
29	2275	1625	2025	1450	1850	1325	1725	1225
32	2875	2050	2575	1850	2350	1675	2175	1550
36	3525	2525	3150	2250	2875	2050	2675	1925
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class B Tension Splice

Center-to-center spacing ³ 150 mm and clear cover ³ 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	425	400	425	400	425	400	425	400
13	575	400	575	400	575	400	575	400
16	725	525	725	525	725	525	725	525
19	850	625	850	625	850	625	850	625
22	1100	775	1000	700	1000	700	1000	700
25	1450	1025	1275	925	1175	850	1125	800
29	1825	1300	1625	1175	1475	1050	1375	1000
32	2300	1650	2050	1475	1875	1350	1750	1250
36	2825	2025	2525	1800	2300	1650	2150	1525
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Uncoated Class C Tension Splice
Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
Development Length, l_d (mm)								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	575	525	575	525	575	525	575	525
13	775	550	775	550	775	550	775	550
16	975	700	975	700	975	700	975	700
19	1150	825	1150	825	1150	825	1150	825
22	1500	1075	1350	975	1350	975	1350	975
25	1950	1400	1750	1250	1600	1150	1525	1100
29	2475	1775	2200	1575	2025	1450	1875	1350
32	3125	2250	2800	2000	2550	1825	2375	1700
36	3850	2750	3425	2450	3125	2250	2925	2075
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Uncoated Class C Tension Splice
Center-to-center spacing \geq 150 mm and clear cover \geq 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
Development Length, l_d (mm)								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	525	525	525	525	525	525	525	525
13	625	525	625	525	625	525	625	525
16	775	550	775	550	775	550	775	550
19	925	675	925	675	925	675	925	675
22	1200	850	1075	775	1075	775	1075	775
25	1575	1125	1400	1000	1275	925	1225	875
29	1975	1425	1775	1275	1625	1150	1500	1075
32	2500	1800	2250	1600	2050	1475	1900	1375
36	3075	2200	2750	1975	2500	1800	2325	1675
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class C Tension Splice
Center-to-center spacing < 150 mm or clear cover < 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
Development Length, l_d (mm)								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	700	525	700	525	700	525	700	525
13	925	675	925	675	925	675	925	675
16	1150	825	1150	825	1150	825	1150	825
19	1375	1000	1375	1000	1375	1000	1375	1000
22	1775	1275	1600	1150	1600	1150	1600	1150
25	2350	1675	2100	1500	1900	1375	1850	1325
29	2975	2125	2650	1900	2425	1725	2250	1600
32	3750	2700	3350	2400	3050	2200	2850	2050
36	4625	3300	4125	2950	3750	2700	3500	2500
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class C Tension Splice
Center-to-center spacing ³ 150 mm and clear cover ³ 75 mm

Concrete	$f'_c = 27.5$ MPa		$f'_c = 34.5$ MPa		$f'_c = 41.5$ MPa		$f'_c = 48$ MPa	
	Development Length, l_d (mm)							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
10	550	525	550	525	550	525	550	525
13	750	525	750	525	750	525	750	525
16	925	675	925	675	925	675	925	675
19	1100	800	1100	800	1100	800	1100	800
22	1425	1025	1300	925	1300	925	1300	925
25	1875	1350	1675	1200	1525	1100	1475	1050
29	2375	1700	2125	1525	1925	1375	1800	1300
32	3000	2150	2700	1925	2450	1750	2275	1625
36	3700	2650	3300	2350	3000	2150	2800	2000
43	Not Allowed per Article 5.11.5.2.1							
57	Not Allowed per Article 5.11.5.2.1							

Compression Lap Splices - Article 5.11.5.5

Notes

1. Where bars of different size are lap spliced in compression, the splice length shall not be less than the development length of the larger bar or the splice length of the smaller bar. Bar sizes No. 43 and No. 57 may be lapped to No. 36 and smaller bars.
2. Ties along the splice have an effective area not less than 0.15 percent of the product of the thickness of the compression component times the tie spacing.

Lap Slices in Compression

Bar Size	$f'_c < 21$ MPa	Ties	Spirals	Others
10	400	300	300	300
13	525	325	300	400
16	650	425	375	500
19	800	500	450	600
22	925	575	525	700
25	1050	650	600	800
29	1175	750	675	900
32	1325	825	750	1000
36	1475	925	825	1100
43	1775	1100	1000	1325
57	2350	1475	1325	1775

US Units

Areas for Various Number of Bars and Sizes US (in²)

# Bars	Bar Designation										
	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
1	0.11	0.20	0.31	0.44	0.60	0.79	1.00	1.27	1.56	2.25	4.00
2	0.22	0.40	0.62	0.88	1.20	1.58	2.00	2.54	3.12	4.50	8.00
3	0.33	0.60	0.93	1.32	1.80	2.37	3.00	3.81	4.68	6.75	12.00
4	0.44	0.80	1.24	1.76	2.40	3.16	4.00	5.08	6.24	9.00	16.00
5	0.55	1.00	1.55	2.20	3.00	3.95	5.00	6.35	7.80	11.25	20.00
6	0.66	1.20	1.86	2.64	3.60	4.74	6.00	7.62	9.36	13.50	24.00
7	0.77	1.40	2.17	3.08	4.20	5.53	7.00	8.89	10.92	15.75	28.00
8	0.88	1.60	2.48	3.52	4.80	6.32	8.00	10.16	12.48	18.00	32.00
9	0.99	1.80	2.79	3.96	5.40	7.11	9.00	11.43	14.04	20.25	36.00
10	1.10	2.00	3.10	4.40	6.00	7.90	10.00	12.70	15.60	22.50	40.00
11	1.21	2.20	3.41	4.84	6.60	8.69	11.00	13.97	17.16	24.75	44.00
12	1.32	2.40	3.72	5.28	7.20	9.48	12.00	15.24	18.72	27.00	48.00
13	1.43	2.60	4.03	5.72	7.80	10.27	13.00	16.51	20.28	29.25	52.00
14	1.54	2.80	4.34	6.16	8.40	11.06	14.00	17.78	21.84	31.50	56.00
15	1.65	3.00	4.65	6.60	9.00	11.85	15.00	19.05	23.40	33.75	60.00
16	1.76	3.20	4.96	7.04	9.60	12.64	16.00	20.32	24.96	36.00	64.00
17	1.87	3.40	5.27	7.48	10.20	13.43	17.00	21.59	26.52	38.25	68.00
18	1.98	3.60	5.58	7.92	10.80	14.22	18.00	22.86	28.08	40.50	72.00
19	2.09	3.80	5.89	8.36	11.40	15.01	19.00	24.13	29.64	42.75	76.00
20	2.20	4.00	6.20	8.80	12.00	15.80	20.00	25.40	31.20	45.00	80.00
21	2.31	4.20	6.51	9.24	12.60	16.59	21.00	26.67	32.76	47.25	84.00
22	2.42	4.40	6.82	9.68	13.20	17.38	22.00	27.94	34.32	49.50	88.00
23	2.53	4.60	7.13	10.12	13.80	18.17	23.00	29.21	35.88	51.75	92.00
24	2.64	4.80	7.44	10.56	14.40	18.96	24.00	30.48	37.44	54.00	96.00
25	2.75	5.00	7.75	11.00	15.00	19.75	25.00	31.75	39.00	56.25	100.00
26	2.86	5.20	8.06	11.44	15.60	20.54	26.00	33.02	40.56	58.50	104.00
27	2.97	5.40	8.37	11.88	16.20	21.33	27.00	34.29	42.12	60.75	108.00
28	3.08	5.60	8.68	12.32	16.80	22.12	28.00	35.56	43.68	63.00	112.00
29	3.19	5.80	8.99	12.76	17.40	22.91	29.00	36.83	45.24	65.25	116.00
30	3.30	6.00	9.30	13.20	18.00	23.70	30.00	38.10	46.80	67.50	120.00

Deformed Bars In Tension - Article 5.11.2.1

Notes

1. Reinforcement is Grade 60
2. Top bars are horizontal bars so placed that more than 12 IN fresh concrete is cast in the member below the bar
3. Double l_d if cover is not more than d_b or clear spacing is not more than $2d_b$.
4. For epoxy coated bars with cover less than $3d_b$ or with clear spacing less than $6d_b$, multiply l_d by 1.5
5. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required})/(A_s \text{ provided})$
6. Development lengths have been rounded up to the next highest inch

Uncoated Straight Bars

Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4 \text{ ksi}$		$f'_c = 5 \text{ ksi}$		$f'_c = 6 \text{ ksi}$		$f'_c = 7 \text{ ksi}$	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-1"	1'-0"	1'-1"	1'-0"	1'-1"	1'-0"	1'-1"	1'-0"
4	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"
5	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
6	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"
7	2'-8"	1'-11"	2'-6"	1'-9"	2'-6"	1'-9"	2'-6"	1'-9"
8	3'-6"	2'-6"	3'-1"	2'-3"	2'-10"	2'-1"	2'-10"	2'-0"
9	4'-5"	3'-2"	3'-11"	2'-10"	3'-7"	2'-7"	3'-4"	2'-5"
10	5'-7"	4'-0"	5'-0"	3'-7"	4'-7"	3'-3"	4'-3"	3'-0"
11	6'-10"	4'-11"	6'-2"	4'-5"	5'-7"	4'-0"	5'-2"	3'-9"
14	9'-6"	6'-9"	8'-6"	6'-1"	7'-9"	5'-7"	7'-2"	5'-2"
18	12'-3"	8'-9"	11'-0"	7'-10"	10'-0"	7'-2"	9'-4"	6'-8"

Uncoated Straight Bars

Center-to-center spacing \geq 6 IN and clear cover \geq 3 IN

Concrete	$f'_c = 4 \text{ ksi}$		$f'_c = 5 \text{ ksi}$		$f'_c = 6 \text{ ksi}$		$f'_c = 7 \text{ ksi}$	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
4	1'-2"	1'-0"	1'-2"	1'-0"	1'-2"	1'-0"	1'-2"	1'-0"
5	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"
6	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
7	2'-2"	1'-6"	2'-0"	1'-5"	2'-0"	1'-5"	2'-0"	1'-5"
8	2'-10"	2'-0"	2'-6"	1'-10"	2'-3"	1'-8"	2'-3"	1'-8"
9	3'-6"	2'-6"	3'-2"	2'-3"	2'-11"	2'-1"	2'-8"	1'-11"
10	4'-6"	3'-3"	4'-0"	2'-10"	3'-8"	2'-8"	3'-5"	2'-5"
11	5'-6"	3'-11"	4'-11"	3'-6"	4'-6"	3'-3"	4'-2"	3'-0"
14	7'-7"	5'-5"	6'-10"	4'-10"	6'-2"	4'-5"	5'-9"	4'-1"
18	9'-10"	7'-0"	8'-10"	6'-4"	8'-0"	5'-9"	7'-5"	5'-4"

Epoxy Coated Straight Bars

Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-4"	1'-0"	1'-4"	1'-0"	1'-4"	1'-0"	1'-4"	1'-0"
4	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
5	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"
6	2'-7"	1'-10"	2'-7"	1'-10"	2'-7"	1'-10"	2'-7"	1'-10"
7	3'-2"	2'-3"	3'-0"	2'-2"	3'-0"	2'-2"	3'-0"	2'-2"
8	4'-2"	3'-0"	3'-9"	2'-8"	3'-5"	2'-5"	3'-5"	2'-5"
9	5'-3"	3'-9"	4'-9"	3'-5"	4'-4"	3'-1"	4'-0"	2'-10"
10	6'-8"	4'-10"	6'-0"	4'-4"	5'-6"	3'-11"	5'-1"	3'-8"
11	8'-3"	5'-11"	7'-4"	5'-3"	6'-9"	4'-10"	6'-3"	4'-5"
14	11'-4"	8'-2"	10'-2"	7'-3"	9'-4"	6'-8"	8'-7"	6'-2"
18	14'-9"	10'-6"	13'-2"	9'-5"	12'-0"	8'-7"	11'-2"	8'-0"

Epoxy Coated Straight Bars

Center-to-center spacing ³ 6 IN and clear cover ³ 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
4	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"
5	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
6	2'-1"	1'-6"	2'-1"	1'-6"	2'-1"	1'-6"	2'-1"	1'-6"
7	2'-7"	1'-10"	2'-5"	1'-9"	2'-5"	1'-9"	2'-5"	1'-9"
8	3'-4"	2'-5"	3'-0"	2'-2"	2'-9"	2'-0"	2'-9"	1'-11"
9	4'-3"	3'-0"	3'-9"	2'-9"	3'-6"	2'-6"	3'-2"	2'-4"
10	5'-4"	3'-10"	4'-10"	3'-5"	4'-5"	3'-2"	4'-1"	2'-11"
11	6'-7"	4'-9"	5'-11"	4'-3"	5'-5"	3'-10"	5'-0"	3'-7"
14	9'-1"	6'-6"	8'-2"	5'-10"	7'-5"	5'-4"	6'-11"	4'-11"
18	11'-10"	8'-5"	10'-7"	7'-7"	9'-8"	6'-11"	8'-11"	6'-5"

Deformed Bars In Compression - Article 5.11.2.2

Notes

1. Reinforcement is Grade 60
2. Reinforcement is enclosed within a spiral composed of a bar of not less than 0.25-IN in diameter and spaced at not more than a 4.0-IN pitch.
3. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required}) / (A_s \text{ provided})$
4. Development lengths have been rounded up to the next highest inch

Compression Development Lengths of Straight Bars

Concrete	$f'_c = 4 \text{ ksi}$		$f'_c = 5 \text{ ksi}$		$f'_c = 6 \text{ ksi}$		$f'_c = 7 \text{ ksi}$	
	Development Length, l_d							
Bar Size	Enclosed in Spiral	Others	Enclosed in Spiral	Others	Enclosed in Spiral	Others	Enclosed in Spiral	Others
3	0'-8"	0'-8"	0'-8"	0'-8"	0'-8"	0'-8"	0'-8"	0'-8"
4	0'-8"	0'-10"	0'-8"	0'-9"	0'-8"	0'-9"	0'-8"	0'-9"
5	0'-9"	1'-0"	0'-9"	1'-0"	0'-9"	1'-0"	0'-9"	1'-0"
6	0'-11"	1'-3"	0'-11"	1'-2"	0'-11"	1'-2"	0'-11"	1'-2"
7	1'-1"	1'-5"	1'-0"	1'-4"	1'-0"	1'-4"	1'-0"	1'-4"
8	1'-3"	1'-7"	1'-2"	1'-6"	1'-2"	1'-6"	1'-2"	1'-6"
9	1'-4"	1'-10"	1'-4"	1'-9"	1'-4"	1'-9"	1'-4"	1'-9"
10	1'-6"	2'-0"	1'-6"	1'-11"	1'-6"	1'-11"	1'-6"	1'-11"
11	1'-8"	2'-3"	1'-7"	2'-2"	1'-7"	2'-2"	1'-7"	2'-2"
14	2'-0"	2'-8"	1'-11"	2'-7"	1'-11"	2'-7"	1'-11"	2'-7"
18	2'-8"	3'-7"	2'-7"	3'-5"	2'-7"	3'-5"	2'-7"	3'-5"

Standard Hooks In Tension - Article 5.11.2.4

Notes

1. Reinforcement is Grade 60
2. Hook cover is, for a 90° hook, cover on the bar extension beyond the hook.
3. Special confinement is when the hook is enclosed vertically or horizontally within ties or stirrups which are spaced along the full development length, l_{dh} , at a spacing not exceeded $3d_b$.
4. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required})/(A_s \text{ provided})$
5. Development lengths have been rounded up to the next highest inch
6. At discontinuous ends with special confinement, divide l_d by 0.8 (See LRFD 5.11.2.4.3)

Uncoated Standard 90° or 180° Hooks

Concrete	$f'_c = 4 \text{ ksi}$			$f'_c = 5 \text{ ksi}$		
	Development Length, l_d					
Bar Size	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN
3	0'-8"	0'-6"	0'-6"	0'-7"	0'-6"	0'-6"
4	0'-10"	0'-7"	0'-6"	0'-9"	0'-6"	0'-6"
5	1'-0"	0'-9"	0'-7"	0'-11"	0'-8"	0'-6"
6	1'-3"	0'-10"	0'-8"	1'-1"	0'-9"	0'-8"
7	1'-5"	1'-0"	0'-10"	1'-3"	0'-11"	0'-9"
8	1'-7"	1'-2"	0'-11"	1'-5"	1'-0"	0'-10"
9	1'-10"	1'-3"	1'-0"	1'-8"	1'-2"	0'-11"
10	2'-1"	1'-5"	1'-2"	1'-10"	1'-4"	1'-0"
11	2'-3"	2'-3"	2'-3"	2'-0"	2'-0"	2'-0"
14	2'-9"	2'-9"	2'-9"	2'-5"	2'-5"	2'-5"
18	3'-7"	3'-7"	3'-7"	3'-3"	3'-3"	3'-3"
Concrete	$f'_c = 6 \text{ ksi}$			$f'_c = 7 \text{ ksi}$		
	Development Length, l_d					
Bar Size	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN
3	0'-6"	0'-6"	0'-6"	0'-6"	0'-6"	0'-6"
4	0'-8"	0'-6"	0'-6"	0'-8"	0'-6"	0'-6"
5	0'-10"	0'-7"	0'-6"	0'-9"	0'-7"	0'-6"
6	1'-0"	0'-9"	0'-7"	0'-11"	0'-8"	0'-6"
7	1'-2"	0'-10"	0'-8"	1'-1"	0'-9"	0'-7"
8	1'-4"	0'-11"	0'-9"	1'-3"	0'-10"	0'-8"
9	1'-6"	1'-1"	0'-10"	1'-5"	1'-0"	0'-9"
10	1'-8"	1'-2"	0'-11"	1'-7"	1'-1"	0'-11"
11	1'-10"	1'-10"	1'-10"	1'-9"	1'-9"	1'-9"
14	2'-3"	2'-3"	2'-3"	2'-1"	2'-1"	2'-1"
18	2'-11"	2'-11"	2'-11"	2'-9"	2'-9"	2'-9"

Epoxy Coated Standard 90° or 180° Hooks

Concrete	$f'_c = 4$ ksi			$f'_c = 5$ ksi		
	Development Length, l_d					
Bar Size	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN
3	0'-9"	0'-6"	0'-6"	0'-8"	0'-6"	0'-6"
4	1'-0"	0'-8"	0'-7"	0'-11"	0'-8"	0'-6"
5	1'-3"	0'-10"	0'-8"	1'-1"	0'-9"	0'-8"
6	1'-6"	1'-0"	0'-10"	1'-4"	0'-11"	0'-9"
7	1'-8"	1'-2"	1'-0"	1'-6"	1'-1"	0'-10"
8	1'-11"	1'-4"	1'-1"	1'-9"	1'-3"	1'-0"
9	2'-2"	1'-6"	1'-3"	1'-11"	1'-5"	1'-1"
10	2'-5"	1'-9"	1'-5"	2'-2"	1'-7"	1'-3"
11	2'-3"	2'-3"	2'-3"	2'-0"	2'-0"	2'-0"
14	2'-9"	2'-9"	2'-9"	2'-5"	2'-5"	2'-5"
18	3'-7"	3'-7"	3'-7"	3'-3"	3'-3"	3'-3"
Concrete	$f'_c = 6$ ksi			$f'_c = 7$ ksi		
	Development Length, l_d					
Bar Size	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN	Side cover < 2.5 IN and Hook cover < 2 IN	Side cover \geq 2.5 IN and Hook cover \geq 2 IN	Special confinement with side cover \geq 2.5 IN and Hook cover \geq 2 IN
3	0'-7"	0'-6"	0'-6"	0'-7"	0'-6"	0'-6"
4	0'-10"	0'-7"	0'-6"	0'-9"	0'-6"	0'-6"
5	1'-0"	0'-9"	0'-7"	0'-11"	0'-8"	0'-6"
6	1'-2"	0'-10"	0'-8"	1'-1"	0'-9"	0'-8"
7	1'-5"	1'-0"	0'-10"	1'-3"	0'-11"	0'-9"
8	1'-7"	1'-1"	0'-11"	1'-6"	1'-0"	0'-10"
9	1'-9"	1'-3"	1'-0"	1'-8"	1'-2"	0'-11"
10	2'-0"	1'-5"	1'-2"	1'-10"	1'-4"	1'-1"
11	1'-10"	1'-10"	1'-10"	1'-9"	1'-9"	1'-9"
14	2'-3"	2'-3"	2'-3"	2'-1"	2'-1"	2'-1"
18	2'-11"	2'-11"	2'-11"	2'-9"	2'-9"	2'-9"

Tension Lap Splices - Article 5.11.5.3.1

Notes

1. Reinforcement is Grade 60
2. Top bars are horizontal bars so placed that more than 12 IN of fresh concrete is cast in the member below the bar
3. Double l_d if cover is not more than d_b or clear spacing is not more than $2d_b$.
4. For epoxy coated bars with cover less than $3d_b$ or with clear spacing less than $6d_b$, multiply l_d by 1.5
5. When excess bar area is provided, l_d may be reduced by $(A_s \text{ required})/(A_s \text{ provided})$
6. Development lengths have been rounded up to the next highest inch

Uncoated Class A Tension Splice

Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4 \text{ ksi}$		$f'_c = 5 \text{ ksi}$		$f'_c = 6 \text{ ksi}$		$f'_c = 7 \text{ ksi}$	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-1"	1'-0"	1'-1"	1'-0"	1'-1"	1'-0"	1'-1"	1'-0"
4	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"
5	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
6	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"
7	2'-8"	1'-11"	2'-6"	1'-9"	2'-6"	1'-9"	2'-6"	1'-9"
8	3'-6"	2'-6"	3'-1"	2'-3"	2'-10"	2'-1"	2'-10"	2'-0"
9	4'-5"	3'-2"	3'-11"	2'-10"	3'-7"	2'-7"	3'-4"	2'-5"
10	5'-7"	4'-0"	5'-0"	3'-7"	4'-7"	3'-3"	4'-3"	3'-0"
11	6'-10"	4'-11"	6'-2"	4'-5"	5'-7"	4'-0"	5'-2"	3'-9"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Uncoated Class A Tension Splice

Center-to-center spacing $\geq 6 \text{ IN}$ and clear cover $\geq 3 \text{ IN}$

Concrete	$f'_c = 4 \text{ ksi}$		$f'_c = 5 \text{ ksi}$		$f'_c = 6 \text{ ksi}$		$f'_c = 7 \text{ ksi}$	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
4	1'-2"	1'-0"	1'-2"	1'-0"	1'-2"	1'-0"	1'-2"	1'-0"
5	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"
6	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
7	2'-2"	1'-6"	2'-0"	1'-5"	2'-0"	1'-5"	2'-0"	1'-5"
8	2'-10"	2'-0"	2'-6"	1'-10"	2'-3"	1'-8"	2'-3"	1'-8"
9	3'-6"	2'-6"	3'-2"	2'-3"	2'-11"	2'-1"	2'-8"	1'-11"
10	4'-6"	3'-3"	4'-0"	2'-10"	3'-8"	2'-8"	3'-5"	2'-5"
11	5'-6"	3'-11"	4'-11"	3'-6"	4'-6"	3'-3"	4'-2"	3'-0"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class A Tension Splice
Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-4"	1'-0"	1'-4"	1'-0"	1'-4"	1'-0"	1'-4"	1'-0"
4	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
5	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"	2'-2"	1'-6"
6	2'-7"	1'-10"	2'-7"	1'-10"	2'-7"	1'-10"	2'-7"	1'-10"
7	3'-2"	2'-3"	3'-0"	2'-2"	3'-0"	2'-2"	3'-0"	2'-2"
8	4'-2"	3'-0"	3'-9"	2'-8"	3'-5"	2'-5"	3'-5"	2'-5"
9	5'-3"	3'-9"	4'-9"	3'-5"	4'-4"	3'-1"	4'-0"	2'-10"
10	6'-8"	4'-10"	6'-0"	4'-4"	5'-6"	3'-11"	5'-1"	3'-8"
11	8'-3"	5'-11"	7'-4"	5'-3"	6'-9"	4'-10"	6'-3"	4'-5"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class A Tension Splice
Center-to-center spacing \geq 6 IN and clear cover \geq 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
4	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"	1'-5"	1'-0"
5	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"	1'-9"	1'-3"
6	2'-1"	1'-6"	2'-1"	1'-6"	2'-1"	1'-6"	2'-1"	1'-6"
7	2'-7"	1'-10"	2'-5"	1'-9"	2'-5"	1'-9"	2'-5"	1'-9"
8	3'-4"	2'-5"	3'-0"	2'-2"	2'-9"	2'-0"	2'-9"	1'-11"
9	4'-3"	3'-0"	3'-9"	2'-9"	3'-6"	2'-6"	3'-2"	2'-4"
10	5'-4"	3'-10"	4'-10"	3'-5"	4'-5"	3'-2"	4'-1"	2'-11"
11	6'-7"	4'-9"	5'-11"	4'-3"	5'-5"	3'-10"	5'-0"	3'-7"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Uncoated Class B Tension Splice
Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-5"	1'-4"	1'-5"	1'-4"	1'-5"	1'-4"	1'-5"	1'-4"
4	1'-10"	1'-4"	1'-10"	1'-4"	1'-10"	1'-4"	1'-10"	1'-4"
5	2'-4"	1'-8"	2'-4"	1'-8"	2'-4"	1'-8"	2'-4"	1'-8"
6	2'-9"	2'-0"	2'-9"	2'-0"	2'-9"	2'-0"	2'-9"	2'-0"
7	3'-5"	2'-6"	3'-3"	2'-4"	3'-3"	2'-4"	3'-3"	2'-4"
8	4'-6"	3'-3"	4'-1"	2'-11"	3'-8"	2'-8"	3'-8"	2'-8"
9	5'-9"	4'-1"	5'-1"	3'-8"	4'-8"	3'-4"	4'-4"	3'-1"
10	7'-3"	5'-2"	6'-6"	4'-8"	5'-11"	4'-3"	5'-6"	3'-11"
11	8'-11"	6'-4"	8'-0"	5'-8"	7'-3"	5'-2"	6'-9"	4'-10"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Uncoated Class B Tension Splice

Center-to-center spacing ³ 6 IN and clear cover ³ 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
Development Length, l_d								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"
4	1'-6"	1'-4"	1'-6"	1'-4"	1'-6"	1'-4"	1'-6"	1'-4"
5	1'-10"	1'-4"	1'-10"	1'-4"	1'-10"	1'-4"	1'-10"	1'-4"
6	2'-3"	1'-7"	2'-3"	1'-7"	2'-3"	1'-7"	2'-3"	1'-7"
7	2'-9"	2'-0"	2'-7"	1'-10"	2'-7"	1'-10"	2'-7"	1'-10"
8	3'-8"	2'-7"	3'-3"	2'-4"	3'-0"	2'-2"	2'-11"	2'-1"
9	4'-7"	3'-3"	4'-1"	2'-11"	3'-9"	2'-8"	3'-6"	2'-6"
10	5'-10"	4'-2"	5'-2"	3'-9"	4'-9"	3'-5"	4'-5"	3'-2"
11	7'-2"	5'-1"	6'-5"	4'-7"	5'-10"	4'-2"	5'-5"	3'-10"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class B Tension Splice

Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
Development Length, l_d								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-8"	1'-4"	1'-8"	1'-4"	1'-8"	1'-4"	1'-8"	1'-4"
4	2'-3"	1'-7"	2'-3"	1'-7"	2'-3"	1'-7"	2'-3"	1'-7"
5	2'-9"	2'-0"	2'-9"	2'-0"	2'-9"	2'-0"	2'-9"	2'-0"
6	3'-4"	2'-4"	3'-4"	2'-4"	3'-4"	2'-4"	3'-4"	2'-4"
7	4'-2"	3'-0"	3'-10"	2'-9"	3'-10"	2'-9"	3'-10"	2'-9"
8	5'-5"	3'-11"	4'-10"	3'-6"	4'-5"	3'-2"	4'-5"	3'-2"
9	6'-10"	4'-11"	6'-2"	4'-5"	5'-7"	4'-0"	5'-2"	3'-9"
10	8'-8"	6'-3"	7'-9"	5'-7"	7'-1"	5'-1"	6'-7"	4'-9"
11	10'-8"	7'-8"	9'-7"	6'-10"	8'-9"	6'-3"	8'-1"	5'-9"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class B Tension Splice

Center-to-center spacing ³ 6 IN and clear cover ³ 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
Development Length, l_d								
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"	1'-4"
4	1'-9"	1'-4"	1'-9"	1'-4"	1'-9"	1'-4"	1'-9"	1'-4"
5	2'-3"	1'-7"	2'-3"	1'-7"	2'-3"	1'-7"	2'-3"	1'-7"
6	2'-8"	1'-11"	2'-8"	1'-11"	2'-8"	1'-11"	2'-8"	1'-11"
7	3'-4"	2'-4"	3'-1"	2'-3"	3'-1"	2'-3"	3'-1"	2'-3"
8	4'-4"	3'-1"	3'-11"	2'-9"	3'-7"	2'-7"	3'-6"	2'-6"
9	5'-6"	3'-11"	4'-11"	3'-6"	4'-6"	3'-3"	4'-2"	3'-0"
10	7'-0"	5'-0"	6'-3"	4'-6"	5'-8"	4'-1"	5'-3"	3'-9"
11	8'-7"	6'-1"	7'-8"	5'-6"	7'-0"	5'-0"	6'-6"	4'-8"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Uncoated Class C Tension Splice
Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-10"	1'-9"	1'-10"	1'-9"	1'-10"	1'-9"	1'-10"	1'-9"
4	2'-5"	1'-9"	2'-5"	1'-9"	2'-5"	1'-9"	2'-5"	1'-9"
5	3'-0"	2'-2"	3'-0"	2'-2"	3'-0"	2'-2"	3'-0"	2'-2"
6	3'-7"	2'-7"	3'-7"	2'-7"	3'-7"	2'-7"	3'-7"	2'-7"
7	4'-6"	3'-3"	4'-2"	3'-0"	4'-2"	3'-0"	4'-2"	3'-0"
8	5'-11"	4'-3"	5'-3"	3'-9"	4'-10"	3'-6"	4'-10"	3'-5"
9	7'-6"	5'-4"	6'-8"	4'-9"	6'-1"	4'-4"	5'-8"	4'-1"
10	9'-6"	6'-9"	8'-6"	6'-1"	7'-9"	5'-7"	7'-2"	5'-2"
11	11'-8"	8'-4"	10'-5"	7'-5"	9'-6"	6'-10"	8'-10"	6'-4"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Uncoated Class C Tension Splice
Center-to-center spacing \geq 6 IN and clear cover \geq 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"
4	1'-11"	1'-9"	1'-11"	1'-9"	1'-11"	1'-9"	1'-11"	1'-9"
5	2'-5"	1'-9"	2'-5"	1'-9"	2'-5"	1'-9"	2'-5"	1'-9"
6	2'-11"	2'-1"	2'-11"	2'-1"	2'-11"	2'-1"	2'-11"	2'-1"
7	3'-7"	2'-7"	3'-4"	2'-5"	3'-4"	2'-5"	3'-4"	2'-5"
8	4'-9"	3'-5"	4'-3"	3'-0"	3'-10"	2'-9"	3'-10"	2'-9"
9	6'-0"	4'-3"	5'-4"	3'-10"	4'-11"	3'-6"	4'-6"	3'-3"
10	7'-7"	5'-5"	6'-10"	4'-10"	6'-2"	4'-5"	5'-9"	4'-1"
11	9'-4"	6'-8"	8'-4"	6'-0"	7'-7"	5'-5"	7'-1"	5'-1"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class C Tension Splice
Center-to-center spacing < 6 IN or clear cover < 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	2'-2"	1'-9"	2'-2"	1'-9"	2'-2"	1'-9"	2'-2"	1'-9"
4	2'-11"	2'-1"	2'-11"	2'-1"	2'-11"	2'-1"	2'-11"	2'-1"
5	3'-7"	2'-7"	3'-7"	2'-7"	3'-7"	2'-7"	3'-7"	2'-7"
6	4'-4"	3'-1"	4'-4"	3'-1"	4'-4"	3'-1"	4'-4"	3'-1"
7	5'-5"	3'-10"	5'-0"	3'-7"	5'-0"	3'-7"	5'-0"	3'-7"
8	7'-1"	5'-1"	6'-4"	4'-6"	5'-9"	4'-2"	5'-9"	4'-1"
9	9'-0"	6'-5"	8'-0"	5'-9"	7'-4"	5'-3"	6'-9"	4'-10"
10	11'-4"	8'-2"	10'-2"	7'-3"	9'-3"	6'-8"	8'-7"	6'-2"
11	13'-11"	10'-0"	12'-6"	8'-11"	11'-5"	8'-2"	10'-7"	7'-7"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Epoxy coated Class C Tension Splice
Center-to-center spacing ³ 6 IN and clear cover ³ 3 IN

Concrete	$f'_c = 4$ ksi		$f'_c = 5$ ksi		$f'_c = 6$ ksi		$f'_c = 7$ ksi	
	Development Length, l_d							
Bar Size	Top Bars	Others	Top Bars	Others	Top Bars	Others	Top Bars	Others
3	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"
4	2'-4"	1'-9"	2'-4"	1'-9"	2'-4"	1'-9"	2'-4"	1'-9"
5	2'-11"	2'-1"	2'-11"	2'-1"	2'-11"	2'-1"	2'-11"	2'-1"
6	3'-6"	2'-6"	3'-6"	2'-6"	3'-6"	2'-6"	3'-6"	2'-6"
7	4'-4"	3'-1"	4'-0"	2'-11"	4'-0"	2'-11"	4'-0"	2'-11"
8	5'-8"	4'-1"	5'-1"	3'-8"	4'-8"	3'-4"	4'-7"	3'-4"
9	7'-2"	5'-2"	6'-5"	4'-7"	5'-10"	4'-2"	5'-5"	3'-11"
10	9'-1"	6'-6"	8'-2"	5'-10"	7'-5"	5'-4"	6'-11"	4'-11"
11	11'-2"	8'-0"	10'-0"	7'-2"	9'-2"	6'-6"	8'-5"	6'-1"
14	Not Allowed per Article 5.11.5.2.1							
18	Not Allowed per Article 5.11.5.2.1							

Compression Lap Splices - Article 5.11.5.5

Notes

1. Where bars of different size are lap spliced in compression, the splice length shall not be less than the development length of the larger bar or the splice length of the smaller bar. Bar sizes 14 and 18 may be lapped to 11 and smaller bars.
2. Ties along the splice have an effective area not less than 0.15 percent of the product of the thickness of the compression component times the tie spacing.

Lap Slices in Compression

Bar Size	$f'_c < 3$ ksi	Ties	Spirals	Others
3	1'-3"	1'-0"	1'-0"	1'-0"
4	1'-8"	1'-1"	1'-0"	1'-4"
5	2'-1"	1'-4"	1'-3"	1'-7"
6	2'-6"	1'-7"	1'-5"	1'-11"
7	2'-11"	1'-10"	1'-8"	2'-3"
8	3'-4"	2'-1"	1'-11"	2'-7"
9	3'-10"	2'-5"	2'-2"	2'-10"
10	4'-3"	2'-8"	2'-5"	3'-3"
11	4'-9"	3'-0"	2'-8"	3'-7"
14	5'-8"	3'-7"	3'-3"	4'-3"
18	7'-6"	4'-9"	4'-3"	5'-8"

Appendix

Conversion Factors

Multiply	By	To Produce
in	25.40	mm
ft	0.3048	m
in ²	645.2	mm ²
ft ²	0.0929	m ²
in ³	16387	mm ³
ft ³	0.0283	m ³
in ⁴	416231	mm ⁴
ft ⁴	0.00863	m ⁴
lbf	4.448	N
kip	4.448	kN
ton	8.896	kN
lbf/in	0.175	N/mm
lbf/ft	0.015	N/mm
kip/in	175.2	kN/m
kip/ft	14.6	kN/m
lbf	0.453	kg
lbm	0.453	kg
slug	14.594	kg
ft/sec ²	0.3048	m/sec ²
psi	6894.757	Pa
ksi	6.895	MPa
psf	47.88	Pa
ksf	0.04788	MPa
°F	(°t-32°)/1.8	°C

Reinforcing Bar Properties

Bar Size No.	Nominal Mass kg/m	Nominal Diameter mm	Nominal Area mm ²	Bar Size No.	Nominal Weight lb/ft	Nominal Diameter in	Nominal Area in ²
10	0.560	9.5	71	3	0.376	0.375	0.11
13	0.994	12.7	129	4	0.668	0.500	0.20
16	1.552	15.9	199	5	1.043	0.625	0.31
19	2.235	19.1	284	6	1.502	0.750	0.44
22	3.042	22.2	387	7	2.044	0.875	0.60
25	3.973	25.4	510	8	2.670	1.000	0.79
29	5.060	28.7	645	9	3.400	1.128	1.00
32	6.404	32.3	819	10	4.303	1.270	1.27
36	7.907	35.8	1006	11	5.313	1.410	1.56
43	11.380	43.0	1452	14	7.650	1.693	2.25
57	20.240	57.3	2581	18	13.600	2.257	4.00