A

Tables and Graphs

U. S. CUSTOMARY UNITS

Table A.1 Values of Modulus of Elasticity for Normal-Weight Concrete

U.S. customary units	
f'_c (psi)	E_c (psi)
3,000	3,160,000
3,500	3,410,000
4,000	3,640,000
4,500	3,870,000
5,000	4,070,000

Source Notes: Tables A.4, A.6, A.14, and A.15, as well as Graph 1, are reprinted from *Design of Concrete Structures* by Winter and Nilson. Copyright © 1972 by McGraw-Hill, Inc., and with permission of the McGraw-Hill Book Company. Graphs 2–13 reprinted from *Design Handbook, Volume 2, Columns* (SP-17A), 1978, with permission of American Concrete Institute.

Tables A.3(a) and A.3(b) are reprinted from *Manual of Standard Practice*, 22nd ed., 1997, second printing, Concrete Reinforcing Steel Institute, Chicago, IL.

Tables A.16 through A.20 are reprinted from Commentary on Building Code Requirements For Reinforced Concrete (ACI 318-77) with permission of the American Concrete Institute.

Table A.2 Designations, Areas, Perimeters, and Weights of Standard Bars

	U.S. customary units		
Bar no.	Diameter (in.)	Cross-sectional area (in.^{2})	Unit weight (lb/ft)
3	0.375	0.11	0.376
4	0.500	0.20	0.668
5	0.625	0.31	1.043
6	0.750	0.44	1.502
7	0.875	0.60	2.044
8	1.000	0.79	2.670
9	1.128	1.00	3.400
10	1.270	1.27	4.303
11	1.410	1.56	5.313
14	1.693	2.25	7.650
18	2.257	4.00	13.600

Table A.3(A) Common Stock Styles of Welded Wire Fabric—U.S. Customary Units

	Steel area (sq in. per ft)		
Style designation	Longit.	Transv.	Weight approx. (lb per 100 sq ft)
Rolls			
6 × 6—W1.4 × W1.4	0.03	0.03	21
6 × 6—W2 × W2	0.04	0.04	29
6 × 6—W2.9 × W2.9	0.06	0.06	42
6 × 6—W4 × W4	0.08	0.08	58
4 × 4—W1.4 × W1.4	0.04	0.04	31
4 × 4—W2 × W2	0.06	0.06	43
4 × 4—W2.9 × W2.9	0.09	0.09	62
4 × 4—W4 × W4	0.12	0.12	86
Sheets			
6 × 6—W2.9 × W2.9	0.06	0.06	42
6 × 6—W4 × W4	0.08	0.08	58
6 × 6—W5.5 × W5.5	0.11	0.11	80
4 × 4—W4 × W4	0.12	0.12	86

Table A.3(B) Sectional Area and Weight of Welded Wire Fabric—U.S. Customary Units

Wire size number[a]		Nominal diameter (inches)	Nominal weight (lb/lin. ft)	Area in sq. in. per ft of width for various spacings						
				Center-to-center spacing						
Smooth	Deformed			2″	3″	4″	6″	8″	10″	12″
W31	D31	0.628	1.054		1.24	0.93	0.62	0.465	0.372	0.31
W28	D28	0.597	0.952		1.12	0.84	0.56	0.42	0.336	0.28
W26	D26	0.575	0.934		1.04	0.78	0.52	0.39	0.312	0.26
W24	D24	0.553	0.816		0.96	0.72	0.48	0.36	0.288	0.24
W22	D22	0.529	0.748		0.88	0.66	0.44	0.33	0.264	0.22
W20	D20	0.505	0.680	1.20	0.80	0.60	0.40	0.30	0.24	0.20
W18	D18	0.479	0.612	1.08	0.72	0.54	0.36	0.27	0.216	0.18
W16	D16	0.451	0.544	0.96	0.64	0.48	0.32	0.24	0.192	0.16
W14	D14	0.422	0.476	0.84	0.56	0.42	0.28	0.21	0.168	0.14
W12	D12	0.391	0.408	0.72	0.48	0.36	0.24	0.18	0.144	0.12
W11	D11	0.374	0.374	0.66	0.44	0.33	0.22	0.165	0.132	0.11
W10	D10	0.357	0.340	0.60	0.40	0.30	0.20	0.15	0.12	0.10
W9.5		0.348	0.323	0.57	0.38	0.285	0.19	0.142	0.114	0.095
W9	D9	0.339	0.306	0.54	0.36	0.27	0.18	0.135	0.108	0.09
W8.5		0.329	0.289	0.51	0.34	0.255	0.17	0.127	0.102	0.085

Table A.3(B) (Continued)

Wire size number[a]		Nominal diameter (inches)	Nominal weight (lb/lin. ft)	Area in sq. in. per ft of width for various spacings						
				Center-to-center spacing						
Smooth	Deformed			2″	3″	4″	6″	8″	10″	12″
W8	D8	0.319	0.272	0.48	0.32	0.24	0.16	0.12	0.096	0.08
W7.5		0.309	0.255	0.45	0.30	0.225	0.15	0.112	0.09	0.075
W7	D7	0.299	0.238	0.42	0.28	0.21	0.14	0.105	0.084	0.07
W6.5		0.288	0.221	0.39	0.26	0.195	0.13	0.097	0.078	0.065
W6	D6	0.276	0.204	0.36	0.24	0.18	0.12	0.09	0.072	0.06
W5.5		0.265	0.187	0.33	0.22	0.165	0.11	0.082	0.066	0.055
W5	D5	0.252	0.170	0.30	0.20	0.15	0.10	0.075	0.06	0.05
W4.5		0.239	0.153	0.27	0.18	0.135	0.09	0.067	0.054	0.045
W4	D4	0.226	0.136	0.24	0.16	0.12	0.08	0.06	0.048	0.04
W3.5		0.211	0.119	0.21	0.14	0.105	0.07	0.052	0.042	0.035
W2.9		0.192	0.099	0.174	0.116	0.087	0.058	0.043	0.035	0.029
W2.5		0.178	0.085	0.15	0.10	0.075	0.05	0.037	0.03	0.025
W2		0.160	0.068	0.12	0.08	0.06	0.04	0.03	0.024	0.02
W1.4		0.134	0.048	0.084	0.056	0.042	0.028	0.021	0.017	0.014

Note: The above listing of smooth and deformed wire sizes represents wires normally selected to manufacture welded wire fabric styles to specific areas of reinforcement. Wire sizes and spacings other than those listed above may be produced provided the quantity required is sufficient to justify manufacture.

[a]The number following the prefix W or the prefix D identifies the cross-sectional area of the wire in hundredths of a square inch. The nominal diameter of a deformed wire is equivalent to the diameter of a smooth wire having the same weight per foot as the deformed wire.

Table A.4 Areas of Groups of Standard Bars (In.^{2})—U.S. Customary Units

	Number of bars								
Bar no.	2	3	4	5	6	7	8	9	10
4	0.39	0.58	0.78	0.98	1.18	1.37	1.57	1.77	1.96
5	0.61	0.91	1.23	1.53	1.84	2.15	2.45	2.76	3.07
6	0.88	1.32	1.77	2.21	2.65	3.09	3.53	3.98	4.42
7	1.20	1.80	2.41	3.01	3.61	4.21	4.81	5.41	6.01
8	1.57	2.35	3.14	3.93	4.71	5.50	6.28	7.07	7.85
9	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
10	2.53	3.79	5.06	6.33	7.59	8.86	10.12	11.39	12.66
11	3.12	4.68	6.25	7.81	9.37	10.94	12.50	14.06	15.62
14	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25	22.50
18	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00

	Number of bars									
Bar no.	11	12	13	14	15	16	17	18	19	20
4	2.16	2.36	2.55	2.75	2.95	3.14	3.34	3.53	3.73	3.93
5	3.37	3.68	3.99	4.30	4.60	4.91	5.22	5.52	5.83	6.14
6	4.86	5.30	5.74	6.19	6.63	7.07	7.51	7.95	8.39	8.84
7	6.61	7.22	7.82	8.42	9.02	9.62	10.22	10.82	11.43	12.03
8	8.64	9.43	10.21	11.00	11.78	12.57	13.35	14.14	14.92	15.71
9	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00
10	13.92	15.19	16.45	17.72	18.98	20.25	21.52	22.78	24.05	25.31
11	17.19	18.75	20.31	21.87	23.44	25.00	26.56	28.12	29.69	31.25
14	24.75	27.00	29.25	31.50	33.75	36.00	38.25	40.50	42.75	45.00
18	44.00	48.00	52.00	56.00	60.00	64.00	68.00	72.00	76.00	80.00

Table A.5 Minimum Web Width (In.) for Beams with Inside Exposure (1995 ACI Code)[a,b,c]—U.S. Customary Units

Size of bars	Number of bars in single layer of reinforcing							Add for each additional Bar
	2	3	4	5	6	7	8	
#4	6.8	8.3	9.8	11.3	12.8	14.3	15.8	1.50
#5	6.9	8.5	10.2	11.8	13.4	15.0	16.7	1.625
#6	7.0	8.8	10.5	12.3	14.0	15.8	17.5	1.75
#7	7.2	9.0	10.9	12.8	14.7	16.5	18.4	1.875
#8	7.3	9.3	11.3	13.3	15.3	17.3	19.3	2.00
#9	7.6	9.8	12.1	14.3	16.6	18.8	21.1	2.26
#10	7.8	10.4	12.9	15.5	18.0	20.5	23.1	2.54
#11	8.1	10.9	13.8	16.6	19.4	22.2	25.0	2.82
#14	8.9	12.3	15.7	19.0	22.4	25.8	29.2	3.39
#18	10.6	15.1	19.6	24.1	28.6	33.1	37.7	4.51

[a]Minimum beam widths for beams were calculated using #3 stirrups.

[b]Maximum aggregate sizes were assumed not to exceed 3/4 of the clear spacing between the bars (ACI 3.3.2).

[c]The horizontal distance from the center of the outside longitudinal bars to the inside of the stirrups was assumed to equal the larger of 2 times the stirrup diameter (ACI 7.2.2) or half of the longitudinal bar diameter.

Table A.6 Areas of Bars in Slabs (In.^{2}/Ft)—U.S. Customary Units

	Bar no.								
Spacing (in.)	3	4	5	6	7	8	9	10	11
3	0.44	0.78	1.23	1.77	2.40	3.14	4.00	5.06	6.25
$3\frac{1}{2}$	0.38	0.67	1.05	1.51	2.06	2.69	3.43	4.34	5.36
4	0.33	0.59	0.92	1.32	1.80	2.36	3.00	3.80	4.68
$4\frac{1}{2}$	0.29	0.52	0.82	1.18	1.60	2.09	2.67	3.37	4.17
5	0.26	0.47	0.74	1.06	1.44	1.88	2.40	3.04	3.75
$5\frac{1}{2}$	0.24	0.43	0.67	0.96	1.31	1.71	2.18	2.76	3.41
6	0.22	0.39	0.61	0.88	1.20	1.57	2.00	2.53	3.12
$6\frac{1}{2}$	0.20	0.36	0.57	0.82	1.11	1.45	1.85	2.34	2.89
7	0.19	0.34	0.53	0.76	1.03	1.35	1.71	2.17	2.68
$7\frac{1}{2}$	0.18	0.31	0.49	0.71	0.96	1.26	1.60	2.02	2.50
8	0.17	0.29	0.46	0.66	0.90	1.18	1.50	1.89	2.34
9	0.15	0.26	0.41	0.59	0.80	1.05	1.33	1.69	2.08
10	0.13	0.24	0.37	0.53	0.72	0.94	1.20	1.52	1.87
12	0.11	0.20	0.31	0.44	0.60	0.78	1.00	1.27	1.56

Table A.7 Values of ρ Balanced, ρ to Achieve Various ϵ_t Values, and ρ Minimum for Flexure. All Values Are for Tensilely Reinforced Rectangular Sections

f_y \ f'_c		3000 psi $\beta_1 = 0.85$	4000 psi $\beta_1 = 0.85$	5000 psi $\beta_1 = 0.80$	6000 psi $\beta_1 = 0.75$
Grade 40 40,000 psi (275.8 MPa)	ρ balanced	0.0371	0.0495	0.0582	0.0655
	ρ when $\epsilon_t = 0.004$	0.0232	0.0310	0.0364	0.0410
	ρ when $\epsilon_t = 0.005$	0.0203	0.0271	0.0319	0.0359
	ρ when $\epsilon_t = 0.0075$	0.0155	0.0206	0.0243	0.0273
	ρ min for flexure	0.0050	0.0050	0.0053	0.0058
Grade 50 50,000 psi (344.8 MPa)	ρ balanced	0.0275	0.0367	0.0432	0.0486
	ρ when $\epsilon_t = 0.004$	0.0186	0.0248	0.0291	0.0328
	ρ when $\epsilon_t = 0.005$	0.0163	0.0217	0.0255	0.0287
	ρ when $\epsilon_t = 0.0075$	0.0124	0.0165	0.0194	0.0219
	ρ min for flexure	0.0040	0.0040	0.0042	0.0046
Grade 60 60,000 psi (413.7 MPa)	ρ balanced	0.0214	0.0285	0.0335	0.0377
	ρ when $\epsilon_t = 0.004$	0.0155	0.0206	0.0243	0.0273
	ρ when $\epsilon_t = 0.005$	0.0136	0.0181	0.0212	0.0239
	ρ when $\epsilon_t = 0.0075$	0.0103	0.0138	0.0162	0.0182
	ρ min for flexure	0.0033	0.0033	0.0035	0.0039
Grade 75 75,000 psi (517.1 MPa)	ρ balanced	0.0155	0.0207	0.0243	0.0274
	ρ when $\epsilon_t = 0.004$	0.0124	0.0165	0.0194	0.0219
	ρ when $\epsilon_t = 0.005$	0.0108	0.0144	0.0170	0.0191
	ρ when $\epsilon_t = 0.0075$	0.0083	0.0110	0.0130	0.0146
	ρ min for flexure	0.0027	0.0027	0.0028	0.0031

Table A.8 $f_y = 40{,}000$ PSI; $f'_c = 3000$ PSI—U.S. Customary Units

	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage	0.0020	78.74	0.0061	232.3	0.0102	375.3	0.0143	507.6
	0.0021	82.62	0.0062	235.9	0.0103	378.6	0.0144	510.7
	0.0022	86.48	0.0063	239.5	0.0104	382.0	0.0145	513.8
	0.0023	90.34	0.0064	243.1	0.0105	385.3	0.0146	516.9
	0.0024	94.19	0.0065	246.7	0.0106	388.6	0.0147	520.0
	0.0025	98.04	0.0066	250.3	0.0107	392.0	0.0148	523.1
	0.0026	101.9	0.0067	253.9	0.0108	395.3	0.0149	526.1
	0.0027	105.7	0.0068	257.4	0.0109	398.6	0.0150	529.2
	0.0028	109.5	0.0069	261.0	0.0110	401.9	0.0151	532.2
	0.0029	113.4	0.0070	264.6	0.0111	405.2	0.0152	535.3
	0.0030	117.2	0.0071	268.1	0.0112	408.5	0.0153	538.3
	0.0031	121.0	0.0072	271.7	0.0113	411.8	0.0154	541.4
	0.0032	124.8	0.0073	275.2	0.0114	415.1	0.0155	544.4
	0.0033	128.6	0.0074	278.8	0.0115	418.4	0.0156	547.4
	0.0034	132.4	0.0075	282.3	0.0116	421.7	0.0157	550.4
	0.0035	136.2	0.0076	285.8	0.0117	424.9	0.0158	553.4
	0.0036	139.9	0.0077	289.3	0.0118	428.2	0.0159	556.4
	0.0037	143.7	0.0078	292.9	0.0119	431.4	0.0160	559.4
	0.0038	147.5	0.0079	296.4	0.0120	434.7	0.0161	562.4
	0.0039	151.2	0.0080	299.9	0.0121	437.9	0.0162	565.4
	0.0040	155.0	0.0081	303.4	0.0122	441.2	0.0163	568.4
	0.0041	158.7	0.0082	306.8	0.0123	444.4	0.0164	571.4
	0.0042	162.5	0.0083	310.3	0.0124	447.6	0.0165	574.3
	0.0043	166.2	0.0084	313.8	0.0125	450.8	0.0166	577.3
	0.0044	169.9	0.0085	317.3	0.0126	454.0	0.0167	580.2
	0.0045	173.6	0.0086	320.7	0.0127	457.2	0.0168	583.2
	0.0046	177.4	0.0087	324.2	0.0128	460.4	0.0169	586.1
	0.0047	181.1	0.0088	327.6	0.0129	463.6	0.0170	589.1
	0.0048	184.8	0.0089	331.1	0.0130	466.8	0.0171	592.0
	0.0049	188.5	0.0090	334.5	0.0131	470.0	0.0172	594.9
ρ_{min} for flexure	0.0050	192.1	0.0091	337.9	0.0132	473.2	0.0173	597.8
	0.0051	195.8	0.0092	341.4	0.0133	476.3	0.0174	600.7
	0.0052	199.5	0.0093	344.8	0.0134	479.5	0.0175	603.6
	0.0053	203.2	0.0094	348.2	0.0135	482.6	0.0176	606.5
	0.0054	206.8	0.0095	351.6	0.0136	485.8	0.0177	609.4
	0.0055	210.5	0.0096	355.0	0.0137	488.9	0.0178	612.3
	0.0056	214.1	0.0097	358.4	0.0138	492.1	0.0179	615.2
	0.0057	217.8	0.0098	361.8	0.0139	495.2	0.0180	618.0
	0.0058	221.4	0.0099	365.2	0.0140	498.3	0.0181	620.9
	0.0059	225.0	0.0100	368.5	0.0141	501.4	0.0182	623.8
	0.0060	228.7	0.0101	371.9	0.0142	504.5	0.0183	626.6

Table A.8 (Continued)

ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
0.0184	629.5	0.0189	643.6	0.0194	657.6	0.0199	671.4
0.0185	632.3	0.0190	646.4	0.0195	660.3	0.0200	674.1
0.0186	635.1	0.0191	649.2	0.0196	663.1	0.0201	676.9
0.0187	638.0	0.0192	652.0	0.0197	665.9	0.0202	679.6
0.0188	640.8	0.0193	654.8	0.0198	668.6	0.0203	682.3

Table A.9 f_y = 40,000 PSI; f'_c = 4000 PSI—U.S. Customary Units

ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage 0.0020	79.06	0.0046	179.0	0.0072	275.8	0.0098	369.3
0.0021	82.96	0.0047	182.8	0.0073	279.4	0.0099	372.9
0.0022	86.86	0.0048	186.6	0.0074	283.1	0.0100	376.4
0.0023	90.75	0.0049	190.4	0.0075	286.7	0.0101	379.9
0.0024	94.64	ρ_{min} for flexure 0.0050	194.1	0.0076	290.4	0.0102	383.4
0.0025	98.53	0.0051	197.9	0.0077	294.0	0.0103	387.0
0.0026	102.4	0.0052	201.6	0.0078	297.6	0.0104	390.5
0.0027	106.3	0.0053	205.4	0.0079	301.3	0.0105	394.0
0.0028	110.2	0.0054	209.1	0.0080	304.9	0.0106	397.5
0.0029	114.0	0.0055	212.9	0.0081	308.5	0.0107	401.0
0.0030	117.9	0.0056	216.6	0.0082	312.1	0.0108	404.5
0.0031	121.7	0.0057	220.3	0.0083	315.7	0.0109	408.0
0.0032	125.6	0.0058	224.1	0.0084	319.3	0.0110	411.4
0.0033	129.4	0.0059	227.8	0.0085	322.9	0.0111	414.9
0.0034	133.3	0.0060	231.5	0.0086	326.5	0.0112	418.4
0.0035	137.1	0.0061	235.2	0.0087	330.1	0.0113	421.9
0.0036	141.0	0.0062	238.9	0.0088	333.7	0.0114	425.3
0.0037	144.8	0.0063	242.6	0.0089	337.3	0.0115	428.8
0.0038	148.6	0.0064	246.3	0.0090	340.9	0.0116	432.2
0.0039	152.4	0.0065	250.0	0.0091	344.5	0.0117	435.7
0.0040	156.2	0.0066	253.7	0.0092	348.0	0.0118	439.1
0.0041	160.0	0.0067	257.4	0.0093	351.6	0.0119	442.6
0.0042	163.8	0.0068	261.1	0.0094	355.1	0.0120	446.0
0.0043	167.6	0.0069	264.8	0.0095	358.7	0.0121	449.4
0.0044	171.4	0.0070	268.4	0.0096	362.2	0.0122	452.9
0.0045	175.2	0.0071	272.1	0.0097	365.8	0.0123	456.3

Table A.9 (Continued)

ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
0.0124	459.7	0.0161	582.8	0.0198	699.5	0.0235	809.7
0.0125	463.1	0.0162	586.1	0.0199	702.5	0.0236	812.5
0.0126	466.5	0.0163	589.3	0.0200	705.6	0.0237	815.4
0.0127	469.9	0.0164	592.5	0.0201	708.6	0.0238	818.3
0.0128	473.3	0.0165	595.7	0.0202	711.7	0.0239	821.2
0.0129	476.7	0.0166	599.0	0.0203	714.7	0.0240	824.1
0.0130	480.1	0.0167	602.2	0.0204	717.8	0.0241	826.9
0.0131	483.5	0.0168	605.4	0.0205	720.8	0.0242	829.8
0.0132	486.9	0.0169	608.6	0.0206	723.8	0.0243	832.6
0.0133	490.2	0.0170	611.8	0.0207	726.9	0.0244	835.5
0.0134	493.6	0.0171	615.0	0.0208	729.9	0.0245	838.3
0.0135	497.0	0.0172	618.2	0.0209	732.9	0.0246	841.2
0.0136	500.3	0.0173	621.4	0.0210	735.9	0.0247	844.0
0.0137	503.7	0.0174	624.5	0.0211	738.9	0.0248	846.8
0.0138	507.0	0.0175	627.7	0.0212	741.9	0.0249	849.7
0.0139	510.4	0.0176	630.9	0.0213	744.9	0.0250	852.5
0.0140	513.7	0.0177	634.1	0.0214	747.9	0.0251	855.3
0.0141	517.1	0.0178	637.2	0.0215	750.9	0.0252	858.1
0.0142	520.4	0.0179	640.4	0.0216	753.9	0.0253	860.9
0.0143	523.7	0.0180	643.5	0.0217	756.9	0.0254	863.7
0.0144	527.1	0.0181	646.7	0.0218	759.8	0.0255	866.5
0.0145	530.4	0.0182	649.8	0.0219	762.8	0.0256	869.3
0.0146	533.7	0.0183	653.0	0.0220	765.8	0.0257	872.1
0.0147	537.0	0.0184	656.1	0.0221	768.7	0.0258	874.9
0.0148	540.3	0.0185	659.2	0.0222	771.7	0.0259	877.7
0.0149	543.6	0.0186	662.3	0.0223	774.6	0.0260	880.5
0.0150	546.9	0.0187	665.5	0.0224	777.6	0.0261	883.2
0.0151	550.2	0.0188	668.6	0.0225	780.5	0.0262	886.0
0.0152	553.5	0.0189	671.7	0.0226	783.4	0.0263	888.7
0.0153	556.7	0.0190	674.8	0.0227	786.4	0.0264	891.5
0.0154	560.0	0.0191	677.9	0.0228	789.3	0.0265	894.3
0.0155	563.3	0.0192	681.0	0.0229	792.2	0.0266	897.0
0.0156	566.6	0.0193	684.1	0.0230	795.1	0.0267	899.7
0.0157	569.8	0.0194	687.2	0.0231	798.1	0.0268	902.5
0.0158	573.1	0.0195	690.3	0.0232	801.0	0.0269	905.2
0.0159	576.3	0.0196	693.3	0.0233	803.9	0.0270	907.9
0.0160	579.6	0.0197	696.4	0.0234	806.8	0.0271	910.7

Table A.10 f_y = 50,000 PSI; f'_c = 3000 PSI—U.S. Customary Units

	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage	0.0020	98.04	0.0056	264.6	0.0092	418.4	0.0128	559.4
	0.0021	102.8	0.0057	269.0	0.0093	422.5	0.0129	563.2
	0.0022	107.6	0.0058	273.5	0.0094	426.6	0.0130	566.9
	0.0023	112.4	0.0059	277.9	0.0095	430.6	0.0131	570.6
	0.0024	117.2	0.0060	282.3	0.0096	434.7	0.0132	574.3
	0.0025	121.9	0.0061	286.7	0.0097	438.7	0.0133	578.0
	0.0026	126.7	0.0062	291.1	0.0098	442.8	0.0134	581.7
	0.0027	131.4	0.0063	295.5	0.0099	446.8	0.0135	585.4
	0.0028	136.2	0.0064	299.9	0.0100	450.8	0.0136	589.1
	0.0029	140.9	0.0065	304.2	0.0101	454.8	0.0137	592.7
	0.0030	145.6	0.0066	308.6	0.0102	458.8	0.0138	596.4
	0.0031	150.3	0.0067	312.9	0.0103	462.8	0.0139	600.0
	0.0032	155.0	0.0068	317.3	0.0104	466.8	0.0140	603.6
	0.0033	159.7	0.0069	321.6	0.0105	470.8	0.0141	607.2
	0.0034	164.3	0.0070	325.9	0.0106	474.8	0.0142	610.9
	0.0035	169.0	0.0071	330.2	0.0107	478.7	0.0143	614.5
	0.0036	173.6	0.0072	334.5	0.0108	482.6	0.0144	618.0
	0.0037	178.3	0.0073	338.8	0.0109	486.6	0.0145	621.6
	0.0038	182.9	0.0074	343.1	0.0110	490.5	0.0146	625.2
	0.0039	187.5	0.0075	347.3	0.0111	494.4	0.0147	628.7
ρ_{min} for flexure	0.0040	192.1	0.0076	351.6	0.0112	498.3	0.0148	632.3
	0.0041	196.7	0.0077	355.8	0.0113	502.2	0.0149	635.8
	0.0042	201.3	0.0078	360.1	0.0114	506.1	0.0150	639.4
	0.0043	205.9	0.0079	364.3	0.0115	510.0	0.0151	642.9
	0.0044	210.5	0.0080	368.5	0.0116	513.8	0.0152	646.4
	0.0045	215.0	0.0081	372.7	0.0117	517.7	0.0153	649.9
	0.0046	219.6	0.0082	376.9	0.0118	521.5	0.0154	653.4
	0.0047	224.1	0.0083	381.1	0.0119	525.4	0.0155	656.9
	0.0048	228.7	0.0084	385.3	0.0120	529.2	0.0156	660.3
	0.0049	233.2	0.0085	389.5	0.0121	533.0	0.0157	663.8
	0.0050	237.7	0.0086	393.6	0.0122	536.8	0.0158	667.3
	0.0051	242.2	0.0087	397.8	0.0123	540.6	0.0159	670.7
	0.0052	246.7	0.0088	401.9	0.0124	544.4	0.0160	674.1
	0.0053	251.2	0.0089	406.1	0.0125	548.2	0.0161	677.5
	0.0054	255.7	0.0090	410.2	0.0126	551.9	0.0162	681.0
	0.0055	260.1	0.0091	414.3	0.0127	555.7	0.0163	684.4

Table A.11 f_y = 50,000 PSI; f'_c = 4000 PSI—U.S. Customary Units

	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage	0.0020	98.53	0.0061	291.3	0.0102	471.6	0.0143	639.6
	0.0021	103.4	0.0062	295.8	0.0103	475.9	0.0144	643.5
	0.0022	108.2	0.0063	300.4	0.0104	480.1	0.0145	647.5
	0.0023	113.0	0.0064	304.9	0.0105	484.3	0.0146	651.4
	0.0024	117.9	0.0065	309.4	0.0106	488.6	0.0147	655.3
	0.0025	122.7	0.0066	313.9	0.0107	492.8	0.0148	659.2
	0.0026	127.5	0.0067	318.4	0.0108	497.0	0.0149	663.1
	0.0027	132.3	0.0068	322.9	0.0109	501.2	0.0150	667.0
	0.0028	137.1	0.0069	327.4	0.0110	505.4	0.0151	670.9
	0.0029	141.9	0.0070	331.9	0.0111	509.6	0.0152	674.8
	0.0030	146.7	0.0071	336.4	0.0112	513.7	0.0153	678.7
	0.0031	151.5	0.0072	340.9	0.0113	517.9	0.0154	682.5
	0.0032	156.2	0.0073	345.3	0.0114	522.1	0.0155	686.4
	0.0033	161.0	0.0074	349.8	0.0115	526.2	0.0156	690.3
	0.0034	165.7	0.0075	354.3	0.0116	530.4	0.0157	694.1
	0.0035	170.5	0.0076	358.7	0.0117	534.5	0.0158	697.9
	0.0036	175.2	0.0077	363.1	0.0118	538.6	0.0159	701.8
	0.0037	180.0	0.0078	367.6	0.0119	542.8	0.0160	705.6
	0.0038	184.7	0.0079	372.0	0.0120	546.9	0.0161	709.4
	0.0039	189.4	0.0080	376.4	0.0121	551.0	0.0162	713.2
ρ_{min} for flexure	0.0040	194.1	0.0081	380.8	0.0122	555.1	0.0163	717.0
	0.0041	198.8	0.0082	385.2	0.0123	559.2	0.0164	720.8
	0.0042	203.5	0.0083	389.6	0.0124	563.3	0.0165	724.6
	0.0043	208.2	0.0084	394.0	0.0125	567.4	0.0166	728.4
	0.0044	212.9	0.0085	398.4	0.0126	571.4	0.0167	732.1
	0.0045	217.5	0.0086	402.7	0.0127	575.5	0.0168	735.9
	0.0046	222.2	0.0087	407.1	0.0128	579.6	0.0169	327.4
	0.0047	226.9	0.0088	411.4	0.0129	583.6	0.0170	743.4
	0.0048	231.5	0.0089	415.8	0.0130	587.7	0.0171	747.2
	0.0049	236.1	0.0090	420.1	0.0131	591.7	0.0172	750.9
	0.0050	240.8	0.0091	424.5	0.0132	595.7	0.0173	754.6
	0.0051	245.4	0.0092	428.8	0.0133	599.8	0.0174	758.3
	0.0052	250.0	0.0093	433.1	0.0134	603.8	0.0175	762.1
	0.0053	254.6	0.0094	437.4	0.0135	607.8	0.0176	765.8
	0.0054	259.2	0.0095	441.7	0.0136	611.8	0.0177	769.5
	0.0055	263.8	0.0096	446.0	0.0137	615.8	0.0178	773.2
	0.0056	268.4	0.0097	450.3	0.0138	619.8	0.0179	776.8
	0.0057	273.0	0.0098	454.6	0.0139	623.7	0.0180	780.5
	0.0058	277.6	0.0099	458.9	0.0140	627.7	0.0181	784.2
	0.0059	282.2	0.0100	463.1	0.0141	631.7	0.0182	787.8
	0.0060	286.7	0.0101	467.4	0.0142	635.6	0.0183	791.5

Table A.11 (Continued)

ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
0.0184	795.1	0.0193	827.6	0.0202	859.5	0.0210	887.4
0.0185	798.8	0.0194	831.2	0.0203	863.0	0.0211	890.8
0.0186	802.4	0.0195	834.8	0.0204	866.5	0.0212	894.3
0.0187	806.0	0.0196	838.3	0.0205	870.0	0.0213	897.7
0.0188	809.7	0.0197	841.9	0.0206	873.5	0.0214	901.1
0.0189	813.3	0.0198	845.4	0.0207	877.0	0.0215	904.5
0.0190	816.9	0.0199	849.0	0.0208	880.5	0.0216	907.9
0.0191	820.5	0.0200	852.5	0.0209	883.9	0.0217	911.3
0.0192	824.1	0.0201	856.0				

Table A.12 f_y = 60,000 PSI; f'_c = 3000 PSI—U.S. Customary Units

	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage	0.0018	105.7	0.0039	223.2	0.0060	334.5	0.0081	439.5
	0.0019	111.5	0.0040	228.7	0.0061	339.7	0.0082	444.4
	0.0020	117.2	0.0041	234.1	0.0062	344.8	0.0083	449.2
	0.0021	122.9	0.0042	239.5	0.0063	349.9	0.0084	454.0
	0.0022	128.6	0.0043	244.9	0.0064	355.0	0.0085	458.8
	0.0023	134.3	0.0044	250.3	0.0065	360.1	0.0086	463.6
	0.0024	139.9	0.0045	255.7	0.0066	365.2	0.0087	468.4
	0.0025	145.6	0.0046	261.0	0.0067	370.2	0.0088	473.2
	0.0026	151.2	0.0047	266.4	0.0068	375.3	0.0089	477.9
	0.0027	156.9	0.0048	271.7	0.0069	380.3	0.0090	482.6
	0.0028	162.5	0.0049	277.0	0.0070	385.3	0.0091	487.4
	0.0029	168.1	0.0050	282.3	0.0071	390.3	0.0092	492.1
	0.0030	173.7	0.0051	287.6	0.0072	395.3	0.0093	496.8
	0.0031	179.2	0.0052	292.9	0.0073	400.3	0.0094	501.4
	0.0032	184.8	0.0053	298.1	0.0074	405.2	0.0095	506.1
ρ_{min} for flexure	0.0033	190.3	0.0054	303.4	0.0075	410.2	0.0096	510.7
	0.0034	195.8	0.0055	308.6	0.0076	415.1	0.0097	515.4
	0.0035	201.3	0.0056	313.8	0.0077	420.0	0.0098	520.0
	0.0036	206.8	0.0057	319.0	0.0078	424.9	0.0099	524.6
	0.0037	212.3	0.0058	324.2	0.0079	429.8	0.0100	529.2
	0.0038	217.8	0.0059	329.4	0.0080	434.7	0.0101	533.8

Table A.12 (Continued)

ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
0.0102	538.3	0.0111	578.8	0.0120	618.0	0.0129	656.2
0.0103	542.9	0.0112	582.3	0.0121	622.3	0.0130	660.9
0.0104	547.4	0.0113	587.6	0.0122	626.6	0.0131	664.5
0.0105	551.9	0.0114	592.0	0.0123	630.9	0.0132	668.6
0.0106	556.4	0.0115	596.4	0.0124	635.1	0.0133	672.8
0.0107	560.9	0.0116	600.7	0.0125	639.4	0.0134	676.9
0.0108	565.4	0.0117	605.1	0.0126	643.6	0.0135	681.0
0.0109	569.9	0.0118	609.4	0.0127	647.8	0.0136	685.0
0.0110	574.3	0.0119	613.7	0.0128	652.0		

Table A.13 f_y = 60,000 PSI; f'_c = 4000 PSI—U.S. Customary Units

	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage	0.0018	106.3	0.0041	237.1	0.0064	362.2	0.0087	481.8
	0.0019	112.1	0.0042	242.6	0.0065	367.6	0.0088	486.9
	0.0020	117.1	0.0043	248.2	0.0066	372.9	0.0089	491.9
	0.0021	123.7	0.0044	253.7	0.0067	378.2	0.0090	497.0
	0.0022	129.4	0.0045	259.2	0.0068	383.4	0.0091	502.0
	0.0023	135.2	0.0046	264.8	0.0069	388.7	0.0092	507.1
	0.0024	141.0	0.0047	270.3	0.0070	394.0	0.0093	512.1
	0.0025	146.7	0.0048	275.8	0.0071	399.2	0.0094	517.1
	0.0026	152.4	0.0049	281.2	0.0072	404.5	0.0095	522.1
	0.0027	158.1	0.0050	286.7	0.0073	409.7	0.0096	527.1
	0.0028	163.8	0.0051	292.2	0.0074	414.9	0.0097	532.0
	0.0029	169.5	0.0052	297.6	0.0075	420.1	0.0098	537.0
	0.0030	175.2	0.0053	303.1	0.0076	425.3	0.0099	542.0
	0.0031	180.9	0.0054	308.5	0.0077	430.5	0.0100	546.9
	0.0032	186.6	0.0055	313.9	0.0078	435.7	0.0101	551.8
ρ_{min} for flexure	0.0033	192.2	0.0056	319.3	0.0079	440.9	0.0102	556.7
	0.0034	197.9	0.0057	324.7	0.0080	446.0	0.0103	561.7
	0.0035	203.5	0.0058	330.1	0.0081	451.2	0.0104	566.6
	0.0036	209.1	0.0059	335.5	0.0082	456.3	0.0105	571.5
	0.0037	214.7	0.0060	340.9	0.0083	461.4	0.0106	576.3
	0.0038	220.3	0.0061	346.2	0.0084	466.5	0.0107	581.2
	0.0039	225.9	0.0062	351.6	0.0085	471.6	0.0108	586.1
	0.0040	231.5	0.0063	356.9	0.0086	476.7	0.0109	590.9

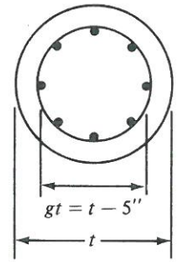
Table A.13 (Continued)

ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
0.0110	595.7	0.0128	681.0	0.0146	762.8	0.0164	841.2
0.0111	600.6	0.0129	685.6	0.0147	767.2	0.0165	845.4
0.0112	605.4	0.0130	690.3	0.0148	771.7	0.0166	849.7
0.0113	610.2	0.0131	694.9	0.0149	776.1	0.0167	853.9
0.0114	615.0	0.0132	699.5	0.0150	780.5	0.0168	858.1
0.0115	619.8	0.0133	704.1	0.0151	784.9	0.0169	862.3
0.0116	624.5	0.0134	708.6	0.0152	789.3	0.0170	866.5
0.0117	629.3	0.0135	713.2	0.0153	793.7	0.0171	870.7
0.0118	634.1	0.0136	717.8	0.0154	798.1	0.0172	874.9
0.0119	638.8	0.0137	722.3	0.0155	802.4	0.0173	879.1
0.0120	643.5	0.0138	726.9	0.0156	806.8	0.0174	883.2
0.0121	648.2	0.0139	731.4	0.0157	811.1	0.0175	887.4
0.0122	653.0	0.0140	735.9	0.0158	815.4	0.0176	891.5
0.0123	657.7	0.0141	740.4	0.0159	819.7	0.0177	895.6
0.0124	662.3	0.0142	744.9	0.0160	824.1	0.0178	899.7
0.0125	667.0	0.0143	749.4	0.0161	828.3	0.0179	903.9
0.0126	671.7	0.0144	753.9	0.0162	832.6	0.0180	907.9
0.0127	676.3	0.0145	758.3	0.0163	836.9	0.0181	912.0

Table A.14 Size and Pitch of Spirals, ACI Code—U.S. Customary Units

Diameter of column (in.)	Out to out of spiral (in.)	f'_c			
		2500	3000	4000	5000
f_y = 40,000:					
14, 15	11,12	$\frac{3}{8}$–2	$\frac{3}{8}$–$1\frac{3}{4}$	$\frac{1}{2}$–$2\frac{1}{2}$	$\frac{1}{2}$–$1\frac{3}{4}$
16	13	$\frac{3}{8}$–2	$\frac{3}{8}$–$1\frac{3}{4}$	$\frac{1}{2}$–$2\frac{1}{2}$	$\frac{1}{2}$–2
17–19	14–16	$\frac{3}{8}$–$2\frac{1}{4}$	$\frac{3}{8}$–$1\frac{3}{4}$	$\frac{1}{2}$–$2\frac{1}{2}$	$\frac{1}{2}$–2
20–23	17–20	$\frac{3}{8}$–$2\frac{1}{4}$	$\frac{3}{8}$–$1\frac{3}{4}$	$\frac{1}{2}$–$2\frac{1}{2}$	$\frac{1}{2}$–2
24–30	21–27	$\frac{3}{8}$–$2\frac{1}{4}$	$\frac{3}{8}$–2	$\frac{1}{2}$–$2\frac{1}{2}$	$\frac{1}{2}$–2
f_y = 60,000:					
14, 15	11, 12	$\frac{1}{4}$–$1\frac{3}{4}$	$\frac{3}{8}$–$2\frac{3}{4}$	$\frac{3}{8}$–2	$\frac{1}{2}$–$2\frac{3}{4}$
16–23	13–20	$\frac{1}{4}$–$1\frac{3}{4}$	$\frac{3}{8}$–$2\frac{3}{4}$	$\frac{3}{8}$–2	$\frac{1}{2}$–3
24–29	21–26	$\frac{1}{4}$–$1\frac{3}{4}$	$\frac{3}{8}$–3	$\frac{3}{8}$–$2\frac{1}{4}$	$\frac{1}{2}$–3
30	17	$\frac{1}{4}$–$1\frac{3}{4}$	$\frac{3}{8}$–3	$\frac{3}{8}$–$2\frac{1}{4}$	$\frac{1}{2}$–$3\frac{1}{4}$

Table A.15 Weights, Areas, and Moments of Inertia of Circular Columns and Moments of Inertia of Column Verticals Arranged in a Circle 5 In. Less Than the Diameter of Column: U.S. Customary Units

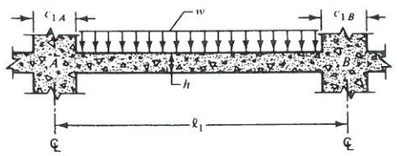


Diameter of column h (in.)	Weight per foot (lb)	Area (in.^{2})	I (in.^{4})	A_s, where $\rho_g = 0.01$*	I_s (in.^{4})†
12	118	113	1,018	1.13	6.92
13	138	133	1,402	1.33	10.64
14	160	154	1,886	1.54	15.59
15	184	177	2,485	1.77	22.13
16	210	201	3,217	2.01	30.40
17	237	227	4,100	2.27	40.86
18	265	255	5,153	2.55	53.87
19	295	284	6,397	2.84	69.58
20	327	314	7,854	3.14	88.31
21	361	346	9,547	3.46	110.7
22	396	380	11,500	3.80	137.2
23	433	416	13,740	4.16	168.4
24	471	452	16,290	4.52	203.9
25	511	491	19,170	4.91	245.5
26	553	531	22,430	5.31	292.7
27	597	573	26,090	5.73	346.7
28	642	616	30,170	6.16	407.3
29	688	661	34,720	6.61	475.9
30	736	707	39,760	7.07	552.3

*For other values of ρ_g, multiply the value by 100 ρ_g.

†The bars are assumed transformed into a thin-walled cylinder having the same sectional area as the bars. Then $I_s = A_s(\gamma t)^2/8$.

Table A.16 Moment Distribution Constants for Slabs Without Drop Panels[a]



Column dimension		Uniform load FEM = Coef. ($w\ell_2\ell_1^2$)		Stiffness factor†		Carryover factor	
$\frac{c_{1A}}{\ell_1}$	$\frac{c_{1B}}{\ell_1}$	M_{AB}	M_{BA}	k_{AB}	k_{BA}	COF_{AB}	COF_{BA}
	0.00	0.083	0.083	4.00	4.00	0.500	0.500
	0.05	0.083	0.084	4.01	4.04	0.504	0.500
	0.10	0.082	0.086	4.03	4.15	0.513	0.499
	0.15	0.081	0.089	4.07	4.32	0.528	0.498
0.00	0.20	0.079	0.093	4.12	4.56	0.548	0.495
	0.25	0.077	0.097	4.18	4.88	0.573	0.491
	0.30	0.075	0.102	4.25	5.28	0.603	0.485
	0.35	0.073	0.107	4.33	5.78	0.638	0.478
	0.05	0.084	0.084	4.05	4.05	0.503	0.503
	0.10	0.083	0.086	4.07	4.15	0.513	0.503
	0.15	0.081	0.089	4.11	4.33	0.528	0.501
0.05	0.20	0.080	0.092	4.16	4.58	0.548	0.499
	0.25	0.078	0.096	4.22	4.89	0.573	0.494
	0.30	0.076	0.101	4.29	5.30	0.603	0.489
	0.35	0.074	0.107	4.37	5.80	0.638	0.481
	0.10	0.085	0.085	4.18	4.18	0.513	0.513
	0.15	0.083	0.088	4.22	4.36	0.528	0.511
0.10	0.20	0.082	0.091	4.27	4.61	0.548	0.508
	0.25	0.080	0.095	4.34	4.93	0.573	0.504
	0.30	0.078	0.100	4.41	5.34	0.602	0.498
	0.35	0.075	0.105	4.50	5.85	0.637	0.491
	0.15	0.086	0.086	4.40	4.40	0.526	0.526
	0.20	0.084	0.090	4.46	4.65	0.546	0.523
0.15	0.25	0.083	0.094	4.53	4.98	0.571	0.519
	0.30	0.080	0.099	4.61	5.40	0.601	0.513
	0.35	0.078	0.104	4.70	5.92	0.635	0.505
	0.20	0.088	0.088	4.72	4.72	0.543	0.543

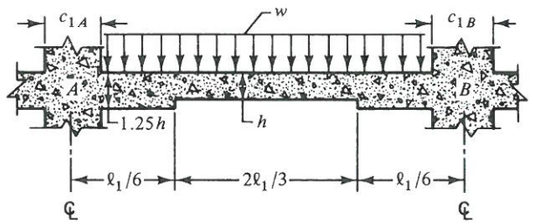
Table A.16 (Continued)

Column dimension		Uniform load FEM = Coef. ($w\ell_2\ell_1^2$)		Stiffness factor†		Carryover factor	
$\frac{c_{1A}}{\ell_1}$	$\frac{c_{1B}}{\ell_1}$	M_{AB}	M_{BA}	k_{AB}	k_{BA}	COF_{AB}	COF_{BA}
0.20	0.25	0.086	0.092	4.79	5.05	0.568	0.539
	0.30	0.083	0.097	4.88	5.48	0.597	0.532
	0.35	0.081	0.102	4.99	6.01	0.632	0.524
	0.25	0.090	0.090	5.14	5.14	0.563	0.563
0.25	0.30	0.088	0.095	5.24	5.58	0.592	0.556
	0.35	0.085	0.100	5.36	6.12	0.626	0.548
0.30	0.30	0.092	0.092	5.69	5.69	0.585	0.585
	0.35	0.090	0.097	5.83	6.26	0.619	0.576
0.35	0.35	0.095	0.095	6.42	6.42	0.609	0.609

[a]Applicable when $c_1/\ell_1 = c_2/\ell_2$. For other relationships between these ratios, the constants will be slightly in error.

†Stiffness is $K_{AB} = k_{AB}E\frac{\ell_2 h^3}{12\ell_1}$ and $K_{BA} = k_{BA}E\frac{\ell_2 h^3}{12\ell_1}$

Table A.17 Moment Distribution Constants for Slabs with Drop Panels[a]



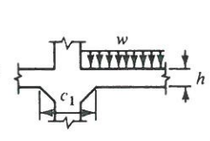
Column dimension		Uniform load FEM = Coef. ($w\ell_2\ell_1^2$)		Stiffness factor†		Carryover factor	
$\frac{c_{1A}}{\ell_1}$	$\frac{c_{1B}}{\ell_1}$	M_{AB}	M_{BA}	k_{AB}	k_{BA}	COF_{AB}	COF_{BA}
	0.00	0.088	0.088	4.78	4.78	0.541	0.541
	0.05	0.087	0.089	4.80	4.82	0.545	0.541
	0.10	0.087	0.090	4.83	4.94	0.553	0.541
0.00	0.15	0.085	0.093	4.87	5.12	0.567	0.540
	0.20	0.084	0.096	4.93	5.36	0.585	0.537
	0.25	0.082	0.100	5.00	5.68	0.606	0.534
	0.30	0.080	0.105	5.09	6.07	0.631	0.529
	0.05	0.088	0.088	4.84	4.84	0.545	0.545
	0.10	0.087	0.090	4.87	4.95	0.553	0.544
	0.15	0.085	0.093	4.91	5.13	0.567	0.543
0.05	0.20	0.084	0.096	4.97	5.38	0.584	0.541
	0.25	0.082	0.100	5.05	5.70	0.606	0.537
	0.30	0.080	0.104	5.13	6.09	0.632	0.532
	0.10	0.089	0.089	4.98	4.98	0.553	0.553
	0.15	0.088	0.092	5.03	5.16	0.566	0.551
0.10	0.20	0.086	0.094	5.09	5.42	0.584	0.549
	0.25	0.084	0.099	5.17	5.74	0.606	0.546
	0.30	0.082	0.103	5.26	6.13	0.631	0.541
	0.15	0.090	0.090	5.22	5.22	0.565	0.565
	0.20	0.089	0.094	5.28	5.47	0.583	0.563
0.15	0.25	0.087	0.097	5.37	5.80	0.604	0.559
	0.30	0.085	0.102	5.46	6.21	0.630	0.554
	0.20	0.092	0.092	5.55	5.55	0.580	0.580
0.20	0.25	0.090	0.096	5.64	5.88	0.602	0.577
	0.30	0.088	0.100	5.74	6.30	0.627	0.571
0.25	0.25	0.094	0.094	5.98	5.98	0.598	0.598
	0.30	0.091	0.098	6.10	6.41	0.622	0.593
0.30	0.30	0.095	0.095	6.54	6.54	0.617	0.617

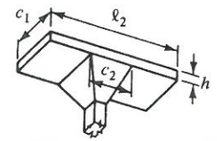
[a]Applicable when $c_1/\ell_1 = c_2/\ell_2$. For other relationships between these ratios, the constants will be slightly in error.

†Stiffness is $K_{AB} = k_{AB}E\frac{\ell_2 h^3}{12\ell_1}$ and $K_{BA} = k_{BA}E\frac{\ell_2 h^3}{12\ell_1}$

Table A.18 Moment Distribution Constants for Slab-Beam Members with Column Capitals

FEM (uniform load w) $= Mw\ell_2(\ell_1)^2$
K (stiffness) $= kE\ell_2 h^3/12\ell_1$
Carryover factor $= C$





c_1/ℓ_1	c_1/ℓ_2	M	k	C	c_1/ℓ_1	c_2/ℓ_2	M	k	C
	0.00	0.083	4.000	0.500		0.00	0.083	4.000	0.500
	0.05	0.083	4.000	0.500		0.05	0.085	4.170	0.511
	0.10	0.083	4.000	0.500		0.10	0.086	4.346	0.522
	0.15	0.083	4.000	0.500		0.15	0.087	4.529	0.532
	0.20	0.083	4.000	0.500		0.20	0.088	4.717	0.543
0.00	0.25	0.083	4.000	0.500	0.20	0.25	0.089	4.910	0.554
	0.30	0.083	4.000	0.500		0.30	0.090	5.108	0.564
	0.35	0.083	4.000	0.500		0.35	0.091	5.308	0.574
	0.40	0.083	4.000	0.500		0.40	0.092	5.509	0.584
	0.45	0.083	4.000	0.500		0.45	0.093	5.710	0.593
	0.50	0.083	4.000	0.500		0.50	0.094	5.908	0.602
	0.00	0.083	4.000	0.500		0.00	0.083	4.000	0.500
	0.05	0.084	4.047	0.503		0.05	0.085	4.204	0.512
	0.10	0.084	4.093	0.507		0.10	0.086	4.420	0.525
	0.15	0.084	4.138	0.510		0.15	0.087	4.648	0.538
	0.20	0.085	4.181	0.513		0.20	0.089	4.887	0.550
0.05	0.25	0.085	4.222	0.516	0.25	0.25	0.090	5.138	0.563
	0.30	0.085	4.261	0.518		0.30	0.091	5.401	0.576
	0.35	0.086	4.299	0.521		0.35	0.093	5.672	0.588
	0.40	0.086	4.334	0.523		0.40	0.094	5.952	0.600
	0.45	0.086	4.368	0.526		0.45	0.095	6.238	0.612
	0.50	0.086	4.398	0.528		0.50	0.096	6.527	0.623
	0.00	0.083	4.000	0.500		0.00	0.083	4.000	0.500
	0.05	0.084	4.091	0.506		0.05	0.085	4.235	0.514
	0.10	0.085	4.182	0.513		0.10	0.086	4.488	0.527
	0.15	0.085	4.272	0.519		0.15	0.088	4.760	0.542
	0.20	0.086	4.362	0.524		0.20	0.089	5.050	0.556
0.10	0.25	0.087	4.449	0.530	0.30	0.25	0.091	5.361	0.571
	0.30	0.087	4.535	0.535		0.30	0.092	5.692	0.585
	0.35	0.088	4.618	0.540		0.35	0.094	6.044	0.600
	0.40	0.088	4.698	0.545		0.40	0.095	6.414	0.614
	0.45	0.089	4.774	0.550		0.45	0.096	6.802	0.628
	0.50	0.089	4.846	0.554		0.50	0.098	7.205	0.642
	0.00	0.083	4.000	0.500		0.00	0.083	4.000	0.500
	0.05	0.084	4.132	0.509		0.05	0.085	4.264	0.514
	0.10	0.085	4.267	0.517		0.10	0.087	4.551	0.529
	0.15	0.086	4.403	0.526		0.15	0.088	4.864	0.545
	0.20	0.087	4.541	0.534		0.20	0.090	5.204	0.560
0.15	0.25	0.088	4.680	0.543	0.35	0.25	0.091	5.575	0.576
	0.30	0.089	4.818	0.550		0.30	0.093	5.979	0.593

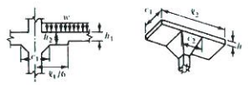
Table A.18 (Continued)

c_1/ℓ_1	c_1/ℓ_2	M	k	C	c_1/ℓ_1	c_1/ℓ_2	M	k	C
	0.35	0.090	4.955	0.558		0.35	0.095	6.416	0.609
	0.40	0.090	5.090	0.565		0.40	0.096	6.888	0.626
	0.45	0.091	5.222	0.572		0.45	0.098	7.395	0.642
	0.50	0.092	5.349	0.579		0.50	0.099	7.935	0.658
	0.00	0.083	4.000	0.500		0.30	0.094	6.517	0.602
	0.05	0.085	4.289	0.515		0.35	0.096	7.136	0.621
	0.10	0.087	4.607	0.530		0.40	0.098	7.836	0.642
	0.15	0.088	4.959	0.546		0.45	0.100	8.625	0.662
	0.20	0.090	5.348	0.563		0.50	0.101	9.514	0.683
0.40	0.25	0.092	5.778	0.580		0.00	0.083	4.000	0.500
	0.30	0.094	6.255	0.598		0.05	0.085	4.331	0.515
	0.35	0.095	6.782	0.617		0.10	0.087	4.703	0.530
	0.40	0.097	7.365	0.635		0.15	0.088	5.123	0.547
	0.45	0.099	8.007	0.654		0.20	0.090	5.599	0.564
	0.50	0.100	8.710	0.672	0.50	0.25	0.092	6.141	0.583
	0.00	0.083	4.000	0.500		0.30	0.094	6.760	0.603
	0.05	0.085	4.311	0.515		0.35	0.096	7.470	0.624
	0.10	0.087	4.658	0.530		0.40	0.098	8.289	0.645
	0.15	0.088	5.046	0.547		0.45	0.100	9.234	0.667
	0.20	0.090	5.480	0.564		0.50	0.102	10.329	0.690
0.45	0.25	0.092	5.967	0.583					

Table A.19 Moment Distribution Constants for Slab-Beam Members with Column Capitals and Drop Panels

FEM (uniform load w) $= Mw\ell(\ell_1^2)$

K (stiffness) $= kE\ell_2 h^3/12\ell_1$

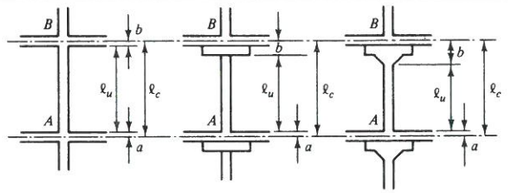


c_1/ℓ_1	c_2/ℓ_2	Constants for $h_2 = 1.25h_1$			Constants for $h_2 = 1.5h_2$		
		M	k	C	M	k	C
	0.00	0.088	4.795	0.542	0.093	5.837	0.589
	0.05	0.088	4.795	0.542	0.093	5.837	0.589
	0.10	0.088	4.795	0.542	0.093	5.837	0.589
0.00	0.15	0.088	4.795	0.542	0.093	5.837	0.589
	0.20	0.088	4.795	0.542	0.093	5.837	0.589
	0.25	0.088	4.795	0.542	0.093	5.837	0.589
	0.30	0.088	4.797	0.542	0.093	5.837	0.589
	0.00	0.088	4.795	0.542	0.093	5.837	0.589
	0.05	0.088	4.846	0.545	0.093	5.890	0.591
	0.10	0.089	4.896	0.548	0.093	5.942	0.594

Table A.19 (Continued)

c_1/ℓ_1	c_2/ℓ_2	Constants for $h_2 = 1.25h_1$			Constants for $h_2 = 1.5h_2$		
		M	k	C	M	k	C
0.05	0.15	0.089	4.944	0.551	0.093	5.993	0.596
	0.20	0.089	4.990	0.553	0.094	6.041	0.598
	0.25	0.089	5.035	0.556	0.094	6.087	0.600
	0.30	0.090	5.077	0.558	0.094	6.131	0.602
	0.00	0.088	4.795	0.542	0.093	5.837	0.589
	0.05	0.088	4.894	0.548	0.093	5.940	0.593
	0.10	0.089	4.992	0.553	0.094	6.042	0.598
0.10	0.15	0.090	5.039	0.559	0.094	6.142	0.602
	0.20	0.090	5.184	0.564	0.094	6.240	0.607
	0.25	0.091	5.278	0.569	0.095	6.335	0.611
	0.30	0.091	5.368	0.573	0.095	6.427	0.615
	0.00	0.088	4.795	0.542	0.093	5.837	0.589
	0.05	0.089	4.938	0.550	0.093	5.986	0.595
	0.10	0.090	5.082	0.558	0.094	6.135	0.602
0.15	0.15	0.090	5.228	0.565	0.095	6.284	0.608
	0.20	0.091	5.374	0.573	0.095	6.432	0.614
	0.25	0.092	5.520	0.580	0.096	6.579	0.620
	0.30	0.092	5.665	0.587	0.096	6.723	0.626
	0.00	0.088	4.795	0.542	0.093	5.837	0.589
	0.05	0.089	4.978	0.552	0.093	6.027	0.597
	0.10	0.090	5.167	0.562	0.094	6.221	0.605
0.20	0.15	0.091	5.361	0.571	0.095	6.418	0.613
	0.20	0.092	5.558	0.581	0.096	6.616	0.621
	0.25	0.093	5.760	0.590	0.096	6.816	0.628
	0.30	0.094	5.962	0.590	0.097	7.015	0.635
	0.00	0.088	4.795	0.542	0.093	5.837	0.589
	0.05	0.089	5.015	0.553	0.094	6.065	0.598
	0.10	0.090	5.245	0.565	0.094	6.300	0.608
0.25	0.15	0.091	5.485	0.576	0.095	6.543	0.617
	0.20	0.092	5.735	0.587	0.096	6.790	0.626
	0.25	0.094	5.994	0.598	0.097	7.043	0.635
	0.30	0.095	6.261	0.600	0.098	7.298	0.644
	0.00	0.088	4.795	0.542	0.093	5.837	0.589
	0.05	0.089	5.048	0.554	0.094	6.099	0.599
	0.10	0.090	5.317	0.567	0.095	6.372	0.610
0.30	0.15	0.092	5.601	0.580	0.096	6.657	0.620
	0.20	0.093	5.902	0.593	0.097	6.953	0.631
	0.25	0.094	6.219	0.605	0.098	7.258	0.641
	0.30	0.095	6.550	0.618	0.099	7.571	0.651

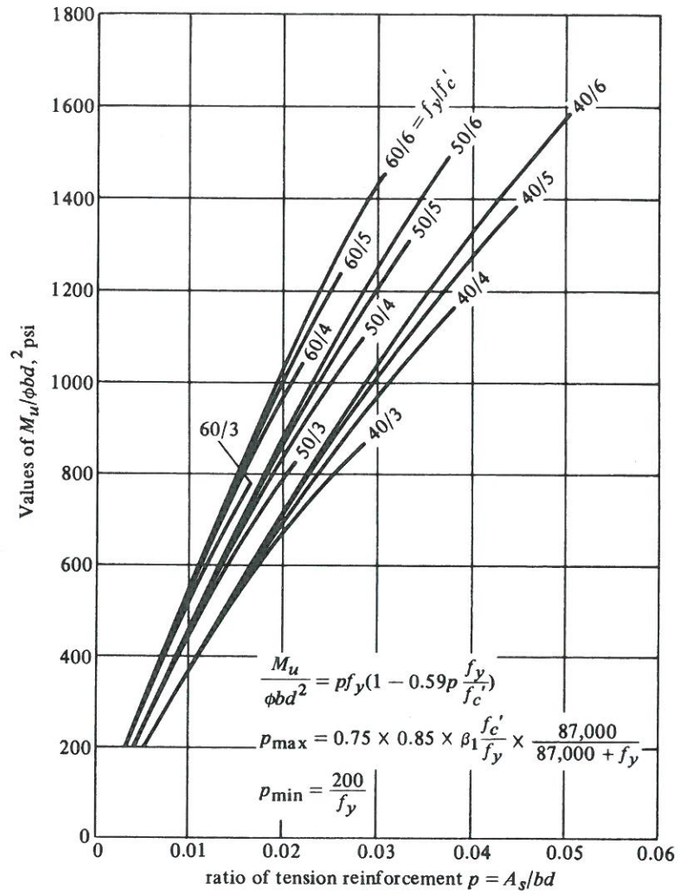
Table A20 Stiffness Factors and Carryover Factors for Columns



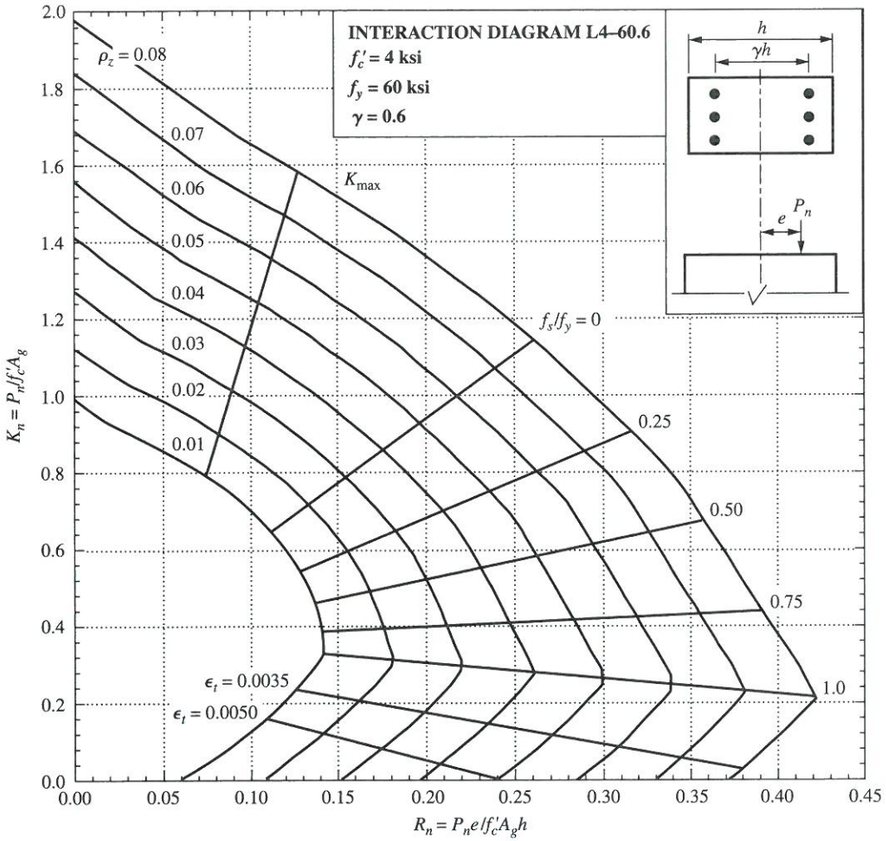
a/b		ℓ_u/ℓ_n = 0.95	0.90	0.85	0.80	0.75
0.20	k_{AB}	4.32	4.70	5.33	5.65	6.27
	C_{AB}	0.57	0.64	0.71	0.80	0.89
0.40	k_{AB}	4.40	4.89	5.45	6.15	7.00
	C_{AB}	0.56	0.61	0.68	0.74	0.81
0.60	k_{AB}	4.46	5.02	5.70	6.54	7.58
	C_{AB}	0.55	0.60	0.65	0.70	0.76
0.80	k_{AB}	4.51	5.14	5.90	6.85	8.05
	C_{AB}	0.54	0.58	0.63	0.67	0.72
1.00	k_{AB}	4.55	5.23	6.06	7.11	8.44
	C_{AB}	0.54	0.57	0.61	0.65	0.68
1.20	k_{AB}	4.58	5.30	6.20	7.32	8.77
	C_{AB}	0.53	0.57	0.60	0.63	0.66
1.40	k_{AB}	4.61	5.36	6.31	7.51	9.05
	C_{AB}	0.53	0.56	0.59	0.61	0.64
1.60	k_{AB}	4.63	5.42	6.41	7.66	9.29
	C_{AB}	0.53	0.55	0.58	0.60	0.62
1.80	k_{AB}	4.65	5.46	6.49	7.80	9.50
	C_{AB}	0.53	0.55	0.57	0.59	0.60
2.00	k_{AB}	4.67	5.51	6.56	7.92	9.68
	C_{AB}	0.52	0.54	0.56	0.58	0.59

Notes: 1. Values computed by column analogy method.

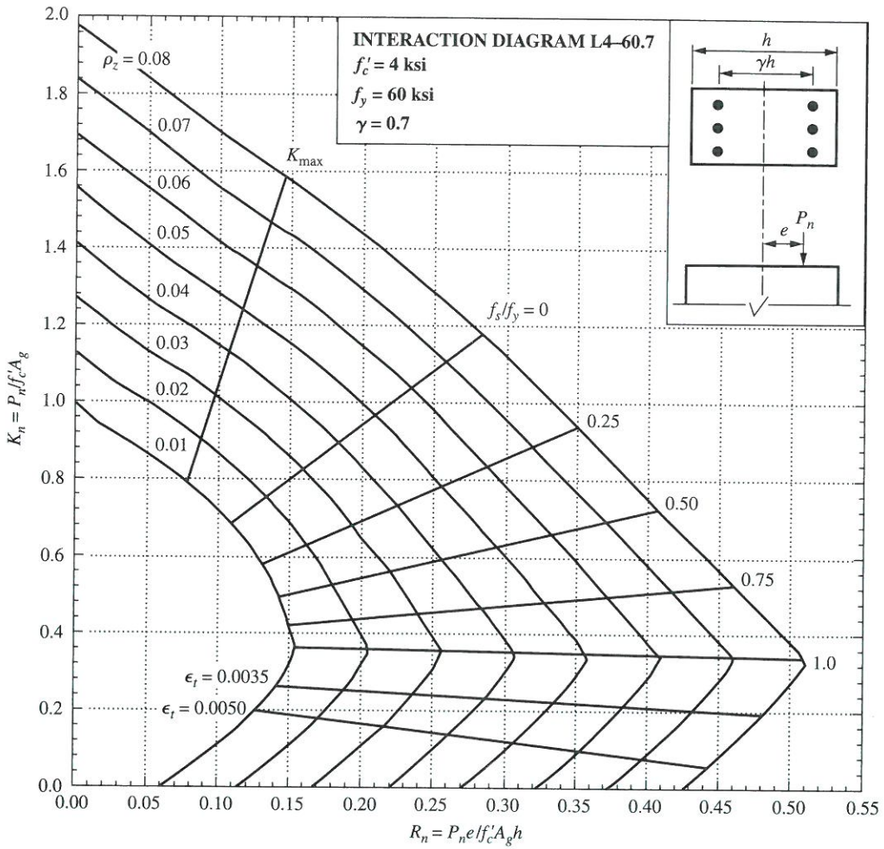
2. $k_c = (k_{AB} \text{ from table})\left(\frac{EI_0}{\ell_n}\right)$.



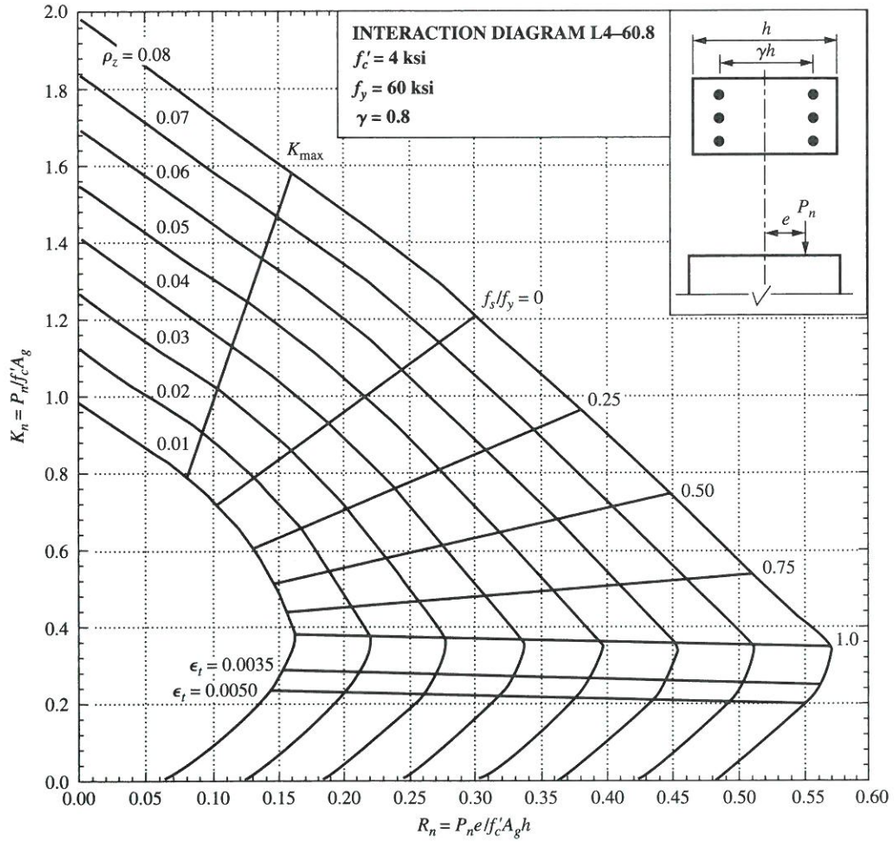
Graph 1 Moment capacity of rectangular sections. (*Note:* The upper ends of the curves shown here for 40 and 50 ksi bars correspond to ρ values for which $\epsilon_t < 0.004$ in the steel.)



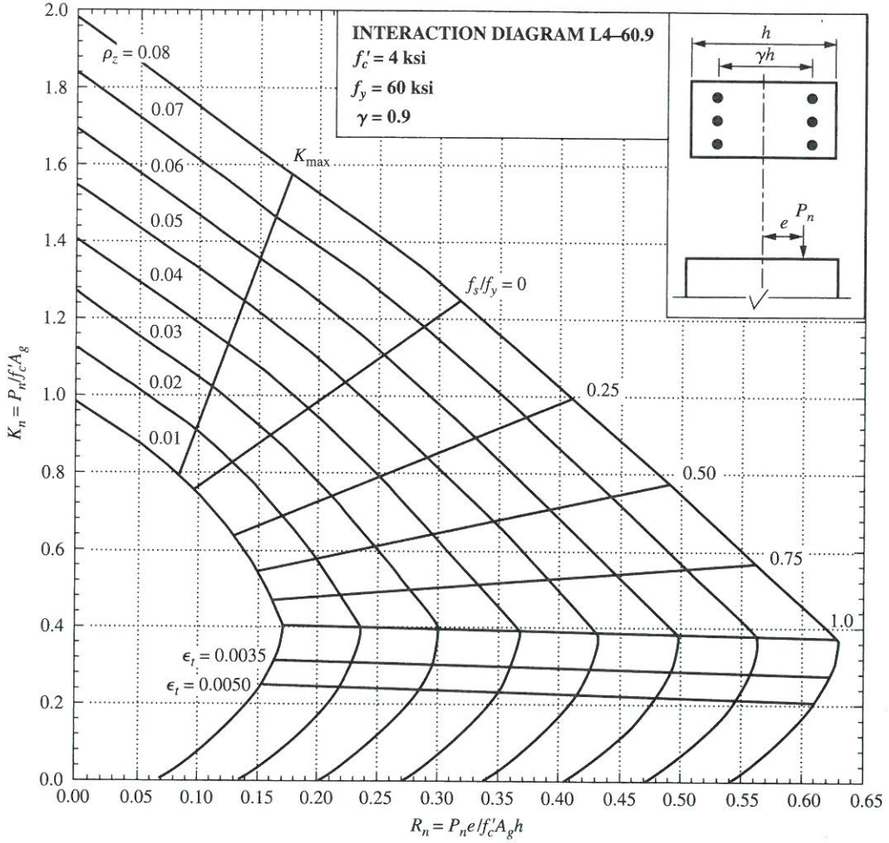
Graph 2 Column interaction diagrams for rectangular tied columns with bars on end faces only. (Graphs 2 through 13 are published with the permission of the American Concrete Institute.)



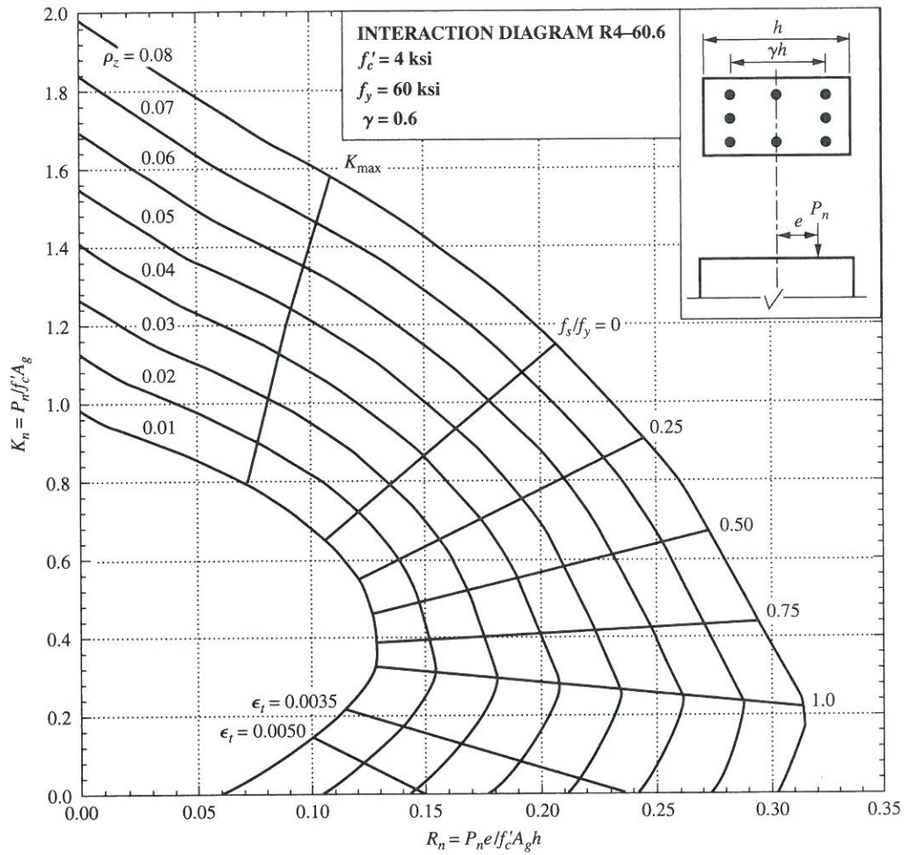
Graph 3 Column interaction diagrams for rectangular tied columns with bars on end faces only.



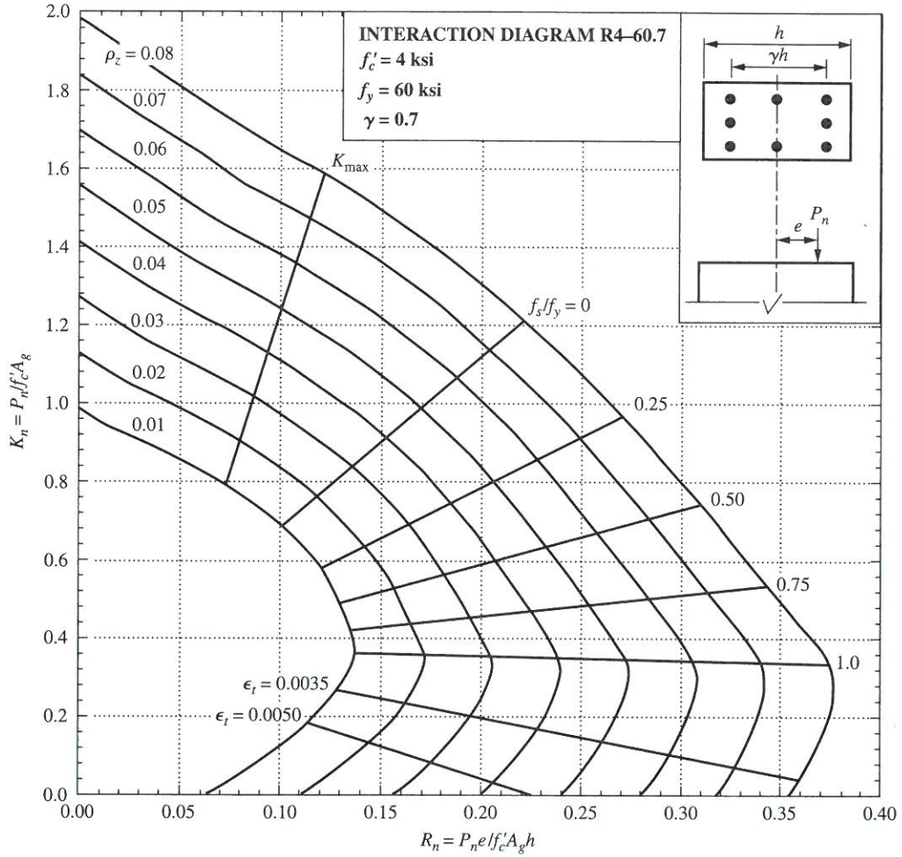
Graph 4 Column interaction diagrams for rectangular tied columns with bars on end faces only.



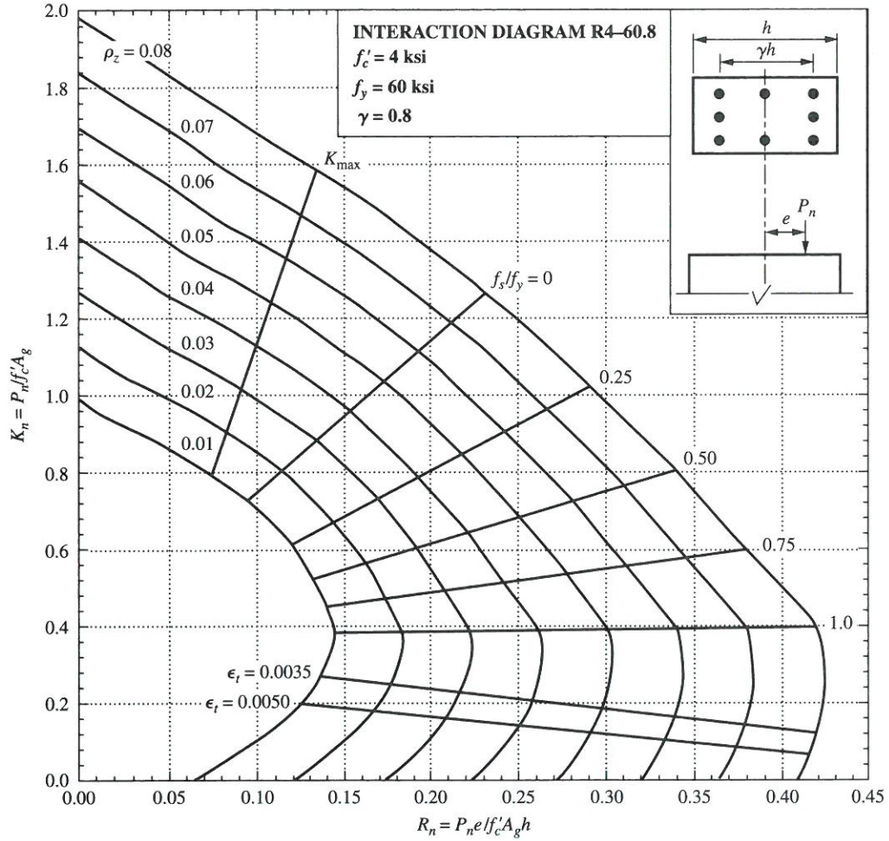
Graph 5 Column interaction diagrams for rectangular tied columns with bars on end faces only.



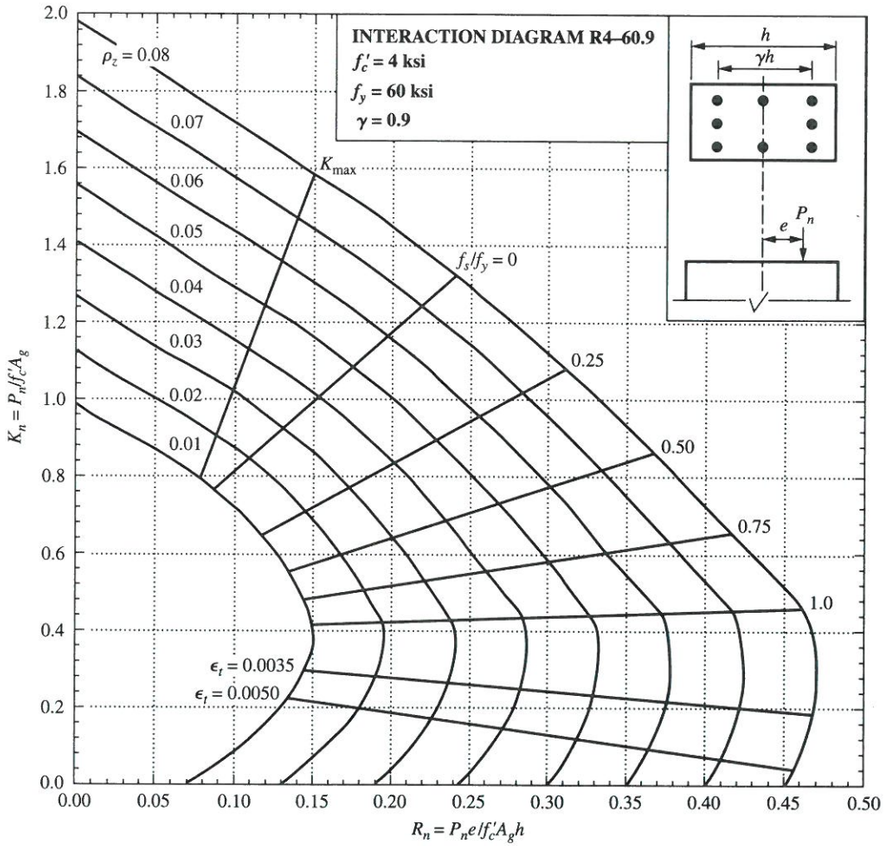
Graph 6 Column interaction diagrams for rectangular tied columns with bars on all four faces.



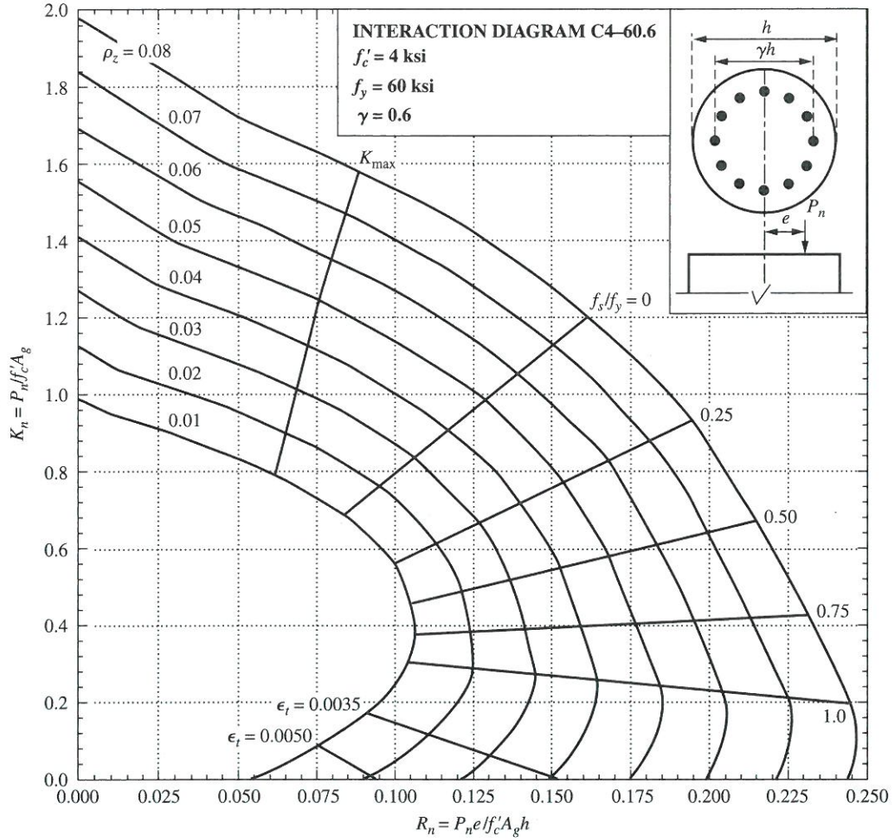
Graph 7 Column interaction diagrams for rectangular tied columns with bars on all four faces.



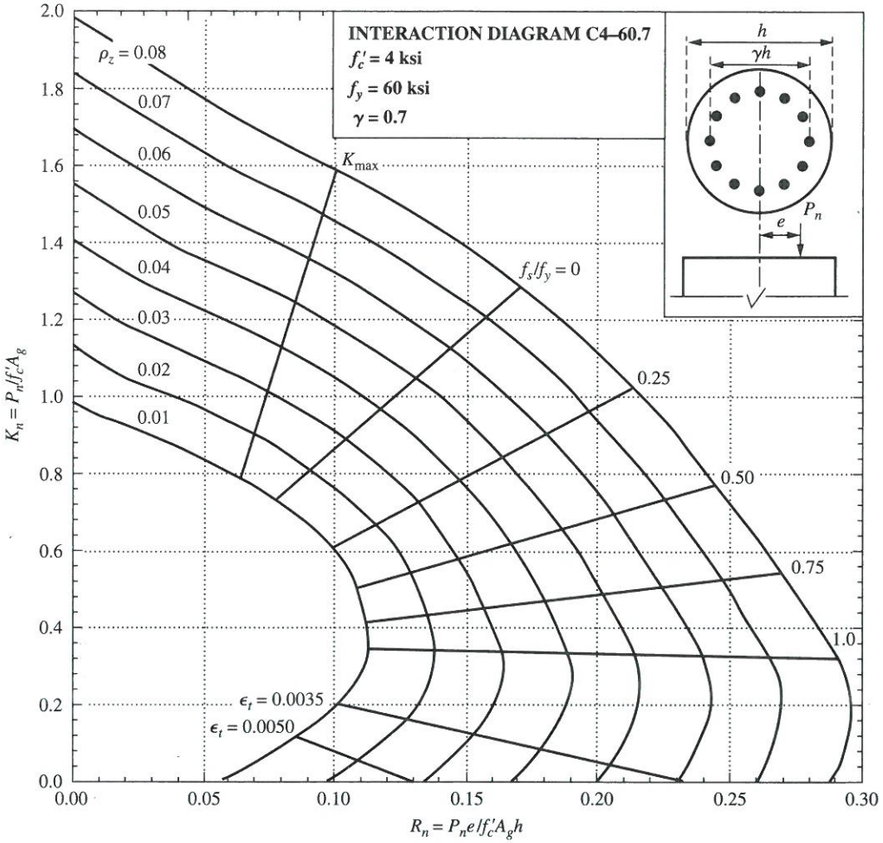
Graph 8 Column interaction diagrams for rectangular tied columns with bars on all four faces.



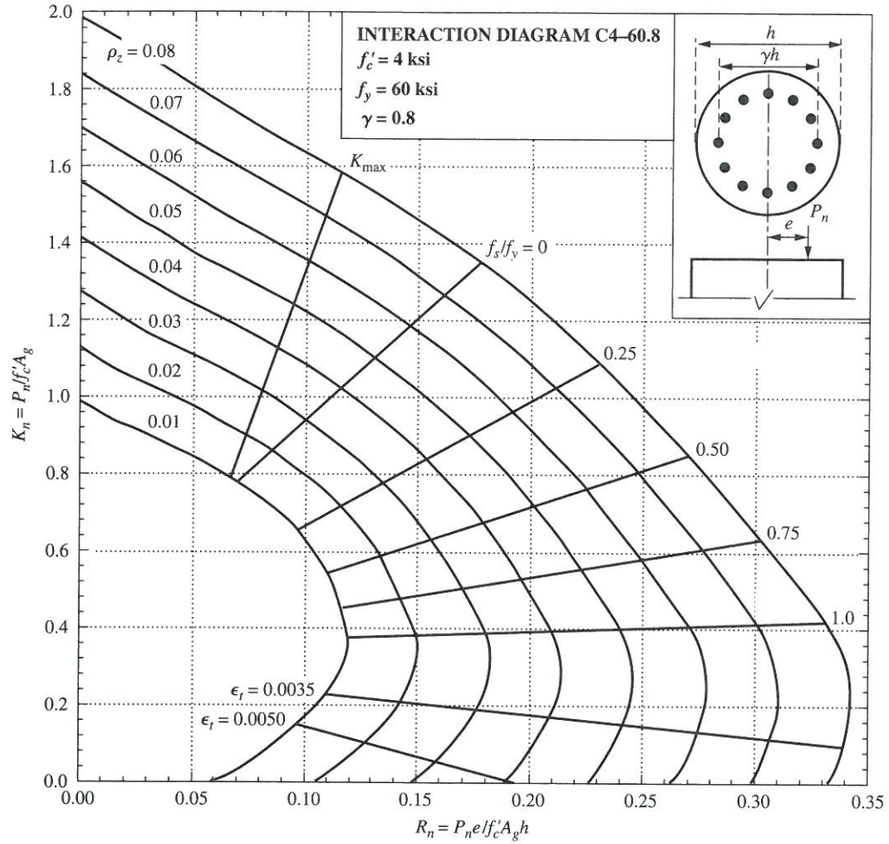
Graph 9 Column interaction diagrams for rectangular tied columns with bars on all four faces.



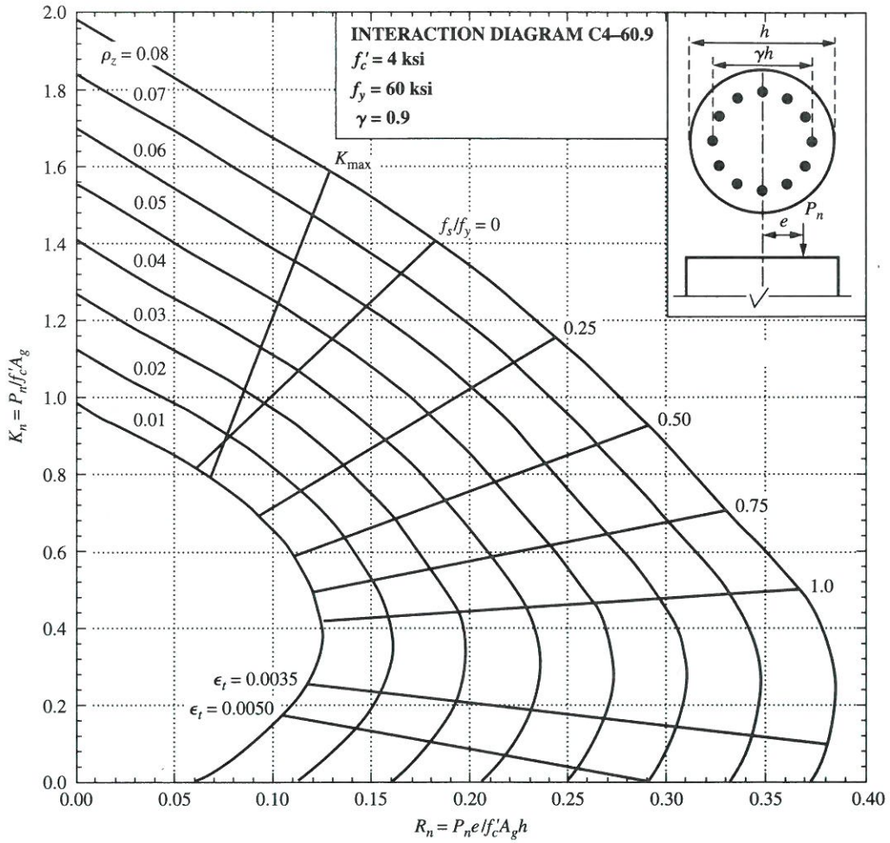
Graph 10 Column interaction diagrams for circular spiral columns.



Graph 11 Column interaction diagrams for circular spiral columns.



Graph 12 Column interaction diagrams for circular spiral columns.



Graph 13 Column interaction diagrams for circular spiral columns.