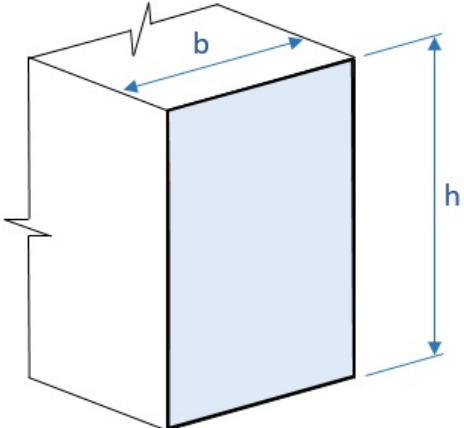


REFERENCES	CALCULATIONS	RESULTS
<p>Code: ACI 318-14</p>	<p>MEMBER #1 (SECTION POSITION 192.0 INCHES) COLUMN DESIGN REPORT</p> <p>Project details</p> <p>Project Name: Project ID: Company: Designer: Client: Project Notes: Project Units: Imperial</p> <p>General member design information</p> <p>Dimensions:</p>  <p>Height $h = 14$ in Width $b = 12$ in Member length = 192 in</p> <p>Material properties: Concrete strength $f_c = 4000$ psi Steel strength of longitudinal rebar $f_y = 60000$ psi Steel strength of shear rebar $f_{yt} = 50000$ psi Permissible crack width $c_w = 0.012$ in</p> <p>Load Combinations</p> <p>Ultimate Limit State: LC 1: 1.4DL (N = 175.00 Kip, Mz = -14.00 Kip-ft, My = 0.00 Kip-ft) LC 2: 1.2DL+1.6LL (N = 250.00 Kip, Mz = -60.00 Kip-ft, My = 0.00 Kip-ft) LC 3: 0.9DL+1.6WL (N = 112.50 Kip, Mz = -9.00 Kip-ft, My = 0.00 Kip-ft) LC 4: 1.2DL+1.0LL+1.6WL (N = 212.50 Kip, Mz = -42.00 Kip-ft, My = 0.00 Kip-ft) LC 5: 0.9DL+1.0EL (N = 112.50 Kip, Mz = -9.00 Kip-ft, My = 0.00 Kip-ft) LC 6: 1.2DL+1.0LL+1.0EL (N = 212.50 Kip, Mz = -42.00 Kip-ft, My = 0.00 Kip-ft) LC 7: 1.2DL+1.6LL+0.5SL (N = 250.00 Kip, Mz = -60.00 Kip-ft, My = 0.00 Kip-ft) LC 8: 1.2DL+1.0LL+1.6SL (N = 212.50 Kip, Mz = -42.00 Kip-ft, My = 0.00 Kip-ft) LC 9: 1.2DL+1.6SL+0.8WL (N = 150.00 Kip, Mz = -12.00 Kip-ft, My = 0.00 Kip-ft) LC 10: 1.2DL+1.0LL+0.5SL+1.6WL (N = 212.50 Kip, Mz = -42.00 Kip-ft, My = 0.00 Kip-ft) LC 11: 1.2DL+1.0LL+0.2SL+1.0EL (N = 212.50 Kip, Mz = -42.00 Kip-ft, My = 0.00 Kip-ft)</p> <p>Serviceability Limit State: LC 1: 1.0DL (N = 125.00 Kip, Mz = -10.00 Kip-ft, My = 0.00 Kip-ft) LC 2: 1.0DL+1.0LL (N = 187.50 Kip, Mz = -40.00 Kip-ft, My = 0.00 Kip-ft)</p> <p>DL - Dead Load LL - Live Load WL - Wind Load LrL - Roof Live Load RL - Rain Load SL - Snow Load EL - Earthquake Load</p>	
	<p>Strength status of column section based on all load combinations</p>	

LC #	Description	P (Kip)	Mz (Kip-ft)	My (Kip-ft)	Ratio	Status
1	1.4DL	175.00	-14.00	0.00	0.562	OK
2	1.2DL+1.6LL	250.00	-60.00	0.00	1.770	NG
3	0.9DL+1.6WL	112.50	-9.00	0.00	0.327	OK
4	1.2DL+1.0LL+1.6WL	212.50	-42.00	0.00	1.066	NG
5	0.9DL+1.0EL	112.50	-9.00	0.00	0.327	OK
6	1.2DL+1.0LL+1.0EL	212.50	-42.00	0.00	1.066	NG
7	1.2DL+1.6LL+0.5SL	250.00	-60.00	0.00	1.770	NG
8	1.2DL+1.0LL+1.6SL	212.50	-42.00	0.00	1.066	NG
9	1.2DL+1.6SL+0.8WL	150.00	-12.00	0.00	0.436	OK
10	1.2DL+1.0LL+0.5SL+1.6WL	212.50	-42.00	0.00	1.066	NG
11	1.2DL+1.0LL+0.2SL+1.0EL	212.50	-42.00	0.00	1.066	NG

The below detailed report is based on the worst load combination: 1.2DL+1.6LL

Detailing of Members

DETAILING RULES FOR COLUMN (LONGITUDINAL REINFORCEMENT)

Section input data:

Section concrete area $A_g = 168.00 \text{ in}^2$

Longitudinal rebar area $A_{st} = 1.60 \text{ in}^2$

Check the steel ratio for the longitudinal steel:

$$\rho = \frac{A_{st}}{A_g} = \frac{1.60}{168.00} = 0.00952$$

$$0.00952 < 0.01$$

STATUS NG!

Slenderness of column braced against sidesway

Section input data:

Effective Length factor $K_z = 0.90$

Effective Length factor $K_y = 0.75$

Unsupported length of the column $l_u = 192.00 \text{ in}$

Section axial Dead Load $P = 125.00 \text{ Kip}$

Section axial Live Load $P = 62.50 \text{ Kip}$

Section axial load based on current load combination $P_u = 250.00 \text{ Kip}$

Section moment about major axis based on current load combination $M_{uz} = -60.00 \text{ Kip-ft}$

Section moment about minor axis based on current load combination $M_{uy} = 0.00 \text{ Kip-ft}$

Top column section moment about major axis $M_{uz} = 10.00 \text{ Kip-ft}$

Top column section moment about minor axis $M_{uy} = 0.00 \text{ Kip-ft}$

Bottom column section moment about major axis $M_{uz} = -60.00 \text{ Kip-ft}$

Bottom column section moment about minor axis $M_{uy} = 0.00 \text{ Kip-ft}$

Second-order moment about major axis Z

1. Check if the column is long

End moment $M_1 = -10.00 \text{ Kip-ft}$

End moment $M_2 = 60.00 \text{ Kip-ft}$

Radius of gyration $r_z = 0.3 \cdot h = 0.3 \cdot 14 = 4.20 \text{ in}$

$$34 - 12 \cdot \frac{M_1}{M_2} = 34 - 12 \cdot \frac{-10.00}{60.00} = 36.00 \leq 40$$

$$\frac{K_y \cdot l_c}{r_z} = \frac{0.75 \cdot 192}{4.20} = 34.29 \leq 36.00$$

Column is short. Slenderness effect may be neglected.

Moment-magnifier factor along Y axis $\delta_{ns} = 1.0$

$$M_{cx} = -60.00 \text{ Kip-ft}$$

Second-order moment about minor axis Y

1. Check if the column is long

End moment $M_1 = 0.00 \text{ Kip-ft}$

End moment $M_2 = 0.00 \text{ Kip-ft}$

Radius of gyration $r_z = 0.3 \cdot h = 0.3 \cdot 12 = 3.60 \text{ in}$

$$34 - 12 \cdot \frac{M_1}{M_2} = 34 - 12 \cdot \frac{0.00}{0.00} = 34.00 \leq 40$$

$$\frac{K_y \cdot l_c}{r_z} = \frac{0.9 \cdot 192}{3.60} = 48.00 \geq 34.00$$

Column is long. Slenderness effect must be considered.

2. Calculate member stiffness EI

$$E_c = 57000 \cdot \sqrt{f_c} = 57000 \cdot \sqrt{4000} \cdot 0.001 = 3605.00 \text{ ksi}$$

$$I_g = \frac{b \cdot h^3}{12} = \frac{14 \cdot 12^3}{12} = 2016.00 \text{ in}^3$$

$$\beta_{dns} = \frac{1.2 \cdot P(DL)}{1.2 \cdot P(DL) + 1.6 \cdot P(LL)} = \frac{1.2 \cdot 125.00}{1.2 \cdot 125.00 + 1.6 \cdot 62.50} = 0.60$$

$$EI_y = \frac{0.4 \cdot E_c \cdot I_g}{1 + \beta_{dns}} = \frac{0.4 \cdot 3605.00 \cdot 2016.00}{1 + 0.60} = 1816918.25 \text{ kip-in}^2$$

2. Calculate the Euler buckling force

$$P_c = \frac{\pi^2 \cdot EI_y}{(K \cdot l_u)^2} = \frac{3.14^2 \cdot 1816918.25}{(0.9 \cdot 192)^2} = 600.55 \text{ kip}$$

3. moment-magnifier factor

$$M_{2,min} = P_u \cdot (0.6 + 0.03 \cdot h) = 250.00 \cdot (0.6 + 0.03 \cdot 12)/12 = 20.00 \text{ Kip-ft}$$

$$M_2 = 0.00 \text{ Kip-ft} < M_{2,min} = 20.00 \text{ Kip-ft}$$

$$C_m = 1.0, M_2 = 20.00 \text{ Kip-ft}$$

$$\delta_{ns} = \frac{C_m}{1 - (P_u/0.75 \cdot P_c)} = \frac{1.00}{1 - (250.00/0.75 \cdot 600.55)} = 2.25 \geq 1.0$$

$$M_2 \geq M_{uy}$$

$$M_{cy} = \delta_{ns} \cdot M_2 = 2.25 \cdot 20.00 = 44.95 \text{ Kip-ft}$$

Column check

MAXIMUM AXIAL COMPRESSION

Section input data:

Section concrete area $A_g = 168.00 \text{ in}^2$

Longitudinal rebar area $A_{st} = 1.60 \text{ in}^2$

Calculate the axial load capacity for concentric loading

$$P_u = \phi \cdot P_n = \phi \cdot K \cdot [0.85 \cdot f_c \cdot (A_g - A_{st}) + f_y \cdot A_{st}] =$$

$$= 0.65 \cdot 0.8 \cdot [0.85 \cdot f_c \cdot (A_g - A_{st}) + f_y \cdot A_{st}] =$$

$$= 0.65 \cdot 0.8 \cdot [0.85 \cdot 4000 \cdot (168.00 - 1.60) + 60000 \cdot 1.60] \cdot 0.001 = 344.12 \text{ Kip}$$

MAXIMUM AXIAL TENSION

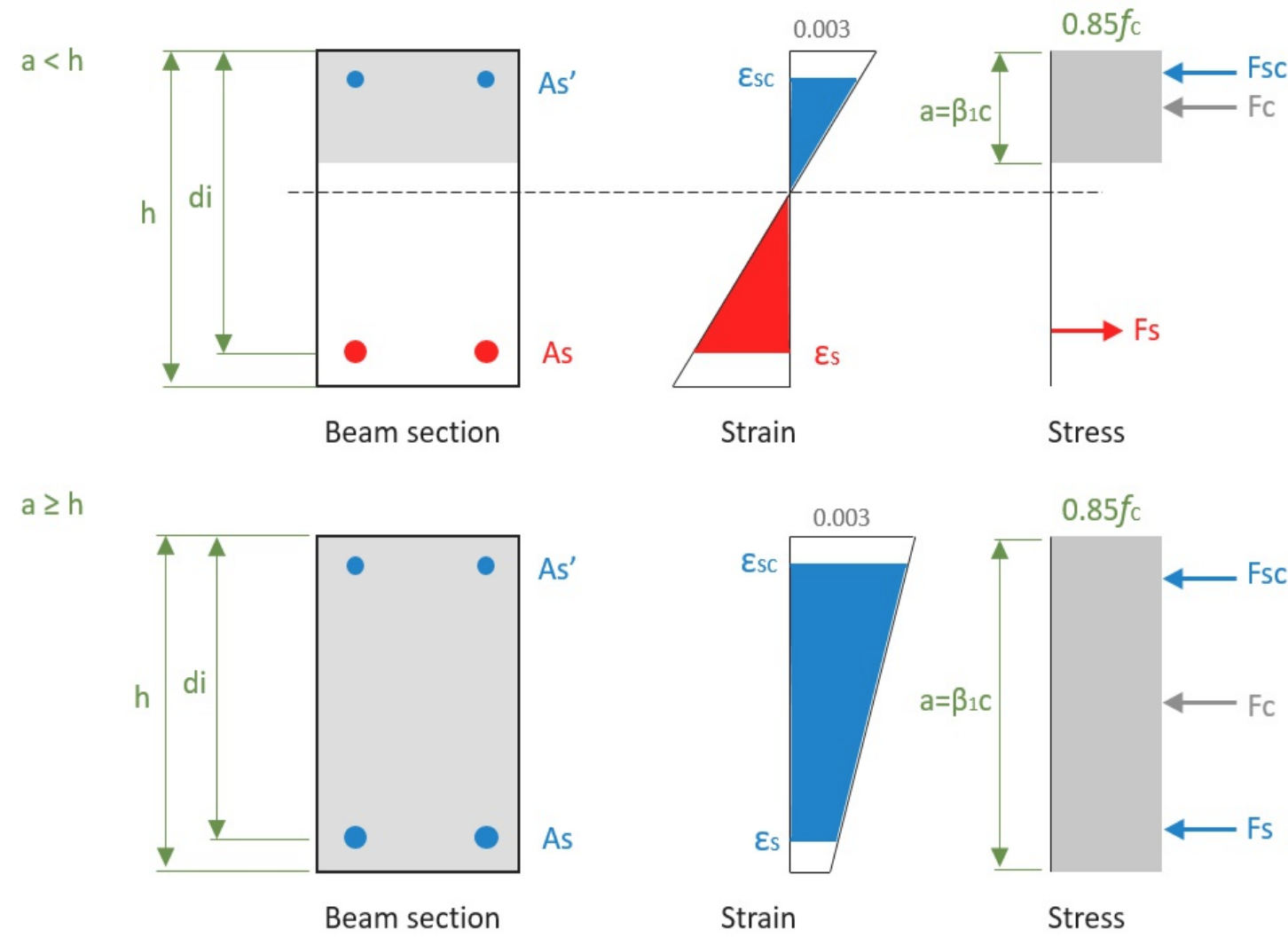
Section input data:

Longitudinal rebar area $A_{st} = 1.60 \text{ in}^2$

Calculate the axial load capacity for concentric loading

$$T_n = -0.9 \cdot f_{yd} \cdot A_{st} = -0.9 \cdot 60000 \cdot 1.60 \cdot 0.001 = -86.40 \text{ Kip}$$

M-N INTERACTION



Calculation is based on iterative process:

- Calculate plastic centroid location \bar{x}_p
- Assume c in tension control zone and compression control zone
- Calculate strain e_s and e_{sc} when $a < h$:

$$e_{sc} = e_c \cdot ((c - \bar{d}')/c)$$

$$e_s = e_c \cdot ((\bar{d} - c)/c)$$

and $a > h$:

$$e_{sc} = 0.002 \cdot (7 \cdot (c - \bar{d}') / (7 \cdot c - 3 \cdot h))$$

$$e_s = 0.002 \cdot (7 \cdot (c - \bar{d}') / (7 \cdot c - 3 \cdot h))$$

- Calculate reinforcement stresses $f_s = \{e_s E_s (e_s \leq e_y), e_y (e_s > e_y)\}$

- Calculate equilibrium forces:

$$N = F_{cc} + F_{sc} + F_s$$

$$a < h: N = f'_c \cdot b \cdot \beta_1 \cdot x + \sum f_{sci} \cdot A'_{si} + \sum f_{si} \cdot A_{si}$$

$$a \geq h: N = f'_c \cdot b \cdot h + \sum f_{sci} \cdot A'_{si} + \sum f_{si} \cdot A_{si}$$

$$a < h: M = F_{cc} \cdot (\bar{x}_p - \beta_1 x/2) + \sum f_{sci} \cdot (\bar{x}_p - \bar{d}'_i) - \sum f_{si} \cdot (d_i - \bar{x}_p)$$

$$a \geq h: M = F_{cc} \cdot (\bar{x}_p - h/2) + \sum f_{sci} \cdot (\bar{x}_p - \bar{d}'_i) - \sum f_{si} \cdot (d_i - \bar{x}_p)$$

1. Axial + positive flexure about major axis

Section input data:

Section height h based on major axis: 14 in

Section width b based on major axis: 12 in

Rectangular compression block factors:

$$4000 \text{ psi} \leq f_c \leq 8000 \text{ psi} \rightarrow \beta_1 = 0.85 - \left(\frac{f_c - 4000}{1000}\right) \cdot 0.05 = 0.85 - \left(\frac{4000 - 4000}{1000}\right) \cdot 0.05 = 0.85$$

Section Rebar

Depth di (in)	bar diameter (in)	bar area Asi (in^2)
11.50	0.50	0.20
11.50	0.50	0.20
11.50	0.50	0.20
11.50	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20

Calculation of plastic centroid location

$$\bar{x}_p = \frac{f'_c \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{f'_c \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \bar{A}_s} =$$

$$= \frac{4000.00 \cdot 168.00 \cdot (14 - 7) + 552000.00 + 120000.00}{4000.00 \cdot 168.00 + 60000.00 \cdot 0.8 + 60000.00 \cdot 0.80} = 7.00 \text{ in}$$

M-N interaction values

Iter.	c (in)	a (in)	φ	Pn (Kip)	Mn (Kip-ft)	φPn (Kip)	φMn (Kip-ft)	e (in)
Tension Control								
1	-	-	0.9	-96.0	0	-86.4	0	0
2	0.27	0.23	0.90	-86.6	5.4	-77.9	4.9	-0.8
3	0.54	0.46	0.90	-77.1	10.7	-69.4	9.6	-1.7
4	0.82	0.69	0.90	-67.7	15.7	-60.9	14.1	-2.8
5	1.09	0.93	0.90	-58.2	20.6	-52.4	18.5	-4.2
6	1.36	1.16	0.90	-48.8	25.3	-43.9	22.7	-6.2
7	1.63	1.39	0.90	-28.3	33.9	-25.4	30.5	-14.4
8	1.91	1.62	0.90	-3.6	44.0	-3.3	39.6	-145.9
9	2.18	1.85	0.90	17.2	52.4	15.5	47.1	36.5
10	2.45	2.08	0.90	35.6	59.7	32.0	53.7	20.1
11	2.72	2.31	0.90	52.1	66.1	46.9	59.5	15.2
12	2.99	2.55	0.90	67.4	71.9	60.6	64.7	12.8
13	3.27	2.78	0.90	81.6	77.1	73.5	69.4	11.3
14	3.54	3.01	0.90	95.2	81.9	85.7	73.7	10.3
15	3.81	3.24	0.90	108.1	86.2	97.3	77.6	9.6
16	4.08	3.47	0.90	120.6	90.3	108.6	81.2	9.0
17	4.36	3.70	0.89	132.7	93.9	118.5	83.9	8.5
18	4.63	3.93	0.85	144.5	97.3	123.3	83.1	8.1
19	4.90	4.17	0.82	156.0	100.4	127.7	82.2	7.7
20	5.17	4.40	0.79	167.3	103.3	131.6	81.2	7.4
21	5.44	4.63	0.76	178.5	105.9	135.3	80.2	7.1
22	5.72	4.86	0.73	189.4	108.2	138.7	79.2	6.9
23	5.99	5.09	0.71	200.3	110.3	142.0	78.2	6.6
24	6.26	5.32	0.69	211.0	112.2	145.1	77.1	6.4

25	6.53	5.55	0.67	221.6	113.9	148.0	76.1	6.2
26	6.81	5.79	0.65	232.1	115.3	150.8	74.9	6.0
Compression Control								
27	7.09	6.03	0.65	247.9	114.8	161.1	74.6	5.6
28	7.38	6.27	0.65	263.2	114.2	171.1	74.2	5.2
29	7.67	6.52	0.65	278.1	113.5	180.8	73.8	4.9
30	7.96	6.76	0.65	292.7	112.7	190.3	73.3	4.6
31	8.24	7.01	0.65	306.5	111.6	199.2	72.5	4.4
32	8.53	7.25	0.65	319.7	110.3	207.8	71.7	4.1
33	8.82	7.50	0.65	332.7	108.8	216.3	70.7	3.9
34	9.11	7.74	0.65	345.6	107.2	224.6	69.7	3.7
35	9.40	7.99	0.65	358.3	105.5	232.9	68.6	3.5
36	9.68	8.23	0.65	370.8	103.6	241.0	67.4	3.4
37	9.97	8.48	0.65	383.1	101.6	249.0	66.0	3.2
38	10.26	8.72	0.65	395.4	99.4	257.0	64.6	3.0
39	10.55	8.96	0.65	407.5	97.1	264.9	63.1	2.9
40	10.83	9.21	0.65	419.5	94.6	272.7	61.5	2.7
41	11.12	9.45	0.65	431.4	91.9	280.4	59.8	2.6
42	11.41	9.70	0.65	443.2	89.1	288.1	57.9	2.4
43	11.70	9.94	0.65	454.9	86.1	295.7	56.0	2.3
44	11.99	10.19	0.65	466.5	83.0	303.2	53.9	2.1
45	12.27	10.43	0.65	478.0	79.6	310.7	51.8	2.0
46	12.56	10.68	0.65	489.5	76.1	318.2	49.5	1.9
47	12.85	10.92	0.65	500.9	72.4	325.6	47.1	1.7
48	13.14	11.17	0.65	512.3	68.5	333.0	44.6	1.6
49	13.42	11.41	0.65	523.5	64.5	340.3	41.9	1.5
50	13.71	11.66	0.65	534.8	60.2	347.6	39.2	1.4
51	14.00	11.90	0.65	545.9	55.8	354.9	36.3	1.2
52	-	-	0.65	529.4	0	344.1	0	0

2. Axial + negative flexure about major axis

Section input data:

Section height h based on major axis: 14 in

Section width b based on major axis: 12 in

Rectangular compression block factors:

$$4000 \text{ psi} \leq f_c \leq 8000 \text{ psi} \rightarrow \beta_1 = 0.85 - \left(\frac{f_c - 4000}{1000} \right) \cdot 0.05 = 0.85 - \left(\frac{4000 - 4000}{1000} \right) \cdot 0.05 = 0.85$$

Section Rebar

Depth di (in)	bar diameter (in)	bar area Asi (in ²)
11.50	0.50	0.20
11.50	0.50	0.20
11.50	0.50	0.20
11.50	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20

Calculation of plastic centroid location

$$\bar{x}_p = \frac{f'_c \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{f'_c \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \dot{A}_s} =$$

$$= \frac{4000.00 \cdot 168.00 \cdot (14 - 7) + 552000.00 + 120000.00}{4000.00 \cdot 168.00 + 60000.00 \cdot 0.8 + 60000.00 \cdot 0.80} = 7.00 \text{ in}$$

M-N interaction values

Iter.	c (in)	a (in)	φ	Pn (Kip)	Mn (Kip-ft)	φPn (Kip)	φMn (Kip-ft)	e (in)
Tension Control								
1	-	-	0.9	-96.0	0	-86.4	0	0
2	0.27	0.23	0.90	-86.6	5.4	-77.9	4.9	-0.8
3	0.54	0.46	0.90	-77.1	10.7	-69.4	9.6	-1.7
4	0.82	0.69	0.90	-67.7	15.7	-60.9	14.1	-2.8
5	1.09	0.93	0.90	-58.2	20.6	-52.4	18.5	-4.2
6	1.36	1.16	0.90	-48.8	25.3	-43.9	22.7	-6.2
7	1.63	1.39	0.90	-28.3	33.9	-25.4	30.5	-14.4
8	1.91	1.62	0.90	-3.6	44.0	-3.3	39.6	-145.9
9	2.18	1.85	0.90	17.2	52.4	15.5	47.1	36.5
10	2.45	2.08	0.90	35.6	59.7	32.0	53.7	20.1
11	2.72	2.31	0.90	52.1	66.1	46.9	59.5	15.2
12	2.99	2.55	0.90	67.4	71.9	60.6	64.7	12.8
13	3.27	2.78	0.90	81.6	77.1	73.5	69.4	11.3
14	3.54	3.01	0.90	95.2	81.9	85.7	73.7	10.3
15	3.81	3.24	0.90	108.1	86.2	97.3	77.6	9.6
16	4.08	3.47	0.90	120.6	90.3	108.6	81.2	9.0
17	4.36	3.70	0.89	132.7	93.9	118.5	83.9	8.5
18	4.63	3.93	0.85	144.5	97.3	123.3	83.1	8.1
19	4.90	4.17	0.82	156.0	100.4	127.7	82.2	7.7
20	5.17	4.40	0.79	167.3	103.3	131.6	81.2	7.4
21	5.44	4.63	0.76	178.5	105.9	135.3	80.2	7.1
22	5.72	4.86	0.73	189.4	108.2	138.7	79.2	6.9
23	5.99	5.09	0.71	200.3	110.3	142.0	78.2	6.6
24	6.26	5.32	0.69	211.0	112.2	145.1	77.1	6.4

25	6.53	5.55	0.67	221.6	113.9	148.0	76.1	6.2
26	6.81	5.79	0.65	232.1	115.3	150.8	74.9	6.0
Compression Control								
27	7.09	6.03	0.65	247.9	114.8	161.1	74.6	5.6
28	7.38	6.27	0.65	263.2	114.2	171.1	74.2	5.2
29	7.67	6.52	0.65	278.1	113.5	180.8	73.8	4.9
30	7.96	6.76	0.65	292.7	112.7	190.3	73.3	4.6
31	8.24	7.01	0.65	306.5	111.6	199.2	72.5	4.4
32	8.53	7.25	0.65	319.7	110.3	207.8	71.7	4.1
33	8.82	7.50	0.65	332.7	108.8	216.3	70.7	3.9
34	9.11	7.74	0.65	345.6	107.2	224.6	69.7	3.7
35	9.40	7.99	0.65	358.3	105.5	232.9	68.6	3.5
36	9.68	8.23	0.65	370.8	103.6	241.0	67.4	3.4
37	9.97	8.48	0.65	383.1	101.6	249.0	66.0	3.2
38	10.26	8.72	0.65	395.4	99.4	257.0	64.6	3.0
39	10.55	8.96	0.65	407.5	97.1	264.9	63.1	2.9
40	10.83	9.21	0.65	419.5	94.6	272.7	61.5	2.7
41	11.12	9.45	0.65	431.4	91.9	280.4	59.8	2.6
42	11.41	9.70	0.65	443.2	89.1	288.1	57.9	2.4
43	11.70	9.94	0.65	454.9	86.1	295.7	56.0	2.3
44	11.99	10.19	0.65	466.5	83.0	303.2	53.9	2.1
45	12.27	10.43	0.65	478.0	79.6	310.7	51.8	2.0
46	12.56	10.68	0.65	489.5	76.1	318.2	49.5	1.9
47	12.85	10.92	0.65	500.9	72.4	325.6	47.1	1.7
48	13.14	11.17	0.65	512.3	68.5	333.0	44.6	1.6
49	13.42	11.41	0.65	523.5	64.5	340.3	41.9	1.5
50	13.71	11.66	0.65	534.8	60.2	347.6	39.2	1.4
51	14.00	11.90	0.65	545.9	55.8	354.9	36.3	1.2
52	-	-	0.65	529.4	0	344.1	0	0

3. Axial + positive flexure about minor axis

Section input data:

Section height h based on minor axis: 12 in

Section width b based on minor axis: 14 in

Rectangular compression block factors:

$$4000 \text{ psi} \leq f_c \leq 8000 \text{ psi} \rightarrow \beta_1 = 0.85 - \left(\frac{f_c - 4000}{1000} \right) \cdot 0.05 = 0.85 - \left(\frac{4000 - 4000}{1000} \right) \cdot 0.05 = 0.85$$

Section Rebar

Depth di (in)	bar diameter (in)	bar area Asi (in^2)
9.50	0.50	0.20
9.50	0.50	0.20
7.17	0.50	0.20
7.17	0.50	0.20
4.83	0.50	0.20
4.83	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20

Calculation of plastic centroid location

$$\bar{x}_p = \frac{f'_c \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{f'_c \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \dot{A}_s} =$$

$$= \frac{4000.00 \cdot 168.00 \cdot (12 - 6) + 400000.00 + 176000.00}{4000.00 \cdot 168.00 + 60000.00 \cdot 0.8 + 60000.00 \cdot 0.80} = 6.00 \text{ in}$$

M-N interaction values

Iter.	c (in)	a (in)	φ	Pn (Kip)	Mn (Kip-ft)	φPn (Kip)	φMn (Kip-ft)	e (in)
Tension Control								
1	-	-	0.9	-96.0	0	-86.4	0	0
2	0.20	0.17	0.90	-88.0	3.9	-79.2	3.5	-0.5
3	0.39	0.34	0.90	-80.0	7.8	-72.0	7.0	-1.2
4	0.59	0.50	0.90	-72.1	11.5	-64.8	10.3	-1.9
5	0.79	0.67	0.90	-64.1	15.1	-57.7	13.6	-2.8
6	0.99	0.84	0.90	-56.1	18.6	-50.5	16.7	-4.0
7	1.18	1.01	0.90	-48.1	21.9	-43.3	19.7	-5.5
8	1.38	1.17	0.90	-40.1	25.2	-36.1	22.7	-7.5
9	1.58	1.34	0.90	-28.5	29.4	-25.6	26.5	-12.4
10	1.78	1.51	0.90	-14.4	34.3	-12.9	30.8	-28.6
11	1.97	1.68	0.90	-1.5	38.6	-1.3	34.8	-312.9
12	2.17	1.84	0.90	10.5	42.6	9.5	38.3	48.6
13	2.37	2.01	0.90	21.8	46.3	19.6	41.7	25.4
14	2.56	2.18	0.90	32.6	49.7	29.4	44.7	18.3
15	2.76	2.35	0.90	43.0	52.9	38.7	47.6	14.7
16	2.96	2.52	0.90	55.1	56.1	49.6	50.5	12.2
17	3.16	2.68	0.90	68.5	59.2	61.6	53.3	10.4
18	3.35	2.85	0.90	81.2	62.2	73.1	55.9	9.2
19	3.55	3.02	0.90	93.4	64.9	84.1	58.4	8.3
20	3.75	3.19	0.87	105.2	67.4	91.1	58.4	7.7
21	3.95	3.35	0.83	116.6	69.8	97.2	58.2	7.2
22	4.14	3.52	0.80	127.6	72.0	102.7	57.9	6.8
23	4.34	3.69	0.78	139.7	73.9	108.7	57.5	6.3
24	4.54	3.86	0.75	152.8	75.6	115.1	56.9	5.9

25	4.73	4.02	0.73	165.4	77.1	120.9	56.4	5.6
26	4.93	4.19	0.71	177.6	78.5	126.2	55.8	5.3
Compression Control								
27	5.21	4.43	0.68	194.6	80.3	133.1	54.9	5.0
28	5.50	4.67	0.66	211.0	81.9	139.2	54.0	4.7
29	5.78	4.91	0.65	228.6	82.7	148.6	53.8	4.3
30	6.06	5.15	0.65	246.7	83.0	160.4	53.9	4.0
31	6.35	5.39	0.65	264.3	83.1	171.8	54.0	3.8
32	6.63	5.63	0.65	281.4	83.0	182.9	54.0	3.5
33	6.91	5.87	0.65	298.0	82.8	193.7	53.8	3.3
34	7.19	6.11	0.65	314.2	82.3	204.2	53.5	3.1
35	7.48	6.35	0.65	330.0	81.7	214.5	53.1	3.0
36	7.76	6.60	0.65	345.5	80.9	224.6	52.6	2.8
37	8.04	6.84	0.65	360.7	79.8	234.5	51.9	2.7
38	8.32	7.08	0.65	375.3	78.5	244.0	51.0	2.5
39	8.61	7.32	0.65	389.7	76.9	253.3	50.0	2.4
40	8.89	7.56	0.65	403.9	75.2	262.6	48.9	2.2
41	9.17	7.80	0.65	418.0	73.2	271.7	47.6	2.1
42	9.46	8.04	0.65	431.8	71.1	280.7	46.2	2.0
43	9.74	8.28	0.65	445.6	68.7	289.6	44.6	1.8
44	10.02	8.52	0.65	459.2	66.1	298.5	43.0	1.7
45	10.30	8.76	0.65	472.7	63.3	307.2	41.1	1.6
46	10.59	9.00	0.65	486.0	60.3	315.9	39.2	1.5
47	10.87	9.24	0.65	499.3	57.0	324.6	37.1	1.4
48	11.15	9.48	0.65	512.5	53.6	333.1	34.8	1.3
49	11.43	9.72	0.65	525.6	49.9	341.6	32.5	1.1
50	11.72	9.96	0.65	538.6	46.1	350.1	29.9	1.0
51	12.00	10.20	0.65	551.6	42.0	358.5	27.3	0.9
52	-	-	0.65	529.4	0	344.1	0	0

4. Axial + negative flexure about minor axis

Section input data:

Section height h based on minor axis: 12 in

Section width b based on minor axis: 14 in

Rectangular compression block factors:

$$4000 \text{ psi} \leq f_c \leq 8000 \text{ psi} \rightarrow \beta_1 = 0.85 - \left(\frac{f_c - 4000}{1000} \right) \cdot 0.05 = 0.85 - \left(\frac{4000 - 4000}{1000} \right) \cdot 0.05 = 0.85$$

Section Rebar

Depth di (in)	bar diameter (in)	bar area Asi (in ²)
9.50	0.50	0.20
9.50	0.50	0.20
7.17	0.50	0.20
7.17	0.50	0.20
4.83	0.50	0.20
4.83	0.50	0.20
2.50	0.50	0.20
2.50	0.50	0.20

Calculation of plastic centroid location

$$\bar{x}_p = \frac{f'_c \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{f'_c \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \dot{A}_s} =$$

$$= \frac{4000.00 \cdot 168.00 \cdot (12 - 6) + 400000.00 + 176000.00}{4000.00 \cdot 168.00 + 60000.00 \cdot 0.8 + 60000.00 \cdot 0.80} = 6.00 \text{ in}$$

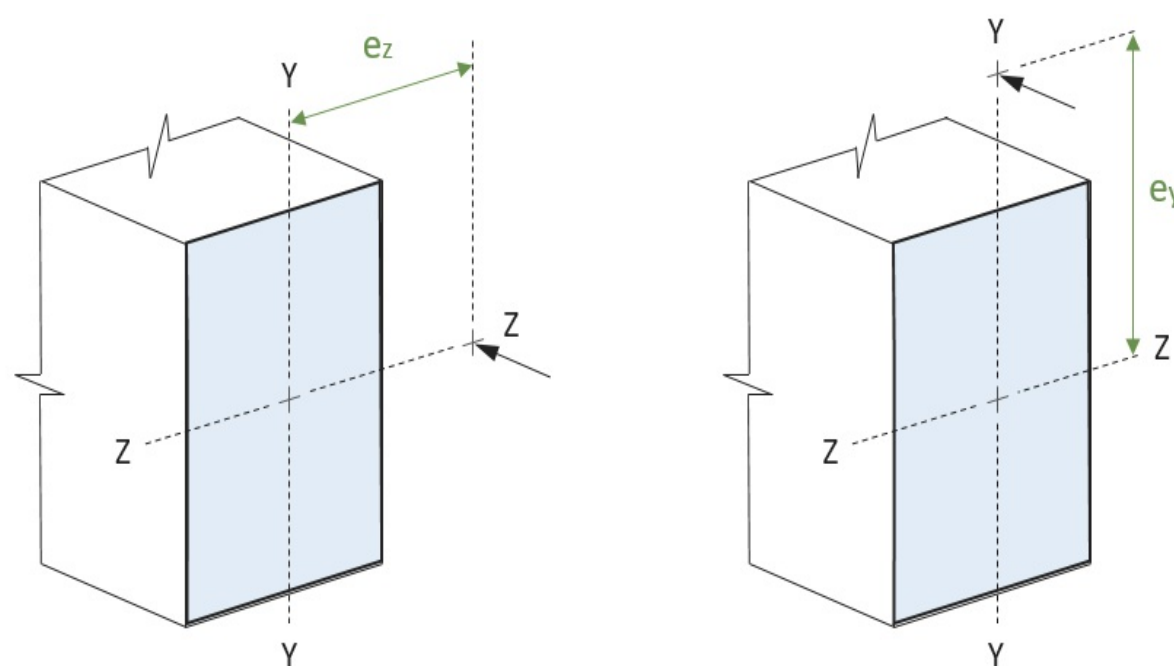
M-N interaction values

Iter.	c (in)	a (in)	φ	Pn (Kip)	Mn (Kip-ft)	φPn (Kip)	φMn (Kip-ft)	e (in)
Tension Control								
1	-	-	0.9	-96.0	0	-86.4	0	0
2	0.20	0.17	0.90	-88.0	3.9	-79.2	3.5	-0.5
3	0.39	0.34	0.90	-80.0	7.8	-72.0	7.0	-1.2
4	0.59	0.50	0.90	-72.1	11.5	-64.8	10.3	-1.9
5	0.79	0.67	0.90	-64.1	15.1	-57.7	13.6	-2.8
6	0.99	0.84	0.90	-56.1	18.6	-50.5	16.7	-4.0
7	1.18	1.01	0.90	-48.1	21.9	-43.3	19.7	-5.5
8	1.38	1.17	0.90	-40.1	25.2	-36.1	22.7	-7.5
9	1.58	1.34	0.90	-28.5	29.4	-25.6	26.5	-12.4
10	1.78	1.51	0.90	-14.4	34.3	-12.9	30.8	-28.6
11	1.97	1.68	0.90	-1.5	38.6	-1.3	34.8	-312.9
12	2.17	1.84	0.90	10.5	42.6	9.5	38.3	48.6
13	2.37	2.01	0.90	21.8	46.3	19.6	41.7	25.4
14	2.56	2.18	0.90	32.6	49.7	29.4	44.7	18.3
15	2.76	2.35	0.90	43.0	52.9	38.7	47.6	14.7
16	2.96	2.52	0.90	55.1	56.1	49.6	50.5	12.2
17	3.16	2.68	0.90	68.5	59.2	61.6	53.3	10.4
18	3.35	2.85	0.90	81.2	62.2	73.1	55.9	9.2
19	3.55	3.02	0.90	93.4	64.9	84.1	58.4	8.3
20	3.75	3.19	0.87	105.2	67.4	91.1	58.4	7.7
21	3.95	3.35	0.83	116.6	69.8	97.2	58.2	7.2
22	4.14	3.52	0.80	127.6	72.0	102.7	57.9	6.8
23	4.34	3.69	0.78	139.7	73.9	108.7	57.5	6.3
24	4.54	3.86	0.75	152.8	75.6	115.1	56.9	5.9

25	4.73	4.02	0.73	165.4	77.1	120.9	56.4	5.6
26	4.93	4.19	0.71	177.6	78.5	126.2	55.8	5.3
Compression Control								
27	5.21	4.43	0.68	194.6	80.3	133.1	54.9	5.0
28	5.50	4.67	0.66	211.0	81.9	139.2	54.0	4.7
29	5.78	4.91	0.65	228.6	82.7	148.6	53.8	4.3
30	6.06	5.15	0.65	246.7	83.0	160.4	53.9	4.0
31	6.35	5.39	0.65	264.3	83.1	171.8	54.0	3.8
32	6.63	5.63	0.65	281.4	83.0	182.9	54.0	3.5
33	6.91	5.87	0.65	298.0	82.8	193.7	53.8	3.3
34	7.19	6.11	0.65	314.2	82.3	204.2	53.5	3.1
35	7.48	6.35	0.65	330.0	81.7	214.5	53.1	3.0
36	7.76	6.60	0.65	345.5	80.9	224.6	52.6	2.8
37	8.04	6.84	0.65	360.7	79.8	234.5	51.9	2.7
38	8.32	7.08	0.65	375.3	78.5	244.0	51.0	2.5
39	8.61	7.32	0.65	389.7	76.9	253.3	50.0	2.4
40	8.89	7.56	0.65	403.9	75.2	262.6	48.9	2.2
41	9.17	7.80	0.65	418.0	73.2	271.7	47.6	2.1
42	9.46	8.04	0.65	431.8	71.1	280.7	46.2	2.0
43	9.74	8.28	0.65	445.6	68.7	289.6	44.6	1.8
44	10.02	8.52	0.65	459.2	66.1	298.5	43.0	1.7
45	10.30	8.76	0.65	472.7	63.3	307.2	41.1	1.6
46	10.59	9.00	0.65	486.0	60.3	315.9	39.2	1.5
47	10.87	9.24	0.65	499.3	57.0	324.6	37.1	1.4
48	11.15	9.48	0.65	512.5	53.6	333.1	34.8	1.3
49	11.43	9.72	0.65	525.6	49.9	341.6	32.5	1.1
50	11.72	9.96	0.65	538.6	46.1	350.1	29.9	1.0
51	12.00	10.20	0.65	551.6	42.0	358.5	27.3	0.9
52	-	-	0.65	529.4	0	344.1	0	0

STATUS NG!

5. Strength check



Section input data:

Actual axial force $P = 250.00$ Kip
 Actual bending moment about major axis $M_{uz} = 60.00$ Kip-ft
 Actual bending moment about minor axis $M_{uy} = 44.95$ Kip-ft
 Eccentricity of actual forces along major axis $e_y = 2.8800$ in
 Eccentricity of actual forces along minor axis $e_z = 2.1575$ in
 Limited axial force (Mx-N axis plane) $\phi \cdot P_{nz} = 263.84$ Kip
 Limited axial force (My-N axis plane) $\phi \cdot P_{ny} = 267.83$ Kip
 Limited bending moment about major axis $\phi \cdot M_{nz} = 63.31$ Kip-ft
 Limited bending moment about minor axis $\phi \cdot M_{ny} = 48.13$ Kip-ft

Axial + biaxial bending check case for rectangular section

$$\alpha_n = 0.7 + \frac{1.7 \cdot P_u}{0.6 \cdot P_{no}} = 0.7 + \frac{1.7 \cdot 250}{0.6 \cdot 344.12} = 2.76$$

$$\alpha_n > 2.0 \rightarrow \alpha_n = 2.0$$

$$\left[\frac{M_z}{\phi \cdot M_{ux}} \right]^{\alpha_n} + \left[\frac{M_y}{\phi \cdot M_{uy}} \right]^{\alpha_n} = \left[\frac{60.00}{63.31} \right]^{2.00} + \left[\frac{44.95}{48.13} \right]^{2.00} = 1.77 > 1.0$$

Axial compression check case

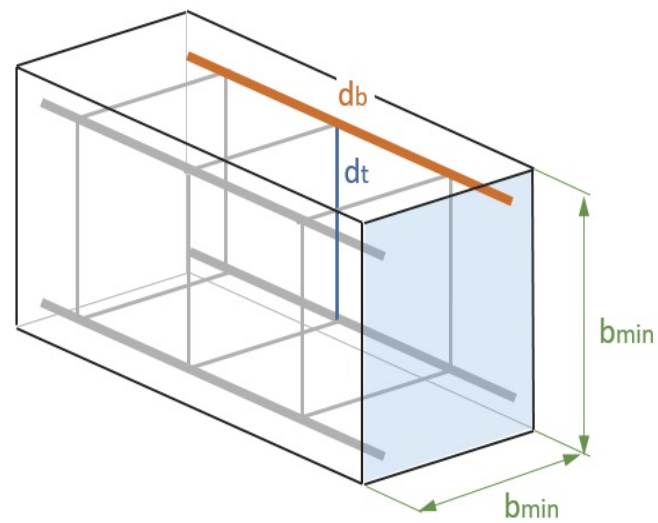
$$P_n = 250.00 \text{ Kip} \leq \phi \cdot P_{no} = 344.12 \text{ Kip}$$

STATUS OK!

CHAPTER 9 (Section 9.7)

Lateral support check for compression steel

BUCKLING OF SLENDER REINFORCING BARS



Section input data:

Spacing of the stirrups $s = 10$ in

Diameter of the main bars $16 \cdot d_b = 16 \cdot 0.5 = 8$ in

Diameter of the transverse reinforcement (stirrups) $48 \cdot d_t = 48 \cdot 0.5 = 24$ in

Smaller dimension of the beam section $b_{min} = 12$ in

Calculate maximum spacing of the stirrups for purpose of buckling bar stability

$$s_{max} = \min[16 \cdot d_b, 48 \cdot d_t, b_{min}] = 8 \text{ in}$$

$$s = 10 \text{ in} > s_{max} = 8 \text{ in}$$

STATUS NG!