REFERENCES	CALCULATIONS	RESULTS
Code: AS 3600-2009		

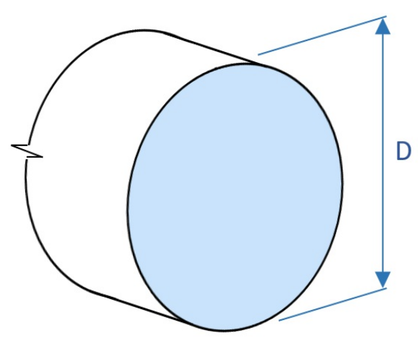
MEMBER #1 (SECTION POSITION 4000.0 mm) COLUMN DESIGN REPORT

Project details

Project Name:
Project ID:
Company:
Designer:
Client:
Project Notes:
Project Units: Metric

General member design information

Dimentions:



Diameter $D = 450\ \mathrm{mm}$
Member length = $8000\ \mathrm{mm}$

Material properties:

Concrete strength $\acute{f_c} = 25\ \mathrm{MPa}$
Steel strength of longitudinal rebar $f_{sy} = 500\ \mathrm{MPa}$
Steel strength of shear rebar $f_{syv} = 500\ \mathrm{MPa}$

Design Factors and Settings:
Reinforcement Class : N

Load Combinations

Ultimate Limit State:
LC 1: 1.35DL (N = 2025.00 kN, Mz = 38.48 kN-m, My = -48.26 kN-m)
LC 2: 1.2DL+1.5LL (N = 1800.00 kN, Mz = 34.20 kN-m, My = -42.90 kN-m)
LC 3: 0.9DL+1.0WL (N = 1350.00 kN, Mz = 25.65 kN-m, My = -32.17 kN-m)
LC 4: 1.2DL+1.0WL (N = 1800.00 kN, Mz = 34.20 kN-m, My = -42.90 kN-m)
LC 5: 1.2DL+0.6LL+1.0WL (N = 1800.00 kN, Mz = 34.20 kN-m, My = -42.90 kN-m)
LC 6: 1.0DL+1.0EL (N = 1500.00 kN, Mz = 28.50 kN-m, My = -35.75 kN-m)
LC 7: 1.0DL+0.6LL+1.0EL (N = 1500.00 kN, Mz = 28.50 kN-m, My = -35.75 kN-m)

Serviceabiity Limit State:
LC 1: 1.0DL (N = 1500.00 kN, Mz = 28.50 kN-m, My = -35.75 kN-m)
LC 2: 1.0DL+1.0LL (N = 1500.00 kN, Mz = 28.50 kN-m, My = -35.75 kN-m)

DL - Dead Load
LL - Live Load
WL - Wind Load
LrL - Roof Live Load
RL - Rain Load
SL - Snow Load
EL - Earthquake Load

Strength status of column section based on all load combinations

LC #	Description	N (kN)	Mz (kN-m)	My (kN-m)	Ratio	Status
1	1.35DL	2025.00	38.48	-48.26	4.57	NG
2	1.2DL+1.5LL	1800.00	34.20	-42.90	3.61	NG
3	0.9DL+1.0WL	1350.00	25.65	-32.17	2.03	NG
4	1.2DL+1.0WL	1800.00	34.20	-42.90	3.61	NG
5	1.2DL+0.6LL+1.0WL	1800.00	34.20	-42.90	3.61	NG
6	1.0DL+1.0EL	1500.00	28.50	-35.75	2.51	NG
7	1.0DL+0.6LL+1.0EL	1500.00	28.50	-35.75	2.51	NG

The below detailed report is based on the worst load combination: 1.35DL

Detailing of Members

10.7.1(b)
10.7.1(a)

DETAILING RULES FOR COLUMN (LONGITUDINAL REINFORCEMENT)

Section input data:
Section concrete area $A_g = 159043.13\ \mathrm{mm}^2$
Longitudinal rebar area $A_{st} = 2010.62\ \mathrm{mm}^2$

1. Maximum allowed longitudinal reinforcement (10.7.1(b))

$$A_{s,max} = 0.04 \cdot A_g = 0.04 \cdot 159043.13 = 6361.73\ \mathrm{mm}^2$$

2. Minimum allowed longitudinal reinforcement (10.7.1(a))

$$A_{s,min} = 0.01 \cdot A_g = 0.01 \cdot 159043.13 = 1590.43\ \mathrm{mm}^2$$

3. Check of allowed longitudinal reinforcement

$$A_{st} = 2010.62\ \mathrm{mm}^2 \leq A_{s,max} = 6361.73\ \mathrm{mm}^2$$

STATUS OK!

$$A_{st} = 2010.62\ \mathrm{mm}^2 \geq A_{s,min} = 1590.43\ \mathrm{mm}^2$$

STATUS OK!

Column check data

MAXIMUM AXIAL COMPRESSION

Section input data:
Section concrete area $A_g = 159043.13\ \mathrm{mm}^2$
Longitudinal rebar area $A_{st} = 2010.62\ \mathrm{mm}^2$

$$\alpha_1 = 1.0 - 0.003 \cdot \acute{f_c} = 1.0 - 0.003 \cdot 25 = 0.93$$

$$\alpha_1 > 0.85 \rightarrow \alpha_1 = 0.85$$

Calculate the axial load capacity for concentric loading (10.6.2.2)

$$\phi = 0.6$$

$$\phi \cdot N_{uo} = \alpha_1 \cdot \acute{f_c} \cdot (A_g - A_{st}) + f_{sy} \cdot A_{st} =$$

$$= 0.6 \cdot (0.85 \cdot 25 \cdot (159043.13 - 2010.62) + 500 \cdot 2010.62) = 2605.35\ \mathrm{kN}$$

MAXIMUM AXIAL TENSION

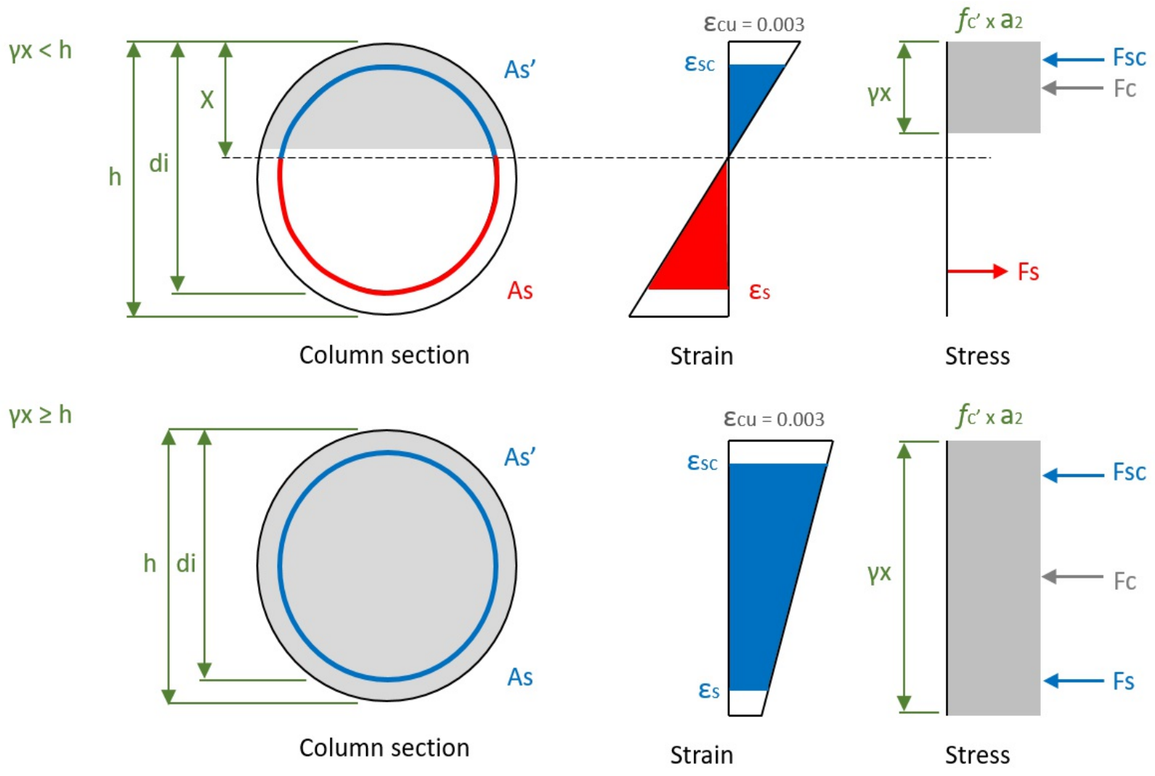
Section input data:
Longitudinal rebar area $A_{st} = 2010.62\ \mathrm{mm}^2$

Calculate the axial load capacity for concentric loading

$$\phi = 0.8$$

$$\phi \cdot N_{ut} = -f_{yd} \cdot A_{st} = 0.8 \cdot (-500 \cdot 2010.62) = -804.25\ \mathrm{kN}$$

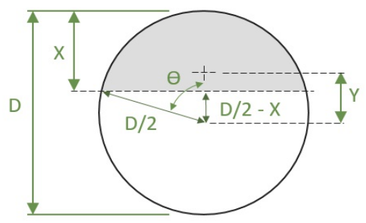
M-N INTERACTION



Calculation is based on iterative process:
- Calculate plastic centroid location $\overline{x}$
- Assume x in tension control zone and compression control zone
- Calculate strain e_s and e_{sc} when x < h:

$e_{sc} = e_{cu} \cdot ((x - \acute{d})/x)$
$e_s = e_{cu} \cdot ((d - x)/x)$
and x > h:
$e_{sc} = 0.002 \cdot (7 \cdot (x - \acute{d})/(7 \cdot x - 3 \cdot h))$
$e_s = 0.002 \cdot (7 \cdot (x - d)/(7 \cdot x - 3 \cdot h))$
- Calculate reinforcement stresses $f_s = \{e_s E_s \ (e_s \leq e_y),\ e_y \ (e_s > e_y)\}$
- Calculate equilibrium forces:

$N = F_{cc} + F_{sc} + F_s$
$\gamma x < h$: $N = \acute{f_c} \cdot D^2 \cdot ((\theta - \sin\theta\cos\theta)/4) \cdot + \sum f_{sci} \cdot \acute{A_{si}} + \sum f_{si} \cdot A_{si}$
$\gamma x \geq h$: $N = \acute{f_c} \cdot \frac{\pi \cdot D^2}{4} + \sum f_{sci} \cdot \acute{A_{si}} + \sum f_{si} \cdot A_{si}$
$\gamma x < h$: $M = F_{cc} \cdot \frac{2}{3} \cdot ((\sin^3\theta \cdot 0.5 \cdot D)/(\theta - \sin\theta \cdot \cos\theta)) + \sum f_{sci} \cdot (\overline{x_p} - \acute{d_i}) - \sum f_{si}$
$\cdot (d_i - \overline{x_p})$
$\gamma x < h$: $M = \sum f_{sci} \cdot (\overline{x_p} - \acute{d_i}) - \sum f_{si} \cdot (d_i - \overline{x_p})$



1. Axial + positive flexure about major axis

Section input data:
Section height h based on major axis: 450 mm
Section width b based on major axis: 450 mm
Rectangular compression block factors (8.1.3(1), 8.1.3(2))

$$\alpha_2 = 1.0 - 0.003 \cdot \acute{f_c} = 1.0 - 0.003 \cdot 25 = 0.93$$

$$\alpha_2 > 0.85 \rightarrow \alpha_2 = 0.85$$

$$\gamma = 1.05 - 0.007 \cdot \acute{f_c} = 1.05 - 0.007 \cdot 25 = 0.88$$

$$\gamma > 0.85 \rightarrow \gamma = 0.85$$

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
400.00	16.00	201.06
366.58	16.00	201.06
366.58	16.00	201.06
279.08	16.00	201.06
279.08	16.00	201.06
170.92	16.00	201.06
170.92	16.00	201.06
83.42	16.00	201.06
83.42	16.00	201.06
50.00	16.00	201.06

Calculation of plastic centroid location

$$\overline{x_p} = \frac{\acute{f_c} \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{\acute{f_c} \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \acute{A_s}} =$$

$$= \frac{25.00 \cdot 159043.13 \cdot (450 - 225) + 170029216.88 + 56165454.18}{25.00 \cdot 159043.13 + 500.00 \cdot 1005.31 + 500.00 \cdot 1005.31} = 225.00 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	φ	Nu (kN)	Mu (kN-m)	φNu (kN)	φMu (kN-m)	e (m)
Tension Control							
1	-	0.80	-1005.3	0	-804.2	0	0
2	7.38	0.80	-995.91	2.08	-796.72	1.66	-0.00
3	14.76	0.80	-978.82	5.76	-783.06	4.61	-0.01
4	22.14	0.80	-956.86	10.36	-765.49	8.28	-0.01
5	29.52	0.80	-914.19	18.54	-731.35	14.84	-0.02
6	36.90	0.80	-844.25	31.42	-675.40	25.13	-0.04
7	44.28	0.80	-785.10	42.26	-628.08	33.81	-0.05
8	51.66	0.80	-678.48	59.47	-542.78	47.58	-0.09
9	59.04	0.80	-578.48	75.45	-462.79	60.36	-0.13
10	66.42	0.80	-490.48	89.46	-392.39	71.56	-0.18
11	73.80	0.80	-410.44	102.06	-328.35	81.65	-0.25
12	81.18	0.80	-335.81	113.62	-268.65	90.89	-0.34
13	88.56	0.80	-264.95	124.35	-211.96	99.48	-0.47
14	95.94	0.80	-184.21	135.09	-147.37	108.07	-0.73
15	103.32	0.80	-87.14	146.24	-69.71	116.99	-1.68
16	110.70	0.80	4.52	156.65	3.61	125.16	34.64
17	118.08	0.78	91.95	166.42	71.59	129.58	1.81
18	125.46	0.76	176.01	175.61	133.61	133.31	1.00
19	132.84	0.74	257.38	184.27	190.51	136.39	0.72
20	140.23	0.72	336.56	192.41	242.93	138.88	0.57
21	147.61	0.70	413.97	200.08	291.36	140.82	0.48
22	154.99	0.68	497.80	206.86	340.66	141.56	0.42

23	162.37	0.66	592.27	212.54	392.31	140.78	0.36
24	169.75	0.64	684.02	217.88	438.49	139.67	0.32
25	177.13	0.62	773.39	222.86	479.73	138.24	0.29
26	184.51	0.60	860.71	227.48	516.43	136.49	0.26
Compression Control							
27	184.51	0.60	860.71	227.48	516.43	136.49	0.26
28	195.13	0.60	983.24	233.48	589.95	140.09	0.24
29	205.75	0.60	1115.07	236.95	669.04	142.17	0.21
30	216.37	0.60	1252.83	238.41	751.70	143.05	0.19
31	226.99	0.60	1394.83	237.86	836.90	142.72	0.17
32	237.61	0.60	1533.94	236.58	920.37	141.95	0.15
33	248.23	0.60	1668.84	234.85	1001.30	140.91	0.14
34	258.84	0.60	1799.94	232.61	1079.96	139.57	0.13
35	269.46	0.60	1927.57	229.84	1156.54	137.91	0.12
36	280.08	0.60	2052.02	226.50	1231.21	135.90	0.11
37	290.70	0.60	2173.47	222.58	1304.08	133.55	0.10
38	301.32	0.60	2292.00	218.05	1375.20	130.83	0.10
39	311.94	0.60	2407.20	212.80	1444.32	127.68	0.09
40	322.56	0.60	2519.81	206.96	1511.89	124.18	0.08
41	333.18	0.60	2629.85	200.54	1577.91	120.32	0.08
42	343.80	0.60	2737.35	193.53	1642.41	116.12	0.07
43	354.42	0.60	2842.28	185.96	1705.37	111.57	0.07
44	365.04	0.60	2944.63	177.85	1766.78	106.71	0.06
45	375.66	0.60	3044.32	169.23	1826.59	101.54	0.06
46	386.28	0.60	3141.28	160.14	1884.77	96.08	0.05
47	396.90	0.60	3235.41	150.62	1941.25	90.37	0.05
48	407.52	0.60	3326.58	140.72	1995.95	84.43	0.04
49	418.14	0.60	3414.65	130.50	2048.79	78.30	0.04
50	428.76	0.60	3499.44	120.02	2099.66	72.01	0.03
51	439.38	0.60	3580.72	109.38	2148.43	65.63	0.03
52	450.00	0.60	3658.26	98.65	2194.95	59.19	0.03
53	-	0.60	4342.3	0	2605.4	0	0

2. Axial + negative flexure about major axis

Section input data:
Section height h based on major axis: 450 mm
Section width b based on major axis: 450 mm
Rectangular compression block factors (8.1.3(1), 8.1.3(2))

$$\alpha_2 = 1.0 - 0.003 \cdot \acute{f}_c = 1.0 - 0.003 \cdot 25 = 0.93$$

$$\alpha_2 > 0.85 \rightarrow \alpha_2 = 0.85$$

$$\gamma = 1.05 - 0.007 \cdot \acute{f}_c = 1.05 - 0.007 \cdot 25 = 0.88$$

$$\gamma > 0.85 \rightarrow \gamma = 0.85$$

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
400.00	16.00	201.06
366.58	16.00	201.06
366.58	16.00	201.06
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50.00	16.00	201.06

Calculation of plastic centroid location

$$\overline{x_p} = \frac{\acute{f_c} \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{\acute{f_c} \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \acute{A_s}} =$$

$$= \frac{25.00 \cdot 159043.13 \cdot (450 - 225) + 170029216.88 + 56165454.18}{25.00 \cdot 159043.13 + 500.00 \cdot 1005.31 + 500.00 \cdot 1005.31} = 225.00 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	φ	Nu (kN)	Mu (kN-m)	φNu (kN)	φMu (kN-m)	e (m)
Tension Control							
1	-	0.80	-1005.3	0	-804.2	0	0
2	7.38	0.80	-995.91	2.08	-796.72	1.66	-0.00
3	14.76	0.80	-978.82	5.76	-783.06	4.61	-0.01
4	22.14	0.80	-956.86	10.36	-765.49	8.28	-0.01
5	29.52	0.80	-914.19	18.54	-731.35	14.84	-0.02
6	36.90	0.80	-844.25	31.42	-675.40	25.13	-0.04
7	44.28	0.80	-785.10	42.26	-628.08	33.81	-0.05
8	51.66	0.80	-678.48	59.47	-542.78	47.58	-0.09
9	59.04	0.80	-578.48	75.45	-462.79	60.36	-0.13
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12	81.18	0.80	-335.81	113.62	-268.65	90.89	-0.34
13	88.56	0.80	-264.95	124.35	-211.96	99.48	-0.47
14	95.94	0.80	-184.21	135.09	-147.37	108.07	-0.73
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16	110.70	0.80	4.52	156.65	3.61	125.16	34.64
17	118.08	0.78	91.95	166.42	71.59	129.58	1.81
18	125.46	0.76	176.01	175.61	133.61	133.31	1.00
19	132.84	0.74	257.38	184.27	190.51	136.39	0.72
20	140.23	0.72	336.56	192.41	242.93	138.88	0.57
21	147.61	0.70	413.97	200.08	291.36	140.82	0.48
22	154.99	0.68	497.80	206.86	340.66	141.56	0.42

23	162.37	0.66	592.27	212.54	392.31	140.78	0.36
24	169.75	0.64	684.02	217.88	438.49	139.67	0.32
25	177.13	0.62	773.39	222.86	479.73	138.24	0.29
26	184.51	0.60	860.71	227.48	516.43	136.49	0.26
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41	333.18	0.60	2629.85	200.54	1577.91	120.32	0.08
42	343.80	0.60	2737.35	193.53	1642.41	116.12	0.07
43	354.42	0.60	2842.28	185.96	1705.37	111.57	0.07
44	365.04	0.60	2944.63	177.85	1766.78	106.71	0.06
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83.42	16.00	201.06
83.42	16.00	201.06
50.00	16.00	201.06

Calculation of plastic centroid location

$$\overline{x_p} = \frac{\acute{f_c} \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{\acute{f_c} \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \acute{A_s}} =$$

$$= \frac{25.00 \cdot 159043.13 \cdot (450 - 225) + 170029216.88 + 56165454.18}{25.00 \cdot 159043.13 + 500.00 \cdot 1005.31 + 500.00 \cdot 1005.31} = 225.00 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	φ	Nu (kN)	Mu (kN-m)	φNu (kN)	φMu (kN-m)	e (m)
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9	59.04	0.80	-578.48	75.45	-462.79	60.36	-0.13
10	66.42	0.80	-490.48	89.46	-392.39	71.56	-0.18
11	73.80	0.80	-410.44	102.06	-328.35	81.65	-0.25
12	81.18	0.80	-335.81	113.62	-268.65	90.89	-0.34
13	88.56	0.80	-264.95	124.35	-211.96	99.48	-0.47
14	95.94	0.80	-184.21	135.09	-147.37	108.07	-0.73
15	103.32	0.80	-87.14	146.24	-69.71	116.99	-1.68
16	110.70	0.80	4.52	156.65	3.61	125.16	34.64
17	118.08	0.78	91.95	166.42	71.59	129.58	1.81
18	125.46	0.76	176.01	175.61	133.61	133.31	1.00
19	132.84	0.74	257.38	184.27	190.51	136.39	0.72
20	140.23	0.72	336.56	192.41	242.93	138.88	0.57
21	147.61	0.70	413.97	200.08	291.36	140.82	0.48
22	154.99	0.68	497.80	206.86	340.66	141.56	0.42

23	162.37	0.66	592.27	212.54	392.31	140.78	0.36
24	169.75	0.64	684.02	217.88	438.49	139.67	0.32
25	177.13	0.62	773.39	222.86	479.73	138.24	0.29
26	184.51	0.60	860.71	227.48	516.43	136.49	0.26
Compression Control							
27	184.51	0.60	860.71	227.48	516.43	136.49	0.26
28	195.13	0.60	983.24	233.48	589.95	140.09	0.24
29	205.75	0.60	1115.07	236.95	669.04	142.17	0.21
30	216.37	0.60	1252.83	238.41	751.70	143.05	0.19
31	226.99	0.60	1394.83	237.86	836.90	142.72	0.17
32	237.61	0.60	1533.94	236.58	920.37	141.95	0.15
33	248.23	0.60	1668.84	234.85	1001.30	140.91	0.14
34	258.84	0.60	1799.94	232.61	1079.96	139.57	0.13
35	269.46	0.60	1927.57	229.84	1156.54	137.91	0.12
36	280.08	0.60	2052.02	226.50	1231.21	135.90	0.11
37	290.70	0.60	2173.47	222.58	1304.08	133.55	0.10
38	301.32	0.60	2292.00	218.05	1375.20	130.83	0.10
39	311.94	0.60	2407.20	212.80	1444.32	127.68	0.09
40	322.56	0.60	2519.81	206.96	1511.89	124.18	0.08
41	333.18	0.60	2629.85	200.54	1577.91	120.32	0.08
42	343.80	0.60	2737.35	193.53	1642.41	116.12	0.07
43	354.42	0.60	2842.28	185.96	1705.37	111.57	0.07
44	365.04	0.60	2944.63	177.85	1766.78	106.71	0.06
45	375.66	0.60	3044.32	169.23	1826.59	101.54	0.06
46	386.28	0.60	3141.28	160.14	1884.77	96.08	0.05
47	396.90	0.60	3235.41	150.62	1941.25	90.37	0.05
48	407.52	0.60	3326.58	140.72	1995.95	84.43	0.04
49	418.14	0.60	3414.65	130.50	2048.79	78.30	0.04
50	428.76	0.60	3499.44	120.02	2099.66	72.01	0.03
51	439.38	0.60	3580.72	109.38	2148.43	65.63	0.03
52	450.00	0.60	3658.26	98.65	2194.95	59.19	0.03
53	-	0.60	4342.3	0	2605.4	0	0

4. Axial + negative flexure about minor axis

Section input data:
Section height h based on minor axis: 450 mm
Section width b based on minor axis: 450 mm
Rectangular compression block factors (8.1.3(1), 8.1.3(2))

$$\alpha_2 = 1.0 - 0.003 \cdot \acute{f_c} = 1.0 - 0.003 \cdot 25 = 0.93$$

$$\alpha_2 > 0.85 \rightarrow \alpha_2 = 0.85$$

$$\gamma = 1.05 - 0.007 \cdot \acute{f_c} = 1.05 - 0.007 \cdot 25 = 0.88$$

$$\gamma > 0.85 \rightarrow \gamma = 0.85$$

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
400.00	16.00	201.06
366.58	16.00	201.06
366.58	16.00	201.06
279.08	16.00	201.06
279.08	16.00	201.06
170.92	16.00	201.06
170.92	16.00	201.06
83.42	16.00	201.06
83.42	16.00	201.06
50.00	16.00	201.06

Calculation of plastic centroid location

$$\overline{x_p} = \frac{\acute{f_c} \cdot A_g \cdot (h - \text{neutral axis}) + \sum F_{sci} \cdot a_{sci} + \sum F_{si} \cdot a_{si}}{\acute{f_c} \cdot A_g + f_{sy} \cdot A_s + f_{sy} \cdot \acute{A_s}} =$$

$$= \frac{25.00 \cdot 159043.13 \cdot (450 - 225) + 170029216.88 + 56165454.18}{25.00 \cdot 159043.13 + 500.00 \cdot 1005.31 + 500.00 \cdot 1005.31} = 225.00 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	φ	Nu (kN)	Mu (kN-m)	φNu (kN)	φMu (kN-m)	e (m)
Tension Control							
1	-	0.80	-1005.3	0	-804.2	0	0
2	7.38	0.80	-995.91	2.08	-796.72	1.66	-0.00
3	14.76	0.80	-978.82	5.76	-783.06	4.61	-0.01
4	22.14	0.80	-956.86	10.36	-765.49	8.28	-0.01
5	29.52	0.80	-914.19	18.54	-731.35	14.84	-0.02
6	36.90	0.80	-844.25	31.42	-675.40	25.13	-0.04
7	44.28	0.80	-785.10	42.26	-628.08	33.81	-0.05
8	51.66	0.80	-678.48	59.47	-542.78	47.58	-0.09
9	59.04	0.80	-578.48	75.45	-462.79	60.36	-0.13
10	66.42	0.80	-490.48	89.46	-392.39	71.56	-0.18
11	73.80	0.80	-410.44	102.06	-328.35	81.65	-0.25
12	81.18	0.80	-335.81	113.62	-268.65	90.89	-0.34
13	88.56	0.80	-264.95	124.35	-211.96	99.48	-0.47
14	95.94	0.80	-184.21	135.09	-147.37	108.07	-0.73
15	103.32	0.80	-87.14	146.24	-69.71	116.99	-1.68
16	110.70	0.80	4.52	156.65	3.61	125.16	34.64
17	118.08	0.78	91.95	166.42	71.59	129.58	1.81
18	125.46	0.76	176.01	175.61	133.61	133.31	1.00
19	132.84	0.74	257.38	184.27	190.51	136.39	0.72
20	140.23	0.72	336.56	192.41	242.93	138.88	0.57
21	147.61	0.70	413.97	200.08	291.36	140.82	0.48
22	154.99	0.68	497.80	206.86	340.66	141.56	0.42

23	162.37	0.66	592.27	212.54	392.31	140.78	0.36
24	169.75	0.64	684.02	217.88	438.49	139.67	0.32
25	177.13	0.62	773.39	222.86	479.73	138.24	0.29
26	184.51	0.60	860.71	227.48	516.43	136.49	0.26
Compression Control							
27	184.51	0.60	860.71	227.48	516.43	136.49	0.26
28	195.13	0.60	983.24	233.48	589.95	140.09	0.24
29	205.75	0.60	1115.07	236.95	669.04	142.17	0.21
30	216.37	0.60	1252.83	238.41	751.70	143.05	0.19
31	226.99	0.60	1394.83	237.86	836.90	142.72	0.17
32	237.61	0.60	1533.94	236.58	920.37	141.95	0.15
33	248.23	0.60	1668.84	234.85	1001.30	140.91	0.14
34	258.84	0.60	1799.94	232.61	1079.96	139.57	0.13
35	269.46	0.60	1927.57	229.84	1156.54	137.91	0.12
36	280.08	0.60	2052.02	226.50	1231.21	135.90	0.11
37	290.70	0.60	2173.47	222.58	1304.08	133.55	0.10
38	301.32	0.60	2292.00	218.05	1375.20	130.83	0.10
39	311.94	0.60	2407.20	212.80	1444.32	127.68	0.09
40	322.56	0.60	2519.81	206.96	1511.89	124.18	0.08
41	333.18	0.60	2629.85	200.54	1577.91	120.32	0.08
42	343.80	0.60	2737.35	193.53	1642.41	116.12	0.07
43	354.42	0.60	2842.28	185.96	1705.37	111.57	0.07
44	365.04	0.60	2944.63	177.85	1766.78	106.71	0.06
45	375.66	0.60	3044.32	169.23	1826.59	101.54	0.06
46	386.28	0.60	3141.28	160.14	1884.77	96.08	0.05
47	396.90	0.60	3235.41	150.62	1941.25	90.37	0.05
48	407.52	0.60	3326.58	140.72	1995.95	84.43	0.04
49	418.14	0.60	3414.65	130.50	2048.79	78.30	0.04
50	428.76	0.60	3499.44	120.02	2099.66	72.01	0.03
51	439.38	0.60	3580.72	109.38	2148.43	65.63	0.03
52	450.00	0.60	3658.26	98.65	2194.95	59.19	0.03
53	-	0.60	4342.3	0	2605.4	0	0

Slenderness of column braced against sidesway

Section input data:
Effective Length factor K_z = 1.00
Effective Length factor K_y = 1.00
Unsupported length of the column $l = 8000.00\ \text{mm}$
Section axial Dead Load $N^*_{DL} = 1500.00\ \text{kN}$
Section axial Live Load $N^*_{LL} = 0.00\ \text{kN}$
Section axial load based on current load combination $N^* = 2025.00\ \text{kN}$
Section moment about major axis based on current load combination $M^*_x = 38.48\ \text{kN-m}$
Section moment about minor axis based on current load combination $M^*_y = -48.26\ \text{kN-m}$
Top column section moment about major axis $M^*_{top,z} = 206.55\ \text{kN-m}$
Top column section moment about minor axis $M^*_{top,y} = 96.53\ \text{kN-m}$
Bottom column section moment about major axis $M^*_{bot,z} = -129.60\ \text{kN-m}$
Bottom column section moment about minor axis $M^*_{bot,y} = -193.05\ \text{kN-m}$

Second-order moment about major axis Z (10.3)

1. Check if the column is long

End moment $M^*_1 = -129.60\ \text{kN-m}$

End moment $M_2^* = 206.55$ kN-m
Radius of gyration $r_z = 0.25 \cdot D = 0.25 \cdot 450 = 112.50$ mm

$$\frac{N^*}{0.6 \cdot N_{uo}} = \frac{2025.00}{2605.35} = 0.78 \geq 0.15$$

$$\alpha_c = \sqrt{2.25 - 2.5 \cdot N^* / 0.6 \cdot N_{uo}} = \sqrt{2.25 - 2.5 \cdot 2025.00 / 0.6 \cdot 4342.25} = 0.55$$

$$\lambda_{lim,1} = 25.0$$

$$\lambda_{lim,2} = \alpha_c \cdot (38 - \frac{f_c}{15}) \cdot (1 + \frac{M_1^*}{M_2^*}) = 0.55 \cdot (38 - \frac{25}{15}) \cdot (1 + \frac{-129.60}{206.55}) = 7.50$$

$$\frac{K_y \cdot l_c}{r_z} = \frac{1 \cdot 8000}{112.50} = 71.11 > max\left\{\lambda_{lim,1}, \lambda_{lim,2}\right\} = 25.00$$

Column is long. Slenderness effect must be considered.

2. Calculate buckling load (10.4.4)

$$\beta_d = \frac{1.2 \cdot P(DL)}{1.2 \cdot P(DL) + 1.6 \cdot P(LL)} = \frac{1.2 \cdot 1500.00}{1.2 \cdot 1500.00 + 1.6 \cdot 0.00} = 1.00$$

$$N_c = (\frac{\pi^2}{l^2}) \cdot \left[182 \cdot d_0 \cdot \frac{\phi \cdot M_c}{1 + \beta_d}\right] = (\frac{3.14^2}{8000^2}) \cdot \left[182 \cdot 400.00 \cdot \frac{0.6 \cdot 227.48 \cdot 10^5}{1 + 1.00}\right] \cdot 0.001 = 766.15 \text{ kN}$$

$$k_m = 0.6 + 0.4 \cdot \frac{M_1}{M_2} = 0.6 + 0.4 \cdot \frac{-129.60}{206.55} = 0.35$$

$$k_m < 0.4$$

3. Calculate moment magnifier for a braced column (10.4.2)

$$\delta_b = \frac{k_m}{1 - (N^* / N_c)} = \frac{0.40}{1 - (2025.00 / 766.15)} = -0.24 < 1.0 \rightarrow \delta_b = 1.0$$

$$M_2^* \geq M_x^*$$

$$M_{cx}^* = \delta_b \cdot M_2^* = 1.00 \cdot 206.55 = 206.55 \text{ kN-m}$$

Second-order moment about minor axis Y (10.3)

1. Check if the column is long

End moment $M_1^* = -96.53$ kN-m
End moment $M_2^* = 193.05$ kN-m
Radius of gyration $r_y = 0.25 \cdot D = 0.25 \cdot 450 = 112.50$ mm

$$\lambda_{lim,1} = 25.0$$

$$\lambda_{lim,2} = \alpha_c \cdot (38 - \frac{f_c}{15}) \cdot (1 + \frac{M_1^*}{M_2^*}) = 0.55 \cdot (38 - \frac{25}{15}) \cdot (1 + \frac{-96.53}{193.05}) = 10.06$$

$$\frac{K_z \cdot l}{r_y} = \frac{1 \cdot 8000}{112.50} = 71.11 > max\left\{\lambda_{lim,1}, \lambda_{lim,2}\right\} = 25.00$$

Column is long. Slenderness effect must be considered.

2. Calculate buckling load (10.4.4)

$$\beta_d = \frac{1.2 \cdot P(DL)}{1.2 \cdot P(DL) + 1.6 \cdot P(LL)} = \frac{1.2 \cdot 1500.00}{1.2 \cdot 1500.00 + 1.6 \cdot 0.00} = 1.00$$

$$N_c = (\frac{\pi^2}{l^2}) \cdot \left[182 \cdot d_0 \cdot \frac{\phi \cdot M_c}{1+\beta_d}\right] = (\frac{3.14^2}{8000^2}) \cdot \left[182 \cdot 400.00 \cdot \frac{0.6 \cdot 227.48 \cdot 10^5}{1+1.00}\right] \cdot 0.001$$
$$= 766.15 \text{ kN}$$

$$k_m = 0.6 + 0.4 \cdot \frac{M_1}{M_2} = 0.6 + 0.4 \cdot \frac{-96.53}{193.05} = 0.40$$

$$k_m < 0.4$$

3. Calculate moment magnifier for a braced column (10.4.2)

$$\delta_b = \frac{k_m}{1-(N^*/N_c)} = \frac{0.40}{1-(2025.00/766.15)} = -0.24 < 1.0 \rightarrow \delta_b = 1.0$$

$$M_2^* \geq M_y^*$$

$$M_{cx}^* = \delta_b \cdot -M_2^* = 1.00 \cdot -193.05 = -193.05 \text{ kN-m}$$

Strength check

Section input data:
Actual axial force $N^* = 2025.00$ kN
Actual bending moment about major axis $M_z^* = 206.55$ kN-m
Actual bending moment about minor axis $M_y^* = 193.05$ kN-m
Eccentricity of actual forces along major axis $e_y = 0.1020$ m
Eccentricity of actual forces along minor axis $e_z = 0.0953$ m
Limited axial force (Mx-N axis plane) $\phi \cdot N_{uz} = 1308.08$ kN
Limited axial force (My-N axis plane) $\phi \cdot N_{uy} = 1373.25$ kN
Limited bending moment about major axis $\phi \cdot M_{uz} = 133.40$ kN-m
Limited bending moment about minor axis $\phi \cdot M_{uy} = 130.90$ kN-m

Axial + biaxial bending check case for round section

$\alpha_n = 2.0$ as for circular section

$$\left[\frac{M_z^*}{\phi \cdot M_{uz}}\right]^{\alpha_n} + \left[\frac{M_y^*}{\phi \cdot M_{uy}}\right]^{\alpha_n} = \left[\frac{206.55}{133.40}\right]^2 + \left[\frac{193.05}{130.90}\right]^2 = 4.57 > 1.0$$

STATUS NG!

Axial compression check case

$$N^* = 2025.00 \text{ kN} \leq \phi \cdot N_{uo} = 2605.35 \text{ kN}$$

STATUS OK!