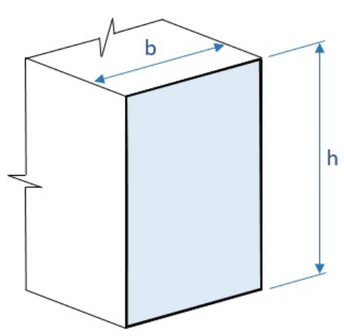
REFERENCES	CALCULATIONS	RESULTS
Code: CSA A23.3-14	**MEMBER #1 (SECTION POSITION 0.0 mm) COLUMN DESIGN REPORT** **Project details** **Project Name:** **Project ID:** Company: Designer: Client: Project Notes: Project Units: Metric **General member design information** Dimentions:  Height $h = 400\ \mathrm{mm}$ Width $b = 400\ \mathrm{mm}$ Member length = $5000\ \mathrm{mm}$ Material properties: Concrete strength $f_c = 25\ \mathrm{MPa}$ Steel strength of longitudinal rebar $f_y = 400\ \mathrm{MPa}$ Steel strength of shear rebar $f_{yt} = 400\ \mathrm{MPa}$ Limit crack control parameter $z_{lim} = 30000\ \mathrm{N/mm}$ **Load Combinations (Ultimate Limit State)** For axial force in section: LC1: USER = $0\ \mathrm{kN}$ For bending moment in section (major axis): LC1: USER = $0\ \mathrm{kN\text{-}m}$ For bending moment in section (minor axis): LC1: USER = $0\ \mathrm{kN\text{-}m}$ **Load Combinations (Serviceability Limit State)** For axial force in section: LC1: USER = $0\ \mathrm{kN}$ For bending moment in section (major axis): LC1: USER = $0\ \mathrm{kN\text{-}m}$ For bending moment in section (minor axis): LC1: USER = $0\ \mathrm{kN\text{-}m}$	
10.9.1, 10.9.2	**Detailing of Members** DETAILING RULES FOR COLUMN (LONGITUDINAL REINFORCEMENT) Section input data: Section concrete area $A_g = 160000.00\ \mathrm{mm}^2$ Longitudinal rebar area $A_{st} = 1999.80\ \mathrm{mm}^2$ Check the steel ratio for the longitudinal steel: $$\rho_t = \frac{A_{st}}{A_g} = \frac{1999.80}{160000.00} = 0.01250$$ $0.01 < 0.01250 < 0.08\ (\mathrm{Ratio}: 0.156)$	**STATUS OK!** **Ratio: 0.156**

Column check

10.1.7, 10.10.4

MAXIMUM AXIAL COMPRESSION

Section input data:
Section concrete area $A_g = 160000.00\ \text{mm}^2$
Longitudinal rebar area $A_{st} = 1999.80\ \text{mm}^2$
Concrete resistance factor (8.4.2) $\phi_c = 0.65$
Reinforcement resistance factor (8.4.3) $\phi_s = 0.85$

Rectangular compression block factors (10.1.7)

$$\alpha_1 = 0.85 - 0.0015 \cdot \alpha_1 \cdot \phi_c \cdot f_c = 0.85 - 0.0015 \cdot 25 = 0.81$$

$$\beta_1 = 0.97 - 0.0025 \cdot \alpha_1 \cdot \phi_c \cdot f_c = 0.97 - 0.0025 \cdot 25 = 0.91$$

Calculate the axial load capacity for concentric loading (10.10.4)

$$P_{rmax} = 0.8 \cdot [\alpha_1 \cdot \phi_c \cdot \alpha_1 \cdot \phi_c \cdot f_c \cdot (A_g - A_{st}) + \phi_s \cdot f_y \cdot A_{st}] =$$

$$= 0.8 \cdot [0.81 \cdot 0.65 \cdot 25 \cdot (160000.00 - 1999.80) + 0.85 \cdot 400 \cdot 1999.80]$$
$$= 2212.82\ \text{kN}$$

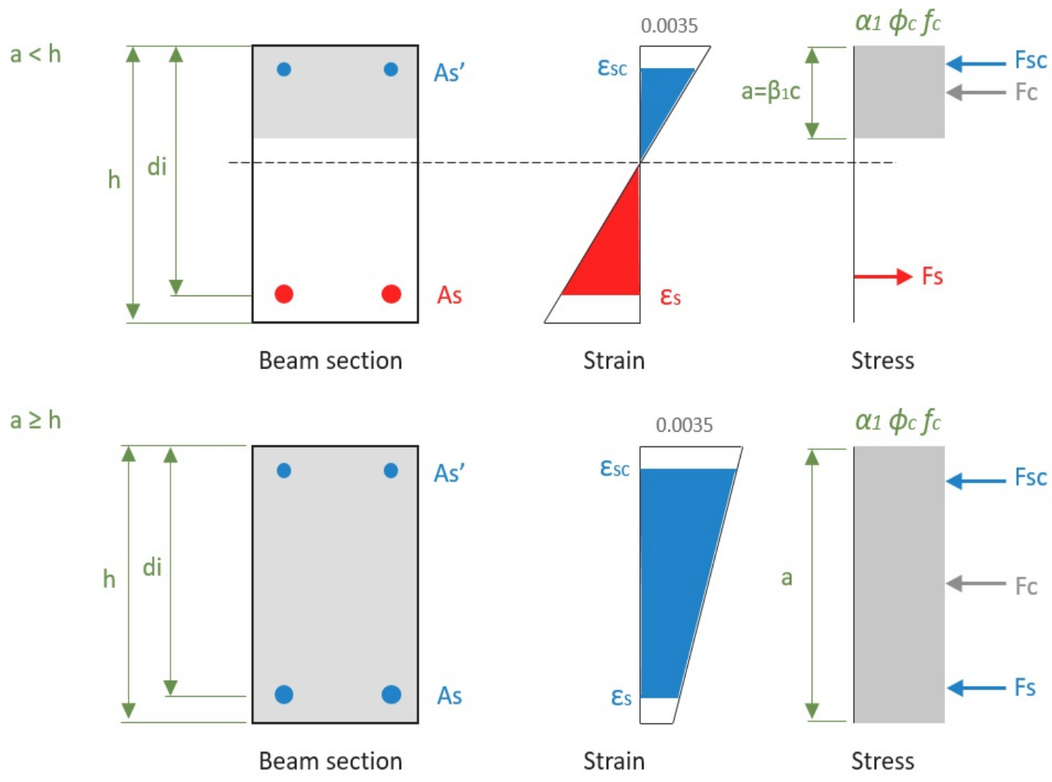
MAXIMUM AXIAL TENSION

Section input data:
Longitudinal rebar area $A_{st} = 1999.80\ \text{mm}^2$

Calculate the axial load capacity for concentric loading

$$T_r = f_y \cdot A_{st} = 400 \cdot 1999.80 = -799.92\ \text{kN}$$

M-N INTERACTION



Calculation is based on iterative process:
- Calculate plastic centroid location $\overline{x_p} = \sum(F_{cc} \cdot h/2 + F_{cs} \cdot \acute{d} \cdot F_s \cdot F_s)/\sum(F_{cc} + F_{cs} + F_s)$
- Assume c in tension control zone and compression control zone
- Calculate strain e_s and e_{sc} when a < h:

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

$N = F_{cc} + F_{sc} + F_s$
$a < h$: $N = \alpha_1 \cdot \phi_c \cdot f_c \cdot b \cdot \beta_1 \cdot c + \phi_s \cdot \sum f_{sci} \cdot \acute{A}_{si} + \phi_s \cdot \sum f_{si} \cdot A_{si}$
$a \geq h$: $N = \alpha_1 \cdot \phi_c \cdot f_c \cdot b \cdot h + \phi_s \cdot \sum f_{sci} \cdot \acute{A}_{si} + \phi_s \cdot \sum f_{si} \cdot A_{si}$
$a < h$: $M = F_{cc} \cdot (\overline{x_p} - \beta_1 c/2) + F_{sc} \cdot (\overline{x_p} - \acute{d}_i) - F_s \cdot (d_i - \overline{x_p})$
$a \geq h$: $M = F_{cc} \cdot (\overline{x_p} - h/2) + F_{sc} \cdot (\overline{x_p} - \acute{d}_i) - F_s \cdot (d_i - \overline{x_p})$

1. Axial + positive flexure about major axis

Section input data:
Section height h based on major axis: 400 mm
Section width b based on major axis: 400 mm

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm^2)
337.50	25.23	499.95
337.50	25.23	499.95
62.50	25.23	499.95
62.50	25.23	499.95

Calculation of plastic centroid location

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

$$= \frac{25.00 \cdot 160000.00 \cdot (400 - 200) + 134986500.00 + 24997500.00}{25.00 \cdot 160000.00 + 400.00 \cdot 999.9 + 400.00 \cdot 999.90}$$
$$= 200.00 \text{ mm}$$

M-N interaction values

Iter.	c (mm)	N (kN)	M (kN-m)	e (m)
Tension Control				
1	-	-799.9	0	0
2	8.6	-638.8	8.1	-0.013
3	17.2	-597.6	15.8	-0.026
4	25.8	-556.4	23.3	-0.042
5	34.4	-515.2	30.4	-0.059
6	43.0	-404.8	46.7	-0.115
7	51.5	-219.4	73.0	-0.333
8	60.1	-75.1	93.3	-1.242
9	68.7	43.3	109.8	2.533
10	77.3	144.6	123.5	0.854
11	85.9	233.9	135.3	0.579
12	94.5	314.4	145.6	0.463
13	103.1	388.4	154.7	0.398
14	111.7	457.3	162.7	0.356
15	120.3	522.2	169.9	0.325
16	128.9	584.0	176.3	0.302
17	137.5	643.2	182.0	0.283
18	146.0	700.0	187.1	0.267
19	154.6	741.1	189.7	0.256
20	163.2	782.3	192.0	0.245
21	171.8	823.5	194.0	0.236
22	180.4	864.7	195.6	0.226
23	189.0	905.8	197.0	0.217
24	197.6	947.0	198.0	0.209
25	206.2	988.2	198.7	0.201
26	214.8	1029.3	199.0	0.193
Compression Control				
27	222.2	1096.0	194.8	0.178

28	229.6	1160.7	190.6	0.164
29	237.0	1223.6	186.5	0.152
30	244.4	1284.8	182.3	0.142
31	251.8	1344.4	178.1	0.132
32	259.2	1402.7	173.8	0.124
33	266.6	1459.8	169.5	0.116
34	274.0	1515.6	165.1	0.109
35	281.5	1570.4	160.5	0.102
36	288.9	1624.2	155.9	0.096
37	296.3	1677.1	151.2	0.090
38	303.7	1729.2	146.4	0.085
39	311.1	1780.4	141.4	0.079
40	318.5	1831.0	136.3	0.074
41	325.9	1880.8	131.1	0.070
42	333.3	1930.0	125.7	0.065
43	340.7	1978.6	120.1	0.061
44	348.1	2026.7	114.4	0.056
45	355.5	2074.2	108.5	0.052
46	363.0	2121.2	102.4	0.048
47	370.4	2167.8	96.2	0.044
48	377.8	2214.0	89.8	0.041
49	385.2	2259.7	83.2	0.037
50	392.6	2305.0	76.4	0.033
51	400.0	2350.0	69.4	0.030
52	-	2212.8	0	0

2. Axial + negative flexure about major axis

Section input data:
Section height h based on major axis: 400 mm
Section width b based on major axis: 400 mm

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm^2)
337.50	25.23	499.95
337.50	25.23	499.95
62.50	25.23	499.95
62.50	25.23	499.95

Calculation of plastic centroid location

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

$$= \frac{25.00 \cdot 160000.00 \cdot (400 - 200) + 134986500.00 + 24997500.00}{25.00 \cdot 160000.00 + 400.00 \cdot 999.9 + 400.00 \cdot 999.90}$$
$$= 200.00 \text{ mm}$$

M-N interaction values

		N		

Iter.	c (mm)	(kN)	M (kN-m)	e (m)
Tension Control				
1	-	-799.9	0	0
2	8.6	-638.8	8.1	-0.013
3	17.2	-597.6	15.8	-0.026
4	25.8	-556.4	23.3	-0.042
5	34.4	-515.2	30.4	-0.059
6	43.0	-404.8	46.7	-0.115
7	51.5	-219.4	73.0	-0.333
8	60.1	-75.1	93.3	-1.242
9	68.7	43.3	109.8	2.533
10	77.3	144.6	123.5	0.854
11	85.9	233.9	135.3	0.579
12	94.5	314.4	145.6	0.463
13	103.1	388.4	154.7	0.398
14	111.7	457.3	162.7	0.356
15	120.3	522.2	169.9	0.325
16	128.9	584.0	176.3	0.302
17	137.5	643.2	182.0	0.283
18	146.0	700.0	187.1	0.267
19	154.6	741.1	189.7	0.256
20	163.2	782.3	192.0	0.245
21	171.8	823.5	194.0	0.236
22	180.4	864.7	195.6	0.226
23	189.0	905.8	197.0	0.217
24	197.6	947.0	198.0	0.209
25	206.2	988.2	198.7	0.201
26	214.8	1029.3	199.0	0.193
Compression Control				
27	222.2	1096.0	194.8	0.178
28	229.6	1160.7	190.6	0.164
29	237.0	1223.6	186.5	0.152
30	244.4	1284.8	182.3	0.142
31	251.8	1344.4	178.1	0.132
32	259.2	1402.7	173.8	0.124
33	266.6	1459.8	169.5	0.116
34	274.0	1515.6	165.1	0.109
35	281.5	1570.4	160.5	0.102
36	288.9	1624.2	155.9	0.096
37	296.3	1677.1	151.2	0.090
38	303.7	1729.2	146.4	0.085
39	311.1	1780.4	141.4	0.079
40	318.5	1831.0	136.3	0.074
41	325.9	1880.8	131.1	0.070

42	333.3	1930.0	125.7	0.065
43	340.7	1978.6	120.1	0.061
44	348.1	2026.7	114.4	0.056
45	355.5	2074.2	108.5	0.052
46	363.0	2121.2	102.4	0.048
47	370.4	2167.8	96.2	0.044
48	377.8	2214.0	89.8	0.041
49	385.2	2259.7	83.2	0.037
50	392.6	2305.0	76.4	0.033
51	400.0	2350.0	69.4	0.030
52	-	2212.8	0	0

3. Axial + positive flexure about minor axis

Section input data:
Section height h based on minor axis: 400 mm
Section width b based on minor axis: 400 mm

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm^2)
337.50	25.23	499.95
337.50	25.23	499.95
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Calculation of plastic centroid location

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

$$= \frac{25.00 \cdot 160000.00 \cdot (400 - 200) + 134986500.00 + 24997500.00}{25.00 \cdot 160000.00 + 400.00 \cdot 999.9 + 400.00 \cdot 999.90}$$
$$= 200.00 \text{ mm}$$

M-N interaction values

Iter.	c (mm)	N (kN)	M (kN-m)	e (m)
Tension Control				
1	-	-799.9	0	0
2	8.6	-638.8	8.1	-0.013
3	17.2	-597.6	15.8	-0.026
4	25.8	-556.4	23.3	-0.042
5	34.4	-515.2	30.4	-0.059
6	43.0	-404.8	46.7	-0.115
7	51.5	-219.4	73.0	-0.333
8	60.1	-75.1	93.3	-1.242
9	68.7	43.3	109.8	2.533
10	77.3	144.6	123.5	0.854
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13	103.1	388.4	154.7	0.398

14	111.7	457.3	162.7	0.356
15	120.3	522.2	169.9	0.325
16	128.9	584.0	176.3	0.302
17	137.5	643.2	182.0	0.283
18	146.0	700.0	187.1	0.267
19	154.6	741.1	189.7	0.256
20	163.2	782.3	192.0	0.245
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4. Axial + negative flexure about minor axis

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$$= \frac{25.00 \cdot 160000.00 \cdot (400 - 200) + 134986500.00 + 24997500.00}{25.00 \cdot 160000.00 + 400.00 \cdot 999.9 + 400.00 \cdot 999.90}$$
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50	392.6	2305.0	76.4	0.033
51	400.0	2350.0	69.4	0.030
52	-	2212.8	0	0

5. Strength check

Section input data:
Actual axial force $N = 0.00$ kN
Actual bending moment about major axis $M_z = 0.00$ kN-m
Actual bending moment about minor axis $M_y = 0.00$ kN-m
Eccentricity of actual forces along major axis $e_y = 0.0000$ m
Eccentricity of actual forces along minor axis $e_z = 0.0000$ m
Limited axial force (Mx-N axis plane) $N_{uz} = 0.00$ kN
Limited axial force (My-N axis plane) $N_{uy} = 0.00$ kN
Limited bending moment about major axis $M_{uz} = 0.00$ kN-m
Limited bending moment about minor axis $M_{uy} = 0.00$ kN-m

Actual forces are not acting in section

STATUS OK!
Ratio: 0.000