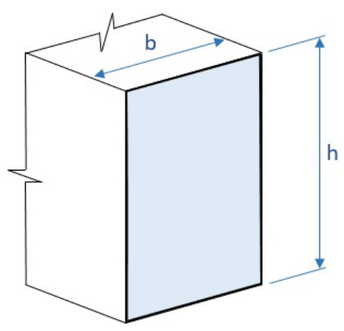
REFERENCES	CALCULATIONS	RESULTS
Code: ENV 1992-1-1 :1991	# MEMBER #1 (SECTION POSITION 0.0 mm) COLUMN DESIGN REPORT ## Project details **Project Name: Not Provided** **Project ID: Not Provided** Company: Not Provided Designer: Not Provided Client: Not Provided Project Notes: Not Provided Project Units: Metric ## General member design information Dimentions:  Height $h = 450\ \mathrm{mm}$ Width $b = 350\ \mathrm{mm}$ Member length = $5000\ \mathrm{mm}$ Material properties: Concrete strength $f_{ck} = 25\ \mathrm{MPa}$ Steel strength of longitudinal rebar $f_{yk} = 500\ \mathrm{MPa}$ Steel strength of shear rebar $f_{ywk} = 500\ \mathrm{MPa}$ Limiting crack width $\omega_{max} = 0.3\ \mathrm{mm}$ Design Factors and Settings: Partial safety factor for concrete $\gamma_c = 1.50$ Partial safety factor for rebar $\gamma_s = 1.15$ Long term and unfavorable effects for concrete $\alpha_{cc} = 0.85$ ## 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 = $0\ \mathrm{kN\text{-}m}$	
9.5.2(2), 9.5.2(3) 9.2.1.1(1)	## Detailing of Members DETAILING RULES FOR COLUMN (LONGITUDINAL REINFORCEMENT) Section input data: Design strength of rebar $f_{yd} = f_{yk}/\gamma_s = 500/1.15 = 434.78\ \mathrm{MPa}$ Mean width of tension zone $b_t = 350\ \mathrm{mm}$ Section concrete area $A_c = 157500.00\ \mathrm{mm}^2$ Longitudinal rebar area $A_{st} = 2590.24\ \mathrm{mm}^2$ Given axial force $N_{ed} = 0.00\ \mathrm{kN}$ 1. Calculation of maximum allowed longitudinal reinforcement (9.5.2(2), 9.5.2(3)) $$f_{ck} = 25\ \mathrm{MPa} \leq 50\ \mathrm{MPa}$$	

$$f_{ctm} = 0.3 \cdot f_{ck}^{2/3} = 0.3 \cdot 25^{2/3} = 2.56 \text{ MPa}$$

$$A_{s,max} = 0.04 \cdot A_c = 0.04 \cdot 157500 = 6300 \text{ mm}^2$$

2. Calculation of minimum allowed longitudinal reinforcement (9.2.1.1(1))

$$A_{s,min1} = 0.1 \cdot \frac{N_{ed}}{f_{yd}} = 0.1 \cdot \frac{0.00}{434.78} = 0.00 \text{ mm}^2$$

$$A_{s,min2} = 0.002 \cdot A_c = 0.002 \cdot 157500.00 = 315.00 \text{ mm}^2$$

$$A_{s,min} = max\left[A_{s,min1}, A_{s,min2}\right] = 315.00 \text{ mm}^2$$

3. Check of allowed longitudinal reinforcement

$$A_{st} = 2590.24 \text{ mm}^2 \leq A_{s,max} = 6300.00 \text{ mm}^2$$

STATUS OK!

$$A_{st} = 2590.24 \text{ mm}^2 \geq A_{s,min} = 315.00 \text{ mm}^2$$

STATUS OK!

Column check

MAXIMUM AXIAL COMPRESSION

Section input data:
Design compressive strength of concrete $f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 0.85 \cdot 25/1.5 = 14.17 \text{ MPa}$
Design strength of rebar $f_{yd} = f_{yk}/\gamma_s = 500/1.15 = 434.78 \text{ MPa}$
Effective strength of concrete factor (3.1.7(3)) $\eta = 1.00$
Section concrete area $A_g = 157500.00 \text{ mm}^2$
Longitudinal rebar area $A_{st} = 2590.24 \text{ mm}^2$

Calculate the axial load capacity for concentric loading

$$N_{Rd} = \eta \cdot f_{cd} \cdot (A_g - A_{st}) + f_{yd} \cdot A_{st} = 1 \cdot 14.17 \cdot (157500.00 - 2590.24) + 434.78 \cdot 2590.24 = 3320.75 \text{ kN}$$

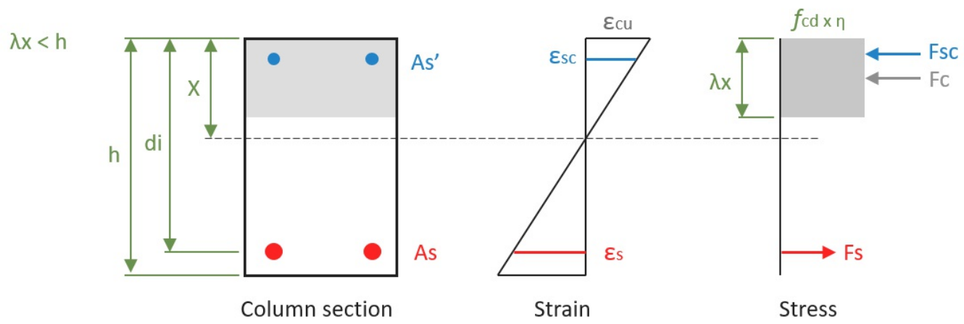
MAXIMUM AXIAL TENSION

Section input data:
Design strength of rebar $f_{yd} = f_{yk}/\gamma_s = 500/1.15 = 434.78 \text{ MPa}$
Longitudinal rebar area $A_{st} = 2590.24 \text{ mm}^2$

Calculate the axial load capacity for concentric loading

$$N_{Rdt} = -f_{yd} \cdot A_{st} = -434.78 \cdot 2590.24 = -1126.19 \text{ kN}$$

M-N INTERACTION



Section input data:
Design compressive strength of concrete $f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 0.85 \cdot 25/1.5 = 14.17 \text{ MPa}$
Design strength of rebar $f_{yd} = f_{yk}/\gamma_s = 500/1.15 = 434.78 \text{ MPa}$
Design yield strain of rebar $e_y = f_{yd}/E_s = 434.78/200000 = 0.00217$
Ultimate strain in concrete (Table 3) $e_{cu} = 0.00350$
Effective height of the compression zone factor (3.1.7(3)) $\lambda = 0.80$
Effective strength of concrete factor (3.1.7(3)) $\eta = 1.00$

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:

$N = F_{cc} + F_{sc} + F_s$
$\lambda x < h$: $N = f_{cd} \cdot b \cdot \lambda \cdot x + \sum f_{sci} \cdot \acute{A}_{si} + \sum f_{si} \cdot A_{si}$
$\lambda x \geq h$: $N = f_{cd} \cdot b \cdot h + \sum f_{sci} \cdot \acute{A}_{si} + \sum f_{si} \cdot A_{si}$
$\lambda x < h$: $M = F_{cc} \cdot (\overline{x_p} - \lambda x/2) + \sum f_{sci} \cdot (\overline{x_p} - \acute{d}_i) - \sum f_{si} \cdot (d_i - \overline{x_p})$
$\lambda x < h$: $M = F_{cc} \cdot (\overline{x_p} - h/2) + \sum f_{sci} \cdot (\overline{x_p} - \acute{d}_i) - \sum f_s \cdot (d_i - \overline{x_p})$

1. Axial + positive flexure about major axis

Section input data:
Section height h based on major axis: 450 mm
Section width b based on major axis: 350 mm

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
400.00	25.00	490.87
400.00	25.00	490.87
50.00	32.00	804.25
50.00	32.00	804.25

Calculation of plastic centroid location

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

$$= \frac{14.17 \cdot 157500.00 \cdot (450 - 225) + 170737391.30 + 34967391.30}{14.17 \cdot 157500.00 + 434.78 \cdot 1608.5 + 434.78 \cdot 981.74} = 210.80 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	N (kN)	M (kN-m)	e (m)
Tension Control				
1	-	-1126.2	0	0
2	39.5	-570.3	63.0	-0.111
3	49.3	-246.0	115.8	-0.471
4	59.2	-16.7	152.9	-9.172
5	69.1	158.3	181.0	1.143
6	79.0	299.3	203.3	0.679
7	88.8	417.7	221.7	0.531
8	98.7	520.2	237.2	0.456
9	108.6	611.2	250.5	0.410
10	118.4	693.6	262.2	0.378
11	128.3	769.3	272.4	0.354
12	138.2	820.6	278.5	0.339
13	148.0	859.8	282.2	0.328
14	157.9	898.9	285.7	0.318
15	167.8	938.1	288.8	0.308
16	177.7	977.2	291.7	0.298

17	187.5	1016.4	294.2	0.289
18	197.4	1055.5	296.4	0.281
19	207.3	1094.7	298.4	0.273
20	217.1	1133.8	300.0	0.265
21	227.0	1173.0	301.3	0.257
22	236.9	1212.1	302.3	0.249
23	246.7	1251.3	302.9	0.242
Compression Control				
24	254.9	1319.0	296.5	0.225
25	263.0	1384.6	290.3	0.210
26	271.1	1448.2	284.3	0.196
27	279.3	1510.0	278.4	0.184
28	287.4	1570.1	272.7	0.174
29	295.5	1628.6	267.0	0.164
30	303.7	1685.8	261.3	0.155
31	311.8	1741.7	255.7	0.147
32	319.9	1796.3	250.1	0.139
33	328.0	1849.9	244.5	0.132
34	336.2	1902.4	238.9	0.126
35	344.3	1953.9	233.3	0.119
36	352.4	2004.6	227.6	0.114
37	360.6	2054.4	221.9	0.108
38	368.7	2103.5	216.1	0.103
39	376.8	2151.8	210.2	0.098
40	385.0	2199.5	204.3	0.093
41	393.1	2246.5	198.3	0.088
42	401.2	2292.9	192.1	0.084
43	409.3	2338.8	185.9	0.079
44	417.5	2384.1	179.5	0.075
45	425.6	2428.9	173.1	0.071
46	433.7	2473.3	166.5	0.067
47	441.9	2517.2	159.8	0.063
48	450.0	2560.7	153.0	0.060
49	-	3320.7	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: 350 mm

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
400.00	32.00	804.25
400.00	32.00	804.25
50.00	25.00	490.87
50.00	25.00	490.87

Calculation of plastic centroid location

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

$$= \frac{14.17 \cdot 157500.00 \cdot (450 - 225) + 279739130.43 + 21342173.91}{14.17 \cdot 157500.00 + 434.78 \cdot 981.74 + 434.78 \cdot 1608.50} = 239.20 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	N (kN)	M (kN-m)	e (m)
Tension Control				
1	-	-1126.2	0	0
2	9.9	-1087.0	40.9	-0.038
3	19.7	-1047.9	49.8	-0.048
4	29.6	-1008.7	58.4	-0.058
5	39.5	-725.9	112.8	-0.155
6	49.3	-512.7	153.7	-0.300
7	59.2	-357.5	183.3	-0.513
8	69.1	-235.4	206.4	-0.877
9	79.0	-134.1	225.2	-1.679
10	88.8	-46.6	241.1	-5.172
11	98.7	31.2	254.8	8.160
12	108.6	102.0	266.9	2.616
13	118.4	167.5	277.7	1.657
14	128.3	229.0	287.4	1.255
15	138.2	275.6	294.0	1.067
16	148.0	314.7	298.9	0.950
17	157.9	353.9	303.5	0.858
18	167.8	393.0	307.7	0.783
19	177.7	432.2	311.7	0.721
20	187.5	471.3	315.3	0.669
21	197.4	510.5	318.7	0.624
22	207.3	549.6	321.7	0.585
23	217.1	588.8	324.4	0.551
24	227.0	627.9	326.8	0.520
25	236.9	667.1	328.9	0.493
26	246.7	706.2	330.7	0.468
Compression Control				
27	254.9	796.7	322.6	0.405
28	263.0	883.6	314.9	0.356

29	271.1	967.2	307.4	0.318
30	279.3	1047.8	300.3	0.287
31	287.4	1125.7	293.3	0.261
32	295.5	1201.0	286.6	0.239
33	303.7	1274.1	280.0	0.220
34	311.8	1345.0	273.6	0.203
35	319.9	1414.0	267.2	0.189
36	328.0	1481.1	261.0	0.176
37	336.2	1546.6	254.8	0.165
38	344.3	1610.5	248.6	0.154
39	352.4	1672.9	242.5	0.145
40	360.6	1734.0	236.4	0.136
41	368.7	1793.7	230.3	0.128
42	376.8	1852.4	224.1	0.121
43	385.0	1909.8	218.0	0.114
44	393.1	1966.3	211.8	0.108
45	401.2	2021.8	205.5	0.102
46	409.3	2076.3	199.2	0.096
47	417.5	2130.0	192.8	0.091
48	425.6	2182.8	186.3	0.085
49	433.7	2234.9	179.7	0.080
50	441.9	2286.3	173.1	0.076
51	450.0	2336.9	166.3	0.071
52	-	3320.7	0	0

3. Axial + positive flexure about minor axis

Section input data:
Section height h based on minor axis: 350 mm
Section width b based on minor axis: 450 mm

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
300.00	25.00	490.87
300.00	32.00	804.25
50.00	25.00	490.87
50.00	32.00	804.25

Calculation of plastic centroid location

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

$$= \frac{14.17 \cdot 157500.00 \cdot (350 - 175) + 168928695.65 + 28154782.61}{14.17 \cdot 157500.00 + 434.78 \cdot 1295.12 + 434.78 \cdot 1295.12} = 175.00 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	N (kN)	M (kN-m)	e (m)
Tension Control				

1	-	-1126.2	0	0
2	7.4	-1088.4	6.5	-0.006
3	14.8	-1050.7	12.8	-0.012
4	22.2	-1012.9	18.8	-0.019
5	29.6	-975.2	24.6	-0.025
6	37.0	-692.5	60.9	-0.088
7	44.4	-450.6	91.7	-0.204
8	51.8	-267.1	115.1	-0.431
9	59.2	-120.0	133.7	-1.115
10	66.6	2.8	149.1	52.365
11	74.0	108.6	162.1	1.492
12	81.4	202.1	173.3	0.858
13	88.8	286.2	183.1	0.640
14	96.2	363.2	191.8	0.528
15	103.6	434.6	199.6	0.459
16	111.0	501.5	206.6	0.412
17	118.4	564.8	213.0	0.377
18	125.8	625.1	218.7	0.350
19	133.2	679.5	223.5	0.329
20	140.6	717.3	225.9	0.315
21	148.0	755.0	228.2	0.302
22	155.4	792.8	230.2	0.290
23	162.9	830.5	232.0	0.279
24	170.3	868.3	233.6	0.269
25	177.7	906.0	234.9	0.259
26	185.1	943.8	236.1	0.250
Compression Control				
27	191.7	1028.0	230.6	0.224
28	198.3	1108.9	225.3	0.203
29	204.9	1186.7	220.2	0.186
30	211.4	1261.8	215.4	0.171
31	218.0	1334.4	210.6	0.158
32	224.6	1404.7	205.9	0.147
33	231.2	1472.9	201.4	0.137
34	237.8	1539.1	196.9	0.128
35	244.4	1603.6	192.4	0.120
36	251.0	1666.5	188.0	0.113
37	257.6	1727.9	183.6	0.106
38	264.2	1787.9	179.1	0.100
39	270.8	1846.7	174.7	0.095
40	277.4	1904.2	170.2	0.089
41	284.0	1960.6	165.7	0.085
42	290.6	2016.0	161.1	0.080
43	297.2	2070.4	156.5	0.076

44	303.8	2123.9	151.8	0.071
45	310.4	2176.6	147.1	0.068
46	317.0	2228.5	142.2	0.064
47	323.6	2279.6	137.3	0.060
48	330.2	2330.1	132.3	0.057
49	336.8	2379.9	127.2	0.053
50	343.4	2429.0	122.0	0.050
51	350.0	2477.6	116.7	0.047
52	-	3320.7	0	0

4. Axial + negative flexure about minor axis

Section input data:
Section height h based on minor axis: 350 mm
Section width b based on minor axis: 450 mm

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
300.00	32.00	804.25
300.00	25.00	490.87
50.00	32.00	804.25
50.00	25.00	490.87

Calculation of plastic centroid location

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

$$= \frac{14.17 \cdot 157500.00 \cdot (350 - 175) + 168928695.65 + 28154782.61}{14.17 \cdot 157500.00 + 434.78 \cdot 1295.12 + 434.78 \cdot 1295.12} = 175.00 \text{ mm}$$

M-N interaction values

Iter.	x (mm)	N (kN)	M (kN-m)	e (m)
Tension Control				
1	-	-1126.2	0	0
2	7.4	-1088.4	6.5	-0.006
3	14.8	-1050.7	12.8	-0.012
4	22.2	-1012.9	18.8	-0.019
5	29.6	-975.2	24.6	-0.025
6	37.0	-692.5	60.9	-0.088
7	44.4	-450.6	91.7	-0.204
8	51.8	-267.1	115.1	-0.431
9	59.2	-120.0	133.7	-1.115
10	66.6	2.8	149.1	52.365
11	74.0	108.6	162.1	1.492
12	81.4	202.1	173.3	0.858
13	88.8	286.2	183.1	0.640
14	96.2	363.2	191.8	0.528
15	103.6	434.6	199.6	0.459
16	111.0	501.5	206.6	0.412

17	118.4	564.8	213.0	0.377
18	125.8	625.1	218.7	0.350
19	133.2	679.5	223.5	0.329
20	140.6	717.3	225.9	0.315
21	148.0	755.0	228.2	0.302
22	155.4	792.8	230.2	0.290
23	162.9	830.5	232.0	0.279
24	170.3	868.3	233.6	0.269
25	177.7	906.0	234.9	0.259
26	185.1	943.8	236.1	0.250
Compression Control				
27	191.7	1028.0	230.6	0.224
28	198.3	1108.9	225.3	0.203
29	204.9	1186.7	220.2	0.186
30	211.4	1261.8	215.4	0.171
31	218.0	1334.4	210.6	0.158
32	224.6	1404.7	205.9	0.147
33	231.2	1472.9	201.4	0.137
34	237.8	1539.1	196.9	0.128
35	244.4	1603.6	192.4	0.120
36	251.0	1666.5	188.0	0.113
37	257.6	1727.9	183.6	0.106
38	264.2	1787.9	179.1	0.100
39	270.8	1846.7	174.7	0.095
40	277.4	1904.2	170.2	0.089
41	284.0	1960.6	165.7	0.085
42	290.6	2016.0	161.1	0.080
43	297.2	2070.4	156.5	0.076
44	303.8	2123.9	151.8	0.071
45	310.4	2176.6	147.1	0.068
46	317.0	2228.5	142.2	0.064
47	323.6	2279.6	137.3	0.060
48	330.2	2330.1	132.3	0.057
49	336.8	2379.9	127.2	0.053
50	343.4	2429.0	122.0	0.050
51	350.0	2477.6	116.7	0.047
52	-	3320.7	0	0

5. Strength check

Section input data:

Actual axial force $N_{ed} = 0.00$ kN
Actual bending moment about major axis $M_{zed} = 0.00$ kN-m
Actual bending moment about minor axis $M_{yed} = 0.00$ 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) $N_{zRd} = 0.00$ kN
Limited axial force (My-N axis plane) $N_{yRd} = 0.00$ kN
Limited bending moment about major axis $M_{zRd} = 0.00$ kN-m
Limited bending moment about minor axis $M_{yRd} = 0.00$ kN-m

	Actual forces are not acting in section	**STATUS OK!**