REFERENCES	CALCULATIONS	RESULTS

MEMBER #1 (SECTION POSITION 0.0 mm) BEAM DESIGN REPORT

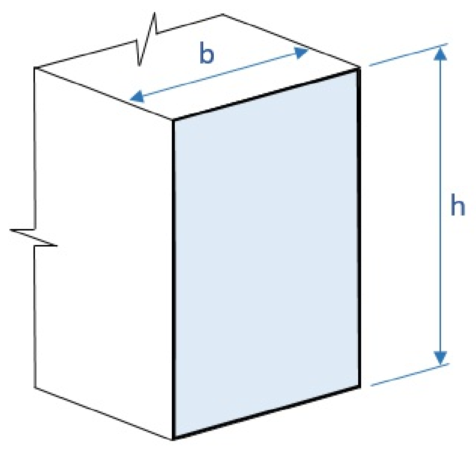
Code: CSA A23.3-14

Project details

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

General member design information

Dimentions:



Height $h = 500\ \mathrm{mm}$
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:
LC1: USER = $0\ \mathrm{kN\text{-}m}$

For shear force in section:
LC1: USER = $0\ \mathrm{kN}$

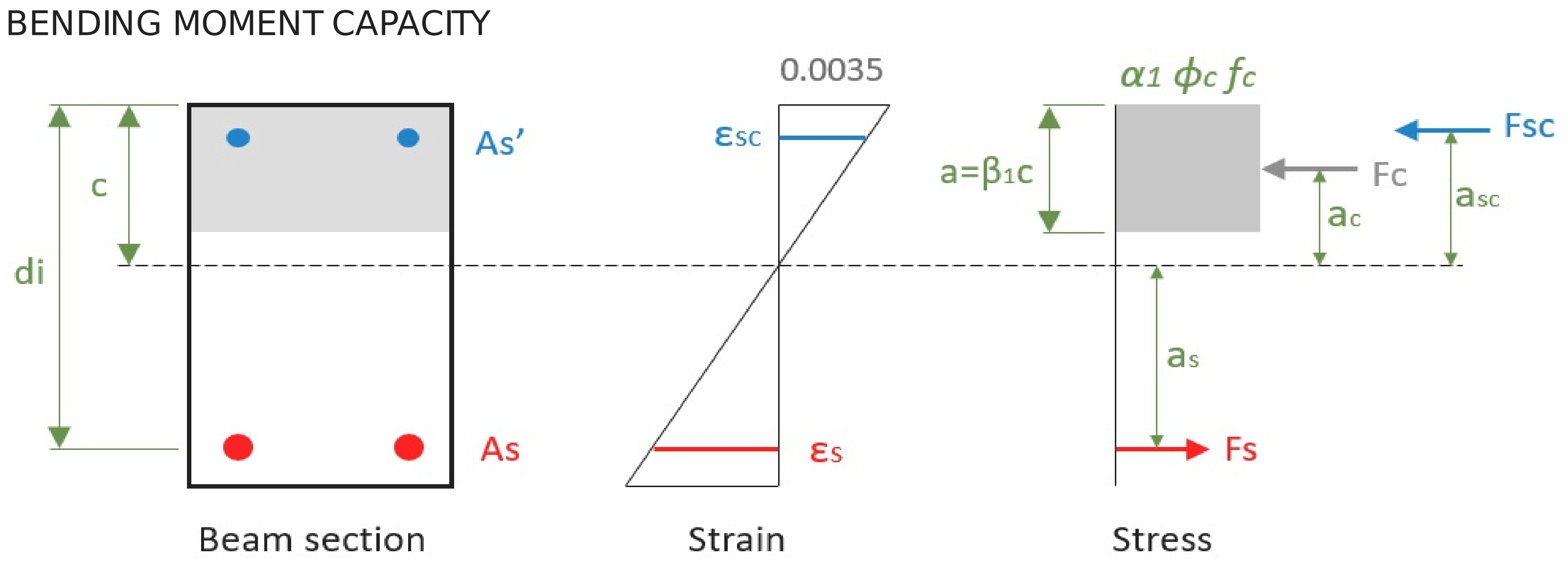
Load Combinations (Serviceability Limit State)

For bending moment in section:
LC1: USER = $0\ \mathrm{kN\text{-}m}$

8.4, 10.1, 10.5

Flexure check (Positive bending moment case)

BENDING MOMENT CAPACITY



Section input data:
Ultimate strain in concrete $e_{cmax} = 0.0035$
Distance to the outermost layer of tensile reinforcement $d = 450\ \mathrm{mm}$
Given bending moment $M = 0.00\ \mathrm{kN\text{-}m}$
Concrete resistance factor (8.4.2) $\phi_c = 0.65$
Reinforcement resistance factor (8.4.3) $\phi_s = 0.85$
Design yield strain of rebar $e_y = f_s/E_s = 400/200000 = 0.00200$

Section Rebar

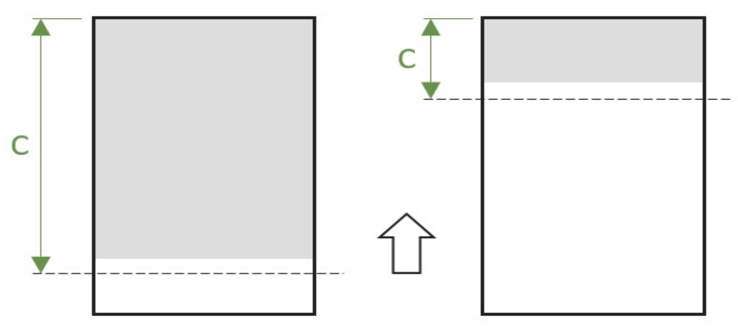
Depth di (mm)	bar diameter (mm)	bar area Asi (mm^2)
450	25.23	499.95
450	25.23	499.95
450	25.23	499.95
450	25.23	499.95
40	25.23	499.95
40	25.23	499.95

Rectangular compression block factors (10.1.7)

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

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

1. Calculation of neutral axis depth c



Calculation is based on iterative process:
- Assume c
- Calculate concrete force $F_c = \alpha_1 \cdot \phi_c \cdot f_c \cdot \int_{dA} \cdot \beta_1 \cdot c$
- Calculate compression force in steel $F_{cs} = \phi_s \cdot \sum A'_{s,i} \cdot f_{s,i}$
- Calculate tensioning force in steel $F_s = \phi_s \cdot \sum A_{s,i} \cdot f_{s,i}$
- Check equilibrium $F_c + F_{cs} = F_s$

Reinforcement stresses $f_s = \{e_s E_s \ (e_s \leq e_y),\ e_y \ (e_s > e_y)\}$
Reinforcement strains above axis $e_s = e_{cu} \cdot (c-d)/c$
Reinforcement strains below axis $e_s = e_{cu} \cdot (d-c)/c$

Searching of neutral axis c (from 450 to 0 mm)

Iter.	c (mm)	a (mm)	Fc (kN)	Fcs (kN)	Fc + Fcs (kN)	Fs (kN)	Ratio
1	450.0	408.4	2156.73	339.97	2496.70	0.00	Infinity
2	441.0	400.2	2113.60	339.97	2453.56	24.28	101.039
3	432.0	392.0	2070.46	339.97	2410.43	49.58	48.619
4	423.0	383.9	2027.33	339.97	2367.29	75.95	31.169
5	414.0	375.7	1984.19	339.97	2324.16	103.47	22.463
6	405.0	367.5	1941.06	339.97	2281.02	132.21	17.253
7	396.0	359.4	1897.92	339.97	2237.89	162.26	13.792
8	387.0	351.2	1854.79	339.97	2194.75	193.70	11.331
9	378.0	343.0	1811.65	339.97	2151.62	226.64	9.493
10	369.0	334.9	1768.52	339.97	2108.48	261.19	8.073
11	360.0	326.7	1725.38	339.97	2065.35	297.47	6.943
12	351.0	318.5	1682.25	339.97	2022.22	335.61	6.026
13	342.0	310.4	1639.12	339.97	1979.08	375.75	5.267
14	333.0	302.2	1595.98	339.97	1935.95	418.07	4.631
15	324.0	294.0	1552.85	339.97	1892.81	462.73	4.091
16	315.0	285.9	1509.71	339.97	1849.68	509.95	3.627
17	306.0	277.7	1466.58	339.97	1806.54	559.94	3.226
18	297.0	269.5	1423.44	339.97	1763.41	612.97	2.877
19	288.0	261.4	1380.31	339.97	1720.27	669.31	2.570

20	279.0	253.2	1337.17	339.97	1677.14	679.93	2.467
21	270.0	245.0	1294.04	339.97	1634.00	679.93	2.403
22	261.0	236.9	1250.90	339.97	1590.87	679.93	2.340
23	252.0	228.7	1207.77	339.97	1547.74	679.93	2.276
24	243.0	220.5	1164.63	339.97	1504.60	679.93	2.213
25	234.0	212.4	1121.50	339.97	1461.47	679.93	2.149
26	225.0	204.2	1078.37	339.97	1418.33	679.93	2.086
27	216.0	196.0	1035.23	339.97	1375.20	679.93	2.023
28	207.0	187.9	992.10	339.97	1332.06	679.93	1.959
29	198.0	179.7	948.96	339.97	1288.93	679.93	1.896
30	189.0	171.5	905.83	339.97	1245.79	679.93	1.832
31	180.0	163.3	862.69	339.97	1202.66	679.93	1.769
32	171.0	155.2	819.56	339.97	1159.52	679.93	1.705
33	162.0	147.0	776.42	339.97	1116.39	679.93	1.642
34	153.0	138.8	733.29	339.97	1073.25	679.93	1.578
35	144.0	130.7	690.15	339.97	1030.12	679.93	1.515
36	135.0	122.5	647.02	339.97	986.99	679.93	1.452
37	126.0	114.3	603.88	339.97	943.85	679.93	1.388
38	117.0	106.2	560.75	339.97	900.72	679.93	1.325
39	108.0	98.0	517.62	339.97	857.58	679.93	1.261
40	99.0	89.8	474.48	339.97	814.45	679.93	1.198
41	90.0	81.7	431.35	330.52	761.87	679.93	1.121
42	81.0	73.5	388.21	301.14	689.35	679.93	1.014
(Fc + Fcs) < Fs. Updating of iterations							
1	72.0	65.3	345.08	264.42	609.49	679.93	0.896
2	80.8	73.3	387.35	300.49	687.84	679.93	1.012
3	80.6	73.2	386.49	299.83	686.32	679.93	1.009
4	80.5	73.0	385.62	299.17	684.79	679.93	1.007
5	80.3	72.9	384.76	298.51	683.27	679.93	1.005
6	80.1	72.7	383.90	297.84	681.74	679.93	1.003
7	79.9	72.5	383.04	297.17	680.21	679.93	1.000
8	79.7	72.4	382.17	296.50	678.67	679.93	0.998

Final value of c is 79.74 mm, flexural tension reinforcement area is 1999.80 mm^2 and flexural compression reinforcement area is 999.90 mm^2
Working depth of reinforcement $d = 450.00 \text{ mm}$

2. Calculation of moment resistance M_r

$$M_r = F_c \cdot a_c + F_{cs} \cdot a_{cs} + F_s \cdot a_s = 16.65 + 11.78 + 251.75 = 280.18 \text{ kN-m}$$

$$M = 0.00 \text{ kN-m} \leq M_r = 280.18 \text{ kN-m (Ratio: 0.000)}$$

STATUS OK!
Ratio: 0.000

3. Minimum required flexural tension reinforcement in a beam section (10.5.1.2)

Width of tension zone $b_t = 400 \text{ mm}$

$$A_{st,min} = \frac{0.2 \cdot \sqrt{f_c}}{f_y} \cdot b_t \cdot h = \frac{0.2 \cdot \sqrt{25}}{400} \cdot 400 \cdot 500 = 500.00 \text{ mm}^2$$

4. Maximum required flexural tension reinforcement in a beam section

$$A_{st,max} = 0.04 \cdot b \cdot d = 0.04 \cdot 400 \cdot 450.00 = 7200.00\ \text{mm}^2$$

5. Check of required flexural tension reinforcement in a beam section

$$A_{st} = 1999.80\ \text{mm}^2 \leq A_{st,max} = 7200.00\ \text{mm}^2\ \text{(Ratio: 0.278)}$$

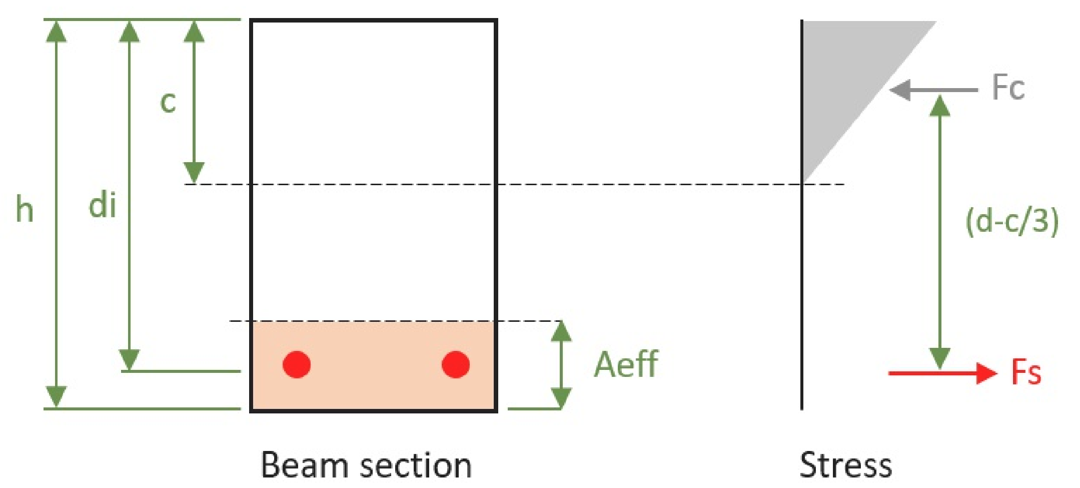
STATUS OK!
Ratio: 0.278

$$A_{st} = 1999.80\ \text{mm}^2 \geq A_{st,min} = 500.00\ \text{mm}^2\ \text{(Ratio: 0.250)}$$

STATUS OK!
Ratio: 0.250

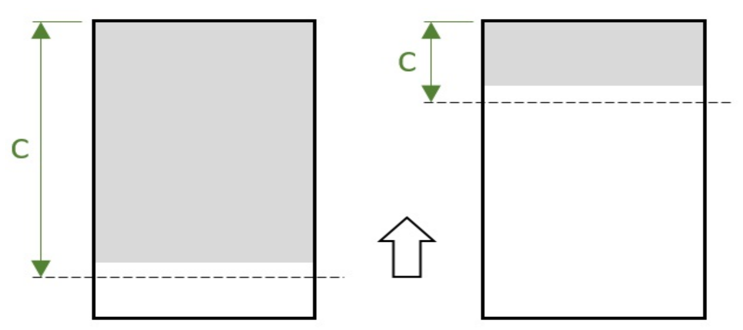
Crack width check (Positive bending moment case)

10.6.1 CRACK CONTROL OF BEAMS



Section input data:
Modulus of elasticity of concrete $E_c = 4500 \cdot \sqrt{f_c} = 4500 \cdot \sqrt{25} = 22500.00\ \text{MPa}$
Modulus of elasticity of steel $E_s = 200000.00\ \text{MPa}$
Modulus Ratio $n = E_s / E_c = 200000/22500.00 = 8.89$
Effective tension area of concrete around the main reinforcing $A = 10000.00\ \text{mm}^2$
Cover of the outermost bar $d_c = 50\ \text{mm}$
Given bending moment $M_a = 0.00\ \text{kN-m}$

1. Calculation of neutral axis depth c of cracked section



Calculation is based on iterative process:
- Assume c
- Calculate left part of force equilibrium $A_{comp.} \cdot 0.5 \cdot c + \sum n \cdot A_s \cdot \acute{d_i} + \sum n \cdot A_s \cdot d_i$
- Calculate right part of force equilibrium $A_{comp.} + n \cdot A_s + n \cdot \acute{A_s}$

Searching of neutral axis c (from 450 to 0 mm)

Iter.	c (mm)	As (mm2)	Left force equil. part (kN)	Right force equil. part (kN)	Ratio
1	450.00	0.00	48854.72	92998.80	1.904
2	441.00	1999.80	47250.92	89551.22	1.895
3	432.00	1999.80	45679.52	86168.45	1.886
4	423.00	1999.80	44140.52	82850.47	1.877
5	414.00	1999.80	42633.92	79597.30	1.867
6	405.00	1999.80	41159.72	76408.92	1.856
7	396.00	1999.80	39717.92	73285.34	1.845
8	387.00	1999.80	38308.52	70226.57	1.833
9	378.00	1999.80	36931.52	67232.59	1.820
10	369.00	1999.80	35586.92	64303.42	1.807
11	360.00	1999.80	34274.72	61439.04	1.793
12	351.00	1999.80	32994.92	58639.46	1.777

13	342.00	1999.80	31747.52	55904.69	1.761
14	333.00	1999.80	30532.52	53234.71	1.744
15	324.00	1999.80	29349.92	50629.54	1.725
16	315.00	1999.80	28199.72	48089.16	1.705
17	306.00	1999.80	27081.92	45613.58	1.684
18	297.00	1999.80	25996.52	43202.81	1.662
19	288.00	1999.80	24943.52	40856.83	1.638
20	279.00	1999.80	23922.92	38575.66	1.612
21	270.00	1999.80	22934.72	36359.28	1.585
22	261.00	1999.80	21978.92	34207.70	1.556
23	252.00	1999.80	21055.52	32120.93	1.526
24	243.00	1999.80	20164.52	30098.95	1.493
25	234.00	1999.80	19305.92	28141.78	1.458
26	225.00	1999.80	18479.72	26249.40	1.420
27	216.00	1999.80	17685.92	24421.82	1.381
28	207.00	1999.80	16924.52	22659.05	1.339
29	198.00	1999.80	16195.52	20961.07	1.294
30	189.00	1999.80	15498.92	19327.90	1.247
31	180.00	1999.80	14834.72	17759.52	1.197
32	171.00	1999.80	14202.92	16255.94	1.145
33	162.00	1999.80	13603.52	14817.17	1.089
34	153.00	1999.80	13036.52	13443.19	1.031
left part < right part. Updating of iterations					
1	144.00	1999.80	12501.92	12134.02	0.971
2	152.82	1999.80	13025.51	13416.37	1.030
3	152.64	1999.80	13014.51	13389.58	1.029
4	152.46	1999.80	13003.53	13362.81	1.028
5	152.28	1999.80	12992.56	13336.07	1.026
6	152.10	1999.80	12981.60	13309.36	1.025
7	151.92	1999.80	12970.66	13282.67	1.024
8	151.74	1999.80	12959.73	13256.01	1.023
9	151.56	1999.80	12948.81	13229.37	1.022
10	151.38	1999.80	12937.90	13202.76	1.020
11	151.20	1999.80	12927.01	13176.17	1.019
12	151.02	1999.80	12916.13	13149.61	1.018
13	150.84	1999.80	12905.26	13123.08	1.017
14	150.66	1999.80	12894.41	13096.57	1.016
15	150.48	1999.80	12883.57	13070.09	1.014
16	150.30	1999.80	12872.74	13043.64	1.013
17	150.12	1999.80	12861.92	13017.21	1.012
18	149.94	1999.80	12851.12	12990.80	1.011
19	149.76	1999.80	12840.33	12964.42	1.010
20	149.58	1999.80	12829.56	12938.07	1.008
21	149.40	1999.80	12818.79	12911.75	1.007

22	149.22	1999.80	12808.04	12885.45	1.006
23	149.04	1999.80	12797.30	12859.17	1.005
24	148.86	1999.80	12786.58	12832.92	1.004
25	148.68	1999.80	12775.87	12806.70	1.002
26	148.50	1999.80	12765.17	12780.50	1.001
27	148.32	1999.80	12754.48	12754.33	1.000

Final value of c is 148.32 mm and tensioning rebar area is $1999.80\ \mathrm{mm}^2$
Working depth of reinforcement $d = 450.00\ \mathrm{mm}$

2. Calculation of stress in tensioning zone of reinforcement

$$f_s = \frac{M_a}{A_s \cdot (d - c/3)} = \frac{0}{1999.80 \cdot (450.00 - 148.32/3)} = 0.00\ \mathrm{MPa}$$

3. Determine the value of z factor (10.6.1)

$$z = f_s \cdot \sqrt[3]{d_c \cdot A} = 0.00 \cdot \sqrt[3]{50.00 \cdot 10000.00} = 0.00\ \mathrm{N/mm}$$

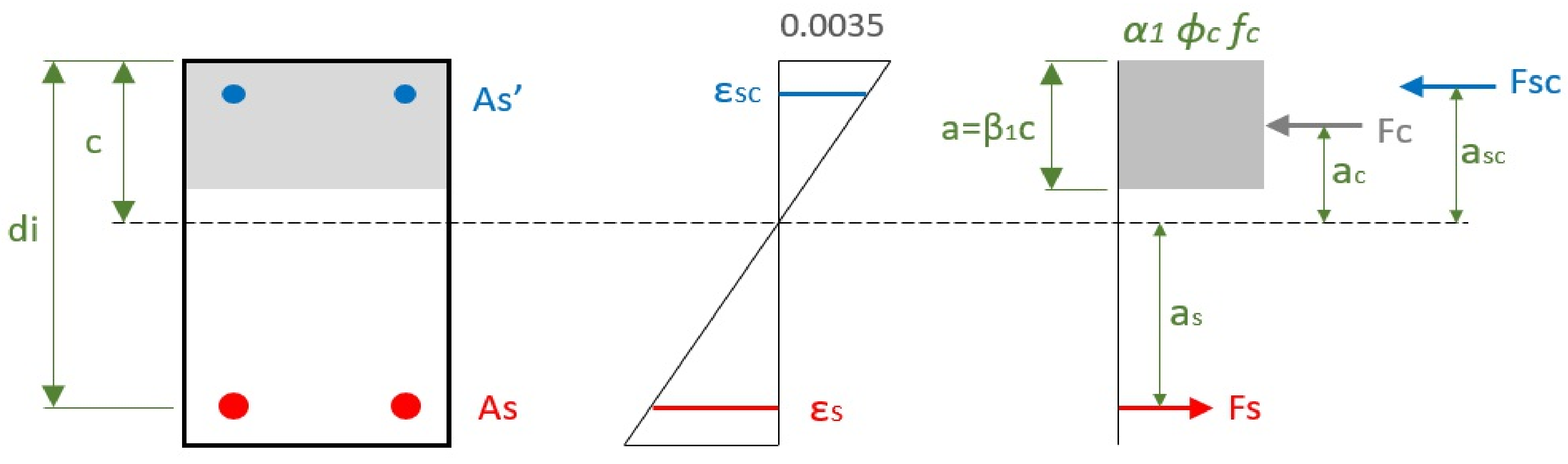
$$z = 0.00\ \mathrm{N/mm} \leq z_{lim} = 30000.00\ \mathrm{N/mm}\ (\text{Ratio: } 0.000)$$

STATUS OK!
Ratio: 0.000

8.4, 10.1, 10.5

Flexure check (Negative bending moment case)

BENDING MOMENT CAPACITY



Beam section Strain Stress

Section input data:
Ultimate strain in concrete $e_{cmax} = 0.0035$
Distance to the outermost layer of tensile reinforcement $d = 460\ \mathrm{mm}$
Given bending moment $M = 0.00\ \mathrm{kN\text{-}m}$
Concrete resistance factor (8.4.2) $\phi_c = 0.65$
Reinforcement resistance factor (8.4.3) $\phi_s = 0.85$
Design yield strain of rebar $e_y = f_s / E_s = 400/200000 = 0.00200$

Section Rebar

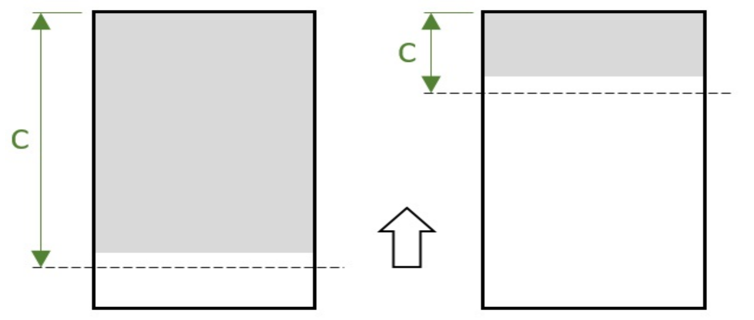
Depth di (mm)	bar diameter (mm)	bar area Asi (mm^2)
460	25.23	499.95
460	25.23	499.95
50	25.23	499.95
50	25.23	499.95
50	25.23	499.95
50	25.23	499.95

Rectangular compression block factors (10.1.7)

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

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

1. Calculation of neutral axis depth c



Calculation is based on iterative process:
- Assume c
- Calculate concrete force $F_c = \alpha_1 \cdot \phi_c \cdot f_c \cdot \int_{dA} \cdot \beta_1 \cdot c$
- Calculate compression force in steel $F_{cs} = \phi_s \cdot \sum \acute{A_{s,i}} \cdot f_{s,i}$
- Calculate tensioning force in steel $F_s = \phi_s \cdot \sum A_{s,i} \cdot f_{s,i}$
- Check equilibrium $F_c + F_{cs} = F_s$

Reinforcement stresses $f_s = \{e_s E_s \ (e_s \leq e_y),\ e_y \ (e_s > e_y)\}$
Reinforcement strains above axis $e_s = e_{cu} \cdot (c - d)/c$
Reinforcement strains below axis $e_s = e_{cu} \cdot (d - c)/c$

Searching of neutral axis c (from 460 to 0 mm)

Iter.	c (mm)	a (mm)	Fc (kN)	Fcs (kN)	Fc + Fcs (kN)	Fs (kN)	Ratio
1	460.0	417.4	2204.66	679.93	2884.59	0.00	Infinity
2	450.8	409.1	2160.56	679.93	2840.50	12.14	233.947
3	441.6	400.8	2116.47	679.93	2796.40	24.79	112.807
4	432.4	392.4	2072.38	679.93	2752.31	37.97	72.477
5	423.2	384.1	2028.29	679.93	2708.22	51.73	52.349
6	414.0	375.7	1984.19	679.93	2664.12	66.10	40.302
7	404.8	367.4	1940.10	679.93	2620.03	81.13	32.295
8	395.6	359.0	1896.01	679.93	2575.94	96.85	26.597
9	386.4	350.7	1851.91	679.93	2531.84	113.32	22.342
10	377.2	342.3	1807.82	679.93	2487.75	130.60	19.049
11	368.0	334.0	1763.73	679.93	2443.66	148.74	16.430
12	358.8	325.6	1719.63	679.93	2399.57	167.80	14.300
13	349.6	317.3	1675.54	679.93	2355.47	187.88	12.537
14	340.4	308.9	1631.45	679.93	2311.38	209.03	11.057
15	331.2	300.6	1587.35	679.93	2267.29	231.37	9.800
16	322.0	292.2	1543.26	679.93	2223.19	254.97	8.719
17	312.8	283.9	1499.17	679.93	2179.10	279.97	7.783
18	303.6	275.5	1455.07	679.93	2135.01	306.48	6.966
19	294.4	267.2	1410.98	679.93	2090.91	334.65	6.248
20	285.2	258.8	1366.89	679.93	2046.82	339.97	6.021
21	276.0	250.5	1322.79	679.93	2002.73	339.97	5.891
22	266.8	242.1	1278.70	679.93	1958.63	339.97	5.761
23	257.6	233.8	1234.61	679.93	1914.54	339.97	5.632
24	248.4	225.4	1190.52	679.93	1870.45	339.97	5.502
25	239.2	217.1	1146.42	679.93	1826.35	339.97	5.372
26	230.0	208.7	1102.33	679.93	1782.26	339.97	5.242
27	220.8	200.4	1058.24	679.93	1738.17	339.97	5.113
28	211.6	192.0	1014.14	679.93	1694.07	339.97	4.983
29	202.4	183.7	970.05	679.93	1649.98	339.97	4.853
30	193.2	175.3	925.96	679.93	1605.89	339.97	4.724
31	184.0	167.0	881.86	679.93	1561.80	339.97	4.594
32	174.8	158.6	837.77	679.93	1517.70	339.97	4.464
33	165.6	150.3	793.68	679.93	1473.61	339.97	4.335

34	156.4	141.9	749.58	679.93	1429.52	339.97	4.205
35	147.2	133.6	705.49	679.93	1385.42	339.97	4.075
36	138.0	125.2	661.40	679.93	1341.33	339.97	3.945
37	128.8	116.9	617.30	679.93	1297.24	339.97	3.816
38	119.6	108.5	573.21	679.93	1253.14	339.97	3.686
39	110.4	100.2	529.12	650.99	1180.10	339.97	3.471
40	101.2	91.8	485.02	602.00	1087.02	339.97	3.197
41	92.0	83.5	440.93	543.21	984.14	339.97	2.895
42	82.8	75.1	396.84	471.35	868.19	339.97	2.554
43	73.6	66.8	352.75	381.54	734.28	339.97	2.160
44	64.4	58.4	308.65	266.06	574.71	339.97	1.690
45	55.2	50.1	264.56	112.09	376.65	339.97	1.108
(Fc + Fcs) < Fs. Updating of iterations							
1	46.0	41.7	220.47	0.00	220.47	443.43	0.497
2	55.0	49.9	263.68	108.49	372.16	339.97	1.095
3	54.8	49.8	262.80	104.86	367.65	339.97	1.081
4	54.6	49.6	261.91	101.20	363.12	339.97	1.068
5	54.5	49.4	261.03	97.53	358.56	339.97	1.055
6	54.3	49.3	260.15	93.82	353.97	339.97	1.041
7	54.1	49.1	259.27	90.09	349.36	339.97	1.028
8	53.9	48.9	258.39	86.34	344.73	339.97	1.014
9	53.7	48.8	257.50	82.56	340.07	339.97	1.000
10	53.5	48.6	256.62	78.76	335.38	339.97	0.987

Final value of c is 53.54 mm, flexural tension reinforcement area is 999.90 mm^2 and flexural compression reinforcement area is 1999.80 mm^2
Working depth of reinforcement $d = 460.00\text{ mm}$

2. Calculation of moment resistance M_r

$$M_r = F_c \cdot a_c + F_{cs} \cdot a_{cs} + F_s \cdot a_s = 7.51 + 0.28 + 138.18 = 145.97\text{ kN-m}$$

$$M = 0.00\text{ kN-m} \le M_r = 145.97\text{ kN-m (Ratio: 0.000)}$$

STATUS OK!
Ratio: 0.000

3. Minimum required flexural tension reinforcement in a beam section (10.5.1.2)

Width of tension zone $b_t = 400\text{ mm}$

$$A_{st,min} = \frac{0.2 \cdot \sqrt{f_c}}{f_y} \cdot b_t \cdot h = \frac{0.2 \cdot \sqrt{25}}{400} \cdot 400 \cdot 500 = 500.00\text{ mm}^2$$

4. Maximum required flexural tension reinforcement in a beam section

$$A_{st,max} = 0.04 \cdot b \cdot d = 0.04 \cdot 400 \cdot 460.00 = 7360.00\text{ mm}^2$$

5. Check of required flexural tension reinforcement in a beam section

$$A_{st} = 999.90\text{ mm}^2 \le A_{st,max} = 7360.00\text{ mm}^2\text{ (Ratio: 0.136)}$$

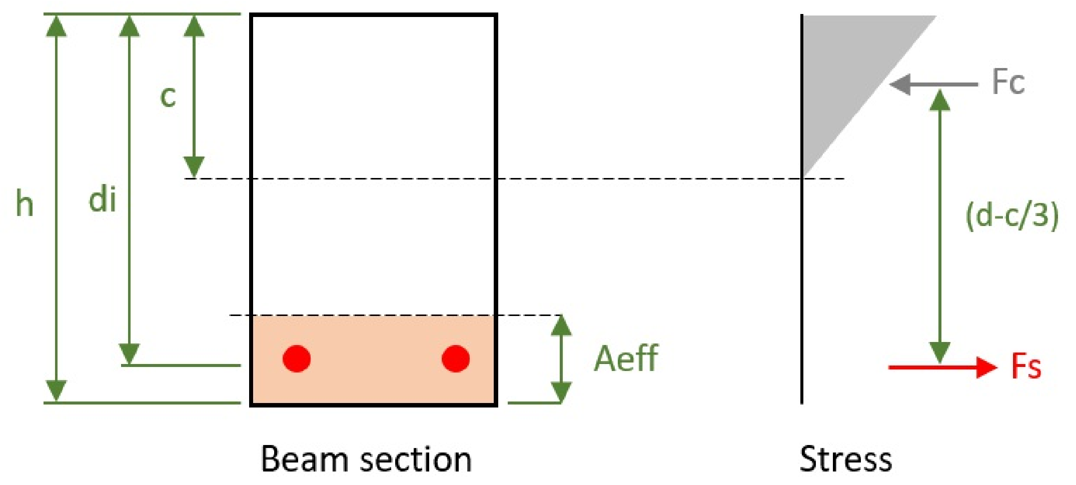
STATUS OK!
Ratio: 0.136

$$A_{st} = 999.90\text{ mm}^2 \ge A_{st,min} = 500.00\text{ mm}^2\text{ (Ratio: 0.500)}$$

STATUS OK!
Ratio: 0.500

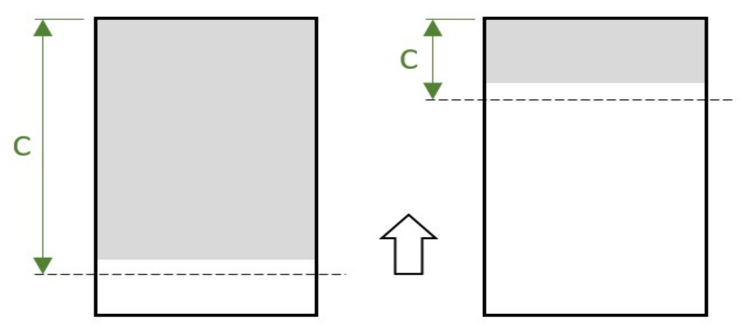
Crack width check (Negative bending moment case)

10.6.1 CRACK CONTROL OF BEAMS



Section input data:
Modulus of elasticity of concrete $E_c = 4500 \cdot \sqrt{f_c} = 4500 \cdot \sqrt{25} = 22500.00 \text{ MPa}$
Modulus of elasticity of steel $E_s = 200000.00 \text{ MPa}$
Modulus Ratio $n = E_s / E_c = 200000/22500.00 = 8.89$
Effective tension area of concrete around the main reinforcing $A = 16000.00 \text{ mm}^2$
Cover of the outermost bar $d_c = 40 \text{ mm}$
Given bending moment $M_a = 0.00 \text{ kN-m}$

1. Calculation of neutral axis depth c of cracked section



Calculation is based on iterative process:
- Assume c
- Calculate left part of force equilibrium $A_{comp.} \cdot 0.5 \cdot c + \sum n \cdot A_s \cdot \acute{d_i} + \sum n \cdot A_s \cdot d_i$
- Calculate right part of force equilibrium $A_{comp.} + n \cdot A_s + n \cdot \acute{A_s}$

Searching of neutral axis c (from 460 to 0 mm)

Iter.	c (mm)	As (mm2)	Left force equil. part (kN)	Right force equil. part (kN)	Ratio
1	460.00	0.00	47297.28	96905.44	2.049
2	450.80	999.90	45621.41	93308.39	2.045
3	441.60	999.90	43979.39	89779.05	2.041
4	432.40	999.90	42371.23	86317.42	2.037
5	423.20	999.90	40796.93	82923.50	2.033
6	414.00	999.90	39256.48	79597.30	2.028
7	404.80	999.90	37749.89	76338.80	2.022
8	395.60	999.90	36277.15	73148.02	2.016
9	386.40	999.90	34838.27	70024.95	2.010
10	377.20	999.90	33433.25	66969.60	2.003
11	368.00	999.90	32062.08	63981.95	1.996
12	358.80	999.90	30724.77	61062.02	1.987
13	349.60	999.90	29421.31	58209.80	1.978
14	340.40	999.90	28151.71	55425.29	1.969
15	331.20	999.90	26915.97	52708.49	1.958
16	322.00	999.90	25714.08	50059.41	1.947
17	312.80	999.90	24546.05	47478.04	1.934
18	303.60	999.90	23411.87	44964.37	1.921
19	294.40	999.90	22311.55	42518.43	1.906

20	285.20	999.90	21245.09	40140.19	1.889
21	276.00	999.90	20212.48	37829.66	1.872
22	266.80	999.90	19213.73	35586.85	1.852
23	257.60	999.90	18248.83	33411.75	1.831
24	248.40	999.90	17317.79	31304.36	1.808
25	239.20	999.90	16420.61	29264.68	1.782
26	230.00	999.90	15557.28	27292.72	1.754
27	220.80	999.90	14727.81	25388.47	1.724
28	211.60	999.90	13932.19	23551.93	1.690
29	202.40	999.90	13170.43	21783.10	1.654
30	193.20	999.90	12442.53	20081.98	1.614
31	184.00	999.90	11748.48	18448.58	1.570
32	174.80	999.90	11088.29	16882.88	1.523
33	165.60	999.90	10461.95	15384.90	1.471
34	156.40	999.90	9869.47	13954.63	1.414
35	147.20	999.90	9310.85	12592.08	1.352
36	138.00	999.90	8786.08	11297.23	1.286
37	128.80	999.90	8295.17	10070.10	1.214
38	119.60	999.90	7838.11	8910.68	1.137
39	110.40	999.90	7414.91	7818.97	1.054
left part < right part. Updating of iterations					
1	101.20	999.90	7025.57	6794.97	0.967
2	110.22	999.90	7406.79	7797.83	1.053
3	110.03	999.90	7398.69	7776.71	1.051
4	109.85	999.90	7390.60	7755.62	1.049
5	109.66	999.90	7382.52	7734.56	1.048
6	109.48	999.90	7374.45	7713.52	1.046
7	109.30	999.90	7366.40	7692.51	1.044
8	109.11	999.90	7358.37	7671.53	1.043
9	108.93	999.90	7350.34	7650.58	1.041
10	108.74	999.90	7342.33	7629.65	1.039
11	108.56	999.90	7334.33	7608.75	1.037
12	108.38	999.90	7326.35	7587.88	1.036
13	108.19	999.90	7318.38	7567.04	1.034
14	108.01	999.90	7310.43	7546.22	1.032
15	107.82	999.90	7302.48	7525.43	1.031
16	107.64	999.90	7294.55	7504.66	1.029
17	107.46	999.90	7286.64	7483.92	1.027
18	107.27	999.90	7278.74	7463.21	1.025
19	107.09	999.90	7270.85	7442.53	1.024
20	106.90	999.90	7262.97	7421.87	1.022
21	106.72	999.90	7255.11	7401.25	1.020
22	106.54	999.90	7247.26	7380.64	1.018
23	106.35	999.90	7239.43	7360.07	1.017

24	106.17	999.90	7231.61	7339.52	1.015
25	105.98	999.90	7223.80	7319.00	1.013
26	105.80	999.90	7216.01	7298.51	1.011
27	105.62	999.90	7208.23	7278.04	1.010
28	105.43	999.90	7200.46	7257.60	1.008
29	105.25	999.90	7192.71	7237.19	1.006
30	105.06	999.90	7184.97	7216.80	1.004
31	104.88	999.90	7177.24	7196.45	1.003
32	104.70	999.90	7169.53	7176.12	1.001
33	104.51	999.90	7161.83	7155.81	0.999

Final value of c is 104.51 mm and tensioning rebar area is $999.90\ \mathrm{mm}^2$
Working depth of reinforcement $d = 460.00\ \mathrm{mm}$

2. Calculation of stress in tensioning zone of reinforcement

$$f_s = \frac{M_a}{A_s \cdot (d - c/3)} = \frac{0}{999.90 \cdot (460.00 - 104.51/3)} = 0.00\ \mathrm{MPa}$$

3. Determine the value of z factor (10.6.1)

$$z = f_s \cdot \sqrt[3]{d_c \cdot A} = 0.00 \cdot \sqrt[3]{40.00 \cdot 16000.00} = 0.00\ \mathrm{N/mm}$$

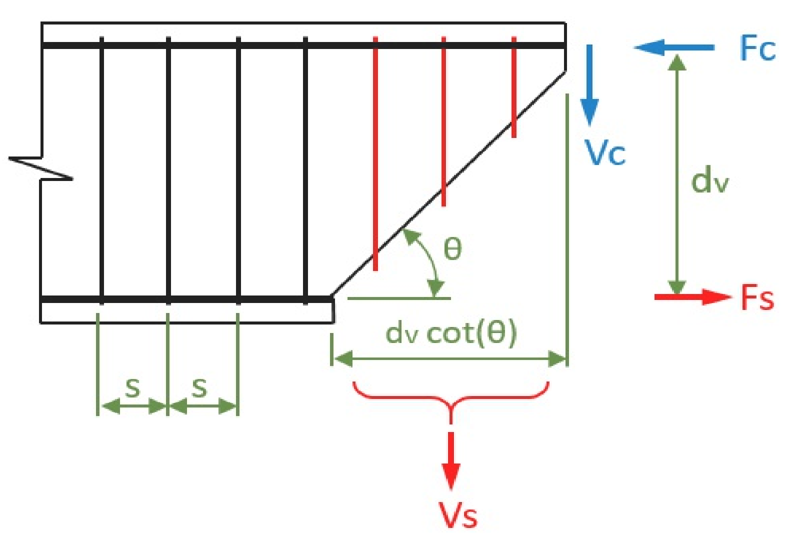
$$z = 0.00\ \mathrm{N/mm} \leq z_{lim} = 30000.00\ \mathrm{N/mm}\ (\mathrm{Ratio: 0.000})$$

STATUS OK!
Ratio: 0.000

11.2.8.2, 11.3.3, 11.3.4, 11.3.5.1, 11.3.6.3, 11.3.8.1

Shear check

SHEAR FORCE CAPACITY (Members with shear reinforcement)



Section input data:
Mean width of web $b_w = 400\ \mathrm{mm}$
Cross-sectional area of the shear reinforcement $A_v = 157.08\ \mathrm{mm}^2$
Spacing of stirrups $s = 250.00\ \mathrm{mm}$
Given shear force $V = 0.00\ \mathrm{kN}$
Effective shear depth $d_v = max\{0.9d, 0.72h\} = 405.00$
Concrete density factor $\lambda = 1$
Concrete resistance factor (8.4.2) $\phi_c = 0.65$
Reinforcement resistance factor (8.4.3) $\phi_s = 0.85$
Shear resistance factor $\beta = 0.18$
Angle of diagonal compressive stresses $\theta = 35$ deg.

1. Calculate Concrete Shear Capacity (11.3.4)

$$V_c = \phi_c \cdot \lambda \cdot \beta \cdot \sqrt{f_c} \cdot b_w \cdot d_v = 0.65 \cdot 1 \cdot 0.180 \cdot \sqrt{25} \cdot 400 \cdot 405.00 = 94.77\ \mathrm{kN}$$

2. Calculate minimum area of shear reinforcement (11.2.8.2)

$$A_{v,min} = 0.06 \cdot \sqrt{f_c} \cdot \frac{b_w \cdot s}{f_y} = 0.06 \cdot \sqrt{25} \cdot \frac{400 \cdot 250}{400} = 75.00\ \mathrm{mm}^2$$

$$A_v = 157.08\ \mathrm{mm}^2 \geq A_{v,min} = 75.00\ \mathrm{mm}^2$$
$$\rightarrow\ \text{area of shear reinforcement is satisfied (Ratio: 0.477)}$$

STATUS OK!
Ratio: 0.477

	$$V_s = \frac{\phi_s \cdot A_v \cdot f_y \cdot d_v \cdot cot(\theta)}{s} = \frac{0.85 \cdot 157.08 \cdot 400 \cdot 405.00 \cdot cot(35)}{250} = 123.56 \text{ kN}$$ 2. Calculate factored shear resistance (11.3.3) $$V_r = V_c + V_s = 94.77 + 123.56 = 218.33 \text{ kN}$$ Allowed factored shear resistance $$V_{r,max} = 0.25 \cdot \phi_c \cdot f_c \cdot b_w \cdot d_v = 0.25 \cdot 0.65 \cdot 25 \cdot 400 \cdot 405.00 = 658.13 \text{ kN}$$ $$V_r \leq V_{r,max}$$ $$V = 0.00 \text{ kN} \leq V_r = 218.33 \text{ kN (Ratio: 0.000)}$$	**STATUS OK!** **Ratio: 0.000**