REFERENCES	CALCULATIONS	RESULTS

Code: CSA A23.3-14

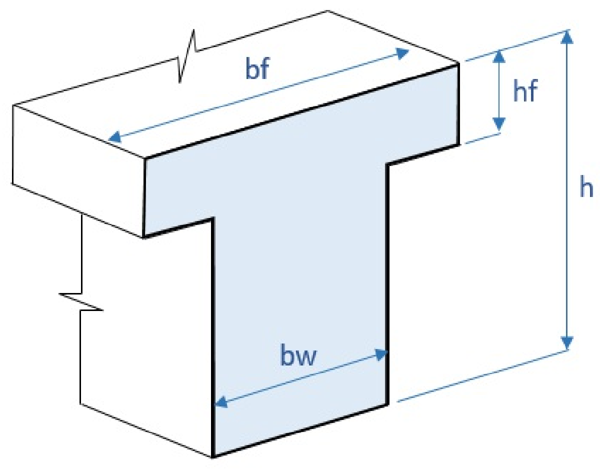
MEMBER #1 (SECTION POSITION 0.0 mm) BEAM DESIGN REPORT

Project details

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

General member design information

Dimentions:



Height $h = 700\ \mathrm{mm}$
Flange width $b_f = 1100\ \mathrm{mm}$
Flange thickness $h_f = 100\ \mathrm{mm}$
Web width $b_w = 300\ \mathrm{mm}$
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 = $0\ \mathrm{kN}$

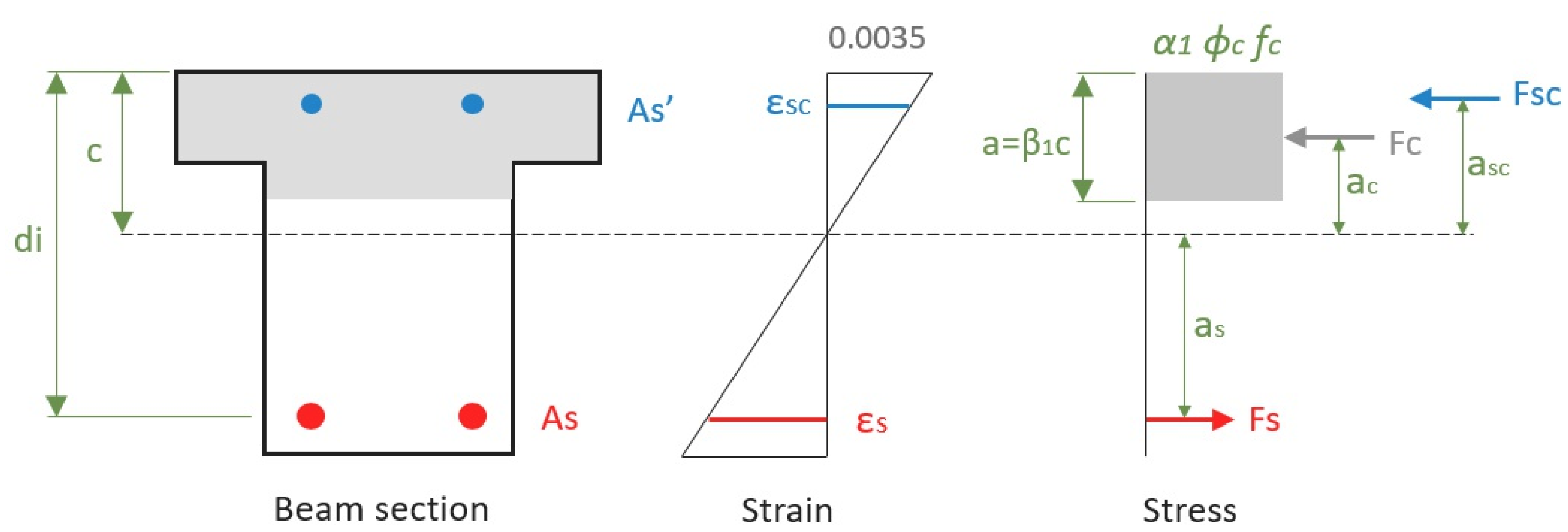
Load Combinations (Serviceability Limit State)

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 $d = 650\ \mathrm{mm}$
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

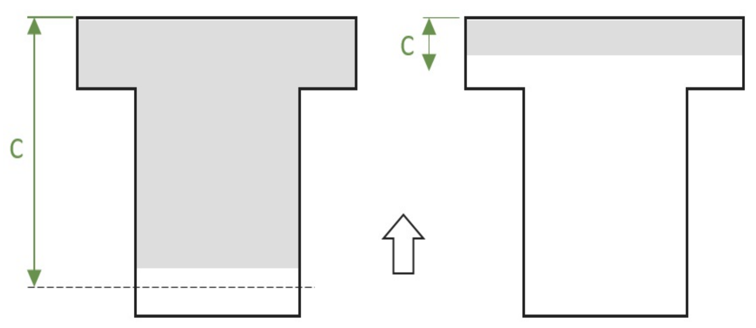
Depth di (mm)	bar diameter (mm)	bar area Asi (mm^2)
650	29.85	699.81
650	29.85	699.81
650	29.85	699.81
650	29.85	699.81
550	29.85	699.81
550	29.85	699.81
550	29.85	699.81
550	29.85	699.81

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 650 to 0 mm)

Iter.	c (mm)	a (mm)	Fc (kN)	Fcs (kN)	Fc + Fcs (kN)	Fs (kN)	Ratio
1	650.0	589.9	3392.71	256.24	3648.95	0.00	Infinity
2	637.0	578.1	3345.98	227.48	3573.46	33.99	105.130
3	624.0	566.3	3299.25	197.52	3496.77	69.40	50.387
4	611.0	554.5	3252.52	166.28	3418.80	106.31	32.158
5	598.0	542.7	3205.79	133.69	3339.48	144.83	23.058
6	585.0	530.9	3159.06	99.65	3258.71	185.06	17.609
7	572.0	519.1	3112.33	64.06	3176.39	227.12	13.986
8	559.0	507.3	3065.60	26.82	3092.42	271.14	11.405
9	546.0	495.5	3018.87	0.00	3018.87	329.45	9.163
10	533.0	483.7	2972.15	0.00	2972.15	418.73	7.098
11	520.0	471.9	2925.42	0.00	2925.42	512.48	5.708
12	507.0	460.1	2878.69	0.00	2878.69	611.03	4.711
13	494.0	448.3	2831.96	0.00	2831.96	714.77	3.962
14	481.0	436.5	2785.23	0.00	2785.23	824.12	3.380
15	468.0	424.7	2738.50	0.00	2738.50	939.54	2.915
16	455.0	412.9	2691.77	0.00	2691.77	1061.56	2.536
17	442.0	401.1	2645.04	0.00	2645.04	1190.75	2.221

18	429.0	389.3	2598.31	0.00	2598.31	1327.78	1.957
19	416.0	377.5	2551.58	0.00	2551.58	1473.37	1.732
20	403.0	365.7	2504.85	0.00	2504.85	1559.27	1.606
21	390.0	353.9	2458.12	0.00	2458.12	1635.04	1.503
22	377.0	342.1	2411.40	0.00	2411.40	1716.04	1.405
23	364.0	330.3	2364.67	0.00	2364.67	1802.82	1.312
24	351.0	318.5	2317.94	0.00	2317.94	1896.03	1.223
25	338.0	306.7	2271.21	0.00	2271.21	1903.48	1.193
26	325.0	294.9	2224.48	0.00	2224.48	1903.48	1.169
27	312.0	283.1	2177.75	0.00	2177.75	1903.48	1.144
28	299.0	271.3	2131.02	0.00	2131.02	1903.48	1.120
29	286.0	259.5	2084.29	0.00	2084.29	1903.48	1.095
30	273.0	247.7	2037.56	0.00	2037.56	1903.48	1.070
31	260.0	235.9	1990.83	0.00	1990.83	1903.48	1.046
32	247.0	224.2	1944.10	0.00	1944.10	1903.48	1.021
(Fc + Fcs) < Fs. Updating of iterations							
1	234.0	212.4	1897.37	0.00	1897.37	1903.48	0.997
2	246.7	223.9	1943.17	0.00	1943.17	1903.48	1.021
3	246.5	223.7	1942.23	0.00	1942.23	1903.48	1.020
4	246.2	223.4	1941.30	0.00	1941.30	1903.48	1.020
5	246.0	223.2	1940.37	0.00	1940.37	1903.48	1.019
6	245.7	223.0	1939.43	0.00	1939.43	1903.48	1.019
7	245.4	222.7	1938.50	0.00	1938.50	1903.48	1.018
8	245.2	222.5	1937.56	0.00	1937.56	1903.48	1.018
9	244.9	222.3	1936.63	0.00	1936.63	1903.48	1.017
10	244.7	222.0	1935.69	0.00	1935.69	1903.48	1.017
11	244.4	221.8	1934.76	0.00	1934.76	1903.48	1.016
12	244.1	221.6	1933.82	0.00	1933.82	1903.48	1.016
13	243.9	221.3	1932.89	0.00	1932.89	1903.48	1.015
14	243.6	221.1	1931.95	0.00	1931.95	1903.48	1.015
15	243.4	220.8	1931.02	0.00	1931.02	1903.48	1.014
16	243.1	220.6	1930.09	0.00	1930.09	1903.48	1.014
17	242.8	220.4	1929.15	0.00	1929.15	1903.48	1.013
18	242.6	220.1	1928.22	0.00	1928.22	1903.48	1.013
19	242.3	219.9	1927.28	0.00	1927.28	1903.48	1.013
20	242.1	219.7	1926.35	0.00	1926.35	1903.48	1.012
21	241.8	219.4	1925.41	0.00	1925.41	1903.48	1.012
22	241.5	219.2	1924.48	0.00	1924.48	1903.48	1.011
23	241.3	219.0	1923.54	0.00	1923.54	1903.48	1.011
24	241.0	218.7	1922.61	0.00	1922.61	1903.48	1.010
25	240.8	218.5	1921.67	0.00	1921.67	1903.48	1.010
26	240.5	218.3	1920.74	0.00	1920.74	1903.48	1.009
27	240.2	218.0	1919.80	0.00	1919.80	1903.48	1.009
28	240.0	217.8	1918.87	0.00	1918.87	1903.48	1.008

29	239.7	217.5	1917.94	0.00	1917.94	1903.48	1.008
30	239.5	217.3	1917.00	0.00	1917.00	1903.48	1.007
31	239.2	217.1	1916.07	0.00	1916.07	1903.48	1.007
32	238.9	216.8	1915.13	0.00	1915.13	1903.48	1.006
33	238.7	216.6	1914.20	0.00	1914.20	1903.48	1.006
34	238.4	216.4	1913.26	0.00	1913.26	1903.48	1.005
35	238.2	216.1	1912.33	0.00	1912.33	1903.48	1.005
36	237.9	215.9	1911.39	0.00	1911.39	1903.48	1.004
37	237.6	215.7	1910.46	0.00	1910.46	1903.48	1.004
38	237.4	215.4	1909.52	0.00	1909.52	1903.48	1.003
39	237.1	215.2	1908.59	0.00	1908.59	1903.48	1.003
40	236.9	215.0	1907.66	0.00	1907.66	1903.48	1.002
41	236.6	214.7	1906.72	0.00	1906.72	1903.48	1.002
42	236.3	214.5	1905.79	0.00	1905.79	1903.48	1.001
43	236.1	214.2	1904.85	0.00	1904.85	1903.48	1.001
44	235.8	214.0	1903.92	0.00	1903.92	1903.48	1.000
45	235.6	213.8	1902.98	0.00	1902.98	1903.48	1.000

Final value of c is 235.56 mm, flexural tension reinforcement area is 5598.48 mm^2 and flexural compression reinforcement area is 0.00 mm^2
Working depth of reinforcement $d = 600.00\ \mathrm{mm}$

2. Calculation of moment resistance M_r

$$M_r = F_c \cdot a_c + F_{cs} \cdot a_{cs} + F_s \cdot a_s = 304.95 + 0.00 + 693.71 = 998.66\ \text{kN-m}$$

$$M = 0.00\ \text{kN-m} \leq M_r = 998.66\ \text{kN-m}\ \text{(Ratio: 0.000)}$$

STATUS OK!
Ratio: 0.000

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

Width of tension zone $b_t = 300\ \mathrm{mm}$

$$A_{st,min} = \frac{0.2 \cdot \sqrt{f_c}}{f_y} \cdot b_t \cdot h = \frac{0.2 \cdot \sqrt{25}}{400} \cdot 300 \cdot 700 = 525.00\ \mathrm{mm}^2$$

4. Maximum required flexural tension reinforcement in a beam section

$$A_{st,max} = 0.04 \cdot b_w \cdot d = 0.04 \cdot 300 \cdot 600.00 = 7200.00\ \mathrm{mm}^2$$

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

$$A_{st} = 5598.48\ \mathrm{mm}^2 \leq A_{st,max} = 7200.00\ \mathrm{mm}^2\ \text{(Ratio: 0.778)}$$

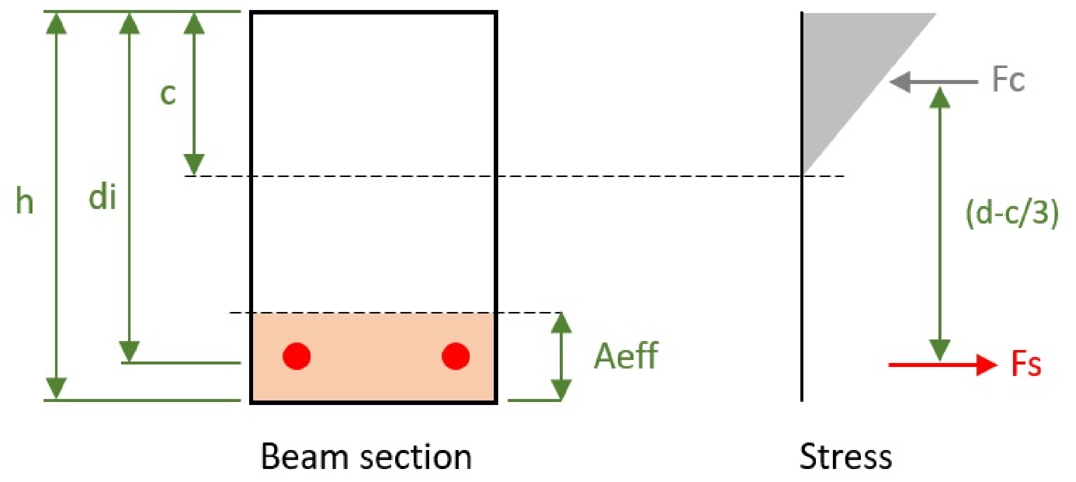
STATUS OK!
Ratio: 0.778

$$A_{st} = 5598.48\ \mathrm{mm}^2 \geq A_{st,min} = 525.00\ \mathrm{mm}^2\ \text{(Ratio: 0.094)}$$

STATUS OK!
Ratio: 0.094

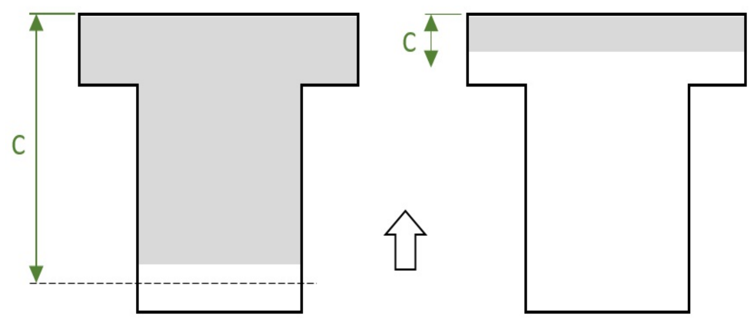
Crack width check (Positive bending moment case)

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 $A = 7500.00 \text{ mm}^2$
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 650 to 0 mm)

Iter.	c (mm)	As (mm2)	Left force equil. part (kN)	Right force equil. part (kN)	Ratio
1	650.00	0.00	97233.56	211096.77	2.171
2	637.00	2799.24	94723.91	204390.54	2.158
3	624.00	2799.24	92264.96	197785.70	2.144
4	611.00	2799.24	89856.71	191282.27	2.129
5	598.00	2799.24	87499.16	184880.23	2.113
6	585.00	2799.24	85192.31	178579.60	2.096
7	572.00	2799.24	82936.16	172380.36	2.078
8	559.00	2799.24	80730.71	166282.53	2.060
9	546.00	5598.48	78575.96	160286.09	2.040
10	533.00	5598.48	76471.91	154391.05	2.019
11	520.00	5598.48	74418.56	148597.42	1.997
12	507.00	5598.48	72415.91	142905.18	1.973
13	494.00	5598.48	70463.96	137314.35	1.949
14	481.00	5598.48	68562.71	131824.91	1.923
15	468.00	5598.48	66712.16	126436.88	1.895
16	455.00	5598.48	64912.31	121150.24	1.866
17	442.00	5598.48	63163.16	115965.01	1.836
18	429.00	5598.48	61464.71	110881.17	1.804
19	416.00	5598.48	59816.96	105898.73	1.770
20	403.00	5598.48	58219.91	101017.70	1.735
21	390.00	5598.48	56673.56	96238.06	1.698
22	377.00	5598.48	55177.91	91559.83	1.659
23	364.00	5598.48	53732.96	86982.99	1.619
24	351.00	5598.48	52338.71	82507.56	1.576

25	338.00	5598.48	50995.16	78133.52	1.532
26	325.00	5598.48	49702.31	73860.89	1.486
27	312.00	5598.48	48460.16	69689.65	1.438
28	299.00	5598.48	47268.71	65619.82	1.388
29	286.00	5598.48	46127.96	61651.38	1.337
30	273.00	5598.48	45037.91	57784.34	1.283
31	260.00	5598.48	43998.56	54018.71	1.228
32	247.00	5598.48	43009.91	50354.47	1.171
33	234.00	5598.48	42071.96	46791.64	1.112
34	221.00	5598.48	41184.71	43330.20	1.052
left part < right part. Updating of iterations					
1	208.00	5598.48	40348.16	39970.17	0.991
2	220.74	5598.48	41167.48	43262.01	1.051
3	220.48	5598.48	41150.27	43193.85	1.050
4	220.22	5598.48	41133.09	43125.74	1.048
5	219.96	5598.48	41115.92	43057.67	1.047
6	219.70	5598.48	41098.77	42989.64	1.046
7	219.44	5598.48	41081.65	42921.64	1.045
8	219.18	5598.48	41064.54	42853.69	1.044
9	218.92	5598.48	41047.45	42785.78	1.042
10	218.66	5598.48	41030.39	42717.91	1.041
11	218.40	5598.48	41013.34	42650.08	1.040
12	218.14	5598.48	40996.32	42582.30	1.039
13	217.88	5598.48	40979.31	42514.55	1.037
14	217.62	5598.48	40962.33	42446.84	1.036
15	217.36	5598.48	40945.37	42379.17	1.035
16	217.10	5598.48	40928.42	42311.55	1.034
17	216.84	5598.48	40911.50	42243.96	1.033
18	216.58	5598.48	40894.59	42176.41	1.031
19	216.32	5598.48	40877.71	42108.91	1.030
20	216.06	5598.48	40860.85	42041.44	1.029
21	215.80	5598.48	40844.01	41974.02	1.028
22	215.54	5598.48	40827.18	41906.64	1.026
23	215.28	5598.48	40810.38	41839.29	1.025
24	215.02	5598.48	40793.60	41771.99	1.024
25	214.76	5598.48	40776.84	41704.73	1.023
26	214.50	5598.48	40760.10	41637.51	1.022
27	214.24	5598.48	40743.38	41570.33	1.020
28	213.98	5598.48	40726.68	41503.19	1.019
29	213.72	5598.48	40710.00	41436.09	1.018
30	213.46	5598.48	40693.34	41369.03	1.017
31	213.20	5598.48	40676.70	41302.01	1.015
32	212.94	5598.48	40660.08	41235.04	1.014
33	212.68	5598.48	40643.48	41168.10	1.013

34	212.42	5598.48	40626.90	41101.20	1.012
35	212.16	5598.48	40610.34	41034.35	1.010
36	211.90	5598.48	40593.80	40967.53	1.009
37	211.64	5598.48	40577.28	40900.76	1.008
38	211.38	5598.48	40560.79	40834.02	1.007
39	211.12	5598.48	40544.31	40767.33	1.006
40	210.86	5598.48	40527.85	40700.68	1.004
41	210.60	5598.48	40511.41	40634.06	1.003
42	210.34	5598.48	40495.00	40567.49	1.002
43	210.08	5598.48	40478.60	40500.96	1.001
44	209.82	5598.48	40462.22	40434.47	0.999

Final value of c is 209.82 mm and tensioning rebar area is $5598.48\ \mathrm{mm}^2$
Working depth of reinforcement $d = 600.00\ \mathrm{mm}$

2. Calculation of stress in tensioning zone of reinforcement

$$f_s = \frac{M_a}{A_s \cdot (d - c/3)} = \frac{0}{5598.48 \cdot (600.00 - 209.82/3)} = 0.00\ \mathrm{MPa}$$

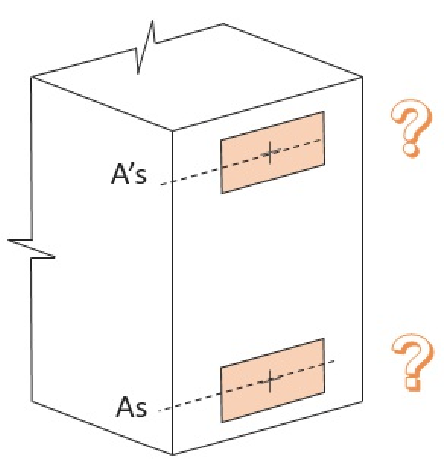
3. Determine the value of z factor (10.6.1)

$$z = f_s \cdot \sqrt[3]{d_c \cdot A} = 0.00 \cdot \sqrt[3]{50.00 \cdot 7500.00} = 0.00\ \mathrm{N/mm}$$

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

STATUS OK!
Ratio: 0.000

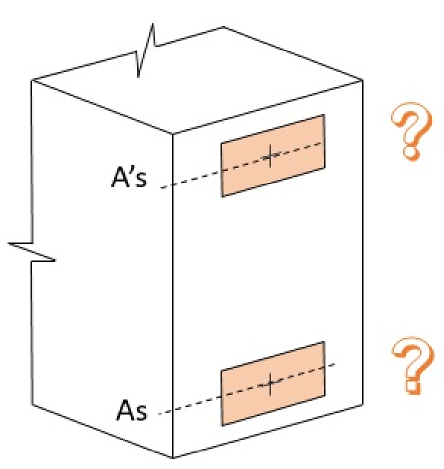
Flexure check (Negative bending moment case)



Bottom Reinforcement is absent in the section. Design checks can't be performed. But as acting moment value is equal to zero no need to check.

STATUS OK!

Crack width check (Negative bending moment case)



Bottom Reinforcement is absent in the section. Design checks can't be performed. But as acting moment value is equal to zero no need to check.

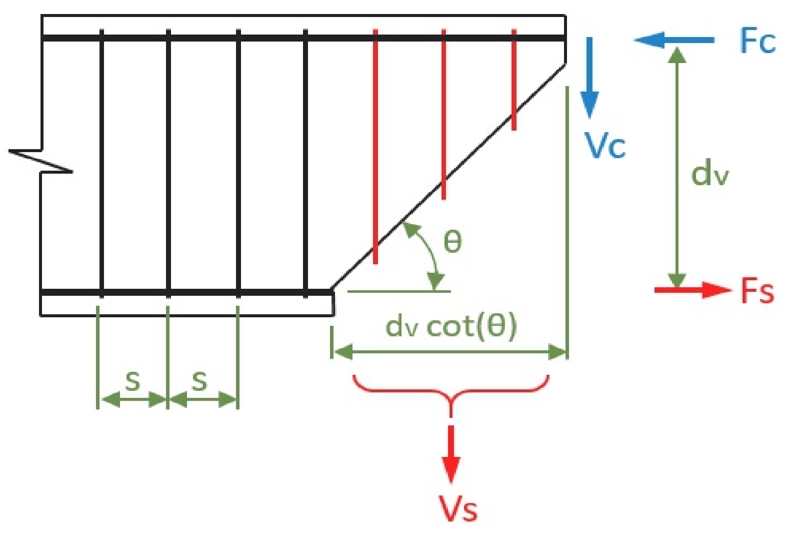
STATUS OK!

Shear check

11.2.8.2, 11.3.3, 11.3.4,

SHEAR FORCE CAPACITY (Members with shear reinforcement)

11.3.5.1, 11.3.6.3, 11.3.8.1



Section input data:
Mean width of web $b_w = 300\ \mathrm{mm}$
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 $d_v = max\,\{0.9d, 0.72h\} = 540.00$
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 $\theta = 35\ \mathrm{deg.}$

1. Calculate Concrete Shear Capacity (11.3.4)

$$V_c = \phi_c \cdot \lambda \cdot \beta \cdot \sqrt{f_c} \cdot b_w \cdot d_v = 0.65 \cdot 1 \cdot 0.180 \cdot \sqrt{25} \cdot 300 \cdot 540.00 = 94.77\ \mathrm{kN}$$

2. Calculate minimum area of shear reinforcement (11.2.8.2)

$$A_{v,min} = 0.06 \cdot \sqrt{f_c} \cdot \frac{b_w \cdot s}{f_y} = 0.06 \cdot \sqrt{25} \cdot \frac{300 \cdot 250}{400} = 56.25\ \mathrm{mm}^2$$

$$A_v = 157.08\ \mathrm{mm}^2 \geq A_{v,min} = 56.25\ \mathrm{mm}^2$$
$$\rightarrow \text{ area of shear reinforcement is satisfied (Ratio: 0.358)}$$

STATUS OK!
Ratio: 0.358

$$V_s = \frac{\phi_s \cdot A_v \cdot f_y \cdot d_v \cdot cot(\theta)}{s} = \frac{0.85 \cdot 157.08 \cdot 400 \cdot 540.00 \cdot cot(35)}{250} = 164.75\ \mathrm{kN}$$

2. Calculate factored shear resistance (11.3.3)

$$V_r = V_c + V_s = 94.77 + 164.75 = 259.52\ \mathrm{kN}$$

Allowed factored shear resistance

$$V_{r,max} = 0.25 \cdot \phi_c \cdot f_c \cdot b_w \cdot d_v = 0.25 \cdot 0.65 \cdot 25 \cdot 300 \cdot 540.00 = 658.13\ \mathrm{kN}$$

$$V_r \leq V_{r,max}$$

$$V = 0.00\ \mathrm{kN} \leq V_r = 259.52\ \mathrm{kN}\ \text{(Ratio: 0.000)}$$

STATUS OK!
Ratio: 0.000