REFERENCES	CALCULATIONS	RESULTS
Code: ENV 1992-1-1 :1991		

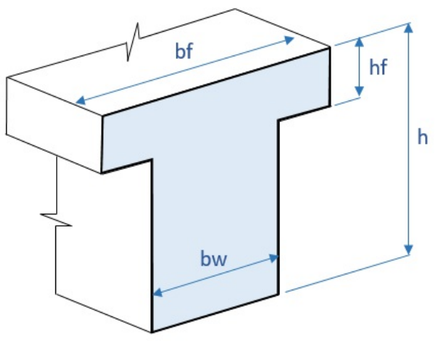
MEMBER #1 (SECTION POSITION 0.0 mm) BEAM DESIGN REPORT

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 $h = 470\ \text{mm}$
Flange width $b_f = 800\ \text{mm}$
Flange thickness $h_f = 150\ \text{mm}$
Web width $b_w = 400\ \text{mm}$
Member length = $5000\ \text{mm}$

Material properties:
Concrete strength $f_{ck} = 25\ \text{MPa}$
Steel strength of longitudinal rebar $f_{yk} = 500\ \text{MPa}$
Steel strength of shear rebar $f_{ywk} = 500\ \text{MPa}$
Limiting crack width $\omega_{max} = 0.3\ \text{mm}$

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 = $0\ \text{kN}$

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

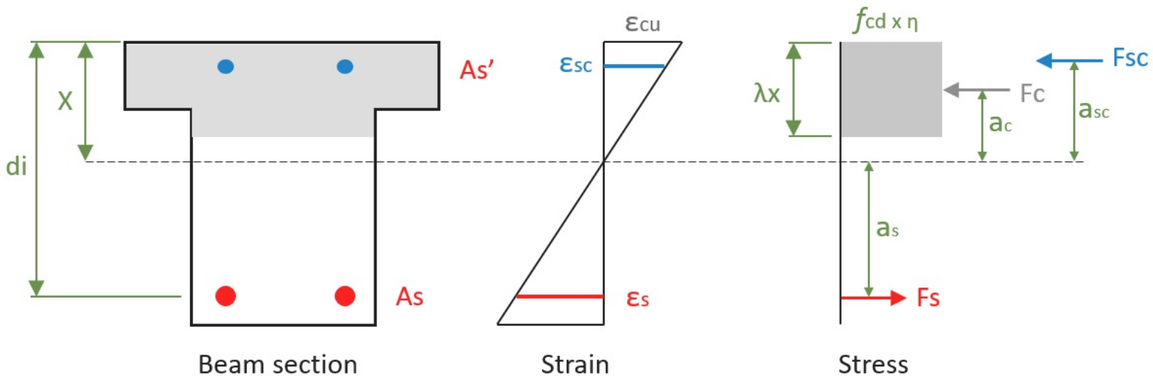
For shear force in section:
LC1: USER = $0\ \text{kN}$

Load Combinations (Serviceability Limit State)

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

Flexure check (Positive bending moment case)

BENDING MOMENT CAPACITY



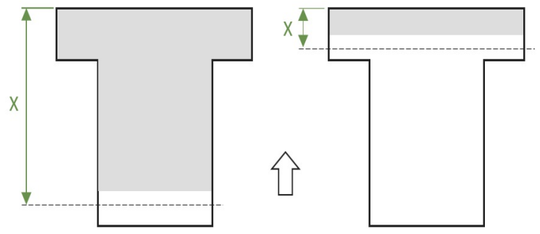
Section input data:
Section concrete area $A_c = 248000\ \text{mm}^2$
Design compressive strength of concrete $f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 0.85 \cdot 25/1.5 = 14.17\ \text{MPa}$
Design strength of rebar $f_{yd} = f_{yk}/\gamma_s = 500/1.15 = 434.78\ \text{MPa}$
Design yield strain of 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)) $\eta = 1.00$
Given bending moment $M_{Ed} = 0.00$ kN-m

Section Rebar

Depth di (mm)	bar diameter (mm)	bar area Asi (mm2)
420	25	490.87
420	25	490.87
420	25	490.87

1. Calculation of neutral axis depth x



Calculation is based on iterative process:
- Assume x
- Calculate concrete force $F_c = \eta \cdot f_{cd} \cdot \int_{dA} \cdot \lambda \cdot x$
- Calculate compression force in steel $F_{cs} = \sum A_{s,i}^{'} \cdot f_{s,i}$
- Calculate tensioning force in steel $F_s = \sum A_{s,i} \cdot f_{s,i}$
- 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 $e_s = e_{cu} \cdot (x - d)/x$
Reinforcement strains below axis $e_s = e_{cu} \cdot (d - x)/x$

Searching of neutral axis x (from 420 to 0 mm)

Iter.	x (mm)	As (mm2)	Fc (kN)	Fcs (kN)	Fc + Fcs (kN)	Fs (kN)	Ratio
1	420.0	0.0	2754.00	0.00	2754.00	0.00	Infinity
2	411.6	1472.6	2715.92	0.00	2715.92	21.04	129.100
3	403.2	1472.6	2677.84	0.00	2677.84	42.95	62.346
4	394.8	1472.6	2639.76	0.00	2639.76	65.80	40.119
5	386.4	1472.6	2601.68	0.00	2601.68	89.64	29.025
6	378.0	1472.6	2563.60	0.00	2563.60	114.54	22.382
7	369.6	1472.6	2525.52	0.00	2525.52	140.57	17.967
8	361.2	1472.6	2487.44	0.00	2487.44	167.81	14.823
9	352.8	1472.6	2449.36	0.00	2449.36	196.35	12.475
10	344.4	1472.6	2411.28	0.00	2411.28	226.28	10.656
11	336.0	1472.6	2373.20	0.00	2373.20	257.71	9.209
12	327.6	1472.6	2335.12	0.00	2335.12	290.75	8.031
13	319.2	1472.6	2297.04	0.00	2297.04	325.52	7.056
14	310.8	1472.6	2258.96	0.00	2258.96	362.18	6.237
15	302.4	1472.6	2220.88	0.00	2220.88	400.88	5.540
16	294.0	1472.6	2182.80	0.00	2182.80	441.78	4.941
17	285.6	1472.6	2144.72	0.00	2144.72	485.10	4.421
18	277.2	1472.6	2106.64	0.00	2106.64	531.03	3.967
19	268.8	1472.6	2068.56	0.00	2068.56	579.84	3.567
20	260.4	1472.6	2030.48	0.00	2030.48	631.80	3.214
21	252.0	1472.6	1992.40	0.00	1992.40	640.27	3.112
22	243.6	1472.6	1954.32	0.00	1954.32	640.27	3.052
23	235.2	1472.6	1916.24	0.00	1916.24	640.27	2.993

24	226.8	1472.6	1878.16	0.00	1878.16	640.27	2.933	
25	218.4	1472.6	1840.08	0.00	1840.08	640.27	2.874	
26	210.0	1472.6	1802.00	0.00	1802.00	640.27	2.814	
27	201.6	1472.6	1763.92	0.00	1763.92	640.27	2.755	
28	193.2	1472.6	1725.84	0.00	1725.84	640.27	2.696	
29	184.8	1472.6	1675.52	0.00	1675.52	640.27	2.617	
30	176.4	1472.6	1599.36	0.00	1599.36	640.27	2.498	
31	168.0	1472.6	1523.20	0.00	1523.20	640.27	2.379	
32	159.6	1472.6	1447.04	0.00	1447.04	640.27	2.260	
33	151.2	1472.6	1370.88	0.00	1370.88	640.27	2.141	
34	142.8	1472.6	1294.72	0.00	1294.72	640.27	2.022	
35	134.4	1472.6	1218.56	0.00	1218.56	640.27	1.903	
36	126.0	1472.6	1142.40	0.00	1142.40	640.27	1.784	
37	117.6	1472.6	1066.24	0.00	1066.24	640.27	1.665	
38	109.2	1472.6	990.08	0.00	990.08	640.27	1.546	
39	100.8	1472.6	913.92	0.00	913.92	640.27	1.427	
40	92.4	1472.6	837.76	0.00	837.76	640.27	1.308	
41	84.0	1472.6	761.60	0.00	761.60	640.27	1.190	
42	75.6	1472.6	685.44	0.00	685.44	640.27	1.071	
(Fc + Fcs) < Fs. Updating of iterations								
1	67.2	1472.6	609.28	0.00	609.28	640.27	0.952	
2	75.4	1472.6	683.92	0.00	683.92	640.27	1.068	
3	75.3	1472.6	682.39	0.00	682.39	640.27	1.066	
4	75.1	1472.6	680.87	0.00	680.87	640.27	1.063	
5	74.9	1472.6	679.35	0.00	679.35	640.27	1.061	
6	74.8	1472.6	677.82	0.00	677.82	640.27	1.059	
7	74.6	1472.6	676.30	0.00	676.30	640.27	1.056	
8	74.4	1472.6	674.78	0.00	674.78	640.27	1.054	
9	74.3	1472.6	673.25	0.00	673.25	640.27	1.052	
10	74.1	1472.6	671.73	0.00	671.73	640.27	1.049	
11	73.9	1472.6	670.21	0.00	670.21	640.27	1.047	
12	73.8	1472.6	668.68	0.00	668.68	640.27	1.044	
13	73.6	1472.6	667.16	0.00	667.16	640.27	1.042	
14	73.4	1472.6	665.64	0.00	665.64	640.27	1.040	
15	73.2	1472.6	664.12	0.00	664.12	640.27	1.037	
16	73.1	1472.6	662.59	0.00	662.59	640.27	1.035	
17	72.9	1472.6	661.07	0.00	661.07	640.27	1.032	
18	72.7	1472.6	659.55	0.00	659.55	640.27	1.030	
19	72.6	1472.6	658.02	0.00	658.02	640.27	1.028	
20	72.4	1472.6	656.50	0.00	656.50	640.27	1.025	
21	72.2	1472.6	654.98	0.00	654.98	640.27	1.023	
22	72.1	1472.6	653.45	0.00	653.45	640.27	1.021	
23	71.9	1472.6	651.93	0.00	651.93	640.27	1.018	
24	71.7	1472.6	650.41	0.00	650.41	640.27	1.016	

25	71.6	1472.6	648.88	0.00	648.88	640.27	1.013
26	71.4	1472.6	647.36	0.00	647.36	640.27	1.011
27	71.2	1472.6	645.84	0.00	645.84	640.27	1.009
28	71.1	1472.6	644.31	0.00	644.31	640.27	1.006
29	70.9	1472.6	642.79	0.00	642.79	640.27	1.004
30	70.7	1472.6	641.27	0.00	641.27	640.27	1.002
31	70.6	1472.6	639.74	0.00	639.74	640.27	0.999

Final value of x is 70.56 mm and tensioning rebar area is 1472.61 mm2
Working depth of reinforcement $d = 420.00\ \text{mm}$

2. Calculation moment resistance M_{Rd}

$$M_{Rd} = F_c \cdot a_c + F_{cs} \cdot a_{cs} + F_s \cdot a_s = 27.08 + 0.00 + 223.73 = 250.82\ \text{kN-m}$$

$$M_{Ed} = 0.00\ \text{kN-m} \leq M_{Rd} = 250.82\ \text{kN-m}$$

STATUS OK!

9.2.1.1 (3)
9.2.1.1(1)

3. Calculation of maximum allowed longitudinal reinforcement (9.2.1.1 (3))

$$f_{ck} = 25\ \text{MPa} \leq 50\ \text{MPa}$$

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

$$A_{s,max} = 0.04 \cdot A_c = 0.04 \cdot 248000 = 9920\ \text{mm}^2$$

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

$$A_{s,min1} = 0.26 \cdot \frac{f_{ctm}}{f_{yk}} \cdot b_t \cdot d = 0.26 \cdot \frac{2.56}{500} \cdot 400 \cdot 420.00 = 224.08\ \text{mm}^2$$

$$A_{s,min2} = 0.0013 \cdot b_t \cdot d = 0.0013 \cdot 400 \cdot 420.00 = 252.000\ \text{mm}^2$$

$$A_{s,min} = max\left[A_{s,min1}, A_{s,min2}\right] = 252.00\ \text{mm}^2$$

Check of allowed longitudinal reinforcement

$$A_s = 1472.61\ \text{mm}^2 \leq A_{s,max} = 9920.00\ \text{mm}^2$$

STATUS OK!

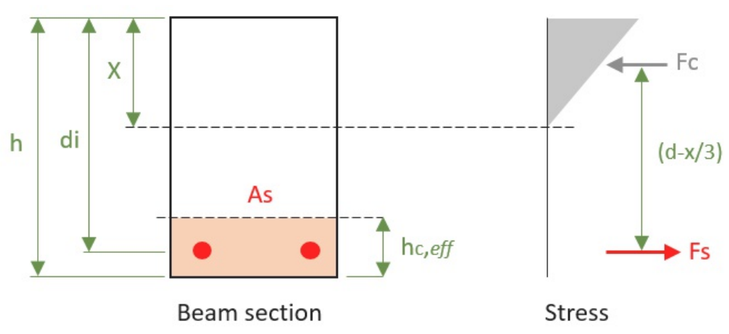
$$A_s = 1472.61\ \text{mm}^2 \geq A_{s,min} = 252.00\ \text{mm}^2$$

STATUS OK!

Crack width check (Positive bending moment case)

7.3.4(2)

CRACK WIDTH CAPACITY



Section input data:
Depth to the outermost tension side of reinforcement $d_t = 420\ \text{mm}$
Section concrete area $A_c = 248000\ \text{mm}^2$
Age of concrete at loading $t_0 = 3\ \text{days}$
Age of concrete at the moment considered $t = 10000\ \text{days}$
Relative humidity $RH = 70\ \%$
Given bending moment $M = 0.00\ \text{kN-m}$

1. Creep coefficient $\phi(t,t_0)$ (ANNEX B)

$$f_{cm} = f_{ck} + 8 = 25 + 8 = 33\ \text{MPa}$$

$$E_{cm} = 22 \cdot \left(\frac{f_{cm}}{10}\right)^{0.3} \cdot 1000 = 22 \cdot \left(\frac{33}{10}\right)^{0.3} \cdot 1000 = 31475.81\ \text{MPa}$$

Notional size of the member

$$h_0 = \frac{2 \cdot A_c}{u} = \frac{2 \cdot 248000.00}{2540} = 195.28\ \text{mm}$$

Factor to allow for the effect of relative humidity on the notional creep coefficient

$$f_{cm} \leq 35\text{MPa} \rightarrow \phi_{RH} = 1 + \frac{1 - \frac{RH}{100}}{0.1 \cdot \sqrt[3]{h_0}} = 1 + \frac{1 - \frac{70}{100}}{0.1 \cdot \sqrt[3]{195.28}} = 1.52$$

Factor to allow for the effect of concrete strength on the notional creep coefficient

$$\beta(f_{cm}) = \frac{16.8}{\sqrt{f_{cm}}} = \frac{16.8}{\sqrt{33}} = 2.92$$

Factor to allow for the effect of concrete age at loading on the notional creep coefficient

$$\beta(t_0) = \frac{1}{0.1 + t_0^{0.2}} = \frac{1}{0.1 + 3^{0.2}} = 0.74$$

Notional creep coefficient

$$\phi_0 = \phi_{RH} \cdot \beta(f_{cm}) \cdot \beta(t_0) = 1.52 \cdot 2.92 \cdot 0.74 = 3.30$$

Coefficient depending on the relative humidity and the notional member size

$$\beta_H = 1.5 \cdot \left[1 + (0.012 \cdot RH)^{18}\right] \cdot h_0 + 250 = 1.5 \cdot \left[1 + (0.012 \cdot 70)^{18}\right] \cdot 195.28 + 250 = 555.61$$

$$\beta_H \leq 1500$$

Coefficient to describe the development of creep with time after loading

$$\beta_c(t,t_0) = \left[\frac{(t - t_0)}{(\beta_H + t - t_0)}\right]^{0.3} = \left[\frac{(10000 - 3)}{(555.61 + 10000 - 3)}\right]^{0.3} = 0.98$$

Creep coefficient

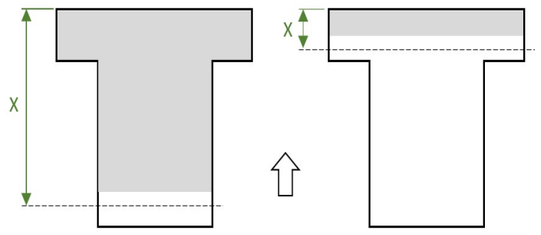
$$\phi(t,t_0) = \phi_0 \cdot \beta_c(t,t_0) = 3.30 \cdot 0.98 = 3.24$$

Effective modulus

$$E_{eff} = \frac{E_{cm}}{1 + \phi(t,t_0)} = \frac{31475.81}{1 + 3.24} = 7416.81\ \text{MPa}$$

$$a_e = \frac{E_s}{E_{eff}} = \frac{200000}{7416.81} = 26.97$$

2. Calculation of neutral axis depth x



Calculation is based on iterative process:
- Assume x
- Calculate left part of force equilibrium $A_{comp.} \cdot \frac{x}{2} + \sum a_e \cdot A_s \cdot \acute{d_i} + \sum a_e \cdot A_s \cdot d_i$
- Calculate right part of force equilibrium $A_{comp.} + a_e \cdot A_s + a_e \cdot \acute{A_s}$

Searching of neutral axis x (from 420 to 0 mm)

Iter.	x (mm)	As (mm2)	Asc (mm2)	Left force equil. part (kN)	Right force equil. part (kN)	Ratio
1	420.00	0.00	0.00	56458.23	112438.23	1.992
2	411.60	1472.61	0.00	55061.14	108806.49	1.976

3	403.20	1472.61	0.00	53692.27	105231.19	1.960
4	394.80	1472.61	0.00	52351.63	101712.35	1.943
5	386.40	1472.61	0.00	51039.22	98249.95	1.925
6	378.00	1472.61	0.00	49755.03	94844.00	1.906
7	369.60	1472.61	0.00	48499.06	91494.50	1.887
8	361.20	1472.61	0.00	47271.31	88201.45	1.866
9	352.80	1472.61	0.00	46071.79	84964.85	1.844
10	344.40	1472.61	0.00	44900.50	81784.69	1.821
11	336.00	1472.61	0.00	43757.43	78660.98	1.798
12	327.60	1472.61	0.00	42642.58	75593.72	1.773
13	319.20	1472.61	0.00	41555.95	72582.91	1.747
14	310.80	1472.61	0.00	40497.55	69628.54	1.719
15	302.40	1472.61	0.00	39467.38	66730.63	1.691
16	294.00	1472.61	0.00	38465.43	63889.16	1.661
17	285.60	1472.61	0.00	37491.70	61104.14	1.630
18	277.20	1472.61	0.00	36546.19	58375.56	1.597
19	268.80	1472.61	0.00	35628.91	55703.44	1.563
20	260.40	1472.61	0.00	34739.86	53087.76	1.528
21	252.00	1472.61	0.00	33879.03	50528.54	1.491
22	243.60	1472.61	0.00	33046.42	48025.75	1.453
23	235.20	1472.61	0.00	32242.03	45579.42	1.414
24	226.80	1472.61	0.00	31465.87	43189.54	1.373
25	218.40	1472.61	0.00	30717.94	40856.10	1.330
26	210.00	1472.61	0.00	29998.23	38579.11	1.286
27	201.60	1472.61	0.00	29306.74	36358.57	1.241
28	193.20	1472.61	0.00	28643.47	34194.48	1.194
29	184.80	1472.61	0.00	28008.43	32086.84	1.146
30	176.40	1472.61	0.00	27401.62	30035.64	1.096
31	168.00	1472.61	0.00	26823.03	28040.89	1.045
left part < right part. Updating of iterations						
1	159.60	1472.61	0.00	26272.66	26102.59	0.994
2	167.83	1472.61	0.00	26811.74	28001.57	1.044
3	167.66	1472.61	0.00	26800.47	27962.27	1.043
4	167.50	1472.61	0.00	26789.21	27923.00	1.042
5	167.33	1472.61	0.00	26777.96	27883.75	1.041
6	167.16	1472.61	0.00	26766.72	27844.52	1.040
7	166.99	1472.61	0.00	26755.49	27805.31	1.039
8	166.82	1472.61	0.00	26744.28	27766.13	1.038
9	166.66	1472.61	0.00	26733.07	27726.97	1.037
10	166.49	1472.61	0.00	26721.88	27687.83	1.036
11	166.32	1472.61	0.00	26710.69	27648.71	1.035
12	166.15	1472.61	0.00	26699.52	27609.62	1.034
13	165.98	1472.61	0.00	26688.36	27570.55	1.033
14	165.82	1472.61	0.00	26677.21	27531.50	1.032

15	165.65	1472.61	0.00	26666.08	27492.48	1.031
16	165.48	1472.61	0.00	26654.95	27453.47	1.030
17	165.31	1472.61	0.00	26643.84	27414.49	1.029
18	165.14	1472.61	0.00	26632.73	27375.53	1.028
19	164.98	1472.61	0.00	26621.64	27336.60	1.027
20	164.81	1472.61	0.00	26610.56	27297.69	1.026
21	164.64	1472.61	0.00	26599.49	27258.80	1.025
22	164.47	1472.61	0.00	26588.43	27219.93	1.024
23	164.30	1472.61	0.00	26577.39	27181.08	1.023
24	164.14	1472.61	0.00	26566.35	27142.26	1.022
25	163.97	1472.61	0.00	26555.33	27103.46	1.021
26	163.80	1472.61	0.00	26544.31	27064.68	1.020
27	163.63	1472.61	0.00	26533.31	27025.93	1.019
28	163.46	1472.61	0.00	26522.32	26987.20	1.018
29	163.30	1472.61	0.00	26511.34	26948.49	1.016
30	163.13	1472.61	0.00	26500.37	26909.80	1.015
31	162.96	1472.61	0.00	26489.42	26871.14	1.014
32	162.79	1472.61	0.00	26478.47	26832.49	1.013
33	162.62	1472.61	0.00	26467.54	26793.88	1.012
34	162.46	1472.61	0.00	26456.62	26755.28	1.011
35	162.29	1472.61	0.00	26445.70	26716.70	1.010
36	162.12	1472.61	0.00	26434.80	26678.15	1.009
37	161.95	1472.61	0.00	26423.92	26639.62	1.008
38	161.78	1472.61	0.00	26413.04	26601.12	1.007
39	161.62	1472.61	0.00	26402.17	26562.63	1.006
40	161.45	1472.61	0.00	26391.32	26524.17	1.005
41	161.28	1472.61	0.00	26380.47	26485.73	1.004
42	161.11	1472.61	0.00	26369.64	26447.32	1.003
43	160.94	1472.61	0.00	26358.82	26408.92	1.002
44	160.78	1472.61	0.00	26348.01	26370.55	1.001
45	160.61	1472.61	0.00	26337.21	26332.21	1.00

Value of x is 160.61 mm
Tensioning rebar area $A_s = 1472.61\ \text{mm}^2$
Compression rebar area $A_{sc} = 0.00\ \text{mm}^2$
Working depth of reinforcement $d = 420.00\ \text{mm}$

3. Calculation of effective strain

$$\sigma_s = \frac{M}{A_s \cdot (d - x/3)} = \frac{0}{1472.61 \cdot (420 - 160.61/3)} = 0.00\ \text{MPa}$$

$k_t = 0.4$ as long term loading

$$f_{ck} = 25\ \text{MPa} \leq 50\ \text{MPa}$$

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

$$f_{ct,eff} = f_{ctm}$$

$$a_e = \frac{E_s}{E_{cm}} = \frac{200000}{31475.81} = 6.35$$

$$h_{eff} = max\left[2.5 \cdot (h - d), \frac{h - x}{3}, \frac{h}{2}\right] = max\left[125.00, 103.13, 235.00\right] = 103.13 \text{ mm}$$

$$A_{c,eff} = b_w \cdot h_{eff} = 400 \cdot 103.13 = 41252.27 \text{ mm}^2$$

$$\rho_{eff} = \frac{A_s}{A_{c,eff}} = \frac{1472.61}{41252.27} = 0.03570$$

$$e_{sm} - e_{cm} = \frac{\sigma_s - k_t \cdot \frac{f_{ct,eff}}{\rho_{p,eff}} \cdot (1 + a_e \cdot \rho_{p,eff})}{E_s} =$$

$$= \frac{0.00 - 0.4 \cdot \frac{2.56}{0.03570} \cdot (1 + 6.35 \cdot 0.03570)}{200000} = -0.00018$$

$$e_{sm} - e_{cm} < 0.6 \cdot \frac{\sigma_s}{E_s} = 0.6 \cdot \frac{0.00}{200000} = 0.00000 \rightarrow e_{sm} - e_{cm} = 0.00000$$

4. Calculation of maximum crack spacing

$$\text{cover } c = 37.5 \text{ mm}$$

$$k_1 = 0.8$$

$$k_2 = 0.5$$

$$s_{r,max} = 3.4 \cdot c \cdot \frac{0.425 \cdot k_1 \cdot k_2 \cdot diameter}{\rho_{p,eff}} = 3.4 \cdot 37.5 \cdot \frac{0.425 \cdot 0.8 \cdot 0.5 \cdot 25}{0.03570}$$
$$= 246.56 \text{ mm}$$

$$s_{r,max} \leq 5 \cdot (c + 0.5 \cdot diameter) = 5 \cdot (37.5 + 0.5 \cdot 25) = 250.00 \text{ mm}$$

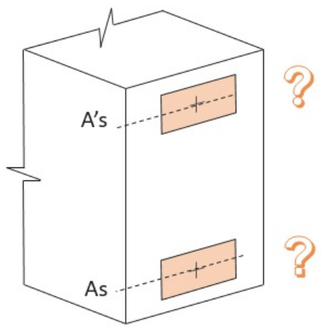
5. Calculation of crack width

$$w_k = (e_{sm} - e_{cm}) \cdot s_{r,max} = 0.00000 \cdot 246.56 = 0.00 \text{ mm}$$

$$w_k = 0.00 \text{ mm} \leq w_{lim} = 0.3 \text{ mm}$$

STATUS OK!

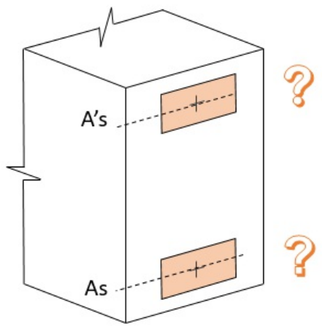
Flexure check (Negative bending moment case)



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

6.2.3(4)
6.2.3(3)
9.2.2(5)
9.2.2(6)

SHEAR FORCE CAPACITY (Members with shear reinforcement)

Section input data:
Design compressive strength of concrete $f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 0.85 \cdot 25/1.5 = 14.17\ \mathrm{MPa}$
Design strength of shear rebar $f_{ywd} = f_{ywk}/\gamma_s = 500/1.15 = 434.78\ \mathrm{MPa}$
Mean width of web $b_w = 400\ \mathrm{mm}$
Section concrete area $A_c = 248000\ \mathrm{mm}^2$
Tensioning rebar area $A_{sl} = 1472.6100000000001\ \mathrm{mm}^2$
Cross-sectional area of the shear reinforcement $A_{sw} = 157.08\ \mathrm{mm}^2$
Spacing of stirrups $s = 250.00\ \mathrm{mm}$
Working depth of reinforcement $d = 420.00\ \mathrm{mm}$
Angle between strut and the beam axis $\theta = 45\ \mathrm{deg}$
Given shear force $V_{Ed} = 0.00\ \mathrm{kN}$

1. Calculation of shear resistance with reinforcement (6.2.3(3),6.2.3(4))

$$\sigma_{cp} = 0 \text{ as } N_{ed} = 0$$

Coefficient taking account of the state of the stress in the compression chord:

$$a_{cw} = 1.0 \text{ as } \sigma_{cp} \leq 0.0\ \mathrm{MPa}$$

Strength reduction factor for concrete cracked in shear

$$v_1 = 0.6 \cdot (1 - \frac{f_{ck}}{250}) = 0.6 \cdot (1 - \frac{25}{250}) = 0.54 \text{ as } f_{ywd} = 434.78\ \mathrm{MPa} \geq 0.8 \cdot f_{ywk} = 400.00\ \mathrm{MPa}$$

$$V_{Rd,max} = \frac{f_{cd} \cdot 0.9 \cdot d \cdot b_w \cdot a_{cw} \cdot v_1}{cot(\theta) + tan(\theta)} = \frac{14.17 \cdot 0.9 \cdot 420.00 \cdot 400 \cdot 1.00 \cdot 0.54}{1.00 + 1.00} = 578.34\ \mathrm{kN}$$

2. Shear Reinforcement detailing (9.2.2(5), 9.2.2(6))
Shear reinforcement ratio

$$\rho_w = \frac{A_{sw}}{b_w \cdot s} = \frac{157.08}{400 \cdot 250} = 0.00157$$

Minimum shear reinforcement ratio

$$\rho_{w,min} = 0.08 \cdot \frac{\sqrt{f_{ck}}}{f_{yk}} = 0.08 \cdot \frac{\sqrt{25}}{500} = 0.00080$$

Minimum vertical links longitudinal spacing

$$s_{max} = 0.75 \cdot d = 0.75 \cdot 420.00 = 315.00\ \mathrm{mm}$$

Maximum shear reinforcement

$$A_{sw,max} = \frac{0.5 \cdot a_{cw} \cdot v_1 \cdot f_{cd} \cdot b_w \cdot s}{f_{ywd}} = \frac{0.5 \cdot 1.00 \cdot 0.54 \cdot 14.17 \cdot 400 \cdot 250}{434.78} = 879.75\ \mathrm{mm}^2$$

$V_{Ed} = 0.00\ \mathrm{kN} \leq V_{Rd,max} = 578.34\ \mathrm{kN}$

STATUS OK!

$\rho_w = 0.00157 \geq \rho_{w,min} = 0.00080$

STATUS OK!

	$A_{sw} = 157.08 \text{ mm}^2 \leq A_{sw,max} = 879.75 \text{ mm}^2$	**STATUS OK!**
	$s = 250.00 \text{ mm} \leq s_{max} = 315.00 \text{ mm}$	**STATUS OK!**