REFERENCES	CALCULATIONS	RESULTS

Code: ENV 1992-1-1 :1991

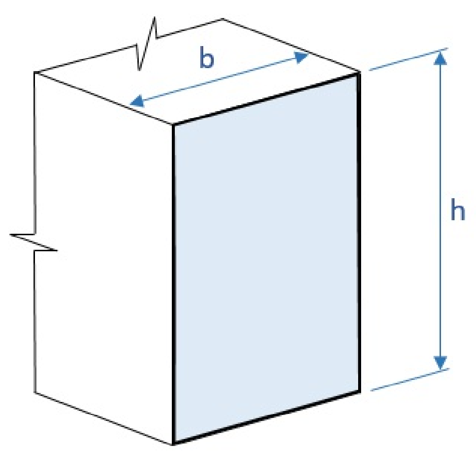
MEMBER #1 (SECTION POSITION 0.0 mm) BEAM DESIGN REPORT

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 $h = 570\ \mathrm{mm}$
Width $b = 300\ \mathrm{mm}$
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:
LC1: USER = $0\ \mathrm{kN\text{-}m}$

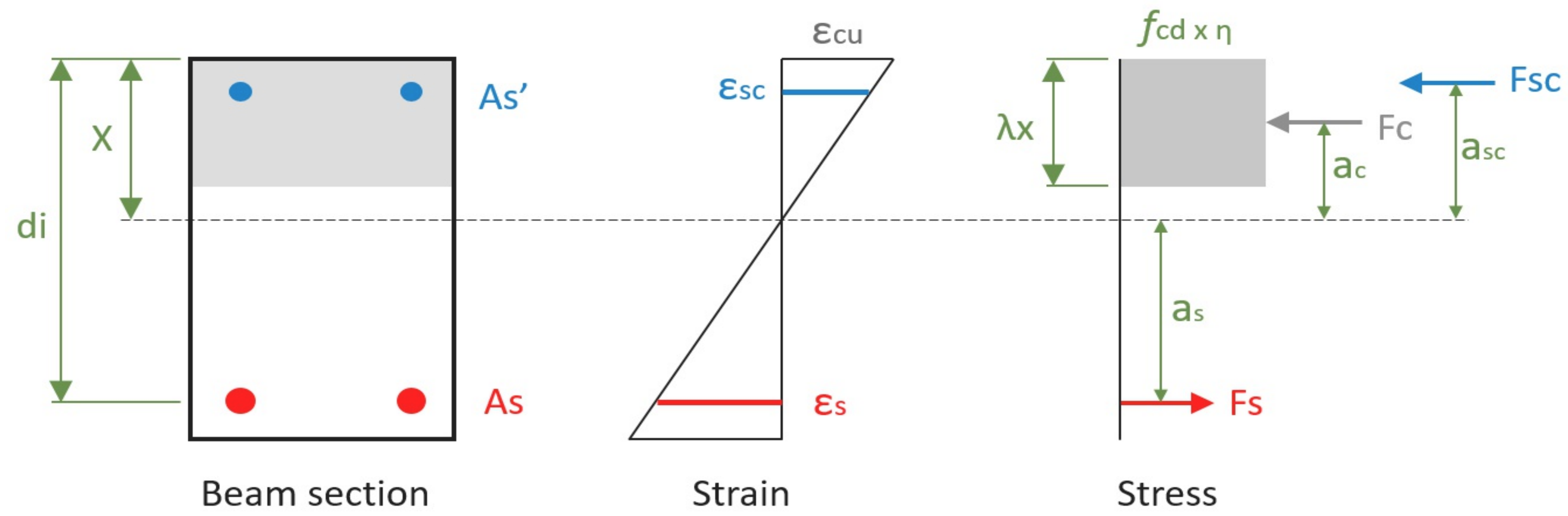
For shear force in section:
LC1: USER = $0\ \mathrm{kN}$

Load Combinations (Serviceability Limit State)

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

Flexure check (Positive bending moment case)

BENDING MOMENT CAPACITY



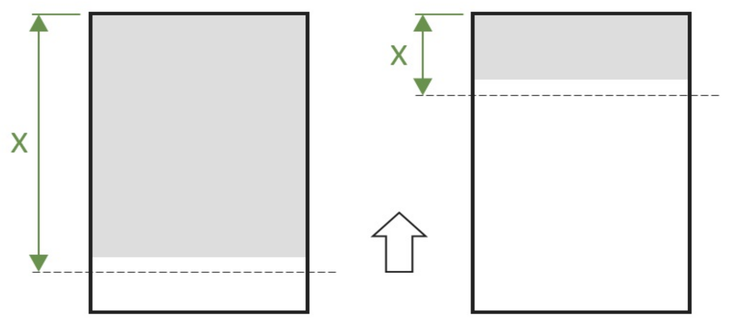
Section input data:
Section concrete area $A_c = 171000\ \mathrm{mm}^2$
Design compressive strength of concrete $f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 0.85 \cdot 25/1.5 = 14.17\ \mathrm{MPa}$
Design strength of rebar $f_{yd} = f_{yk}/\gamma_s = 500/1.15 = 434.78\ \mathrm{MPa}$
Design yield strain 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)
520	25	490.87
520	25	490.87
520	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 520 to 0 mm)

Iter.	x (mm)	As (mm2)	Fc (kN)	Fcs (kN)	Fc + Fcs (kN)	Fs (kN)	Ratio
1	520.0	0.0	1768.00	0.00	1768.00	0.00	Infinity
2	509.6	1472.6	1732.64	0.00	1732.64	21.04	82.360
3	499.2	1472.6	1697.28	0.00	1697.28	42.95	39.517
4	488.8	1472.6	1661.92	0.00	1661.92	65.80	25.258
5	478.4	1472.6	1626.56	0.00	1626.56	89.64	18.146
6	468.0	1472.6	1591.20	0.00	1591.20	114.54	13.893
7	457.6	1472.6	1555.84	0.00	1555.84	140.57	11.068
8	447.2	1472.6	1520.48	0.00	1520.48	167.81	9.061
9	436.8	1472.6	1485.12	0.00	1485.12	196.35	7.564
10	426.4	1472.6	1449.76	0.00	1449.76	226.28	6.407
11	416.0	1472.6	1414.40	0.00	1414.40	257.71	5.488
12	405.6	1472.6	1379.04	0.00	1379.04	290.75	4.743
13	395.2	1472.6	1343.68	0.00	1343.68	325.52	4.128
14	384.8	1472.6	1308.32	0.00	1308.32	362.18	3.612
15	374.4	1472.6	1272.96	0.00	1272.96	400.88	3.175
16	364.0	1472.6	1237.60	0.00	1237.60	441.78	2.801
17	353.6	1472.6	1202.24	0.00	1202.24	485.10	2.478
18	343.2	1472.6	1166.88	0.00	1166.88	531.03	2.197
19	332.8	1472.6	1131.52	0.00	1131.52	579.84	1.951
20	322.4	1472.6	1096.16	0.00	1096.16	631.80	1.735
21	312.0	1472.6	1060.80	0.00	1060.80	640.27	1.657
22	301.6	1472.6	1025.44	0.00	1025.44	640.27	1.602
23	291.2	1472.6	990.08	0.00	990.08	640.27	1.546
24	280.8	1472.6	954.72	0.00	954.72	640.27	1.491

25	270.4	1472.6	919.36	0.00	919.36	640.27	1.436
26	260.0	1472.6	884.00	0.00	884.00	640.27	1.381
27	249.6	1472.6	848.64	0.00	848.64	640.27	1.325
28	239.2	1472.6	813.28	0.00	813.28	640.27	1.270
29	228.8	1472.6	777.92	0.00	777.92	640.27	1.215
30	218.4	1472.6	742.56	0.00	742.56	640.27	1.160
31	208.0	1472.6	707.20	0.00	707.20	640.27	1.105
32	197.6	1472.6	671.84	0.00	671.84	640.27	1.049
(Fc + Fcs) < Fs. Updating of iterations							
1	187.2	1472.6	636.48	0.00	636.48	640.27	0.994
2	197.4	1472.6	671.13	0.00	671.13	640.27	1.048
3	197.2	1472.6	670.43	0.00	670.43	640.27	1.047
4	197.0	1472.6	669.72	0.00	669.72	640.27	1.046
5	196.8	1472.6	669.01	0.00	669.01	640.27	1.045
6	196.6	1472.6	668.30	0.00	668.30	640.27	1.044
7	196.4	1472.6	667.60	0.00	667.60	640.27	1.043
8	196.1	1472.6	666.89	0.00	666.89	640.27	1.042
9	195.9	1472.6	666.18	0.00	666.18	640.27	1.040
10	195.7	1472.6	665.48	0.00	665.48	640.27	1.039
11	195.5	1472.6	664.77	0.00	664.77	640.27	1.038
12	195.3	1472.6	664.06	0.00	664.06	640.27	1.037
13	195.1	1472.6	663.35	0.00	663.35	640.27	1.036
14	194.9	1472.6	662.65	0.00	662.65	640.27	1.035
15	194.7	1472.6	661.94	0.00	661.94	640.27	1.034
16	194.5	1472.6	661.23	0.00	661.23	640.27	1.033
17	194.3	1472.6	660.52	0.00	660.52	640.27	1.032
18	194.1	1472.6	659.82	0.00	659.82	640.27	1.031
19	193.9	1472.6	659.11	0.00	659.11	640.27	1.029
20	193.6	1472.6	658.40	0.00	658.40	640.27	1.028
21	193.4	1472.6	657.70	0.00	657.70	640.27	1.027
22	193.2	1472.6	656.99	0.00	656.99	640.27	1.026
23	193.0	1472.6	656.28	0.00	656.28	640.27	1.025
24	192.8	1472.6	655.57	0.00	655.57	640.27	1.024
25	192.6	1472.6	654.87	0.00	654.87	640.27	1.023
26	192.4	1472.6	654.16	0.00	654.16	640.27	1.022
27	192.2	1472.6	653.45	0.00	653.45	640.27	1.021
28	192.0	1472.6	652.75	0.00	652.75	640.27	1.019
29	191.8	1472.6	652.04	0.00	652.04	640.27	1.018
30	191.6	1472.6	651.33	0.00	651.33	640.27	1.017
31	191.4	1472.6	650.62	0.00	650.62	640.27	1.016
32	191.2	1472.6	649.92	0.00	649.92	640.27	1.015
33	190.9	1472.6	649.21	0.00	649.21	640.27	1.014
34	190.7	1472.6	648.50	0.00	648.50	640.27	1.013
35	190.5	1472.6	647.80	0.00	647.80	640.27	1.012

36	190.3	1472.6	647.09	0.00	647.09	640.27	1.011
37	190.1	1472.6	646.38	0.00	646.38	640.27	1.010
38	189.9	1472.6	645.67	0.00	645.67	640.27	1.008
39	189.7	1472.6	644.97	0.00	644.97	640.27	1.007
40	189.5	1472.6	644.26	0.00	644.26	640.27	1.006
41	189.3	1472.6	643.55	0.00	643.55	640.27	1.005
42	189.1	1472.6	642.84	0.00	642.84	640.27	1.004
43	188.9	1472.6	642.14	0.00	642.14	640.27	1.003
44	188.7	1472.6	641.43	0.00	641.43	640.27	1.002
45	188.4	1472.6	640.72	0.00	640.72	640.27	1.001
46	188.2	1472.6	640.02	0.00	640.02	640.27	1.000

Final value of x is 188.24 mm and tensioning rebar area is 1472.61 mm2
Working depth of reinforcement $d = 520.00\ \mathrm{mm}$

2. Calculation moment resistance M_{Rd}

$$M_{Rd} = F_c \cdot a_c + F_{cs} \cdot a_{cs} + F_s \cdot a_s = 72.29 + 0.00 + 212.41 = 284.70\ \mathrm{kN\text{-}m}$$

$$M_{Ed} = 0.00\ \mathrm{kN\text{-}m} \leq M_{Rd} = 284.70\ \mathrm{kN\text{-}m}$$

STATUS OK!

9.2.1.1 (3)
9.2.1.1(1)

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

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

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

$$A_{s,max} = 0.04 \cdot A_c = 0.04 \cdot 171000 = 6840\ \mathrm{mm}^2$$

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

$$A_{s,min1} = 0.26 \cdot \frac{f_{ctm}}{f_{yk}} \cdot b_t \cdot d = 0.26 \cdot \frac{2.56}{500} \cdot 300 \cdot 520.00 = 208.07\ \mathrm{mm}^2$$

$$A_{s,min2} = 0.0013 \cdot b_t \cdot d = 0.0013 \cdot 300 \cdot 520.00 = 234.000\ \mathrm{mm}^2$$

$$A_{s,min} = max\left[A_{s,min1}, A_{s,min2}\right] = 234.00\ \mathrm{mm}^2$$

Check of allowed longitudinal reinforcement

$$A_s = 1472.61\ \mathrm{mm}^2 \leq A_{s,max} = 6840.00\ \mathrm{mm}^2$$

STATUS OK!

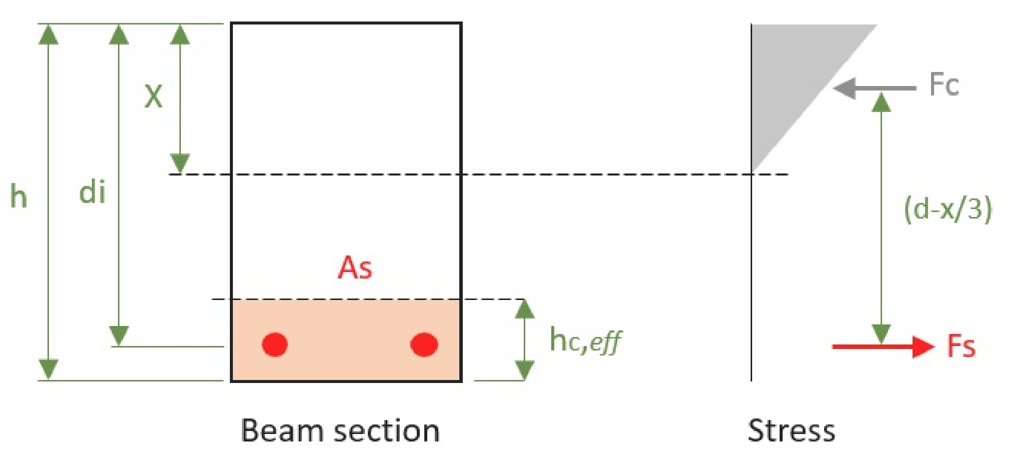
$$A_s = 1472.61\ \mathrm{mm}^2 \geq A_{s,min} = 234.00\ \mathrm{mm}^2$$

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 $d_t = 520 \text{ mm}$
Section concrete area $A_c = 171000 \text{ mm}^2$
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)

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

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

Notional size of the member

$$h_0 = \frac{2 \cdot A_c}{u} = \frac{2 \cdot 171000.00}{1740} = 196.55 \text{ mm}$$

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

$$f_{cm} \leq 35\text{MPa} \rightarrow \phi_{RH} = 1 + \frac{1 - \frac{RH}{100}}{0.1 \cdot \sqrt[3]{h_0}} = 1 + \frac{1 - \frac{70}{100}}{0.1 \cdot \sqrt[3]{196.55}} = 1.52$$

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

$$\phi_0 = \phi_{RH} \cdot \beta(f_{cm}) \cdot \beta(t_0) = 1.52 \cdot 2.92 \cdot 0.74 = 3.29$$

Coefficient depending on the relative humidity and the notional member size

$$\beta_H = 1.5 \cdot \left[1 + (0.012 \cdot RH)^{18}\right] \cdot h_0 + 250 = 1.5 \cdot \left[1 + (0.012 \cdot 70)^{18}\right] \cdot 196.55 + 250 = 557.61$$

$$\beta_H \leq 1500$$

Coefficient to describe the development of creep with time after loading

$$\beta_c(t, t_0) = \left[\frac{(t - t_0)}{(\beta_H + t - t_0)}\right]^{0.3} = \left[\frac{(10000 - 3)}{(557.61 + 10000 - 3)}\right]^{0.3} = 0.98$$

Creep coefficient

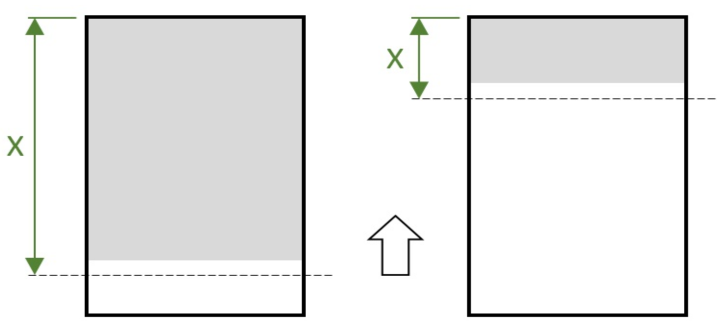
$$\phi(t, t_0) = \phi_0 \cdot \beta_c(t, t_0) = 3.29 \cdot 0.98 = 3.24$$

Effective modulus

$$E_{eff} = \frac{E_{cm}}{1 + \phi(t, t_0)} = \frac{31475.81}{1 + 3.24} = 7421.33 \text{ MPa}$$

$$a_e = \frac{E_s}{E_{eff}} = \frac{200000}{7421.33} = 26.95$$

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 520 to 0 mm)

				Left		

Iter.	x (mm)	As (mm2)	Asc (mm2)	force equil. part (kN)	Right force equil. part (kN)	Ratio
1	520.00	0.00	0.00	61196.67	101756.67	1.663
2	509.60	1472.61	0.00	59590.49	98131.58	1.647
3	499.20	1472.61	0.00	58016.76	94571.39	1.630
4	488.80	1472.61	0.00	56475.48	91076.10	1.613
5	478.40	1472.61	0.00	54966.65	87645.70	1.595
6	468.00	1472.61	0.00	53490.27	84280.20	1.576
7	457.60	1472.61	0.00	52046.33	80979.60	1.556
8	447.20	1472.61	0.00	50634.84	77743.89	1.535
9	436.80	1472.61	0.00	49255.80	74573.07	1.514
10	426.40	1472.61	0.00	47909.21	71467.16	1.492
11	416.00	1472.61	0.00	46595.07	68426.13	1.469
12	405.60	1472.61	0.00	45313.37	65450.01	1.444
13	395.20	1472.61	0.00	44064.12	62538.78	1.419
14	384.80	1472.61	0.00	42847.32	59692.45	1.393
15	374.40	1472.61	0.00	41662.97	56911.01	1.366
16	364.00	1472.61	0.00	40511.07	54194.47	1.338
17	353.60	1472.61	0.00	39391.61	51542.82	1.308
18	343.20	1472.61	0.00	38304.60	48956.07	1.278
19	332.80	1472.61	0.00	37250.04	46434.22	1.247
20	322.40	1472.61	0.00	36227.93	43977.26	1.214
21	312.00	1472.61	0.00	35238.27	41585.20	1.180
22	301.60	1472.61	0.00	34281.05	39258.04	1.145
23	291.20	1472.61	0.00	33356.28	36995.77	1.109
24	280.80	1472.61	0.00	32463.96	34798.39	1.072
25	270.40	1472.61	0.00	31604.09	32665.92	1.034
left part < right part. Updating of iterations						
1	260.00	1472.61	0.00	30776.67	30598.33	0.994
2	270.19	1472.61	0.00	31587.23	32623.93	1.033
3	269.98	1472.61	0.00	31570.37	32581.97	1.032
4	269.78	1472.61	0.00	31553.53	32540.03	1.031
5	269.57	1472.61	0.00	31536.70	32498.12	1.030
6	269.36	1472.61	0.00	31519.89	32456.24	1.030
7	269.15	1472.61	0.00	31503.09	32414.38	1.029
8	268.94	1472.61	0.00	31486.30	32372.55	1.028
9	268.74	1472.61	0.00	31469.52	32330.74	1.027
10	268.53	1472.61	0.00	31452.76	32288.96	1.027
11	268.32	1472.61	0.00	31436.01	32247.21	1.026
12	268.11	1472.61	0.00	31419.27	32205.48	1.025
13	267.90	1472.61	0.00	31402.55	32163.78	1.024
14	267.70	1472.61	0.00	31385.84	32122.10	1.023
15	267.49	1472.61	0.00	31369.14	32080.45	1.023
16	267.28	1472.61	0.00	31352.46	32038.83	1.022

17	267.07	1472.61	0.00	31335.79	31997.23	1.021
18	266.86	1472.61	0.00	31319.13	31955.66	1.020
19	266.66	1472.61	0.00	31302.48	31914.11	1.020
20	266.45	1472.61	0.00	31285.85	31872.59	1.019
21	266.24	1472.61	0.00	31269.23	31831.10	1.018
22	266.03	1472.61	0.00	31252.62	31789.63	1.017
23	265.82	1472.61	0.00	31236.03	31748.18	1.016
24	265.62	1472.61	0.00	31219.45	31706.77	1.016
25	265.41	1472.61	0.00	31202.88	31665.38	1.015
26	265.20	1472.61	0.00	31186.32	31624.01	1.014
27	264.99	1472.61	0.00	31169.78	31582.67	1.013
28	264.78	1472.61	0.00	31153.25	31541.36	1.012
29	264.58	1472.61	0.00	31136.74	31500.07	1.012
30	264.37	1472.61	0.00	31120.23	31458.81	1.011
31	264.16	1472.61	0.00	31103.74	31417.58	1.010
32	263.95	1472.61	0.00	31087.27	31376.37	1.009
33	263.74	1472.61	0.00	31070.80	31335.19	1.009
34	263.54	1472.61	0.00	31054.35	31294.03	1.008
35	263.33	1472.61	0.00	31037.91	31252.90	1.007
36	263.12	1472.61	0.00	31021.49	31211.79	1.006
37	262.91	1472.61	0.00	31005.08	31170.72	1.005
38	262.70	1472.61	0.00	30988.68	31129.66	1.005
39	262.50	1472.61	0.00	30972.29	31088.64	1.004
40	262.29	1472.61	0.00	30955.92	31047.63	1.003
41	262.08	1472.61	0.00	30939.56	31006.66	1.002
42	261.87	1472.61	0.00	30923.21	30965.71	1.001
43	261.66	1472.61	0.00	30906.88	30924.79	1.001
44	261.46	1472.61	0.00	30890.55	30883.89	1.00

Value of x is 261.46 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 $d = 520.00 \text{ mm}$

3. Calculation of effective strain

$$\sigma_s = \frac{M}{A_s \cdot (d - x/3)} = \frac{0}{1472.61 \cdot (520 - 261.46/3)} = 0.00 \text{ MPa}$$

$$k_t = 0.4 \text{ as long term loading}$$

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

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

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

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

$$h_{eff} = max\left[2.5 \cdot (h-d), \frac{h-x}{3}, \frac{h}{2}\right] = max\,[125.00, 102.85, 285.00] = 102.85 \text{ mm}$$

$$A_{c,eff} = b_w \cdot h_{eff} = 300 \cdot 102.85 = 30854.40 \text{ mm}^2$$

$$\rho_{eff} = \frac{A_s}{A_{c,eff}} = \frac{1472.61}{30854.40} = 0.04773$$

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

$$= \frac{0.00 - 0.4 \cdot \frac{2.56}{0.04773} \cdot (1 + 6.35 \cdot 0.04773)}{200000} = -0.00014$$

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

4. Calculation of maximum crack spacing

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

$$k_1 = 0.8$$

$$k_2 = 0.5$$

$$s_{r,max} = 3.4 \cdot c \cdot \frac{0.425 \cdot k_1 \cdot k_2 \cdot diameter}{\rho_{p,eff}} = 3.4 \cdot 37.5 \cdot \frac{0.425 \cdot 0.8 \cdot 0.5 \cdot 25}{0.04773}$$
$$= 216.55 \text{ mm}$$

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

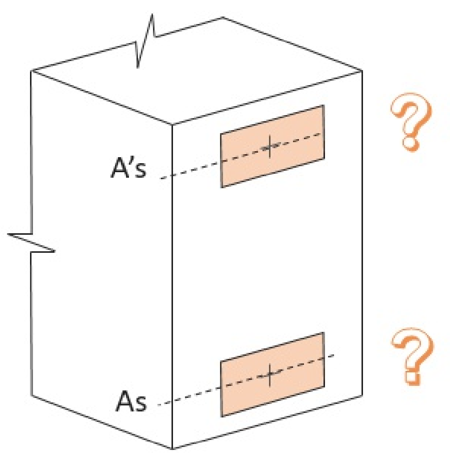
5. Calculation of crack width

$$w_k = (e_{sm} - e_{cm}) \cdot s_{r,max} = 0.00000 \cdot 216.55 = 0.00 \text{ mm}$$

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

STATUS OK!

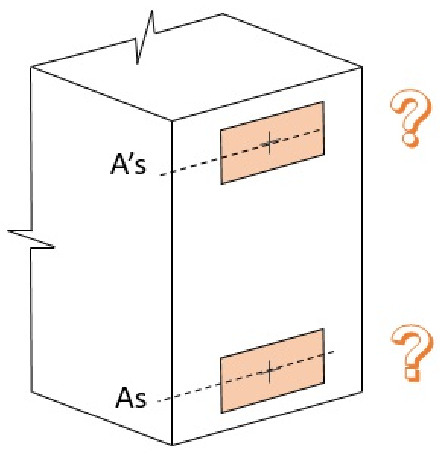
Flexure check (Negative bending moment case)



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)



STATUS OK!

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.

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 $f_{cd} = \alpha_{cc} \cdot f_{ck}/\gamma_c = 0.85 \cdot 25/1.5 = 14.17 \text{ MPa}$
Design strength of shear rebar $f_{ywd} = f_{ywk}/\gamma_s = 500/1.15 = 434.78 \text{ MPa}$
Mean width of web $b_w = 300 \text{ mm}$
Section concrete area $A_c = 171000 \text{ mm}^2$
Tensioning rebar area $A_{sl} = 1472.6100000000001 \text{ mm}^2$
Cross-sectional area of the shear reinforcement $A_{sw} = 157.08 \text{ mm}^2$
Spacing of stirrups $s = 250.00 \text{ mm}$
Working depth of reinforcement $d = 520.00 \text{ mm}$
Angle between strut and the beam axis $\theta = 45 \text{ deg}$
Given shear force $V_{Ed} = 0.00 \text{ kN}$

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:

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

Strength reduction factor for concrete cracked in shear

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

$$V_{Rd,max} = \frac{f_{cd} \cdot 0.9 \cdot d \cdot b_w \cdot a_{cw} \cdot v_1}{cot(\theta) + tan(\theta)} = \frac{14.17 \cdot 0.9 \cdot 520.00 \cdot 300 \cdot 1.00 \cdot 0.54}{1.00 + 1.00} = 537.03 \text{ kN}$$

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

$$\rho_w = \frac{A_{sw}}{b_w \cdot s} = \frac{157.08}{300 \cdot 250} = 0.00209$$

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

$$s_{max} = 0.75 \cdot d = 0.75 \cdot 520.00 = 390.00 \text{ mm}$$

Maximum shear reinforcement

$$A_{sw,max} = \frac{0.5 \cdot a_{cw} \cdot v_1 \cdot f_{cd} \cdot b_w \cdot s}{f_{ywd}} = \frac{0.5 \cdot 1.00 \cdot 0.54 \cdot 14.17 \cdot 300 \cdot 250}{434.78} = 659.81 \text{ mm}^2$$

$$V_{Ed} = 0.00 \text{ kN} \leq V_{Rd,max} = 537.03 \text{ kN}$$

STATUS OK!

$$\rho_w = 0.00209 \geq \rho_{w,min} = 0.00080$$

STATUS OK!

$$A_{sw} = 157.08 \text{ mm}^2 \leq A_{sw,max} = 659.81 \text{ mm}^2$$

STATUS OK!

	$s = 250.00 \text{ mm} \leq s_{max} = 390.00 \text{ mm}$	**STATUS OK!**