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CV3011
SI 1819
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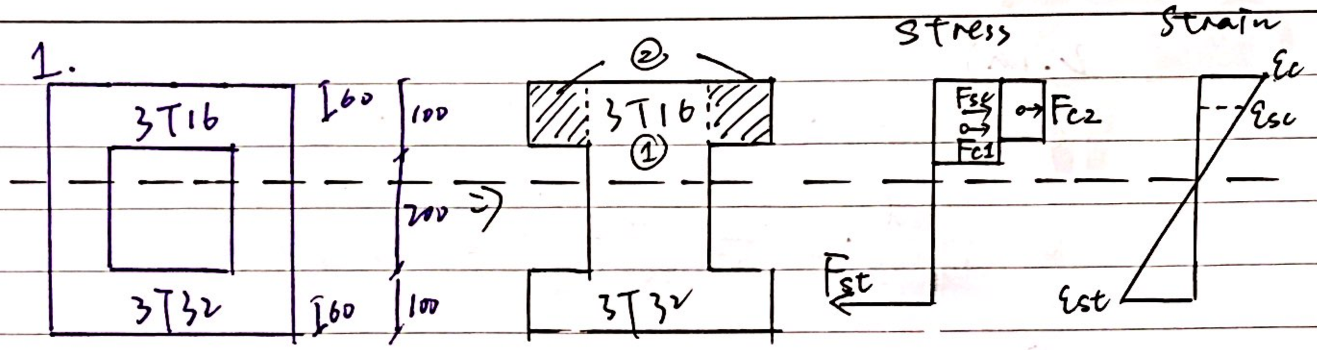
1.



Assume $x = 0.617d = 0.617 \times 340 = 209.78\,mm > h_f = 100\,mm$

$\rightarrow \varepsilon_c = 0.0035$, $\varepsilon_{st} = 0.00217$

$$\varepsilon_{sc} = \frac{x-d'}{x} \cdot \varepsilon_c = \frac{209.78-60}{209.78} \cdot 0.0035 = 0.0025 > 0.00217$$

$\rightarrow$ compression steel has yielded.

① $F_{c1} = 0.567 f_{ck} \cdot b_w \cdot 0.8x = 0.567 \times 40 \times 200 \times 0.8 \times 209.78 = 761.2$ KN

② $F_{c2} = 0.567 f_{ck} \cdot (b_f - b_w) \cdot h_f = 0.567 \times 40 \times (400-200) \times 100 = 453.6$ KN

$F_{sc} = 0.87 \cdot f_{yk} \cdot A_{sc} = 0.87 \times 500 \times 3 \cdot \pi \cdot (\frac{16}{2})^2 = 262.4$ KN

Taking moment at the location of tension steel:

$$M_{Rd} = F_{c1} \cdot (d - \frac{0.8x}{2}) + F_{c2} \cdot (d - \frac{h_f}{2}) + F_{sc} (d - d')$$

$$= 761.2 \cdot (340 - 0.4 \times 209.78) + 453.6 \cdot (340-50) + 262.4 \cdot (340-60)$$

$$= 400\,KN \cdot m > M_{Ed} = 200\,KN \cdot m.$$

$\rightarrow$ Moment capacity sufficient.

2.(a)

$M_{Ed} = \frac{wL^2}{8} = (1.35\times58+1.5\times68.)\cdot\frac{6.8^2}{8} = 1042.134\ KN\cdot m$

$K = \frac{M_{Ed}}{bd^2 f_{ck}} = \frac{1042.134\times10^6}{350\cdot460^2\cdot25} = 0.563 > 0.167 = K_{bal}$

⇒ Compression reinf't is required.

$d' = 25 + \frac{32}{2} = 41\ mm$. $x = 0.45d = 0.45\times460 = 207\ mm$

$\varepsilon_{sc} = \frac{x-d'}{x}\cdot\varepsilon_c = \frac{207-41}{207}\cdot0.0035 = 0.00281 > 0.00217$

⇒ compression reinf't has yielded.

$A_{sc} = \frac{M_{Ed} - K_{bal}\cdot f_{ck}\cdot bd^2}{0.87 f_{yk}(d-d')} = 4021.3\ mm^2 \Rightarrow 5\phi32\ 4023\ mm^2$

$A_{st} = \frac{K_{bal} f_{ck} bd^2}{0.87 f_{yk}\cdot z} + A_{sc} = 5905.7\ mm^2 \Rightarrow 8\phi32\ 6437\ mm^2$

$z = d - \frac{0.8x}{2} = d - 0.4\cdot0.45d = 0.82d = 377.2\ mm$

(b)

$V_{max} = \frac{wL}{2} = 613.02\ KN$

$V_{Ef} = \frac{6.8/2 - 0.2}{6.8/2}\cdot V_{max} = 577\ KN$

$V_{Ed} = \frac{6.8/2 - 0.2 - 0.46}{6.8/2}\cdot V_{max} = 494\ KN$

$V_{Rd,max(22)} = 0.124 b_w d(1-f_{ck}/250)f_{ck} = 449.2\ KN$

$V_{Rd,max(45)} = 0.18 b_w d(1-f_{ck}/250)f_{ck} = 652\ KN$

Zone 1 & 2: $\theta = 0.5\sin^{-1}\left[\frac{V_{Ef}}{V_{Rd,max(45)}}\right] = 31.1° < 45°$

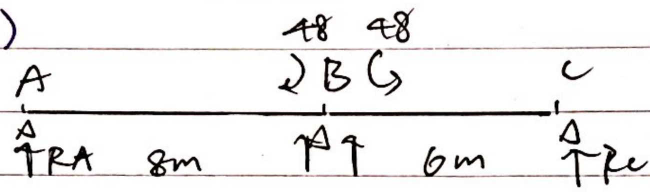
$\frac{A_{sw}}{s} = \frac{V_{Ed}}{0.78 d f_{yk}\cot\theta} = 1.66 \Rightarrow \phi12-150\ \left(\frac{A_{sw}}{s} = 1.508\right)$

Zone 3: $\frac{A_{sw,min}}{s} = \frac{0.08 f_{ck}^{\frac{1}{2}} b_w}{f_{yk}} = 0.28 \Rightarrow \phi12-300$

$V_2 = 0.78 d f_{yk}\cdot\cot\theta\cdot\frac{A_{sw}}{s} = 448.5\ KN$

$x_2 = (V_{max} - V_2)/w = 0.913\ m$ from support centerline

3(a)



$W = 1.5\times5 + 1.35\times25\times0.24 = 15.6\ KPa$

- 20% moment reduction over supports for single load case analysis
- New support moment $= 60\times(1-20\%) = 48\ KN\cdot m$
- Span AB: $\circlearrowright \Sigma M_B = -48 + 8\times15.6\times\frac{8}{2} - 8R_A = 0$

  $\Rightarrow R_A = 56.4\ KN$
- $V=0 \Rightarrow \frac{56.4}{15.6} = 3.62\,m$ from A

Sagging

- $M_{Ed} = M_{max,AB} = \frac{1}{2}\times3.62\times56.4 = 102\ KN\cdot m$
- $K = \frac{M_{Ed}}{bd^2 f_{ck}} = 0.102 < 0.167$, $z = d[0.5+\sqrt{0.25-\frac{K}{1.134}}] = 180\ mm$ $< 190\ mm = 0.95d$.
- $A_s = \frac{M_{Ed}}{0.87 f_{yk}\cdot z} = \frac{102\times10^6}{0.87\times500\times180} = 1303\ mm^2 \Rightarrow$ H13-100 #

  $A_{s,prov} = 1327\ mm^2$

Hogging

- $M_{Ed} = 48\ KN\cdot m$
- $K = \frac{M_{Ed}}{bd^2 f_{yk}} = 0.048$, $z = 191\ mm$ take $z = 190\ mm$.
- $A_s = \frac{M_{Ed}}{0.87 f_{yk}\cdot z} = 581\ mm^2$. $\Rightarrow$ H13-225 # over the support

(b) $K = 1.3$ for end span.

$F_1 = 1$, $F_2 = \frac{7}{8}$, $F_3 = \frac{A_{s,prov}}{A_{s,req}} = \frac{1327}{1303} = 1.02$

$\rho' = 0$, $\rho_0 = 10^{-3}\sqrt{f_{ck}} = 0.5\% < \rho = \frac{A_{s,req}}{bd} = \frac{1303}{1000\cdot200} = 0.6515\% > 0.35\%$

Basic $l/d = K[11 + \frac{1.5\sqrt{f_{ck}}\,\rho_0}{\rho-\rho'} + \frac{\sqrt{f_{ck}}}{12}\sqrt{\frac{\rho'}{\rho_0}}] = 21.78$

Basic $l/d \times F_1\times F_2\times F_3 = 21.78\times1\times\frac{7}{8}\times1.02 = 19.44 < \frac{L}{d} = \frac{8000}{200} = 40$

$\Rightarrow$ The deflection check is not satisfied.

$\Rightarrow$ Increase the slab thickness or concrete grade.

4.(a) $A_c = bh = 500 \cdot 600 = 300000 \, mm^2$

$A_{sc} = 0.03 \cdot bh = 0.03 \times 500 \times 600 = 9000 \, mm^2$

$A_{sc1} = 3000 \, mm^2$,

$A_{sc2} = 6000 \, mm^2$;

$N_0 = 0.567 f_{ck} \cdot A_c + 0.87 f_{yk} \cdot A_{sc}$

$= 0.567 \cdot 50 \cdot 300000 + 0.87 \cdot 500 \cdot 9000$

$= 12420 \, kN$

(b) $d = 0.9h = 0.9 \cdot 600 = 540 \, mm$

$x = \dfrac{d}{1 + \frac{0.00217}{0.0035}} = 333.3 \, mm$

$d' = 0.1h = 0.1 \times 600 = 60 \, mm$.

$\varepsilon_{sc} = \varepsilon_c \cdot \dfrac{x - d'}{x} = 0.0035 \dfrac{333.3 - 60}{333.3} = 2.87 \times 10^{3} > 2.17 \times 10^{3}$

$\hookrightarrow$ compression steel has yielded.

$F_{sc1} = 0.87 f_{yk} \cdot A_{sc1} = 0.87 \cdot 500 \cdot 3000 = 1305 \, kN$

$F_{sc2} = 0.87 f_{yk} \cdot A_{sc2} = 0.87 \cdot 500 \cdot 6000 = 2610 \, kN$

$F_c = 0.567 \cdot f_{ck} \cdot b \cdot 0.8x = 0.567 \cdot 50 \cdot 500 \cdot 0.8 \cdot 333.3 = 3780 \, kN$

$N = F_c + F_{sc1} - F_{sc2} = 4930. \, kN$

$M = F_c \cdot (\frac{600}{2} - 0.4x) + F_{sc1}(\frac{600}{2} - d') + F_{sc2}(d - \frac{600}{2})$

$= 3780(300 - 0.4 \times 333.3) + 1305(300 - 60) + 2610(540 - 300)$

$= 1570 \, kN \cdot m$.

(c) $F_c + F_{sc1} = F_{sc2}$

Assume compression steel has not yielded.

$\varepsilon_{sc1} = \dfrac{x - d'}{x} \cdot \varepsilon_c = \dfrac{x - 60}{x} \times 0.0035$, $f_{sc1} = \varepsilon_{sc1} \cdot E = \dfrac{x - 60}{x} \cdot 700$.

$\Sigma F = 0 \Rightarrow 0.567 \cdot f_{ck} \cdot b \cdot 0.8x + f_{sc1} \cdot A_{sc1} = 0.87 f_{yk} \cdot A_{sc2}$.

$\Rightarrow x = 130.3 \, mm \Rightarrow f_{sc1} = 377.6 \, N/mm^2$

$\varepsilon_{sc1} = 1.8 \times 10^{-3} < 2.17 \times 10^{-3}$ ✓

$M = F_c \cdot (d - 0.4x) + F_{sc1} \cdot (d - d')$

$= 0.567 \cdot f_{ck} \cdot b \cdot 0.8x (540 - 0.4 \cdot 130.3) + 377.6 \times 3000 \times (540 - 60)$

$= 1265 \, kN \cdot m$.

(d) Refer to lecture notes.