CE382- REINFORCED CONCRETE FUNDAMENTALS

HOMEWORK III

Name:

ID:

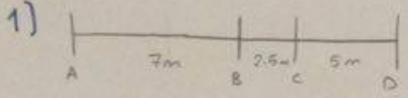
Sec: 3

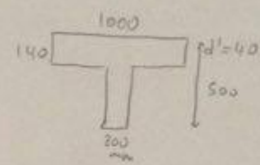
Due Date: 14.12.2016

CE 382 - REINFORCED CONCRETE FUNDAMENTALS

HOMEWORK III.

1)





$\Delta M_A = \frac{V.a}{3} = \frac{250 \times 0.40}{3} = 33.3$ kN.m

$\Delta M_B = \frac{270 \times 0.4}{3} = 36$ kN.m

$f_{yd} = \frac{420}{1.15} = 365$ MPa

$\Delta M_C = \frac{195 \times 0.4}{3} = 26$ kN.m

$\Delta M_D = \frac{170 \times 0.4}{3} = 22.67$ kN.m

* Final Design

$d = 460$ mm From chart $K_m = 199$ mm²/kN , $J_m = 0.776$

$K_\ell = 291$ mm²/kN , $J_\ell = 0.86$

* For Span AB : $K = \frac{1000 \times 460^2}{275} = 770 > K_\ell$

$jd = 0.9d$ or $d - \frac{t}{2}$, $0.9d = 414$, $d - \frac{t}{2} = 460 - \frac{140}{2} = 390$

* $M_d = 275$ kN.m

* $A_s = \frac{M_d}{f_{yd}\, jd} = \frac{275}{365 \times 414} = 1820$ mm² $\Rightarrow$ 4φ14 straight, 4φ20 bent } 1871.4 mm² $\boxed{\text{OK.}}$

* Support A :

Now, considering beam like a rectangular section.

* $M_d = 245 - 33.3 = 211.7$ kN.m $\Rightarrow$ 4φ22 bent = 1519 mm² ✓

1466 ✓

* $K = \frac{b_w d^2}{M_d} = \frac{300 \times 460^2}{211.7} = 299.8 > K_\ell$

* Single reinforcement $\Rightarrow A_s = \frac{211.7}{365 \times 0.86 \times 460} = 1466.1$ mm²

* 2φ12 hanger } a bit larger but no problem.

* $A_s = 1466.1\ mm^2$ $\Rightarrow$ $\left.\begin{array}{l} 4\phi 20 \text{ bent} \\ \text{and} \\ 2\phi 12 \text{ hanger} \end{array}\right\}$ $1482.1\ mm^2 > 1466.1$ $\boxed{OK.}$

<u>* For span BC :</u>

* $J = 0.9d = 414\ mm$ $K = \frac{1000 \cdot 460^2}{100} > K_e$ OK. "Flange"

* $Md = 120\ kN.m$

* $A_s = \frac{120}{365 \times 414} = 794.12\ mm^2$ $\Rightarrow$ $\left.\begin{array}{l} * 2\phi 20 \text{ bent} \\ * 2\phi 14 \text{ straight} \end{array}\right\}$ $937.2\ mm^2$ // $\boxed{OK}$

<u>* Support B</u> (Rectangular)

* $Md = 330 - 36 = 294\ kN.m$

* $K = \frac{300 \times 460^2}{294} = 215.9\ kN.m < K_e$ $215.9 > K_m$

* Double reinforcement

* $M_1 = \frac{300 \times 460^2}{291} = 218.14\ kN.m$

$A_{s_1} = \frac{218.14}{365 \times 0.86 \times 460} = 1510.7\ mm^2$ $\Rightarrow$ $\left.\begin{array}{l} * 4\phi 20 \text{ bent} \\ * 2\phi 20 \text{ bent} \\ * 2\phi 12 \text{ hanger} \end{array}\right\}$ $\underline{2110.1}$ $\boxed{OK.}$

* $M_2 = M_d - M_1 = 294 - 218.14 = 75.86\ kN.m$ //

$A_{s_2} = \frac{75.86}{365(460-40)} = 494.8\ mm^2$ $\longrightarrow$ $\left.\begin{array}{l} 5\phi 14 \text{ from span AB} \\ 2\phi 14 \text{ " span BC} \end{array}\right\}$ $1077\ mm^2$ $\boxed{OK.}$

* $A_s = A_{s_1} + A_{s_2} = 1510.7 + 494.8 = \boxed{2005.5\ mm^2}$

* <u>For span CD</u> : $K = \frac{1000 \times 400^2}{200} = 1069 > K_\ell$ //

* $M_d = 200$ kN.m $jd = 414$ mm //

* $A_s = \frac{200}{365 \; 414} = 1323.5 \text{ mm}^2$

* $4\phi20$ bent $= 1256$ //
* $2\phi14$ straight $= 307.7$ mm² //
} 1563.7 mm² //

$\boxed{OK.}$

* <u>Support C</u>

* $M_d = 300 - 26 = 274$ kN.m

$K = \frac{300 \times 460^2}{274} = 231.7 < K_\ell$ * Double reinforcement //

* $M_1 = \frac{300 \times 460^2}{291} = 218.14$ kN.m

* $A_{s_1} = 1510.7 \text{ mm}^2$ //

Total ⇒ $6\phi20$ bent
$2\phi12$ hanger
} 2110.1 mm²
$\vee$
1875

$\boxed{OK}$

* $M_2 = M_d - M_1 = 274 - 218.14 = 55.86$ kN.m

* $A_{s_2} = \frac{55.86}{365 \times 420} = 364.4 \text{ mm}^2$ // ⇒ * $2\phi14$ straight
* $2\phi14$ "
} 615.6 mm²

$\boxed{OK.}$

$A_s = A_{s_1} + A_{s_2} = 1875.1 \text{ mm}^2$ //

* <u>Support D</u>

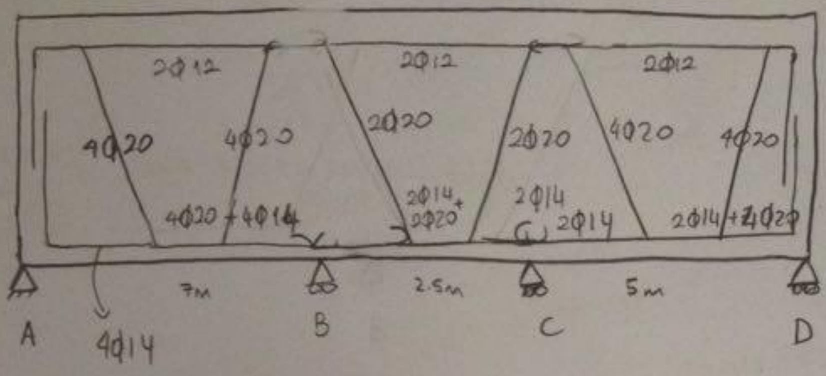
* $M_d = 177$ kN.m $- 22.67 = 154.33$ kN.m

$K = \frac{300 \times 460^2}{154.33} = 411 > K_\ell$ * Single reinforcement //

$A_s = \frac{154.33}{365 \times 0.86 \times 460} = 1068.8 \text{ mm}^2$ //

* $4\phi20$ bent
* $2\phi12$ hanger
} 2110.1 $\boxed{OK.}$

a bit larger but no problem.


2Φ12
2Φ12
2Φ12
4Φ20
4Φ20
2Φ20
2Φ20
4Φ20
4Φ20
4Φ20 + 4Φ14
2Φ14 + 2Φ20
2Φ14
2Φ14
2Φ14 + 4Φ20
7m
2.5m
5m
A
B
C
D
4Φ14

2) $F_{cd} = \frac{25}{1.5} = 17$, $F_{yd} = \frac{420}{1.15} = 365$

$A_c = 400^2 = 160000 mm^2$

$A_{s\,total} = 4 \times \pi \frac{24^2}{4} = 1808.64\ mm^2$

a) $N_{or} = 0.85\, F_{cd}\, A_c + A_{st}\, F_{yd}$

$= 0.85 \times 17 \times 160\,000 + 1808.64 \times 365 = 2972.15\ kN$, $M = 0$

b) Uniaxial Tension:

$N = A_{st}\, F_{cd} = 1808.64 \times 365 = 660.15\ kN$, $M = 0$

c) Balanced Case: $d = 400 - 40 = 360 mm$

$$\frac{C_b}{d} = \frac{0.003}{0.003 + \varepsilon_s} = \frac{0.003}{0.003 + \frac{365}{200000}} \Rightarrow \boxed{C_b = 223.83\ mm}$$

* $\frac{360 - 223.83}{\varepsilon_s} = \frac{223.83}{0.003} \Rightarrow \varepsilon_s = 1.83\ 10^{-3} > 1.825\ 10^{-3}$ OK.

* $\frac{223.83 - 40}{223.83} = \frac{\varepsilon_s'}{0.003} \Rightarrow \varepsilon_s' = 2.46\ 10^{-3} > \varepsilon_y$ OK.

* $N = N_b = 0.85 \times 17 \times 0.85 \times 223.83 \times 400 = 1099.68\ kN$

* $M = M_b = 1099.68 \left(200 - \frac{0.85 \times 223.83}{2}\right) + 1808.64 \times 365 \times (200 - 40) \times 10^{-3}$

$= 220.95\ kN\,m$

d) $N = 0 \Rightarrow F_c + F_s' = F_s$ * Compression steel is not yielded.

* $F_c = 0.85 \times 17 \times 0.85 c\ 400 = 4913 c$

* $F_s = 904.32 \times 365 = 330.07\ kN$

* $F_s' = 904.32 \times 600 \left(1 - \frac{40}{c}\right) = 542.59 - \frac{21703.68}{c}$

$\boxed{c = 48.26}$ & $c = -91.52$

* Check:

$\frac{48.26 - 40}{48.26} = \frac{\varepsilon_s'}{0.003} \Rightarrow \varepsilon_s' = 5.13\ 10^{-4} < \varepsilon_{sy}$ $\boxed{OK}$

* $M = 4913 \times 48.26 \left(200 - \frac{0.85 \times 48.26}{2} \right) + 92.84 \times 2\pi \frac{24^2}{4} \times (200-40)$

$+ 365 \times 904.32 \times 160$

$\boxed{= 108.8 \text{ kN.m}}$

e) $N = 0.85 N_{or} = 0.85 \times 2972.15 = 2526.33 \text{ kN}$

* $2526.33 > N_b = 1099.68 \text{ kN}$ * Compression Failure

* Assume comp. steel yielded but tension steel not yielded.

$F_c + F_s' - F_s = 2526.33$

$F_s = 600 \left(\frac{d}{c} - 1 \right) = 600 \left(\frac{360}{c} - 1 \right) = \left(\frac{216000}{c} - 600 \right) \times 904.32$

$F_s' = 2\pi \frac{24^2}{4} \times 365 = 330.07 \text{ kN}$

$F_c = 4913 c$

$\Rightarrow 4913c + 330070 - \frac{195333120}{c} + 542592 = 2526330 \Rightarrow \boxed{c \cong 429.4 \text{ mm}}$

* $M = 4913 \times 429.4 \left(200 - \frac{0.85 \times 429.4}{2} \right) + 330070 \times (200-40) - 96.97 \times 904.32 \times 160$

$\boxed{= 75.71 \text{ kN.m}}$

f) $0.45 N_{or} = N = 1337.46 > 1099$ * Compression failure.

$F_c + F_s' - F_s = 1337.46$ * Assume comp yield and tension not yielded.

* $F_s' = 330.07 \text{ kN}$

* $F_c = 0.85 \times 17 \times 0.85 c \times 400 = 4913c$

* $F_s = 600 \left(\frac{d}{c} - 1 \right) \times 904.32 = 542592 - \frac{195333120}{c}$

$\Rightarrow \boxed{c = 251.8 \text{ mm}}$

* $M = 4913 \times 251.8 \left(200 - \frac{0.85 \times 251.8}{2} \right) + 365 \times 904.32 (200-40) + 257.8 \times 904.32 \times 160$

$\boxed{= 205.15 \text{ kN.m}}$

9) $N = 0.15 N_{or} = 0.15 \times 2972.15 = 445.83$ kN $< N_b$

* Tension Failure

* Assume comp steel not yielded.

* $F_c + F_s' - F_s = 445.83$

* $F_s' = 600\left(1 - \frac{40}{c}\right) \times 904.32 = 542.59 - \frac{21703.69}{c}$

* $F_s = 365 \times 904.32 = 330.07$ kN

$\Rightarrow \boxed{c = 94.32 \text{ mm}}$

* Check :

$$\frac{94.32 - 40}{94.32} = \frac{\varepsilon_s'}{0.003} \Rightarrow \varepsilon_s' = 1.727\ 10^{-3} < \varepsilon_{sy}$$ Assumption is correct.

f) * $M_r = 4913 \times 94.32\left(200 - \frac{0.85 \times 94.32}{2}\right) + 330070 \times (200 - 40) + 312485\,(160)$

$= 176.9$ kN.m