ENCE 335 / H.W #5

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- Simply Support beam (10m) center to center.

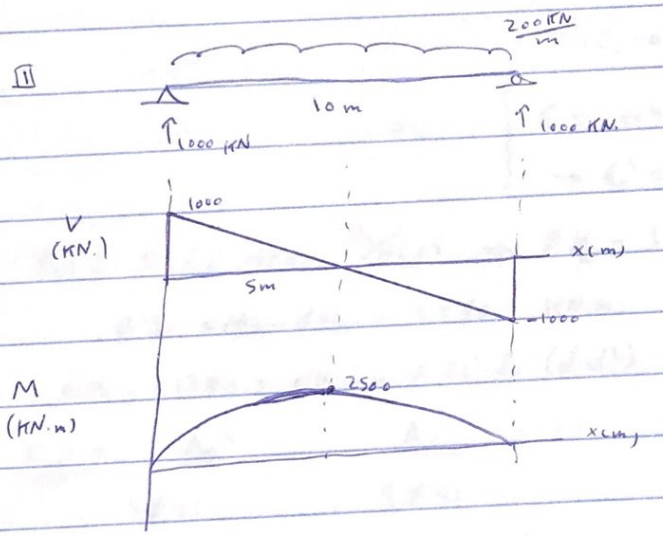
DL = 60 KN/m. LL = 80 KN/m. → $w = 1.2D + 1.6L$ → $w = 200$ KN/m

Beam cross section H x B = 750 x 500 mm.

Column 500 x 500 mm

Closed Loop stirrups (ϕ12).

$f_c' = 36$ MPa , $f_y = 420$ MPa.



$V_u = \pm 1000$ KN

$M_u = {}^{+}2500$ KN.m.

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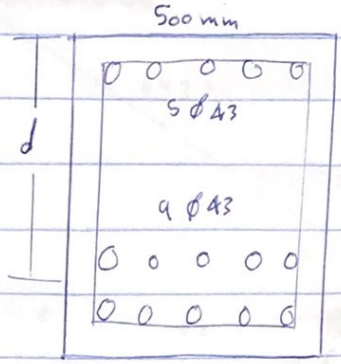


$M_u = 2500$ kN.m.

assume $\phi = 0.9$, 2 layers $\phi 43$

$d = 750 - 40 - 12 - 43 - \frac{43}{2}$

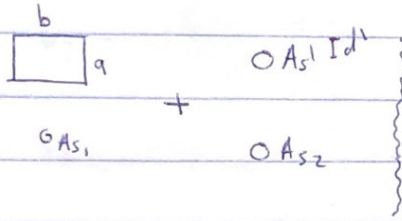
$d = 633.5$ mm.

$R = M_u/\phi bd^2 = 13.843$ MPa.

$\therefore$ doubly Reinforcement $\quad s_{min} = 43$ mm.

from A.4 : $\beta_1 = 0.8$, $\rho_{0.005} = 0.0213$, $\rho_{0.004} = 0.0243$, $\rho_{min} = 0.0033$

Take $\rho = \rho_{0.005} = 0.0213 \Rightarrow A_{s_1} = 6746.775$ mm^2



$T_1 = C_1 \Rightarrow a = \frac{A_{s_1} f_y}{0.85 f_c' b} = 190$ mm $\Rightarrow \bar{y} = a/0.8 = 238$ mm

$\epsilon_s = 0.00498 \Rightarrow \phi = 0.898$ $\quad d' = 40 + 12 + \frac{43}{2} = 73.5$ mm

$\Rightarrow \epsilon_s' = 0.00207 > 0.002$ will yield. $\therefore f_y' = 420$ MPa.

A.5 : $R = 7.6$ MPa $= M_u/\phi bd^2 \Rightarrow \phi M_{n_1} = 1229.8$ kN.m.

$\phi M_{n_2} = M_u - \phi M_{n_1} = 1270.2$ kN.m.

$\phi M_{n_2} = 1270.2$ kN.m $= \phi A_s' f_y (d - d') \Rightarrow A_s' = A_{s_2} = 6014$ mm^2. $\quad A_s = A_{s_1} + A_{s_2}$

$A_s = 12760$ mm^2.

A.2 : $\quad A_s' \quad 5\phi 43 \quad A_s' = 7260$ mm^2 $\quad A_s \quad 9\phi 43 \quad A_s = 13068$ mm^2

check width : $500 - 40 - 40 - 12 - 12 - 5(43) - 45 = 0$

$s = 45.25$ mm $> s_{min}$

$T = C \Rightarrow A_s f_y = 0.85 f_c' b a + A_s' f_y'$

assume $f_y' = 420$ MPa $\Rightarrow a = 164$ mm $\Rightarrow \bar{y} = 205$ mm $\Rightarrow \epsilon_s' = 0.001924 \Rightarrow f_y' = 384.878$ MPa

assume $f_y' = 385$ MPa $\Rightarrow a = 181$ mm $\Rightarrow \bar{y} = 226$ mm $\Rightarrow \epsilon_s' = 0.00202 \Rightarrow f_y' = 404$ MPa. $\Rightarrow a = \cdots, \bar{y} = 215$ mm, $f_y' = 395$ MPa.

~~check width ✓~~ $\quad \epsilon_s = 0.00584 > 0.005$

$\therefore \phi = 0.9$.

$\phi M_n = \phi M_{n_1} + \phi M_{n_2}$

$= \phi\, 0.85 f_c' a b^{(d - a/2)} + \phi A_s' f_y' (d - d') = 2706$ kN.m $> M_u$.

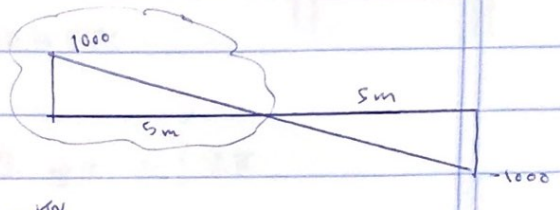
Moment Capacity checked

3- $V_c = 0.17\sqrt{f'_c}\, b\, d$

$V_c = 323.085$ KN

$\phi V_c = 242.3$ KN

$\frac{\phi V_c}{2} = 121.15$ KN.



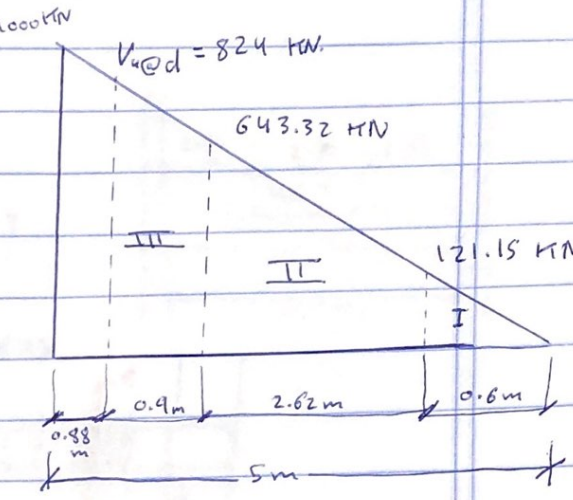
Region I : No Reinforcement needed.

4- $V_{u@d} = \phi V_s + \phi V_c \rightarrow V_s = \frac{V_{u@d} - \phi V_c}{\phi}$

$V_s = 775.6$ KN $> 2V_c = 646.17$ KN

$< 4V_c$

$S_{max} = \min \begin{cases} \frac{A_v f_y}{0.062\sqrt{f'_c}\, b} = 510.5\text{mm} \\ \frac{A_v f_y}{0.35 b} = 542.6\text{ mm} \\ d/4 = 158.4\text{mm} \\ 300\text{m} \end{cases}$



$S_{max} = 150$mm.

5- $\phi V_{s(max)} = \frac{\phi A_s f_y d}{S_{max}} = 401$ KN.

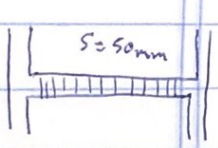
$V_u = \underset{(max)}{\phi V_s} + \phi V_c \Longrightarrow V_u = 643.32$ KN $\rightarrow X_2 = 3.22 - 0.6 = 2.62$m.

6- $S = \frac{\phi A_s f_y d}{V_s} = 58\text{mm} \approx 50\text{mm}.$

7- # of stirrups $= \left(\frac{0.9}{0.05} + \frac{2.62}{0.15} + 1\right) \times 2 = 73.$

Practical Design

8- First approach : Least Calc.



Max Shear stress $V_{u@d}$ = 82.4 KN.

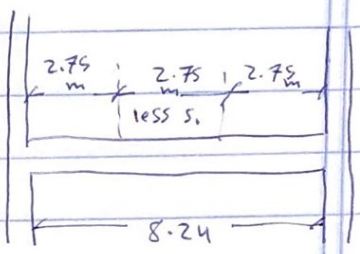
$S_{required}$ = 50mm

$$\#\ of\ stirrups = \frac{10 - 2(0.88)}{0.05} + 2 = 167$$

Second approach :

$$\#\ of\ stirrups = \frac{2(2.75)}{0.05} + \frac{2.75}{0.15} + 2$$

$$= 131.$$



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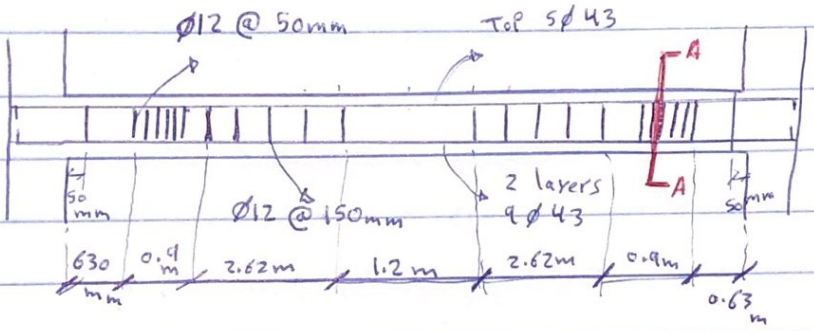

- Section A-A :