Homework Assignment #3

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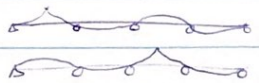
- Continuous beam 4-spans (5 m).

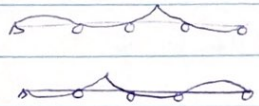
DL = 100 KN/m → (1.2) DL = 120 KN/m

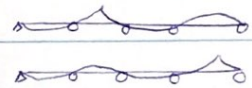
LL = 40 KN/m → (1.6) LL = 64 KN/m.

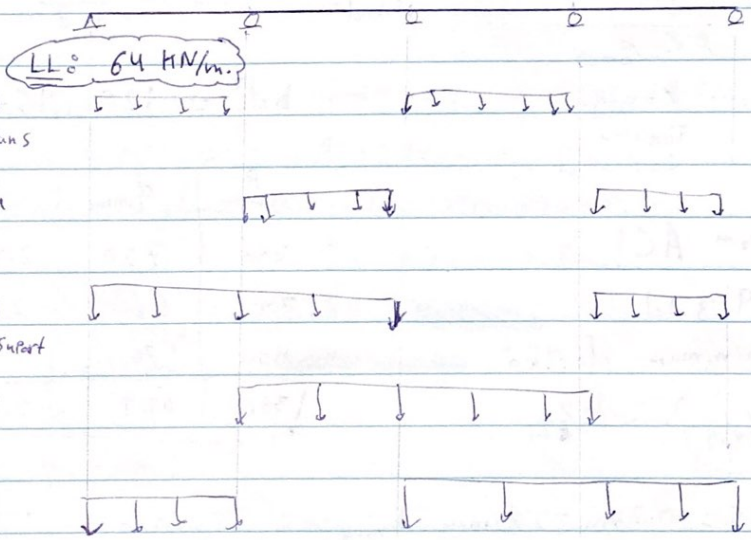
U = 1.2 DL + 1.6 LL = 184 KN/m.

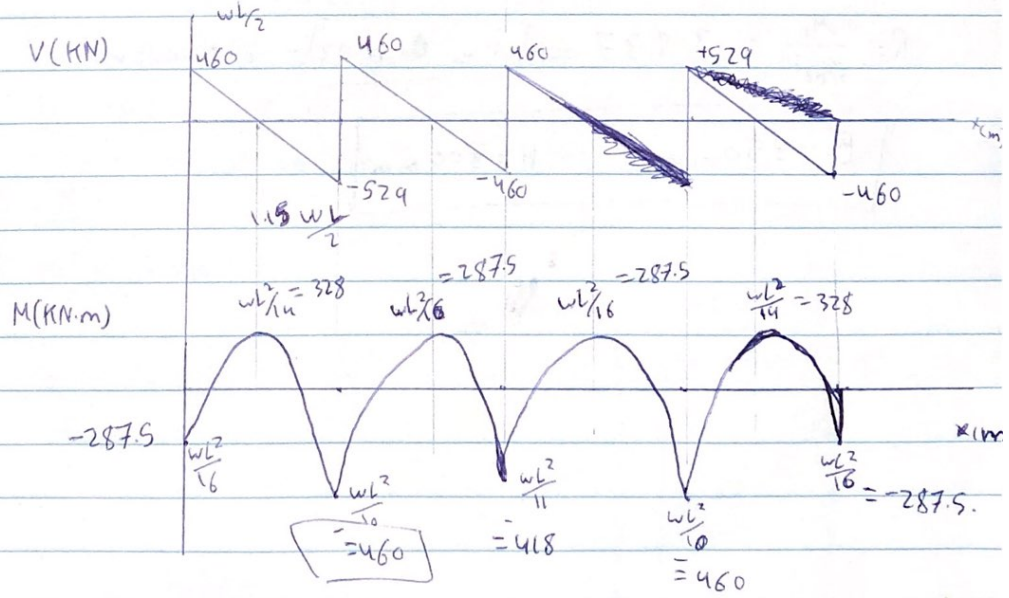
Influence Line:











[3] $f_c' = 28\,MPa$, $f_y = 420\,MPa$

table A.4.°

$\rho_{0.004} = \rho_{max} = 0.0206$ ~~$0.5\rho_{max} < \rho < 0.7\rho_{max}$~~

$\rho_{min} = 0.0033$ from range $\rho = 0.5\rho_{max}$

$\rho_{0.005} = 0.0181$ $\rho = 0.0103$

from Table A.5 a.° ufo * $B = (1.5-3)\,d$.

$R = 3.932\,MPa = \frac{M_n}{\phi bd^2} \rightarrow bd^2 = \frac{M_n}{R\phi}$

while $\rho < \rho_{0.005}$

$\therefore \phi = 0.9$. $\rightarrow bd^2 = 129\,987\,566.4$

Tension. Controlled

B (mm)	d (mm)	B/d
250	720	2.88
300	660	2.2
400	570	1.425
350	609	1.74

* from ACI

9.3.1.1

minimum depth.°

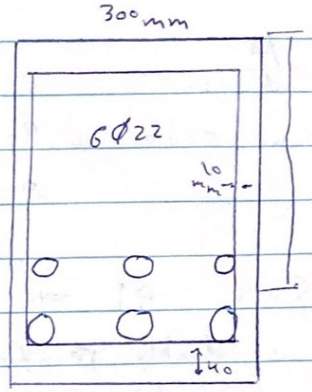
$L/18.5$, $L/21$

$L/18.5 = 0.27m = 270mm = h_{min.}$

$R = \frac{M_n}{\phi bd^2} = 3.937 \Rightarrow \rho = 0.0103 \rightarrow \phi = 0.9$ ✓

$B = 350mm$, $H = 700mm$

- Design for $M = 287.5$ KN.m



assume $\phi = 0.9$

2 layers : 6Ø22

$\Rightarrow d = 415.13$ mm

$R = \frac{M}{\phi b d^2} = 6.1788$ MPa

A.S.a : $\Rightarrow \rho = 0.01736 < \rho_{0.005}$

$\therefore \phi = 0.9$ ✓

$A_s = \rho b d = (0.01736)(300)(415.13) \Rightarrow a = 127.3$ mm $\quad S_{min} = 25.3$ mm

$A_s = 2162\ mm^2 \rightarrow$ A.2 : 6Ø22 $\rightarrow A_s = 2322\ mm^2$.

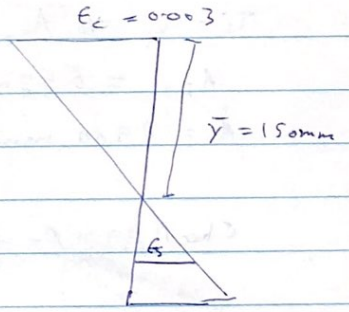
*check width : $300 - 2(50) - 3(22) - 25 = 0$

$S = 67$ mm $> S_{min}$.

*Check $\rho = \frac{A_s}{bd} = \frac{2322}{(300)(415.13)} = 0.0186$ [redacted]

$C = T$ [redacted] $\Rightarrow 0.85 f_c' a b = A_s f_y$ (calculated)

[redacted] $\bar{y} = \frac{a}{\beta_1} = 150$ mm



$\epsilon_s = \frac{\epsilon_c (415.13 - 150)}{150} = 0.0053 > 0.005$

$\phi = 0.9$.

$\rho > \rho_{0.005} \Rightarrow C = T \Rightarrow 0.85 f_c' a b = A_s f_y$ (Pre.)

$a = 135.6$ mm $\Rightarrow \bar{y} = 160$ mm

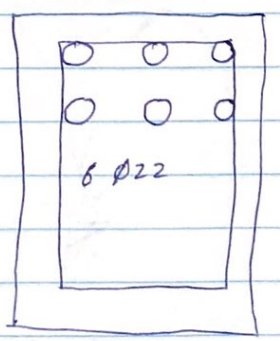
$\epsilon_s = 0.00478 \Rightarrow \phi \neq 0.9$, $\phi = 0.88$.

$\phi M_n = \phi A_s f_y (d - a/2)$

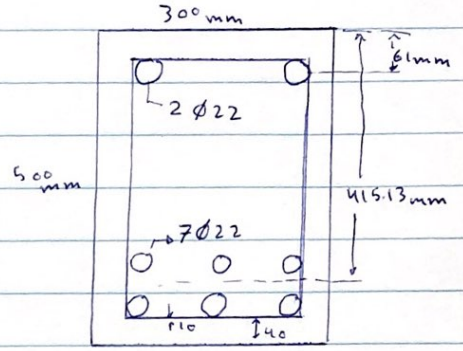
$= 298.75$ KN.m $> M_u$ ✓

- Design for $M = -287.5$ KN.m.

Same Reinforcement above.



- Design for $M_u = 328\ KN.m$



A.4 ∴ $0.003 < \rho < 0.0206$

$R = \frac{M_u}{\phi b d^2}$

assume $\phi = 0.9 \rightarrow R = 7.049\ MPa$

$\rightarrow \rho = 0.020477 > \rho_{0.005}$

$< \rho_{.004}$

$\therefore \phi \neq 0.9$

When $\phi < 0.9 \quad \therefore R? \rightarrow \rho > \rho_{max.}$

$\therefore$ doubly reinforcement.

$d' = 40 + 10 + 11 = 61\ mm.$

$s_{min} = 25.3\ mm$

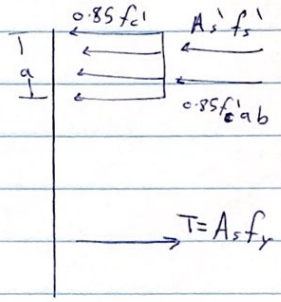
$\frac{d'}{d} = 0.147 > 0.13$

Steel in Compression Side will not Yeild.

Take $\rho = 0.018 \rightarrow A_{s_1} = \rho b d = 2242 mm^2$

$T_1 = C_c \rightarrow 0.85 f_c' a b = A_{s_1} f_y$

$\rightarrow a = 132mm. \rightarrow \bar{y} = 155mm.$



$\epsilon_s = 0.005035$ Tension Controled.

$\epsilon_s' = 0.00182 < 0.002$ not Yeild.

$f_s' = 363.87\ MPa.$

(A) $\cdots T_2 = C_s \Rightarrow A_s' f_s' = A_{s_2} f_y$

$M_{n_1} = R b d^2 \phi = (6.36)(300)(415.13)^2 (0.9)$

$M_{n_1} = 296\ KN.m.$

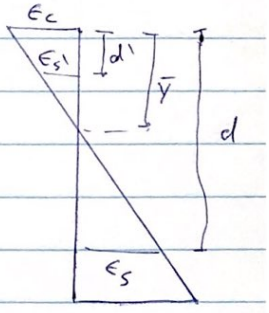
$\phi M_{n_2} = M_u - \phi M_{n_1} = 328 - 0.9(296)$

$\phi M_{n_2} = 61.6\ KN.m. \rightarrow M_{n_2} = A_s' f_s' (d - d')$

$A_s' = 531\ mm^2$

(B) ∴ $(531)(363.87) = A_{s_2}(420)$

$A_{s_2} = 460\ mm^2.$



$A_s = A_{s_1} + A_{s_2} = 2702\ mm^2.$

$A_s' = 531\ mm^2 \quad A_s = 2702\ mm^2$ • check width ✓. ok.

A.2 ∴ 2Ø22 | 7Ø22

$A_s = 774 mm^2 \quad A_s = 2709 mm^2$

$T = C \therefore A_s f_y = 0.85 f_c' a b + A_s' f_s'$, assume $f_s' = 363.87 MPa. \rightarrow a = 120mm \rightarrow \bar{y} = 141mm$

$\rightarrow \epsilon_s' = 0.0017 \rightarrow f_s' = 340 MPa$ (assume), $\rightarrow a = 122.5mm, \bar{y} = 144mm \rightarrow f_s' = 346 MPa$

$\rightarrow \epsilon_s = 0.00565 > 0.005 \therefore \phi = 0.9$ | $\phi M_n = \phi A_s' f_y' (d - d') + \phi\, 0.85 f_c' a b (d - a/2) = 363.9\ KN.m > M_u$ //.

- Design for $M_u = -460\ kN.m$.

assume $\phi = 0.9$. 2 layers.

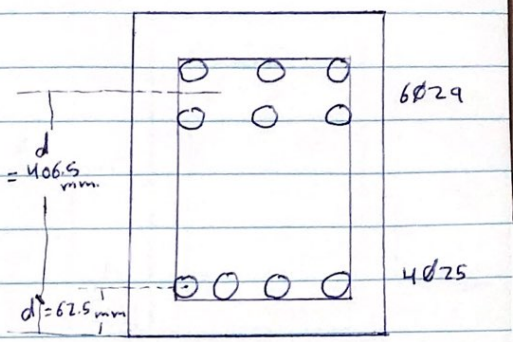
$R = \frac{M_u}{\phi b d^2} = 10.31$ not exist in table.

$d = 500 - 50 - \frac{29}{2} \approx 429 = 406.5\ mm$

$S_{min} = 29mm$.

$\therefore$ doubly reinforcement.

$d' = 40 + 10 + \frac{25}{2} = 62.5\ mm$.



Take $\rho = 0.018 \Rightarrow R = 6.36 MPa \Rightarrow M_n = 284\ kN.m$

$\Rightarrow A_{s_1} = 2195\ mm^2$.

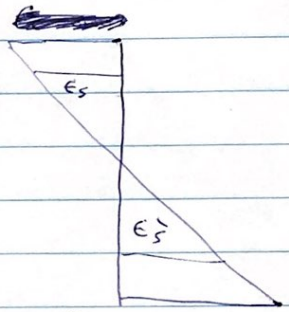
$T_1 = C_c \Rightarrow A_{s_1} f_y = 0.85 f_c' ab \Rightarrow a = 129mm$.

$\Rightarrow \bar{y} = 152mm \Rightarrow \epsilon_s = 0.005023$.

$\epsilon_s' = 0.001766$ not yeild $\Rightarrow f_s' = 353\ MPa$.

$\frac{d'}{d} = 0.154 > 0.13$

steel in Compresion Side not Yeild.



$\phi M_{n2} = M_u - \phi M_{n1} = 204.4\ kN.m$

$\phi M_{n2} = \phi A_s' f_s' (d - d') \Rightarrow A_s' = 1870\ mm^2$.

$A_{s_2} = \frac{A_s' f_s'}{f_y} = 1572 mm^2$

$A_s = 3767 mm^2$

$A_s' = 1870 mm^2$	$A_s = 3767 mm^2$	S_{min} of $25\phi = 25.3 mm$
A.2: 4Ø25	6Ø29	S_{min} of 29 bars $= 29mm$
$A_s = 2040 mm^2$	$A_s = 3870 mm^2$	check width ✓ ok.

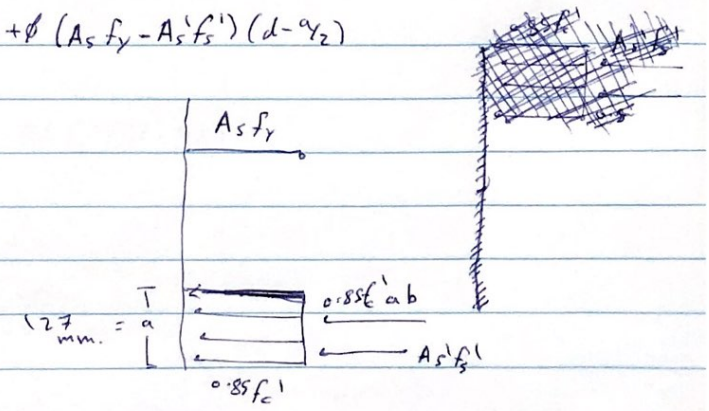
$T = C \Rightarrow A_s f_y = 0.85 f_c' ab + A_s' f_s'$

assume $f_s' = 353\ MPa \rightarrow a = 127mm \rightarrow \bar{y} = 149mm \rightarrow \epsilon_s' = 0.00174 \rightarrow f_s' = 348\ MPa$. ok

$\epsilon_s = 0.00518 > 0.005 \quad \therefore \phi = 0.9$ as I assumed.

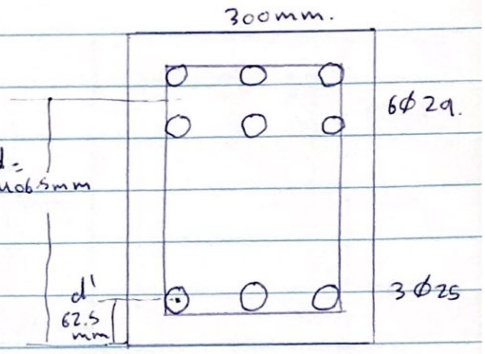
$\phi M_n = \phi M_{n1} + \phi M_{n2} = \phi A_s' f_s' (d - d') + \phi (A_s f_y - A_s' f_s') (d - a/2)$

$\phi M_n = 502.4\ kN.m > M_u$ //.



we can use reinforcement ~~as~~ designed for $M = -460\,kN.m$ here. (but for more economic).

- Design for $M_u = -418\ kN.m$.



assume $\phi = 0.9$, 2 layers.

$R = 9.37\ MPa$ not exist.

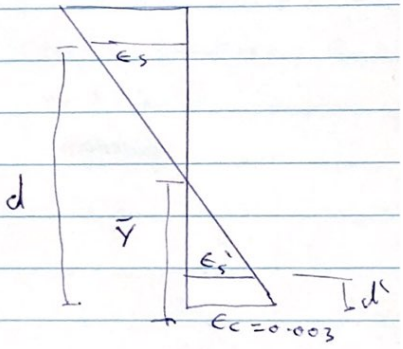
$d = 406.5\ mm$. , $d' = 62.5\ mm$.

∴ doubly reinforcement.

$\rho = 0.018 \rightarrow R = 6.36\ MPa \rightarrow M_{n_1} = 284\ kN.m$.

$\rightarrow A_{s_1} = 2195\ mm^2$.

$\phi M_{n_2} = M_u - \phi M_{n_1} = 162.4\ kN.m$



$T_1 = C_c \Rightarrow A_{s_1} f_y = 0.85 f_c' ab \Rightarrow a = 129\ mm \rightarrow \bar{y} = 152\ mm$

$\rightarrow f_s' = 353\ MPa$

$\Rightarrow \phi M_2 = \phi A_s' f_s' (d - d') \Rightarrow A_s' = 1486\ mm^2$

$\Rightarrow A_{s_2} = 1249\ mm^2$

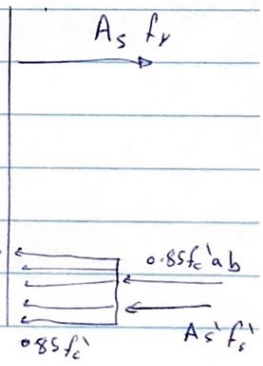
$A_s = 3444\ mm^2$, $A_s' = 1486\ mm^2$

A.2 $6\phi 29$ $3\phi 25$

$A_s = 3870\ mm^2$ $A_s' = 1530\ mm^2$

- check width ✓ o.k

$S_{min} = 29\ mm$ $S_{min} = 25.3\ mm$.



$T = C \Rightarrow A_s f_y = 0.85 f_c' ab + A_s' f_s'$

assume $f_s' = 353\ MPa$

$a = 152\ mm \rightarrow \bar{y} = 179\ mm \rightarrow f_s' = 390\ MPa$

assume $f_s' = 390\ MPa$, $a = 144\ mm \rightarrow \bar{y} = 170\ mm \rightarrow f_s' = 380\ MPa$.

assume $f_s' = 380\ MPa$, $a = 146\ mm \rightarrow \bar{y} = 172\ mm \rightarrow f_s' = 382\ MPa$.

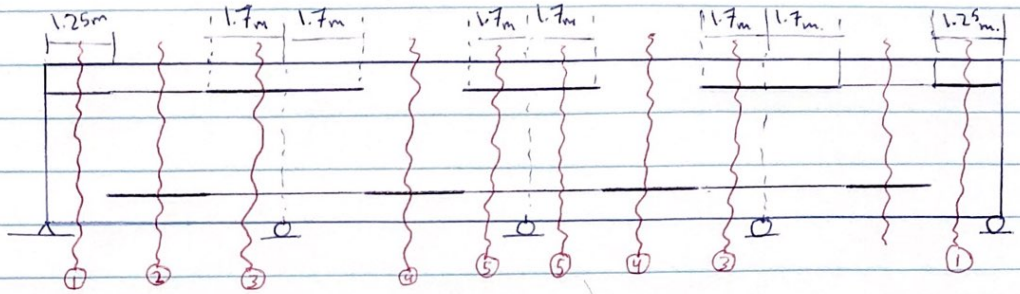
not Yeild $\rightarrow$. $\epsilon_s' = 0.0019 < 0.002$

$\epsilon_s = 0.00409$. Tension Controlled

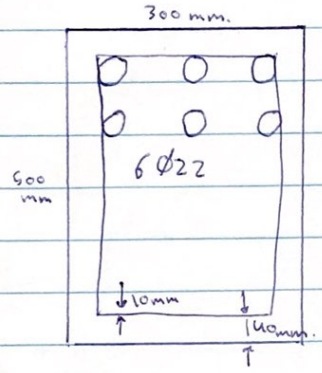
$\phi \neq 0.9$, $\phi = 0.82$.

$\phi M_n = \phi A_s' f_s' (d - d') + \phi (A_s f_y - A_s' f_s') (d - a/2)$

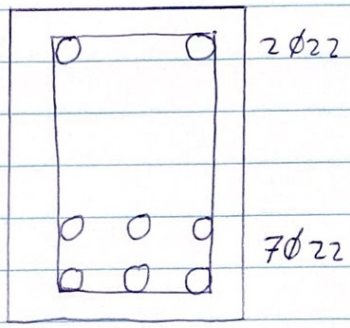
$\phi M_n = 449.53\ kN.m > M_u$ //.



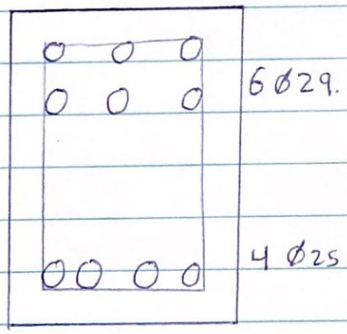
- Section ①:



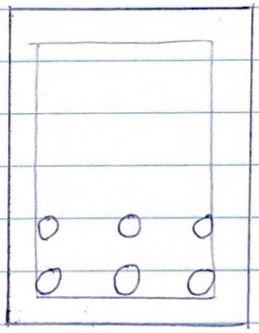
- Section ②:



- Section ③:



- Section ④:



- Section ⑤:

d_s = 10mm

Cover = 40 mm.