

Home work #2 / ENCE335.

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$H_{min} = \frac{L}{8} = \frac{2.625}{8} = 328.125 \text{ mm}$

* Assume:

$H = 950 \text{ mm}$

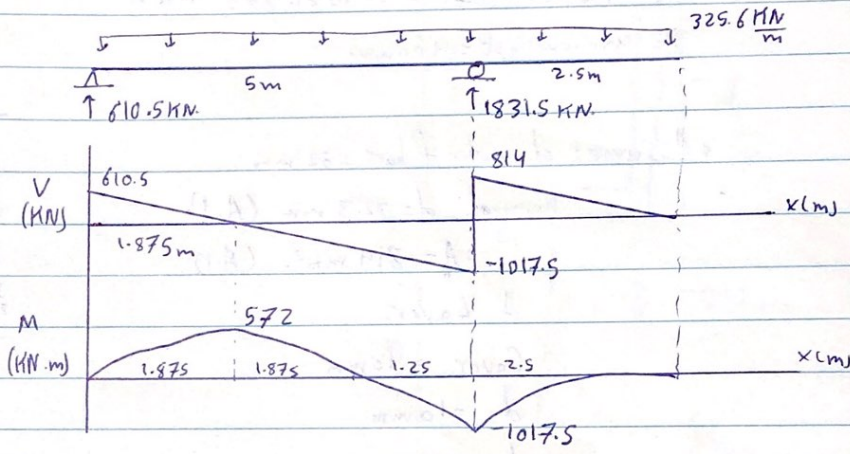
$B = 350 \text{ mm}$

$S.W = 0.35 \times 0.95 \times 1 \times 24$

$S.W = 7.98 \approx 8 \text{ kN/m}$

$V = 1.2D + 1.6L$

$= 325.6 \text{ kN/m}$



initially $M_{-}(\text{Max}) = 1017.5 \text{ kN.m}$

$M_{+}(\text{Max}) = 572 \text{ kN.m}$

* Assume: $\rho = 0.5 \rho_{max} \Rightarrow \rho_{max} = 0.0206 \text{ (A.4)}, \phi = 0.9$

$\rho = 0.0103 \rightarrow \text{(A.5.a)} \rightarrow R = 3.932 \text{ MPa}$

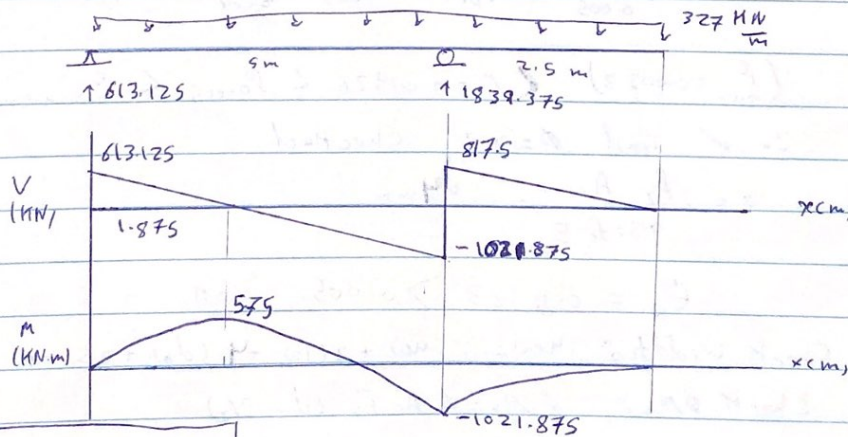
$R = \frac{M_u(\phi)}{\phi B d^2} = 3.932 \text{ MPa} \rightarrow B d^2 = 287.5 \times 10^6$

$\therefore H = 950 \text{ mm}, B = 400 \text{ mm}$

B	d	$\frac{d}{B}$
350	906	≈ 2.6
400	848	≈ 2
450	800	≈ 1.77
500	758	≈ 1.5

Recalculate M_u : $S.W = 9.12 \text{ kN/m}$

$U = 327 \text{ kN/m}$



$M_{-}(\text{Max}) = 1021.875 \text{ kN.m}$
 $M_{+}(\text{Max}) = 575 \text{ kN.m}$

ii) Design for negative moment

~~$M_u = 1021.875$~~ $M_u = 1021.875 \text{ kN.m}$

$H = 950 \text{ mm}$, $B = 400 \text{ mm}$

* Assume: diameter of bars = 32 mm

nominal $d = 32.3 \text{ mm}$ (A.1)

$A_b = 819 \text{ mm}^2$ (A.1)

1 Layer.

Cover = 40 mm

$d_s = 10 \text{ mm}$

$\rightarrow d = 884 \text{ mm}$

$\rightarrow S_{min} = \max \left[\frac{u}{3} \cdot 99, 25, d_b = 32 \right]$

$S_{min} = 32 \text{ mm}$

• find ρ :

$R = \frac{M_u}{0.9 B d^2} = \frac{1021.875 \cdot 10^6}{(0.9)(400)(884)^2} = 3.63 \text{ MPa}$

(A.5): $\rho = 0.00942$

$A_s = \rho B d = 3331 \text{ mm}^2 \rightarrow$ (A.2): # of bars = 4

$\rightarrow A_s = 3276 \text{ mm}^2$

• check ρ : $\rho = \frac{A_s \text{ Provided}}{B d} = 0.00926$

(A.4): $\rho_{min} = 0.0033$, $\rho_{0.005} = 0.0181$, $\rho_{max} = \rho_{0.004} = 0.0206$

$(\rho_{min} = 0.0033) \left\langle \rho = 0.00926 \right\rangle \rho_{0.005} < \rho_{0.004} < \rho_{max}$

$\therefore \checkmark$ and $\phi = 0.9$ checked.

$a = \frac{f_y A_s}{0.85 f_c' B} = 144 \text{ mm}$

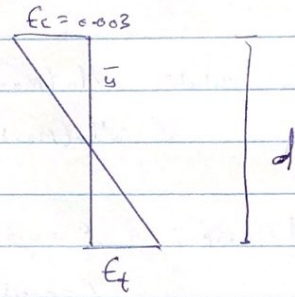
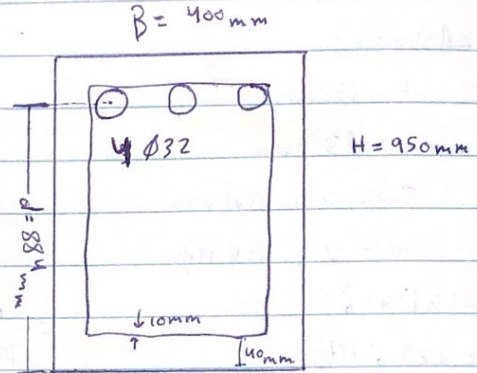
$\epsilon_s = 0.0123 > 0.005$ ok

Check width: $400 = 2(40) + 2(10) + 4(d_b) + 35 \Rightarrow S = 57.3 \text{ mm} > S_{min}$

Check ϕM_n : $\phi M_n = \phi A_s F_y (d - a/2)$

$= 1003 \text{ kN.m} < M_u$

Redesign \rightarrow



* Assume $5 \phi 32$

Cover = 40 mm

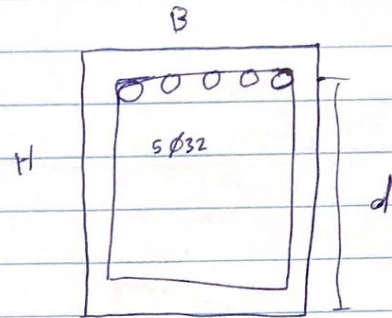
1 layer

$d_s = 10 \text{ mm}$

$d = 884 \text{ mm}$

$S_{\min} = 32 \text{ mm}$

$\beta_1 = 0.85$ (A.4)



find ρ

$$R = \frac{M_u}{0.9 B d^2} = 3.63 \text{ MPa}$$

$$\rho = 0.00942$$

$$A_s = 3331 \text{ mm}^2$$

$$A_{s \text{ provided}} = 4095 \text{ mm}^2 \rightarrow \alpha = \frac{f_y A_s}{0.85 f_c' B} = 180 \text{ mm}$$

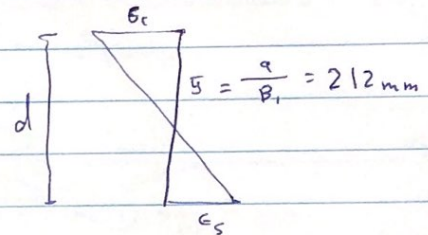
• check width: $400 = 100 + 5(d/b) + 45 \Rightarrow S = 35 \text{ mm} > S_{\min} \checkmark$

• check $\epsilon_t = 0.0095 > 0.005 \quad \therefore \phi = 0.9$

• $\rho = 0.0116 < \rho_{0.005} = 0.0181$, $\rho > \rho_{\min} = 0.0033$

• $\phi M_n = \phi A_s f_y (d - \frac{a}{2})$

$$\phi M_n = 1204 \text{ kN.m} > M_u \checkmark$$



• Design for Positive moment $\rightarrow M_u = 575 \text{ KN.m}$

$H = 950 \text{ mm}$, $B = 400 \text{ mm}$

* Assume diameter $\phi = 32 \text{ mm}$

$$d_n = 32.3 \text{ mm}$$

1 Layer, $\phi = 0.9$

Cover = 40 mm

$d_s = 10 \text{ mm}$

$$\rightarrow d = 884 \text{ mm}$$

$$\rightarrow S_{\min} = 32 \text{ mm}$$

find ρ :

$$\rho = \frac{575 \times 10^6}{(0.9) \times 400 \times (884)^2} = 2.044 \text{ MPa}$$

$$(A.S.) \rho = 0.00501 \rightarrow A_s = 1772 \text{ mm}^2$$

$$\rightarrow (A.2) \text{ : \# of bars} = 3$$

$$\rightarrow A_{s.p} = 2457 \text{ mm}^2$$

$$\rightarrow a = \frac{A_s f_y}{0.85 \rho f_c'} = 108 \text{ mm}$$

$$\text{Check } \epsilon_t \text{ : } \rightarrow \epsilon_s = 0.01788 > 0.005 \therefore \phi = 0.9 \quad \checkmark$$

$$\therefore \text{Check } \rho = \frac{A_s}{B d} = 0.00695 > \rho_{\min} = 0.0033$$

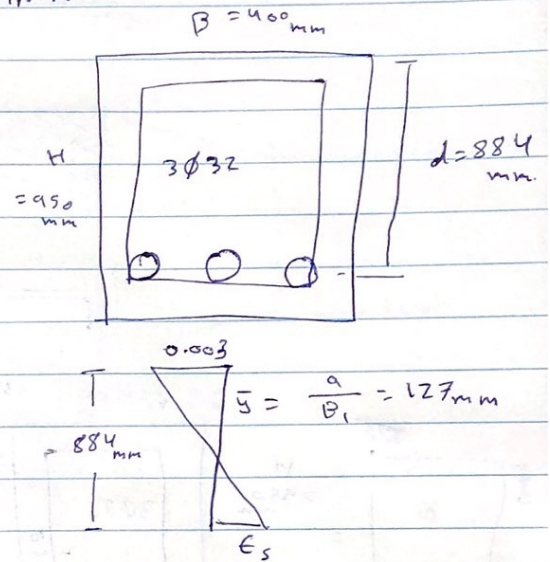
$$\rho < \rho_{0.005} = 0.0181 \quad \checkmark$$

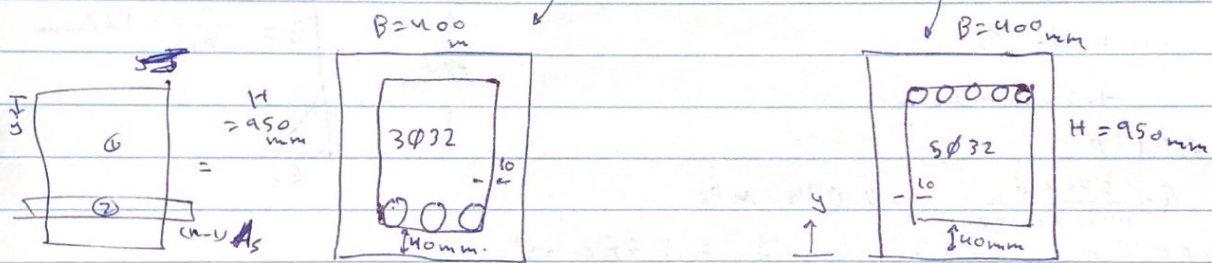
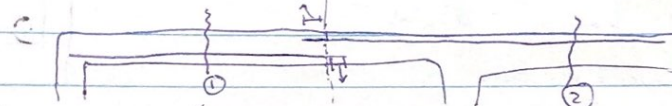
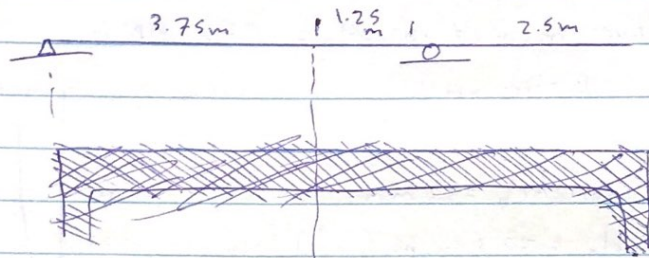
• Check width $\phi u_{00} = 100 + 3(32.3) + 2S$

$$S = 101.55 \text{ mm} > S_{\min} = 32 \text{ mm} \quad \checkmark$$

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

$$\phi M_u = 762 \text{ KN.m} > M_u = 575 \text{ KN.m} \quad \checkmark$$





$$M_u = 575 \text{ KN.m}$$

$$M_u = -1021.875 \text{ KN.m}$$

$$f_c' = 28 \text{ MPa} \rightarrow f_r = 3.28 \text{ MPa}$$

$$n = 8$$

	$A \text{ mm}^2$	$\bar{y} \text{ mm}$	AS
①	380000	475	
②	16880	884	

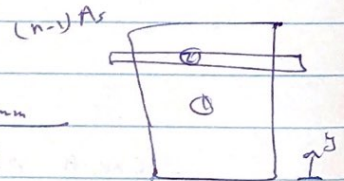
$$\bar{y} = 492 \text{ mm}$$

	$I + Ad^2$
①	28.689×10^9
②	0+

$$\Sigma I + Ad^2 = 31.28 \times 10^9 \text{ mm}^4$$

$$M_{cr} = \frac{f_r I}{y} = 208.55 \text{ KN.m}$$

$$M_u = 575 \text{ KN.m}$$



	$A \text{ mm}^2$	$\bar{y} \text{ mm}$
①	380000	475
②	28134.41	884

$$\bar{y} = 503 \text{ mm}$$

	$I + Ad^2$
①	
②	0+

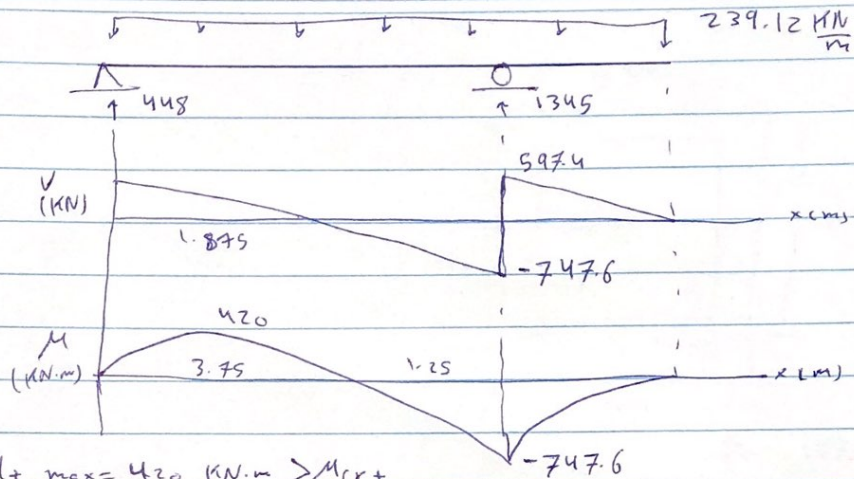
$$\bar{I} = 33 \times 10^9 \text{ mm}^4$$

$$M_{cr} = \frac{f_r \bar{I}}{y} = 215 \text{ KN.m} \ll M_u$$

$$U = D + L$$

$$= 139.12 + 100$$

$$= 239.12 \text{ KN/m}$$

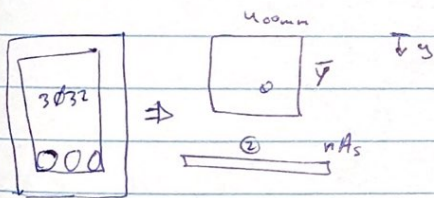


$$M_{+ \text{ max}} = 420 \text{ KN.m} > M_{cr+}$$

$$M_{- \text{ max}} = 747.6 \text{ KN.m} > M_{cr-}$$

∴ Phase 2 ° Linear Cracked °

Section ① °



	A	\bar{y}	$A\bar{y}$
①	$400\bar{y}$	$\bar{y}/2$	$200\bar{y}^2$
②	19292	884	17054128

$$\bar{y} = \frac{200\bar{y}^2 + 17054128}{400\bar{y} + 19292}$$

$$200\bar{y}^2 + 19292\bar{y} - 17054128 = 0$$

$$\bar{y}^2 + 96.26\bar{y} - 85270.64 = 0$$

$$\bar{y} = 248 \text{ mm}$$

$$\bar{I} = 9.84 \times 10^9 \text{ mm}^4$$

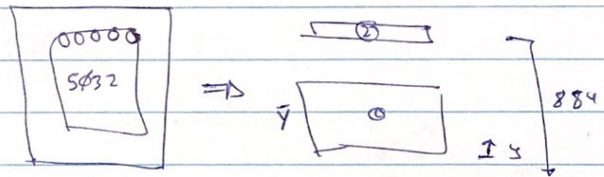
$$\sigma_{\text{Comp, Con}} = \frac{(M_{+ \text{ max}}) Y}{I} = 10.585 \text{ MPa}$$

$$\sigma_{\text{Tens, Concrete}} = 0$$

$$f_s, \text{ Tension} = n \sigma_s = 8 \frac{(420) 10^6 (636)}{I}$$

$$f_s = 217 \text{ MPa}$$

Section ② °



#	A mm ²	\bar{y}	$A\bar{y}$
①	$400\bar{y}$	$\bar{y}/2$	$200\bar{y}^2$
②	8(4019)	884	

$$\bar{y}^2 + 160\bar{y} - 142119 = 0$$

$$\bar{y} = 305 \text{ mm}$$

$$\bar{I} = 14.56 \times 10^9 \text{ mm}^4$$

$$\sigma_{\text{Comp}} = 15.66 \text{ MPa}$$

$$\sigma_{\text{Tens, C}} = 0$$

$$f_s = n \sigma_s = 8 (29.73) = 237.8 \text{ MPa}$$