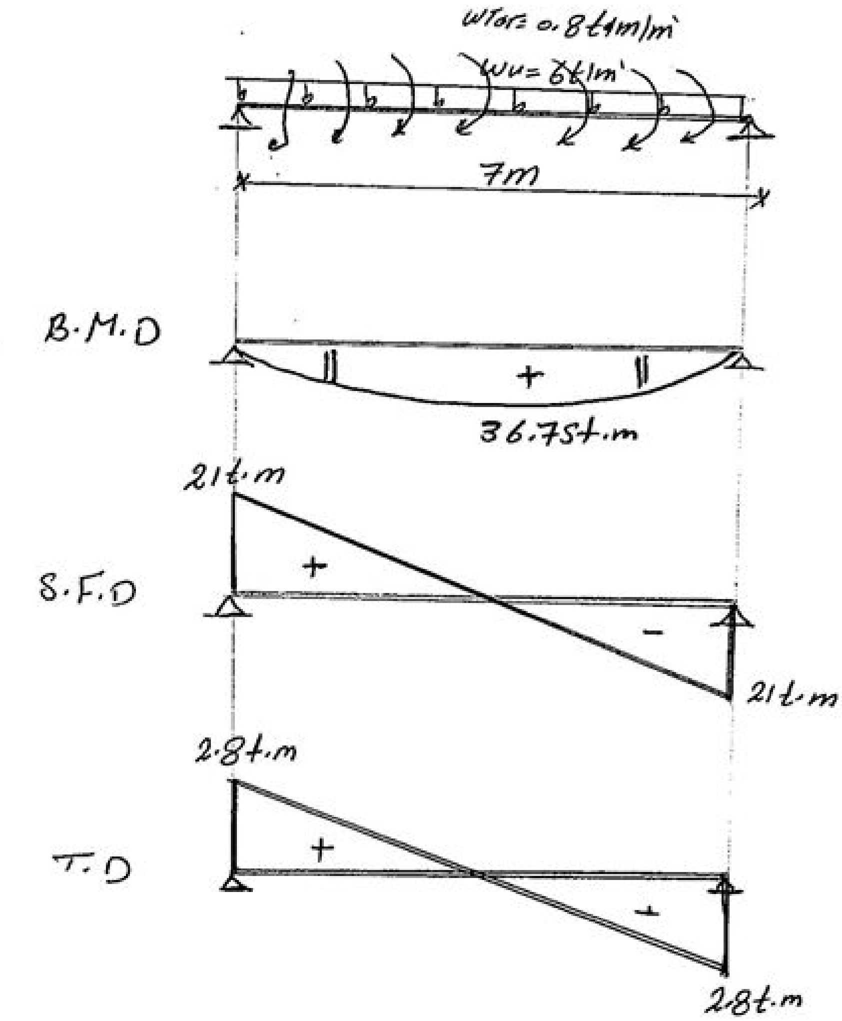
Final exam 2012

قسم الهندسة المدنية

Q1 (A) Design the shown beam due to moment & shear & Torsion.

b = 30 cm



Assum 30 X 80 cm

① Design beam due to shear & Tor

Shear

* $q_u = \frac{21 \times 1000}{75 \times 30} = 9.3\ kg/cm^2$

* $\delta_{si} = \frac{1}{\sqrt{1 + \left(\frac{11.7}{9.3}\right)^2}} = 0.62$

* $q_{cu} = 0.62 \times 0.75 * \sqrt{\frac{f_{cu}}{\gamma_c}} = 6\ kg/cm^2$

* $q_{max} = 0.62 \times 2.2 \sqrt{\frac{250}{1.5}} = 17.6\ kg/cm^2$

$q_{cu} < q_u < q_{max}$

* $q_{su} = q_u - \frac{q_{cu}}{2}$

$= 6.3\ kg/cm^2$

* $q_{su} = \frac{n\ A_{str}\ F_y/\gamma_s}{S\ b}$

$6.3 = \frac{2 * A_{str}\ F_y}{S \times 30 \times 1.15}$

$A_{str} = 108.7 \frac{S}{F_y}$

Torsion

$q_{tu} = \frac{3\ M_{tu}}{t\ b^2}$

$= \frac{3 \times 2.8 \times 10^5}{80 \times 30^2} = 11.7\ kg/cm^2$

$\delta_{ti} = 0.78$

* $q_{cut} = 0.78 \times 0.75 * \sqrt{\frac{250}{1.5}} = 7.5\ kg/cm^2$

* $q_{mut} = 22.1\ kg/cm^2$

$q_{cu} < q_{ut} < q_{max}.$

* $q_{sut} = q_{tu} - \frac{q_{cut}}{2}$

$= 11.7 - \frac{7.5}{2} = 8\ kg/cm^2$

* $A_{st} = \frac{S * q_{sut} * b^2 t}{\alpha_t\ x_1\ y_1 \left(\frac{F_y}{\gamma_s}\right) * 3}$

* $x_1 = 25\ cm$

* $y_1 = 70\ cm$

$\alpha_t = 0.66 + 0.33 \times \frac{70}{25} = 1.58 \not> 1.5$

$$Ast = \frac{S * 8 \times 30^2 * 80}{1.5 \times 70 \times 25 \times \frac{Fy}{1.15} \times 3}$$

$$Ast = 84.11 \frac{S}{Fy}$$

$\therefore (Ast + Astr) = 192.8 \frac{S}{Fy}$

* use #10 → $Fy = 3600$ → $(Ast + Astr) = 0.785$

$\therefore S = 14.6\ Cm > 10\ cm$

$\therefore N = \frac{100}{S} = 6.8$ → 7#10/m'

لأعمدة الطاح — كانات مغلقة

$$* As_{long} = \frac{2\ Ast\ (x_1 + y_1)}{S} \left(\frac{Fy}{Fy}\right)$$

$$= \frac{2 * 84.11\ (25 + 70)}{3600} = 4.439\ Cm^2$$

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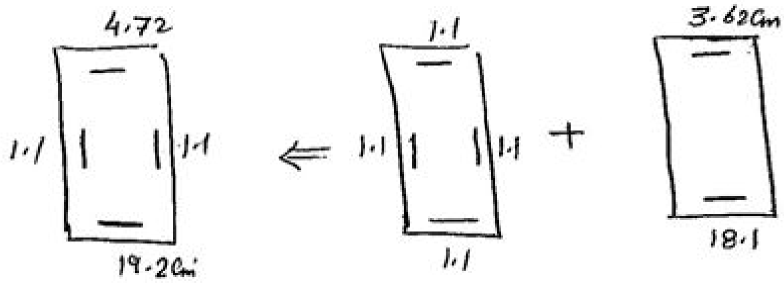
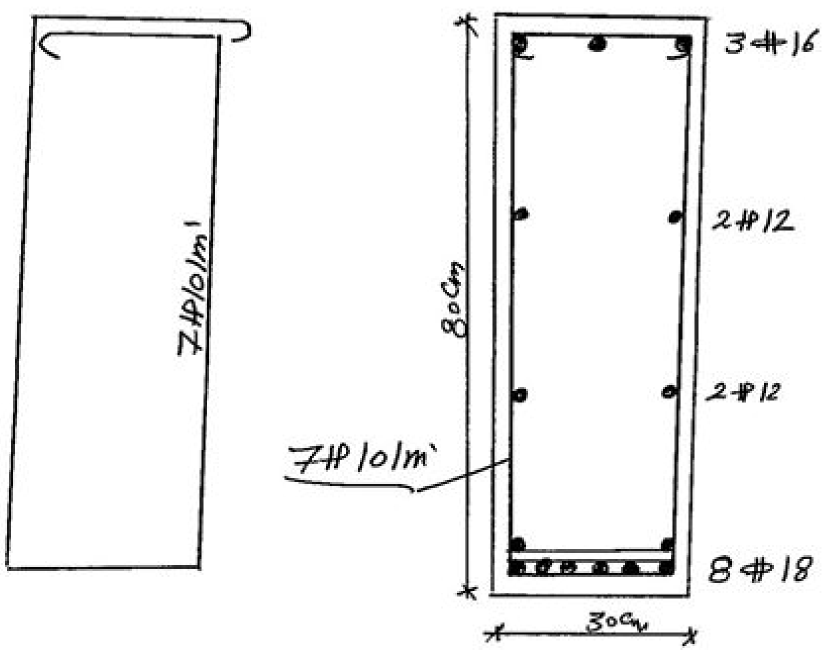
② Design Moment:-

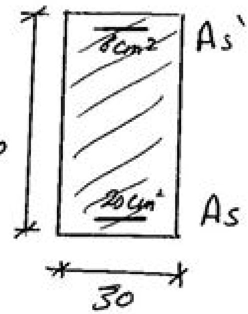
$$* d = C_1 \sqrt{\frac{36.75 \times 10^5}{250 \times 30}} \longrightarrow C_1 = 3.48$$

$$As = \frac{36.75 \times 10^5}{3600 * 0.75 * 75} = 18.1\ Cm^2.$$


4.72
1.1
1.1
19.2Cm
1.1
1.1
1.1
1.1
+
3.62Cm
18.1


7#10/m'
3#16
2#12
80Cm
2#12
7#10/m'
8#18
30Cm

(B) Check deflection :-



1. $M_u = 36.75 \; t.m$

2. $M_{ap} = 24.5 \; t.m$

3. $W_{ap} = 4 \; t/m'$

4. $y_t = 40 \; cm$

5. $I_g = \frac{30 \times 80^3}{12} = 1280000 \; cm^4$

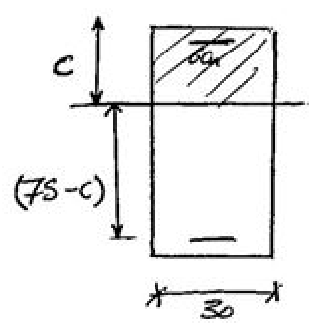
6. $F_{ctr} = 0.75 \, (250)^{2/3} = 29.8 \; kg/cm^2$

7. $E_c = 14000 \sqrt{250} = 221359.4 \; kg/cm^2$

8. $M_{cr} = \frac{f_{ctr} \, I_g}{y_t} = 9.5 \; t.m$

$$M_{ap} > M_{cr}$$

(1) get I_{cr} :-



$$\frac{bc^2}{2} + 15 \times 6 * (c-5) = 15 \times 20 (75-c)$$

$$15c^2 + 90c - 450 = 22500 - 300c$$

$$15c^2 + 390c - 22950 = 0.0$$

$$\therefore \boxed{C = 28.2 \, cm}$$

$\therefore I_{cr} = \frac{bc^3}{3} + nA_s'(c-5)^2 + nA_s(d-c)^2$

$= \frac{30 \times 28.2^3}{3} + 15 \times 6 \times (28.2-5)^2 + 15 \times 20(75-28.2)^2$

$I_{cr} = 929771.3\ Cm^4$

$\therefore I_e = \left(\frac{M_{cr}}{M_{ap}}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_{ap}}\right)^3\right] I_{cr}$

$I_e = 950189.8\ Cm^4$

$\therefore \Delta_I = \frac{5}{384} \frac{W L^4}{E_c I_e}$

$= \frac{5 \times 4 \times 10 \times (700)^4}{384 \times 221359.4 \times 950189} = 0.59\ Cm$

$\Delta_{act} = 0.59\ Cm$

$\Delta_{all} = \frac{L}{250} = \frac{700}{250} = 2.8\ Cm$

$\Delta_{act} < \Delta_{all} \longrightarrow$ ok

(C) Design spairal column to carry $P_u = -500t$

(1) $P_u = 0.4 F_{cu} A_c + 0.67 F_y A_{sc}$

$500 \times 10^3 = 0.4 \times 250 * A_c + 0.67 \times 3600 * 0.01 A_c$

$\therefore A_c = 4028.4 cm^2 = \frac{\pi D_c^2}{4}$

$D_c = 71.6 cm$

$\therefore \boxed{D_c = 80 cm}$

$\boxed{D_k = 75 cm}$

$* A_s = 0.01 A_c = 50.3 cm^2$

$* A_s = 0.012 A_k = 53 cm^2$ → 14 #22

$* [V_{sp}]_{mim} = 0.36 \left(\frac{f_{cu}}{F_{yp}}\right) \left(\frac{A_c}{A_k} - 1\right] A_k$

$= 0.36 \left(\frac{250}{2400}\right) \left(\frac{80^2}{75^2} - 1\right) \frac{\pi \times 75^2}{4}$

$[V_{sp}]_{mim} = 22.8 cm^2$

$$V_{sp} = \frac{\pi \, A_{sp} \, D_k}{P} = 22.8$$

$$\frac{\pi * 0.5 * 75}{P} = 22.8 \longrightarrow P = 5.16 \text{cm}$$

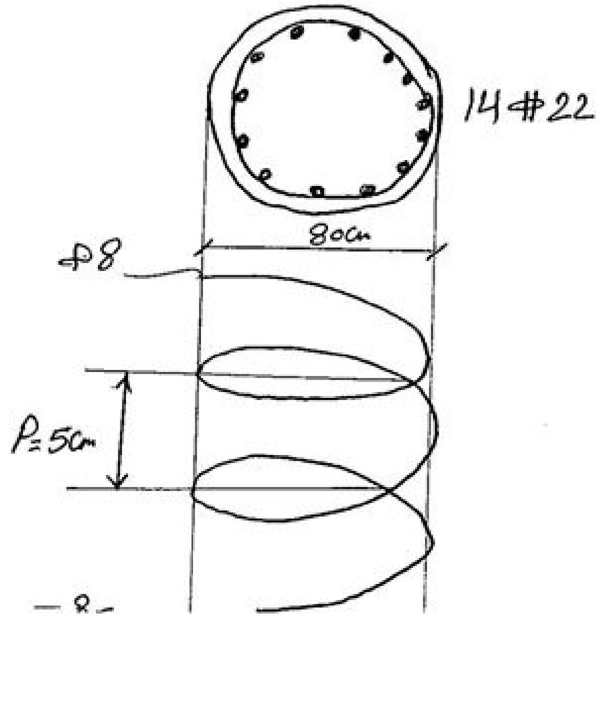
$\therefore P = 5 \text{ cm} \longrightarrow \Phi 8$ كانات مطلوبة

$$\therefore (V_{sp})_{act} = \frac{\pi * 0.5 \times 75}{5} = 23.5 \text{ cm}^2/\text{m}$$

$$\therefore P_u = 0.35 \, f_{cu} \, A_k + 0.67 \, f_y \, A_{sc} + 1.38 \, f_{yp} * V_{sp}$$

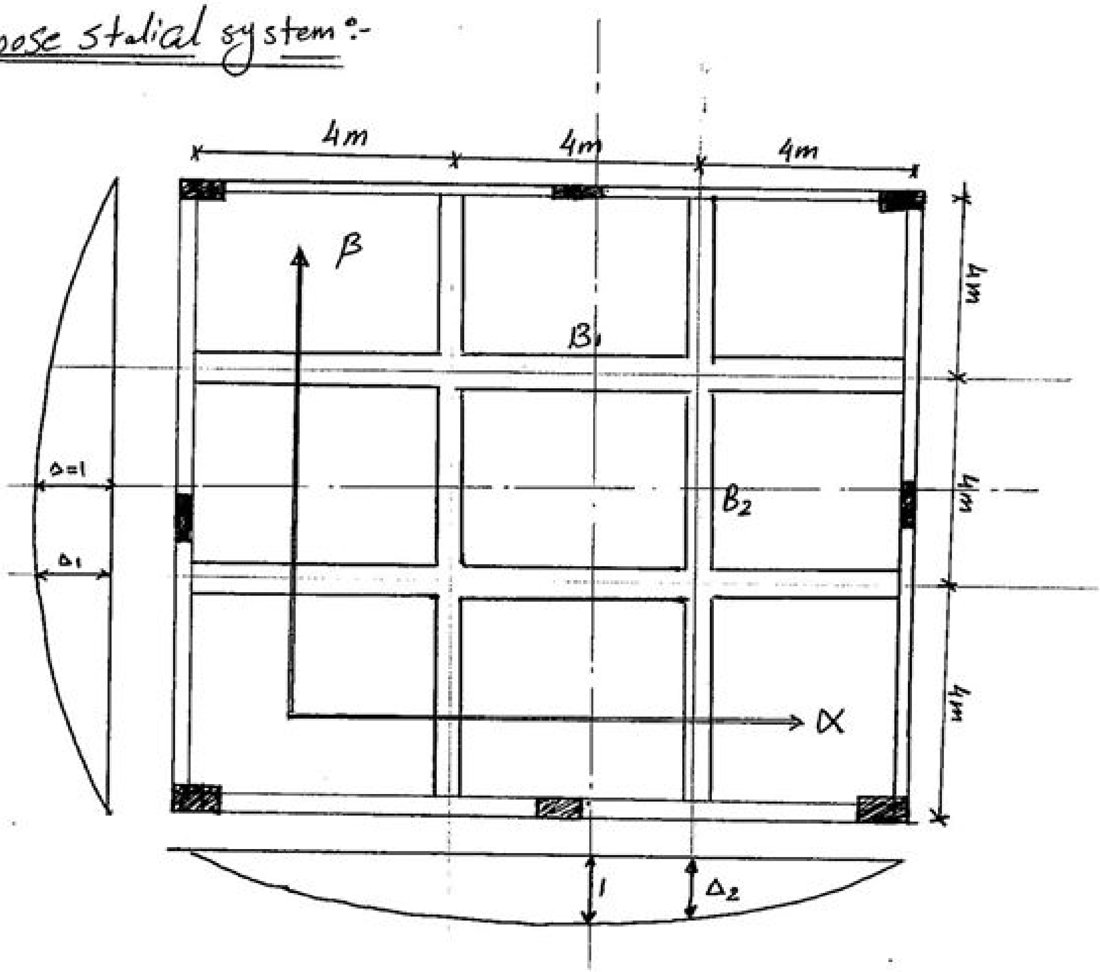
$$= 0.35 \times 250 * \frac{\pi \times 75^2}{4} + 0.67 * 3600 \times 14 * 3.8 + 1.38 \times 2400 \times 23.5$$

$$\boxed{P_u = 592 \, t} > P_{u\,all} \quad \text{ok.}$$



Q2 Area 12X12m^2:

① choose statical system :-



② get Conc. Dim :-

* $t_s = 12cm$ $b = 25cm$ $t = \frac{L}{14} = \frac{1200}{15} = 80cm$

③ get loads :-

* $w_{su} = (\gamma_c * t_s) + F.c + L.L) \times 1.5$

$= (0.12 \times 2.5 + 0.15 + 0.4) \times 1.5$

$W_{su} = 1.28 t/m^2$

* $o.W_{av} = 0.25 \times (0.8 - 0.12) \times 2.5 * \frac{4 \times 12}{12 \times 12}$

$o.W_{av} = 0.14\,t/m^2$

∴ $W_{av} = 1.4 \times 0.14 + 1.28$

∴ $W_{av} = 1.48\,t/m^2$

4] Design "B_2" → at β-dir

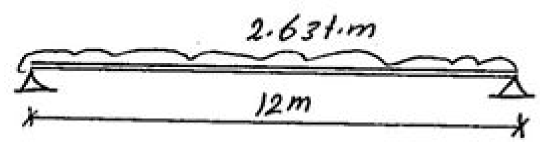
* $r = \frac{12}{12} \longrightarrow 1 \longrightarrow \alpha = \beta = 0.5$

* $W_u = W_{av} + c.c * \beta * \Delta$

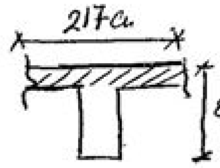
* $\Delta = 1 - \left(\frac{2}{6}\right)^2 = 0.89$

* $W_u = 1.48 * 4 \times 0.5 \times 0.89 = 2.63\,t/m'$

* $M_u = \frac{2.63 \times 12^2}{8} = 47.4\,t.m$

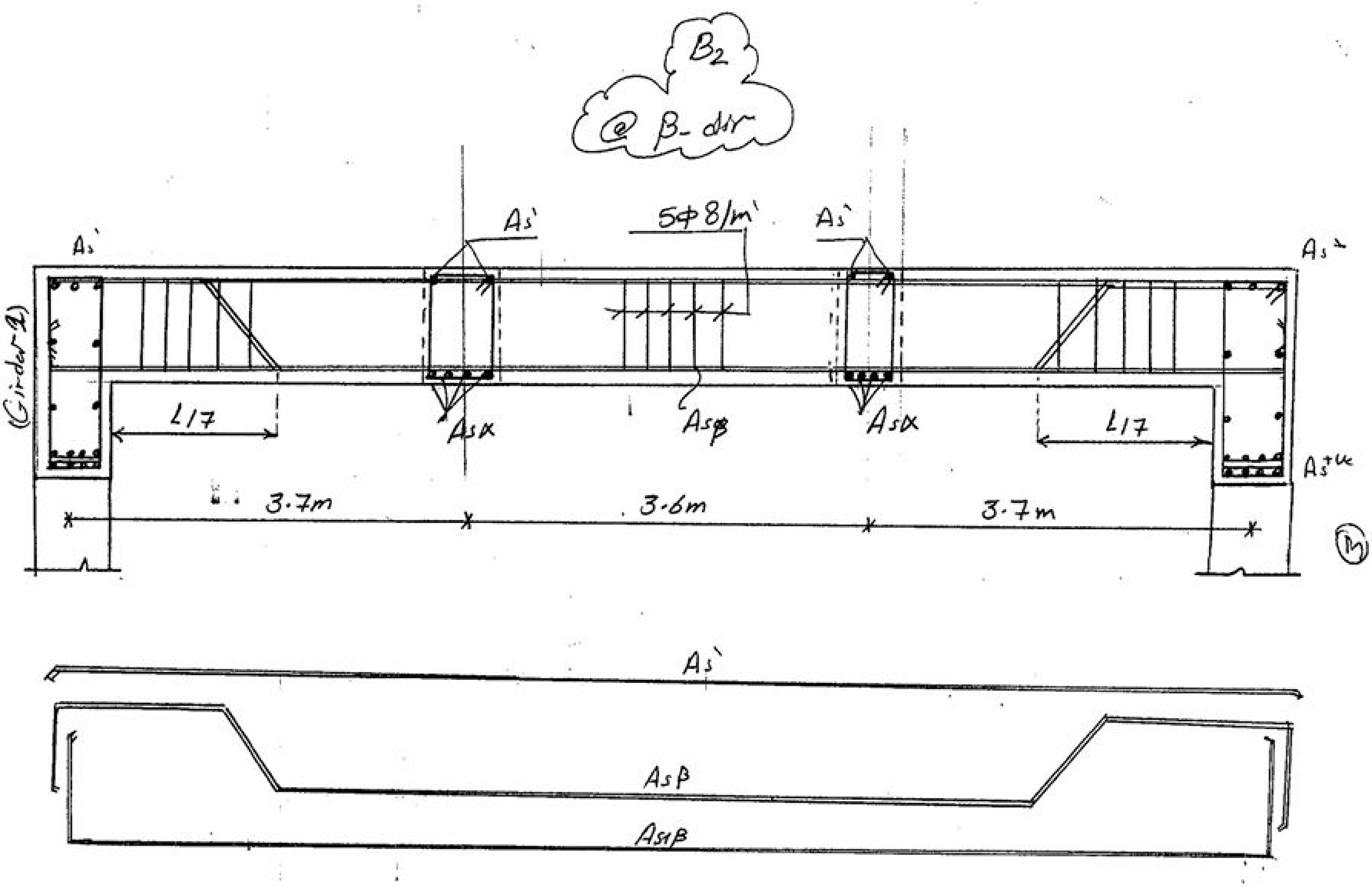


Beff → $16 \times 12 + 25 = 217\,cm$
→ $\frac{12}{5} + 25 = 265\,cm$
→ $400\,cm$
} → Beff = 217 cm



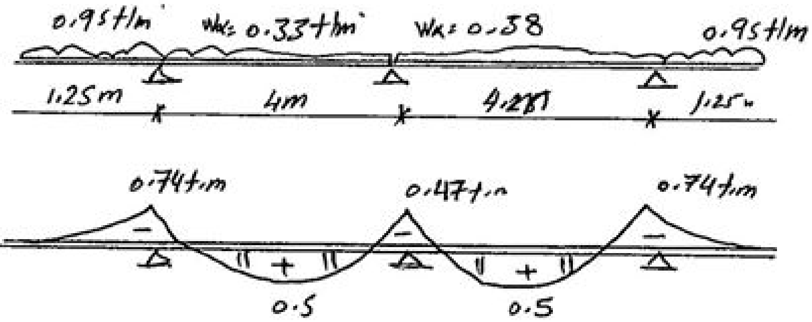
* $d = C_1 \sqrt{\frac{47.4 \times 10^5}{250 \times 217}} \longrightarrow C_1 = 8$

* $A_s = \frac{47.4 \times 10^5}{3600 \times 0.826 \times 73} = 21.8\,cm^2 \longrightarrow 9 \# 18$

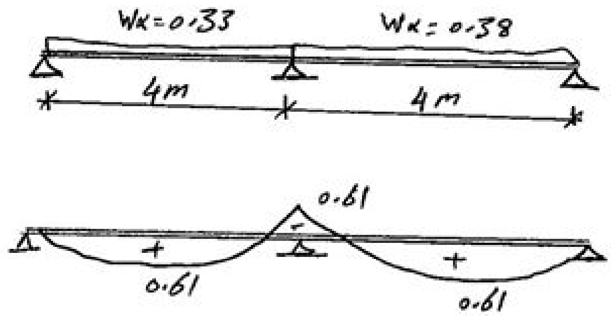

B2
@ β-dir
(Girder 2)
As'
5Φ8/m'
As'
As'
Asα
Asβ
Asα
L/7
L/7
3.7m
3.6m
3.7m
As'
Asβ
Asβ
3

© Take strips :-

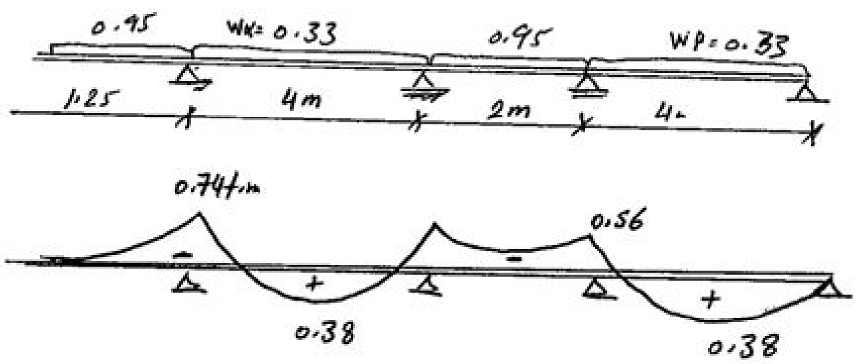
Strip ①

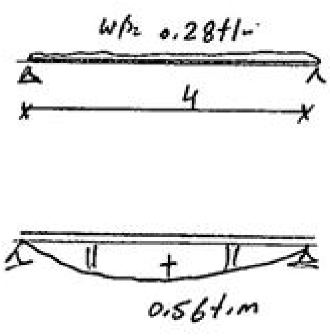


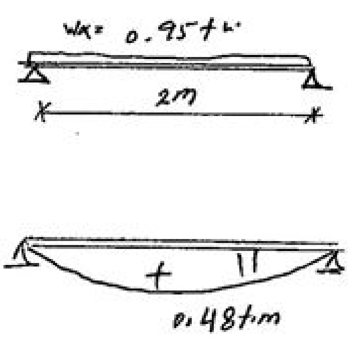
Strip ②

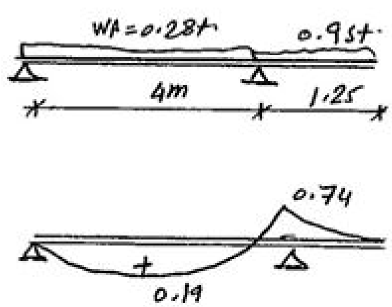


strip ③









① Design of sec:-

* $M_B^{+ve} = 0.56\ t.m$ $\qquad d = 12 - 2.5 = 9.5\ cm$

* $A_s = \dfrac{0.56\times10^5}{3600 * 9.5\times0.8} = 2\ cm^2 \rightarrow 5\#10/m'$

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* $M_\alpha^{+ve} = 0.74\ t.m$

* $A_s = \dfrac{0.74\times10^5}{3600\times10.5\times0.8} = 2.4\ cm^2 \longrightarrow 5\#10/m'$

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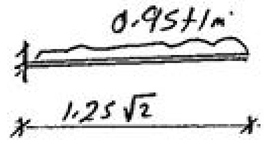
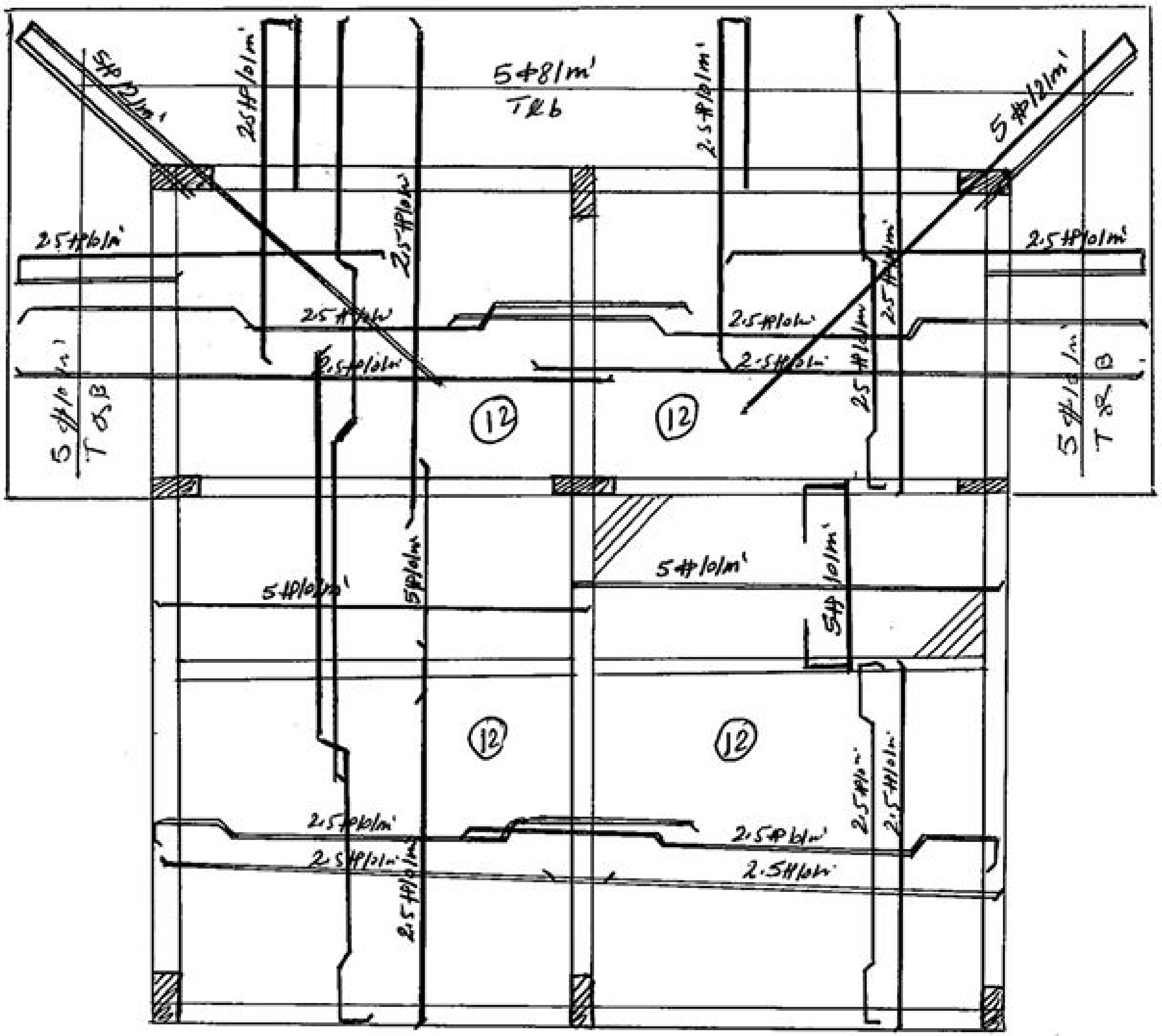
* تصميم الشوكة المرودة

* $M = \dfrac{0.95\times1.77^2}{2} = 1.48\ t.m$

* $d = C_1\sqrt{\dfrac{1.48\times10^5}{250\times100}} \longrightarrow C_1 = $



* $A_s = \dfrac{1.48\times10^5}{3600\times0.8\times10.5} = 4.89\ cm^2 \rightarrow 5\#12/m'$


5Φ8/m'
TRb
5Φ12/m'
5Φ12/m'
2.5Φ10/m'
2.5Φ10/m'
5Φ10/m'
12
12
12
12

Q4 ① Column "C1"

Col. No	Pu	Lx	Ly	Mx	My
C1	198t	70cm	30	2.2	2.2

* $P_u = 1.1 \times 6 \times 30 = 198\,t$

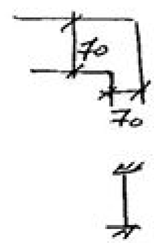
* $P_u = 111.62\,A_c \longrightarrow A_c = 1773\,cm^2 \longrightarrow L_x = 59$

* $M_x = M_y = \dfrac{wL^2}{36} = \dfrac{5 \times 4^2}{36} = 2.2\,t.m$

① check buckling :-

x-dir

* $\lambda_x = \dfrac{3.5 \times 1.2}{0.7} = 6$



$\lambda_x < 10$

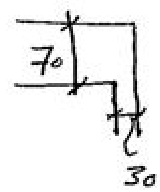
short

* $M_{add\,y} = $ Zero

* $M_y = 2.2\,t.m$

Y-dir

* $\lambda_y = \dfrac{3.5 \times 1.2}{0.3} = 14$



$\lambda_y > 10$

long

* $M_{add\,x} = \delta_y \cdot P_u$

* $\delta_y = \dfrac{14^2 * 0.3}{2000} = 0.0294\,m$

* $M_{add\,x} = 5.82\,t.m$

$M_x = 5.82 + 2.2 = 8\,t.m$

$* \ e_{min\,x} = \left.\begin{matrix} 2cm \\ 0.05 \times 0.7 \end{matrix}\right\} \text{— } 0.035\,m$

$e_{min\,y} = \left.\begin{matrix} 2\,cm \\ 0.05 \times 0.3 \end{matrix}\right\} \longrightarrow 2cm$

$* \ M_{y\,min} = 6.93\,t.m$

$(M_x)_{min} = 0.02 \times 198$

$=$

$M_y = 6.93\,t.m$

$M_x = 8.00\,t.m$

$\therefore M \rightarrow \frac{6.93}{0.65} = 9.9 \quad < \quad \frac{8}{0.35} = 26.7$

$\therefore M_x = 8 + \frac{6.93 * 0.25}{0.65} * 0.7 = 9.9\,t.m$

$* \ e = \frac{9.9}{198} = 0.05 \quad > \quad 0.05 \times 30 = 0.015$

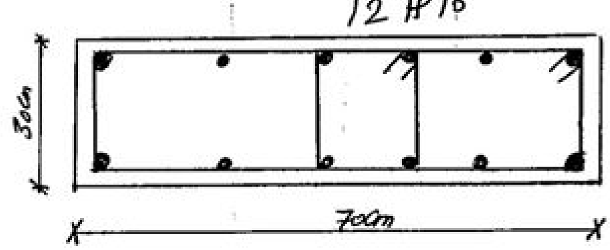
$* P_b = 102.7t \not< P_u$ ⟶ Comp. failure

$* \ \frac{P_u}{F_{cu} A_c} = 0.38 \qquad \frac{M_u}{f_{cu} L_x L_y^2} = 0.063$

$\rho = 5$

$A_s = 5 \times 250 \times 10^{-5} * 25 \times 70 = 21.9\,cm^2$

12 Φ16



C_2 Column

Col.No	Pu	Lx	Ly	Mx	My	
C_2	264	90	30	zero	zero	

* $P_u = 1.1 \times 40 \times 6 = 264\,t$

* $P_u = 111.62\,A_c \longrightarrow A_c = 2365\,cm^2 \longrightarrow L_x = 78.8\,cm$

① check buckling :-

x-dir

* $\lambda_x = \dfrac{K\,H_e}{L_x}$

$= \dfrac{1.3 \times 3.5}{0.9} = 5 < 10$

short

Y-dir

* $\lambda_y = \dfrac{1.2 \times 3.5}{0.3} = 14 > 10$

long

* $\delta_y = \dfrac{14^2 \times 0.3}{2000} = 0.0294\,m$

* $M_{add\,x} = 7.76\,t.m$

* $(e_y)_{min} = 2\,cm$, 0.05×0.3

* $(M_{min})_y = 5.28\,t.m$

$M_x = 7.76\,t.m$

* $e = \frac{7.76}{264} = 0.029$ > $0.05 \times 0.3 = 0.015$

* $P_u > P_b$

* $\frac{P_u}{A_c f_{cu}} = 0.39$ $\frac{M_u}{250 \times 30^2 \times 90} = 0.038$

$\rho = 4$

* $A_s = 4 \times 10^{-5} \times 250 \times 30 \times 90 = 27 cm^2$