Question No. 1

Fig. (1) Shows a sectional elevation of a column in a building ***braced in two directions.***

It is required to:

1- Design the column knowing that:

Pu = 2900 KN ***F_{cu} = 25 N/mm^2*** ***F_y = 360 N/mm^2***

2- Determine the moment design if there are Mu = 200 KN.m and -100 KN.m in t (1050 mm) direction.

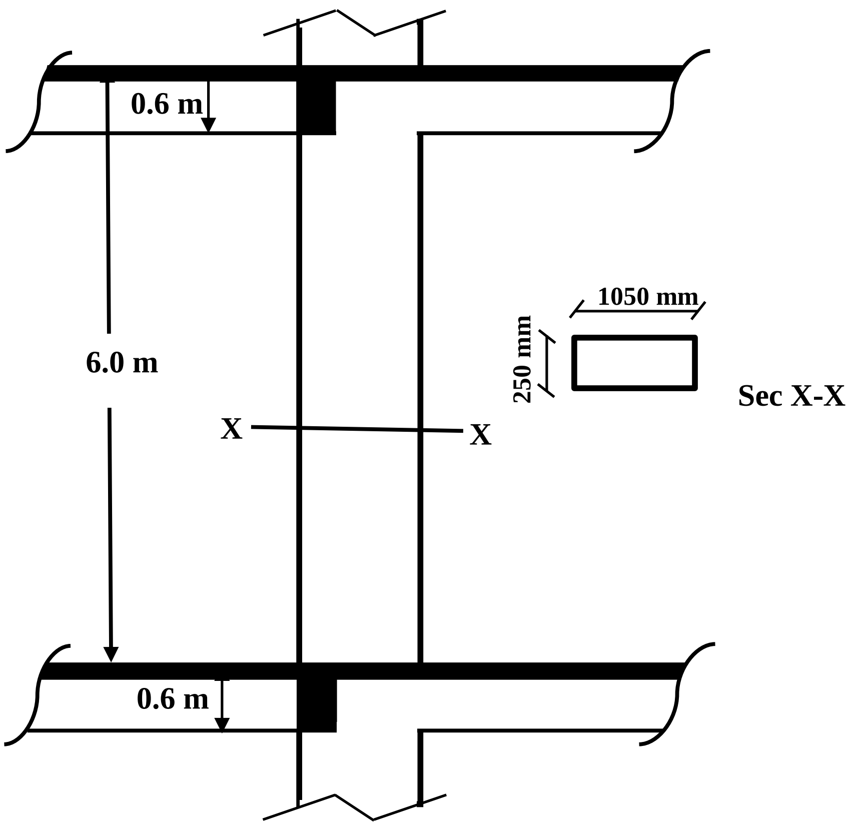

Fig. (1)

Given:

- Braced column
- H_f = 6 m
- M_1 = 200 KN.m
- b_c = 250 mm & t_c = 1050 mm
- Nu = 2900 KN
- M_2 = -100 KN.m

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Solution

1- Braced Column

2- Calculate Slenderness ratio

In plane (t – direction)

$$\lambda_{in} = \lambda_t = \frac{He}{t} = \frac{K\,x\,H_o}{t}$$

- For (K)

For upper part → partially fixed → Case (2)
For lower part → partially fixed → Case (2)
- From table (K = 0.85)

- For (H_o)

$H_o = H_f - t = 6 - 0.6 = 5.4$ m

$$\lambda_t = \frac{0.85\,x\,5.4}{1.05} = 4.37 < 15$$

∴ Column is short in plane

Out of plane (b – direction)

$$\lambda_{out} = \lambda_b = \frac{He}{b} = \frac{K\,x\,H_o}{b}$$

- For (K)

For upper part → fixed → Case (1)
For lower part → fixed → Case (1)
- From table (K = 0.75)

- For (H_o)

$H_o = H_f - t = 6 - 0.6 = 5.4$ m

$$\lambda_b = \frac{0.75\,x\,5.4}{0.25} = 16.20 > 15$$

∴ Column is Long in out of plane

Upper end Condition \ Lower end Condition	Braced Columns			Unbraced Columns		
	Lower end Condition			Lower end Condition		
	Case(1)	Case(2)	Case(3)	Case(1)	Case(2)	Case(3)
Case(1)	0.75	0.80	0.90	1.20	1.30	1.60
Case(2)	0.80	0.85	0.95	1.30	1.50	1.80
Case(3)	0.90	0.95	1.00	1.60	1.80	—
Case(4)	—	—	—	2.20	—	—

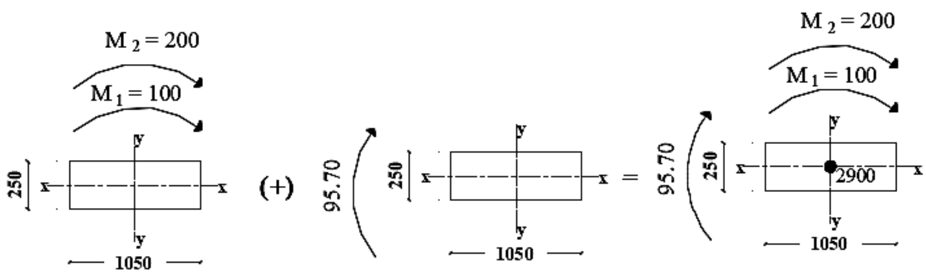
- The column is long at out of plane

3- Calculate M_{add} due to Buckling

$$\delta_{out} = \delta_b = \frac{(\lambda_b)^2\,x\,b}{2000} = \frac{(16.20)^2\,x\,0.25}{2000} = 0.033\,m$$

$$M_{add\,(out)} = Nu\;x\;\delta_b = 2900\,x\;0.033 = 95.70\,KN.m$$

4- Calculate M_{Design}



initial moment *Buckling* *Final Moment*

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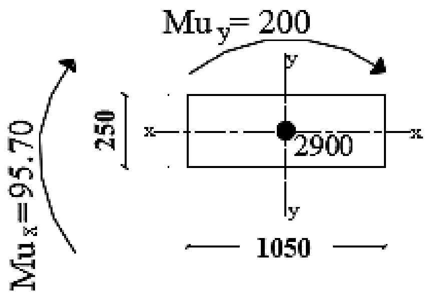
Mu_x = 95.70 KN.m

<u>To get Mu_y</u>

- For braced column

$$M_{uy} = \max of \begin{cases} \rightarrow M_2 = 200\,KN.m \\ \rightarrow M_i + M_{add} = [-0.4x\,100 + 0.6x\,200] + 95.70 = 175.70\,KN.m \\ \rightarrow M_1 + \frac{M_{add}}{2} = 100 + 0.5x\,95.7 = 147.85\,KN.m \\ \rightarrow Nu\;x\;e_{min} = 2900x\;0.05x\;0.25 = 36.25\,KN.m \end{cases}$$

Mu_y = 200 KN.m



Final Moment

<u>- To get M_{Design}</u>

$$\frac{Mu_x}{b^\backslash} = \frac{95.70}{0.25-.05} = 478.50 \quad , \quad \frac{Mu_y}{a^\backslash} = \frac{200}{1.05-.05} = 200$$

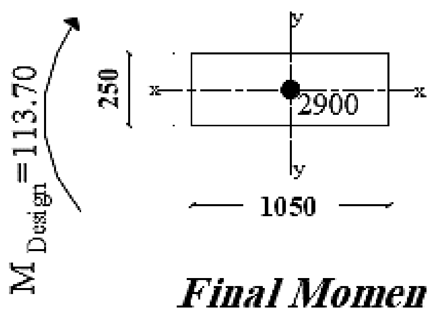
$$\frac{Mu_x}{b^\backslash} > \frac{Mu_y}{a^\backslash}$$

$$Mu_X^\backslash = Mu_X + \beta(\frac{b^\backslash}{a^\backslash})Mu_y$$

$$R_b = \frac{2900x\,10^3}{25x\;250x\;1050} = 0.442$$

$$\beta = 0.9 - \frac{0.442}{2} = 0.68 \xrightarrow{Take} \beta = 0.45$$

$$Mu_x^\backslash = 95.70 + 0.45(\frac{200}{1000})\,200 = 113.70\,KN.m$$



Final Moment

5- Design of section (250 x 1050) mm

Mu = 113.70 KN.m & Nu $_{(comp)}$ = 2900 KN

$$e=\frac{Mu}{Nu}=\frac{113.70}{2900}=0.04\,m$$

$$\frac{e}{b}=\frac{0.04}{0.25}=0.16<0.5\,(small\ Eccentricity\ ) \rightarrow \text{(Use I.D)}$$

$$\zeta=\frac{b-2\,\text{cover}}{b}=\frac{250-2(50)}{250}=0.6$$

$$take \rightarrow \zeta=0.8 \quad \& \quad \alpha=1 \quad \& \quad fy=360$$

$$\frac{Nu\ x\ 10^3}{fcu\ x\ b\ x\ t}=\frac{2900\,x\ 10^3}{25\,x\ 1050\,x\ 250}=0.44 \qquad \& \qquad \frac{Mu\ x\ 10^6}{fcu\ x\ t\ x\ b^2}=\frac{113.7\,x\ 10^6}{25\,x\ 1050\,x\ 250^2}=0.07$$

From Chart → ρ = 4

$$As=(\rho\,x\ fcu\ x\ 10^{-4})\,x\ b\ x\ t$$

$$As=As^{\backslash}=(4\,x\ 25\,x\ 10^{-4})\,x\ 250\,x\ 1050=2625mm^2$$

$$As_{(total)}=As+As^{\backslash}=5250\,mm^2$$

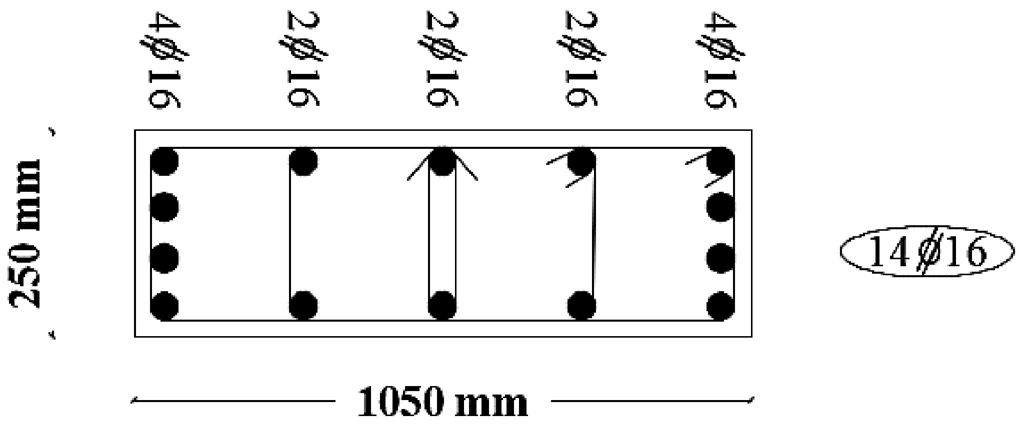
$$As_{(\min)}=\frac{0.25+0.52\,\lambda_{\max}}{100}\,x\ b\ x\ t\ =\frac{0.25+0.052\,(16.20)}{100}\,x\ 250\,x\ 1050=2867.55\,mm^2$$

$$As_{(\min)}<As_{(total)} \qquad \rightarrow take\ As_{(total)}=5250\,mm^2$$

$$As=As^{\backslash}=\frac{5250}{2}=2625\,mm^2 \qquad \rightarrow \qquad \underline{use\ 14\phi16}$$

- يتم وضع ٤ اسياخ فى الاركان والباقى يقسم على ٤

6- Details of R.F.ts



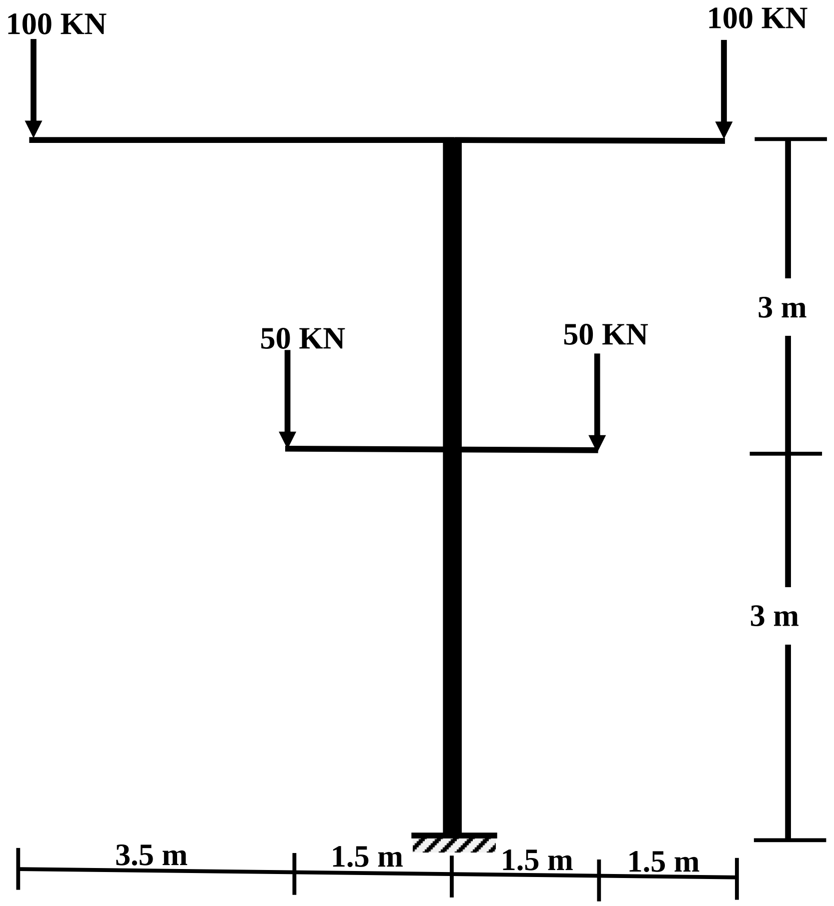
Question No. 2

For the shown frame in Fig. (2), it is required:

1- Draw the N.F and B.M

2- design the critical section

3- Draw details of reinforcement. (with convenient scale).



Solution

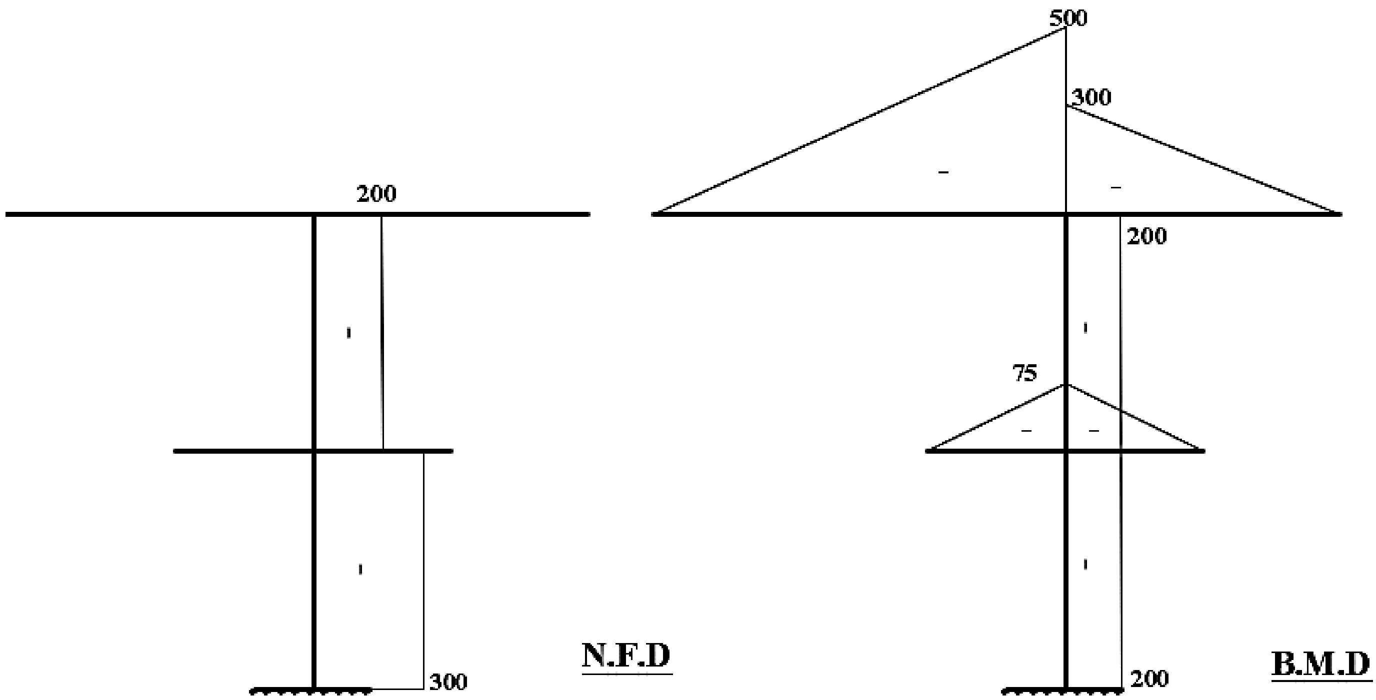
Data:

$F_{cu} = 25\ N/mm^2$ St. 360/520 b = 350 mm

Section (1-1) → Mu = 1.5 x 200 = 300 KN.m Nu = 1.5 x 300 = 450 KN

Section (2-2) → Mu = 1.5 x 500 = 750 KN.m Nu = zero KN

Section (3-3) → Mu = 1.5 x 75 = 150 KN.m Nu = zero KN



Section (1-1) → Mu = 1.5 x 200 = 300 KN.m Nu = 1.5 x 300 = 450 KN

- For rectangular section

1) - Get (t_1) → due to moment (Mu = 300 KN.m)

- Assume C1 = 3.5 → (Rec – sec)

$$d = c_1 \sqrt{\frac{Mu \; x \; 10^6}{fcu \; x \; B}}$$

$$d = 3.5 \sqrt{\frac{300 x \; 10^6}{25 x \; 350}} \quad \rightarrow \quad d = 648.1 mm$$

$$take \; d = 650 mm \quad \rightarrow \quad t_1 = 650 + 50 = 700 \; mm$$

- Get (t_2) → due to compression force (Pu = 450 KN)

$$Pu \; x \; 10^3 = 0.35 x \; fcu \; x \; Ac + 0.67 x \; fy \; x \; As$$

$$Ac = b \; x \; t_2 \quad , \quad As = 0.01 Ac = 0.01 (b \; x \; t_2)$$

$$Pu \; x \; 10^3 = (0.35 x \; fcu \; x \; b + 0.67 x \; fy \; x \; 0.01 x \; b) t_2$$

$$450 x \; 10^3 = (0.35 x \; 25 x \; 350 + 0.67 x \; 360 x \; 0.01 x \; 350) t_2$$

$$t_2 = 115.2 mm$$

$$t_0 = t_1 = 700 \; mm$$

$$\because t = (1.1 \rightarrow 1.3) t_0 = (770 \rightarrow 910) \; mm$$

$$\therefore t = 850 \; mm \;\; \& \;\; b = 350 \; mm$$

2) Check (K)

$$K = \frac{Nu \; x \; 10^3}{fcu \; x \; b \; x \; t} = \frac{450 x \; 10^3}{25 x \; 350 x \; 850} = 0.06 > 0.04$$

- Design moment & compression force (M + N_{comp})

3) Design (M+ N_{comp}) & (Rec-sec)

$$e = \frac{Mu}{Nu} = \frac{300}{450} = 0.67\,m$$

$$\frac{e}{t} = \frac{0.67}{0.85} = 0.8 > 0.5\,(Big\ Eccentricity)$$

4) Design tension failure (Big Eccentricity)

$$e_s = e + \frac{t}{2} - \text{cover}$$

$$\text{e}_s = 0.67 + \frac{0.85}{2} - 0.05 = 1.045\,m$$

$$Mu_s = Nu\ x\ e_s = 450\,x\ 1.045 = 470.25\,KN.m$$

$$d = c_1\sqrt{\frac{Mu_s\ x\ 10^6}{fcu\ x\ B}} \qquad ,d = 850 - 50 = 800\,mm$$

$$800 = C_1\sqrt{\frac{470.25\,x\ 10^6}{25\,x\ 350}}$$

$$C_1 = 3.451 \xrightarrow{from\,chart} J = 0.778$$

$$As = \frac{Mu_s\ x\ 10^6}{fy\ x\ J\ x\ d} - \frac{Nu\ x\ 10^3}{fy/\gamma_s}$$

$$As = \frac{470.25\,x\ 10^6}{360\,x\ 0.778\,x\ 800} - \frac{450\,x\ 10^3}{360/1.15} = 661.231\,mm^2$$

$$As_{(\min)} = \frac{1.1}{fy}\,x\ b\ x\ d = \frac{1.1}{360}\,x\ 350\,x\ 800 = 855.55\,mm^2$$

$$As < As_{(\min)}$$

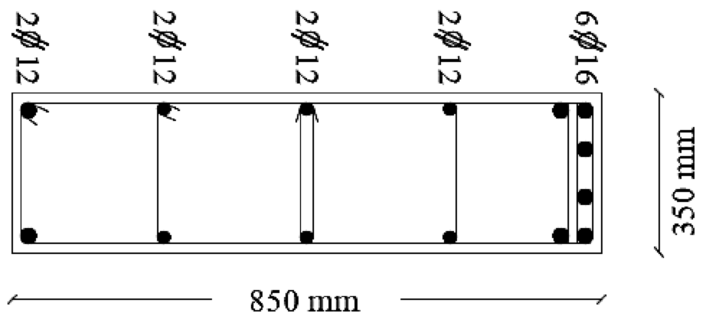
$$Take\ As = As_{(\min)} = 855.55\,mm^2 \quad \rightarrow \quad \underline{Use\ 6\phi16}$$

$$As^{\backslash} = (0.2\,As) = 0.2\,x\ 855.55 = 171.11\,mm^2 \quad \rightarrow \quad \underline{use\ 2\phi12}$$

$$n = \frac{b - 25}{\phi + 25} = \frac{350 - 25}{16 + 25} = 7.9$$

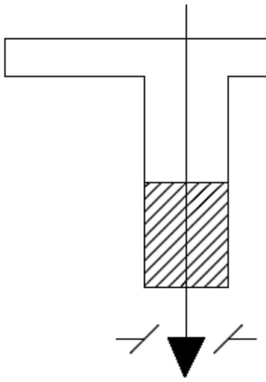
$$Take\ n = 7\,bars$$

4) Details of R.F.Ts



Section (2-2) → Mu = 1.5 x 500 = 750 KN.m   Nu = zero KN

3) Design (M-only) & (Rec-sec) & (t → معلومة)



$$d = c_1 \sqrt{\frac{Mu \ x \ 10^6}{fcu \ x \ B}} \qquad , d = 850 - 50 = 800 \, mm$$

$$800 = C_1 \sqrt{\frac{750 x \ 10^6}{25 x \ 350}}$$

$$C_1 = 2.73 < 2.78 \qquad take \, C_1 = 3$$

$$d = 3 \sqrt{\frac{750 x \ 10^6}{25 x \ 350}} \qquad d = 878.3 \, mm$$

$$take \ d = 900 \, mm \qquad t = 950 \, mm$$

$$C_1 = 3 \xrightarrow{from \, chart} J = 0.743$$

$$As = \frac{Mu \ x \ 10^6}{fy \ x \ J \ x \ d} = \frac{750 x \ 10^6}{360 x \ 0.743 x \ 900} = 3115.5 \, mm^2$$

$$As_{(min)} = \frac{1.1}{fy} x \ b \ x \ d = \frac{1.1}{360} x \ 350 x \ 900 = 962.5 \, mm^2$$

$$As > As_{(min)} \quad (ok) \quad \rightarrow \quad \underline{Use \ 9 \phi 22}$$

$$As^{\backslash} = (0.2 As) = 0.2 x \ 3115.5 = 623.1 mm^2 \quad \rightarrow \quad \underline{use \ 6 \phi 12}$$

$$n = \frac{b - 25}{\phi + 25} = \frac{350 - 25}{22 + 25} = 6.9$$

$$Take \, n = 6 \, bars$$

Section (3-3) → Mu = 1.5 x 75 = 150 KN.m   Nu = zero KN

$$\rightarrow \quad \underline{use \ 4 \phi 16}$$

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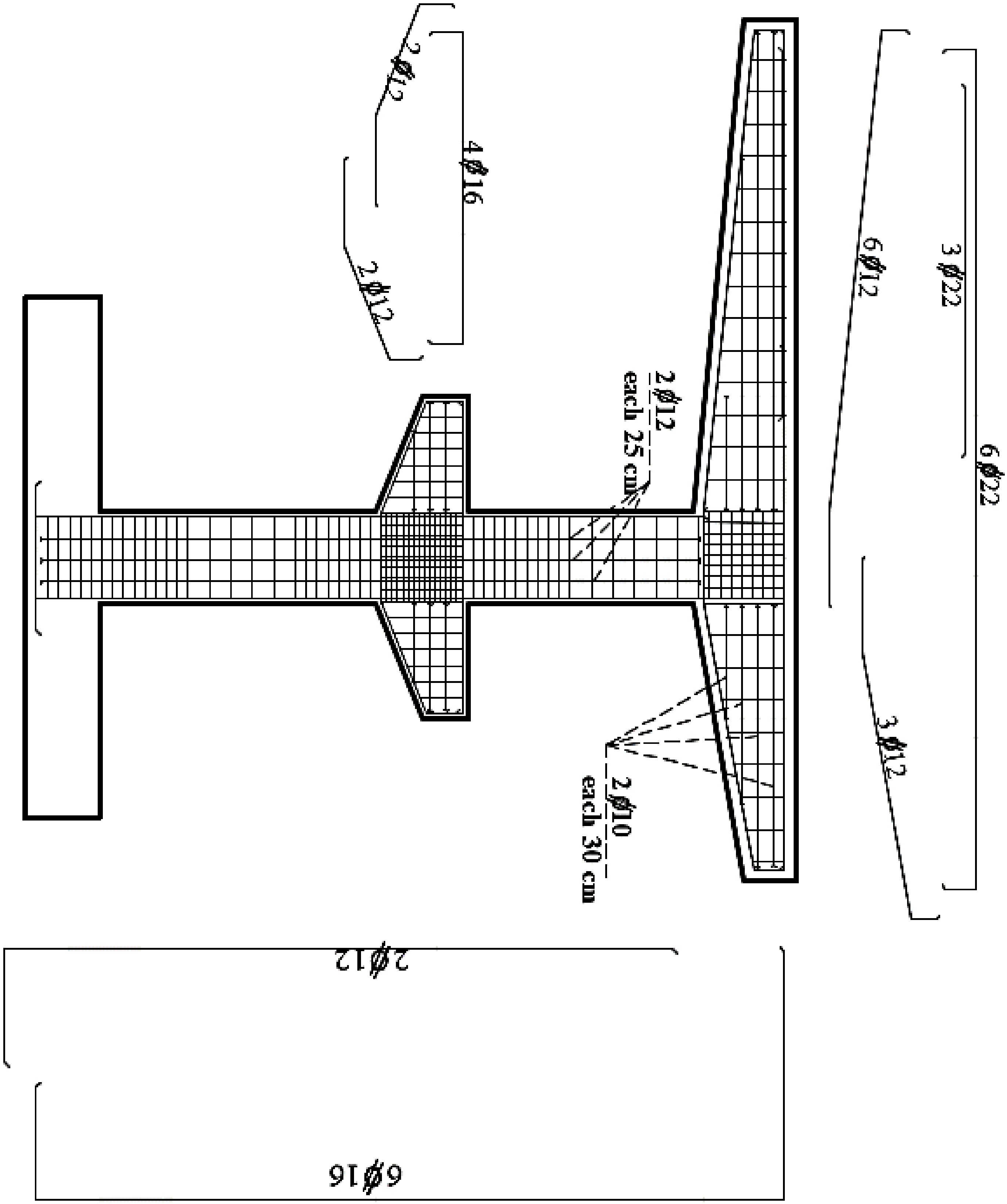
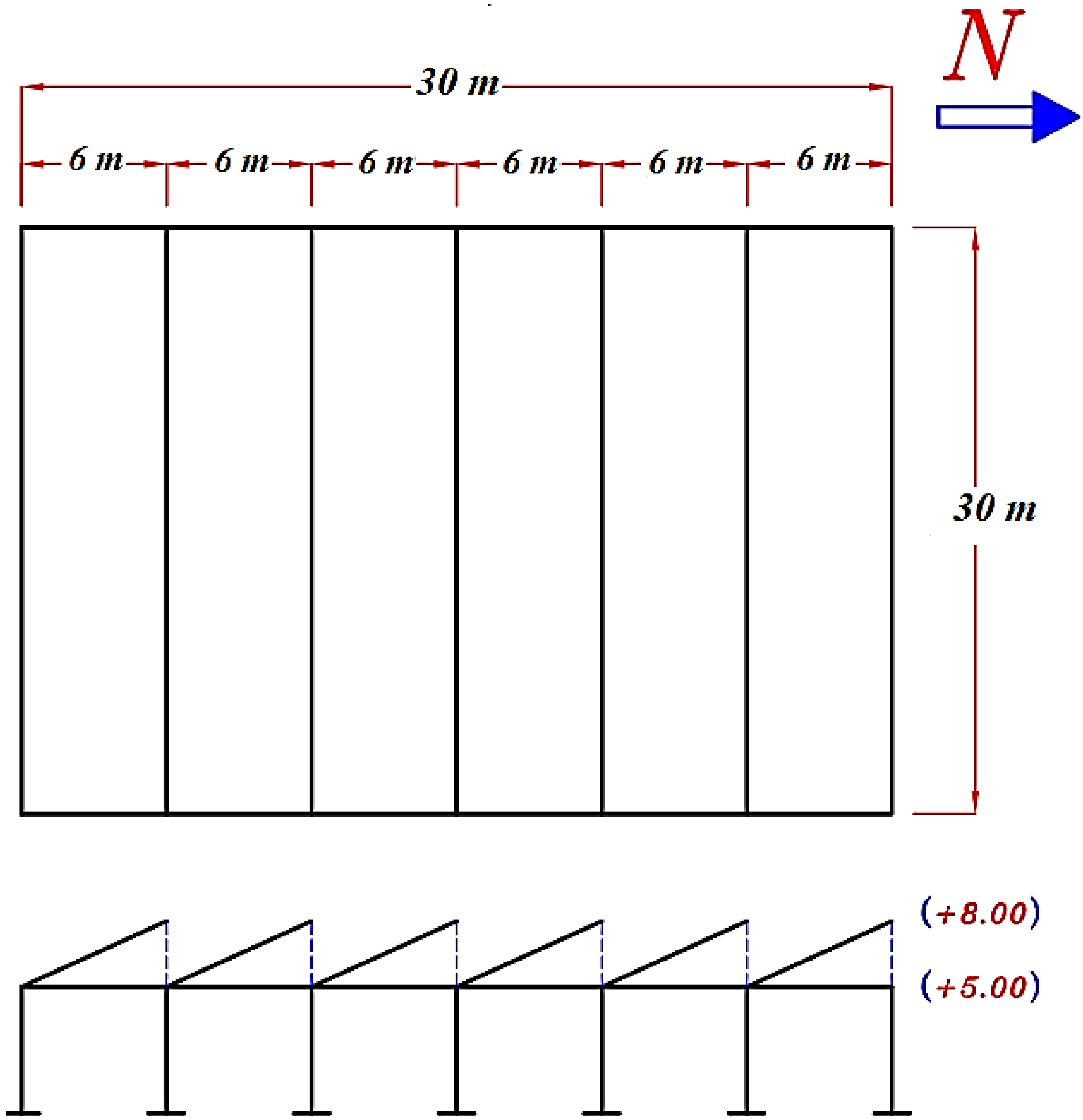

2ϕ12
4ϕ16
2ϕ12
6ϕ12
3ϕ22
6ϕ22
2ϕ12 each 25 cm
2ϕ10 each 30 cm
3ϕ12
2ϕ12
6ϕ16

Question No. 3



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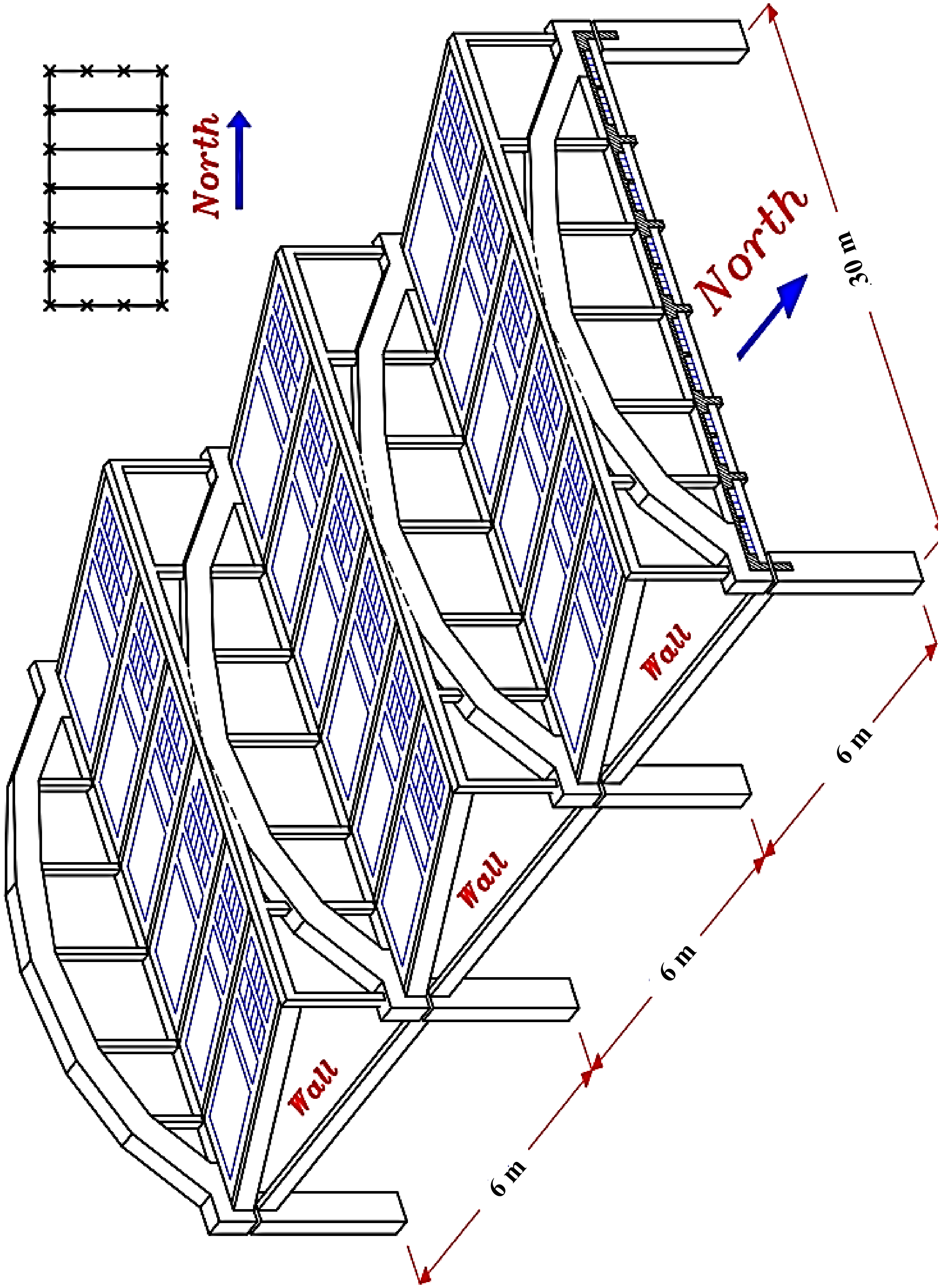
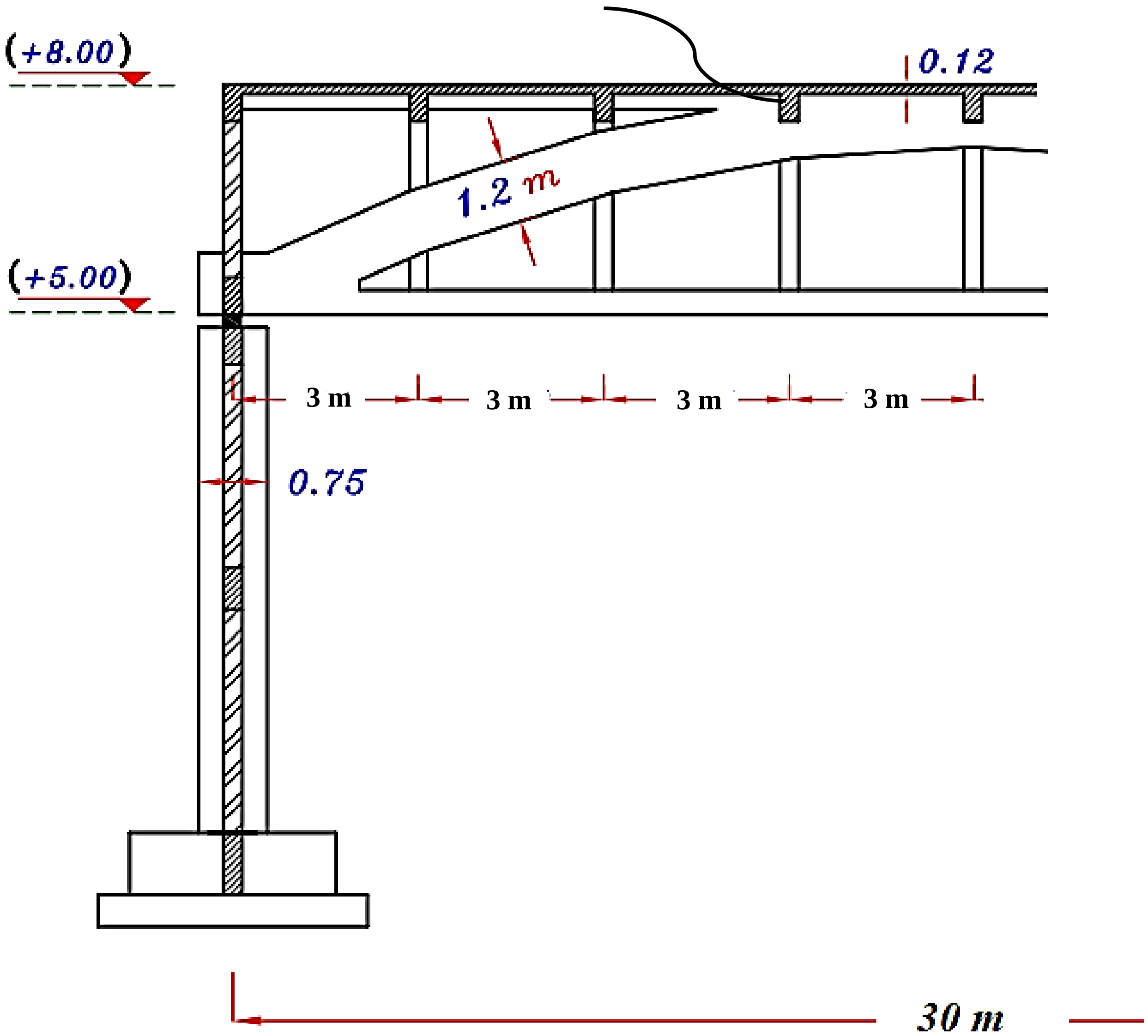


Beam (250 x 700)


(+8.00)
0.12
1.2 m
(+5.00)
3 m
3 m
3 m
3 m
0.75
30 m

③ *Design the Saw Tooth Slab.*

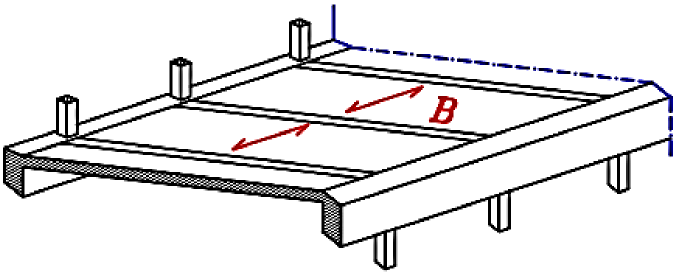
* *Loads on the Slab.* (*One Way Slab*)

Take $\boxed{t_s = 120\ mm}$

$(w_s)_{working} = 8.0\ kN\backslash m^2$ H.P.

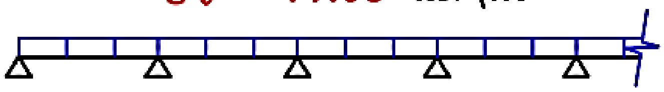
$(w_s)_{U.L.} = 1.5 * 8.0$

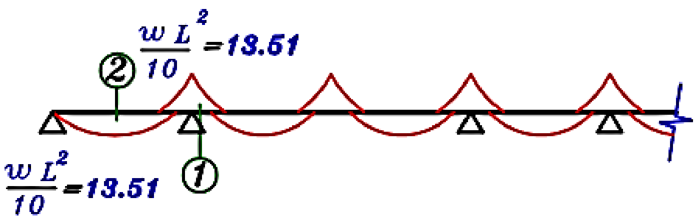
$= 12.0\ kN\backslash m^2$ H.P.



$(w_{si}) = 12.0 * \cos 23.2^{\circ} = 11.03\ kN\backslash m^2$

$w_{si} = 11.03\ kN\backslash m`$





* *Design the Slab.* شريحه افقيه فى بلاطه مائله

$M_{des.} = M \cos \alpha$

$= 13.51 * \cos 23.2^{\circ} = 12.40\ kN.m\backslash m`$

Sec. ① $M_{U.L.} = 12.4\ kN.m\backslash m`$, $t_s = 120\ mm$, $d = 100\ mm$

$$100 = C_1 \sqrt{\frac{12.40 * 10^6}{25 * 1000}} \longrightarrow C_1 = 4.49 \longrightarrow J = 0.819$$

$$A_s = \frac{12.40 * 10^6}{0.819 * 360 * 100} = 420.56\ mm^2\backslash m \quad 6 \phi 10 \backslash m`$$

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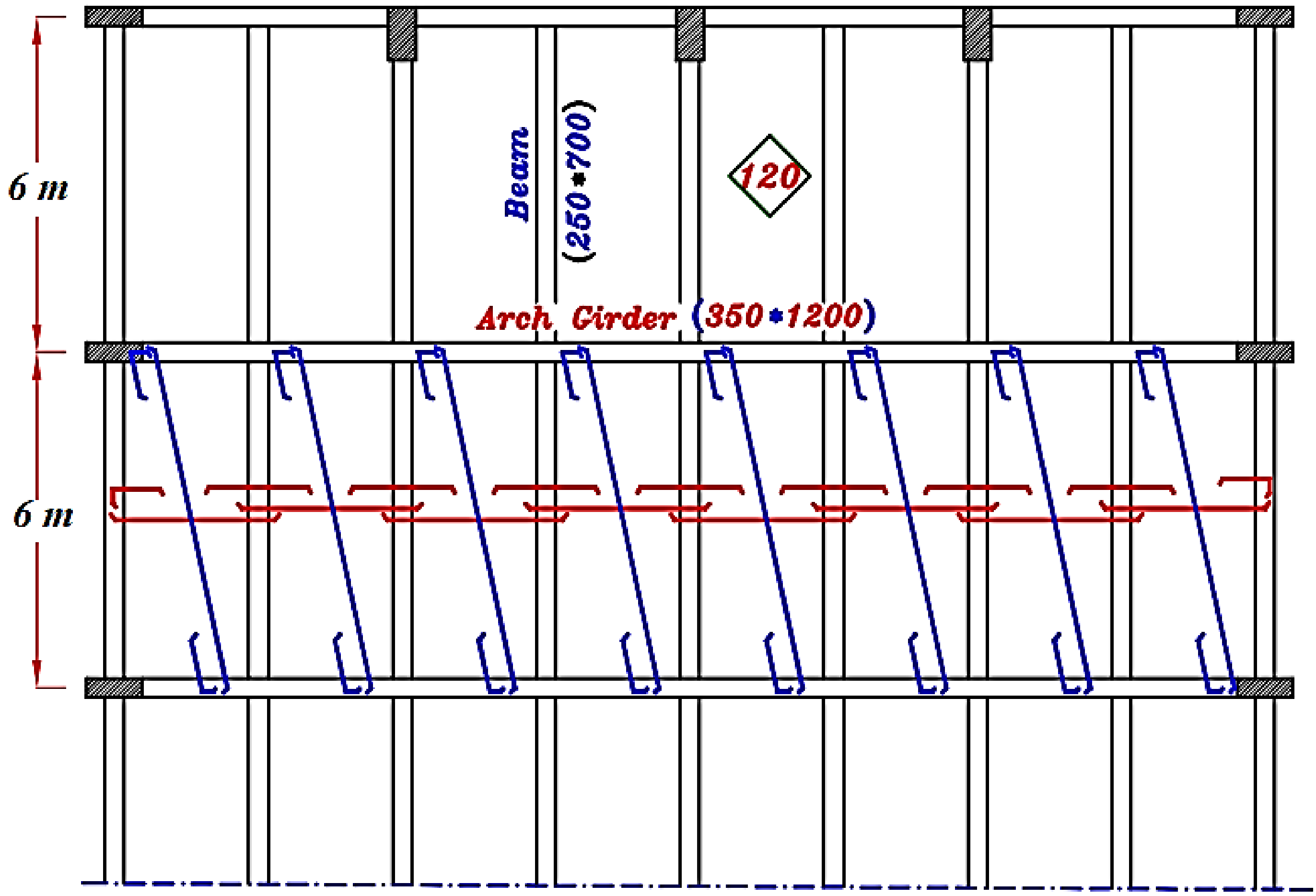
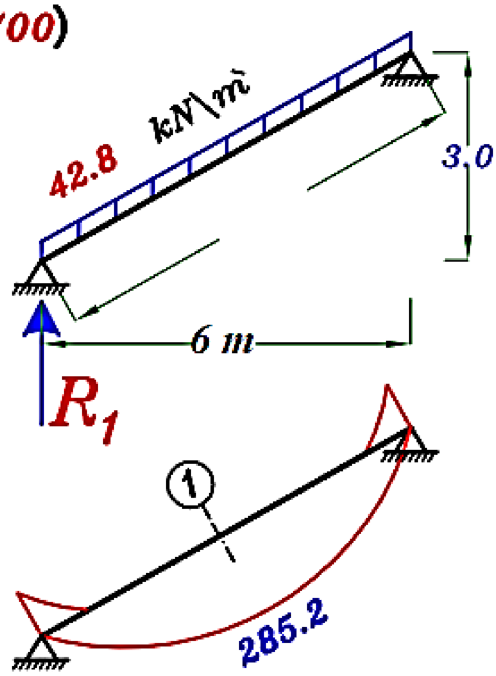


Plan

* Design the Beam. $B\ (250*700)$

$$w = O.W._{(beam)} + w_s * a \quad kN\backslash m'$$

$$w = 4.20 + 11.03 * 3 = 42.8 \quad kN\backslash m'$$



$$M = \frac{w\,L\,L'}{8} = 285.2 \ kN.m$$

$$R_1 = \frac{w\,L'}{2} = 162.96 \ kN$$

Sec. ①

$$M_{U.L.} = 285.2 \ kN.m \qquad T\text{-}Sec.$$

$$B = \begin{cases} C.L.-C.L. = 3.5\,m = 3500 \ mm \\ 16\,t_s + b = 16 * 140 + 250 = 2490\,mm \\ K\,\frac{L}{5} + b = 1.0 * \frac{7615}{5} + 250 = 1773 \ mm \end{cases}$$

$$\boxed{B = 1773 \ mm}$$

$$\therefore 650 = C_1 \sqrt{\frac{285.2 * 10^6}{25 \ * 1773}} \longrightarrow C_1 = 8.10 \longrightarrow J = 0.826$$

$$\therefore A_s = \frac{285.2 * 10^6}{0.826 * 360 \ * 650} = 1475.5 \ mm^2$$

Check $A_{s\,min.}$ $\qquad A_{s_{req.}} = 1475.5 \ mm^2$

$$\mu_{min.}\,b\,d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 650 = 507.8 \ mm^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\,b\ d \quad \therefore Take \ A_s = A_{s_{req.}} = 1475.5 \ mm^2 \qquad 6\ \phi 18$$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{18 + 25} = 5.23 = 5.0 \ bars$$

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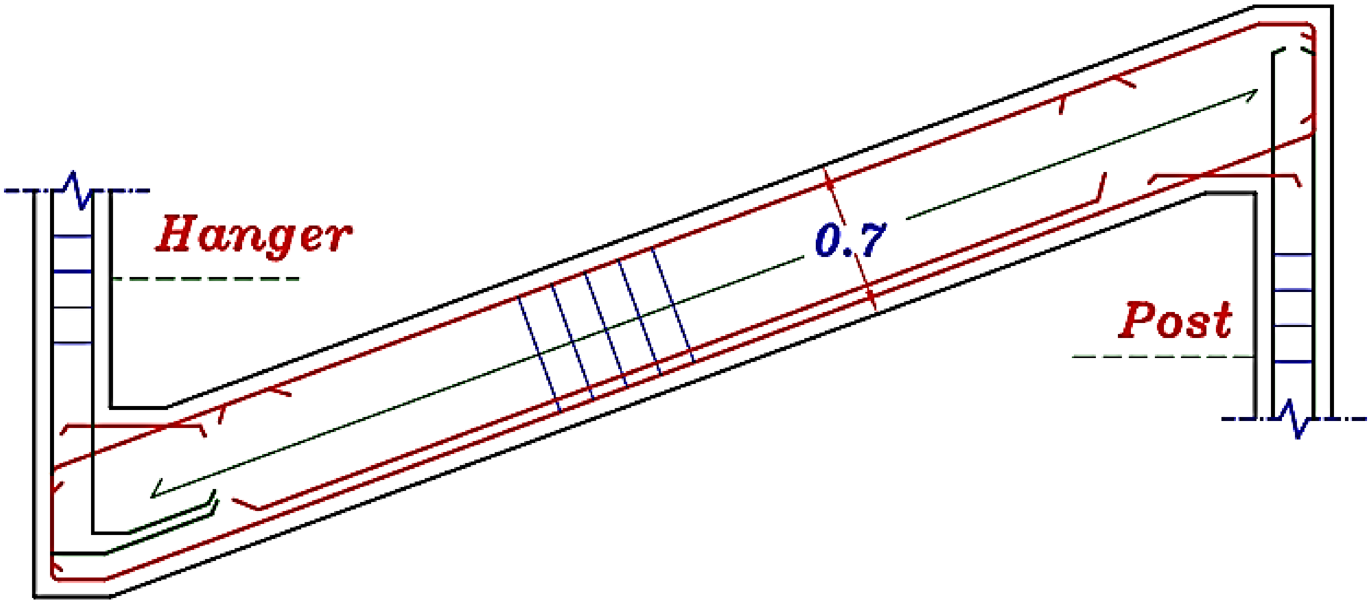
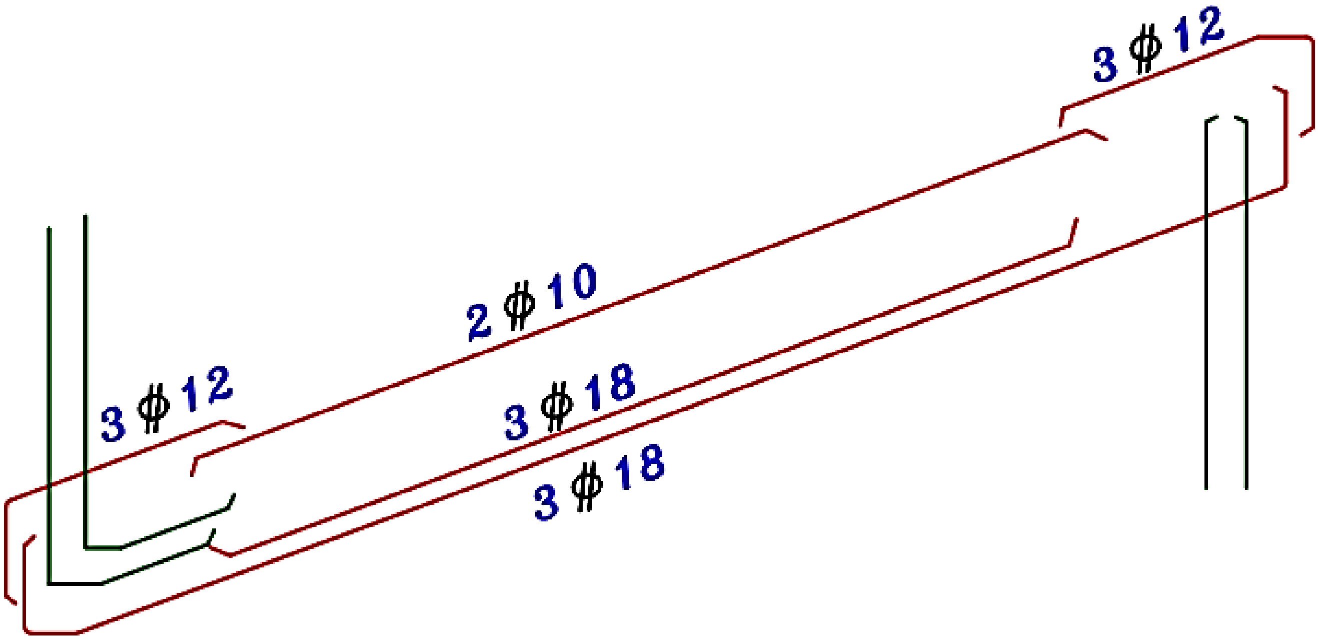
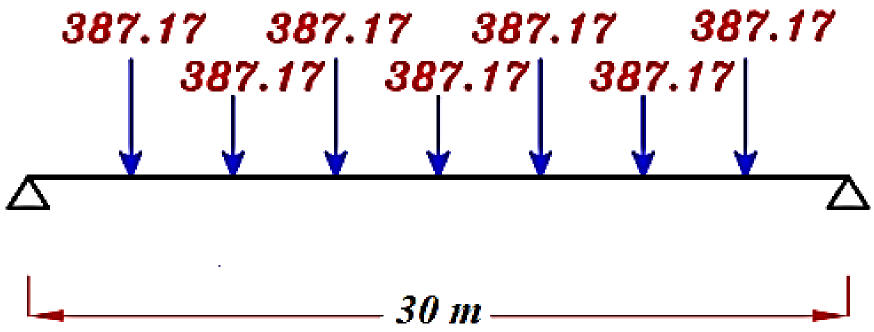

Hanger
0.7
Post

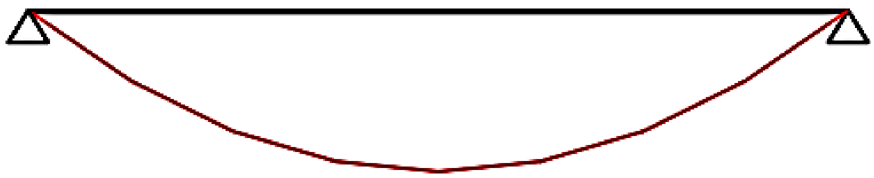

3 ϕ 12
2 ϕ 10
3 ϕ 12
3 ϕ 18
3 ϕ 18

Loads on the Arch Girder.

Take $o.w._{(Arch)} = 17.5\ kN\backslash m'$ (U.L.)

$f = 2\ R_1 + o.w._{(Arch)} * a = 2\,(162.96) + 17.5\,(3.5) = 387.17\ kN$



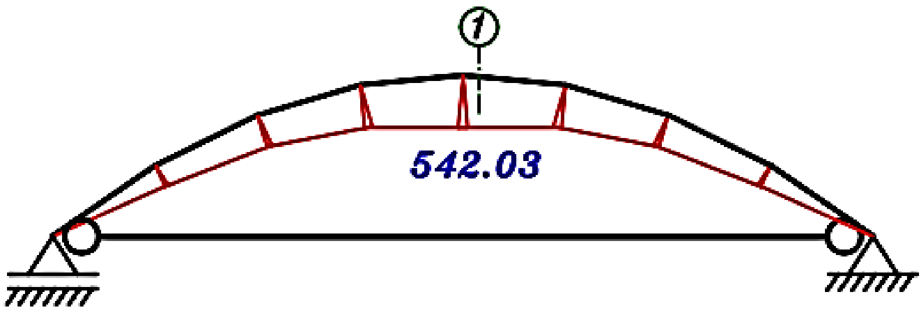


$M_o = 10840.7\ kN.m$

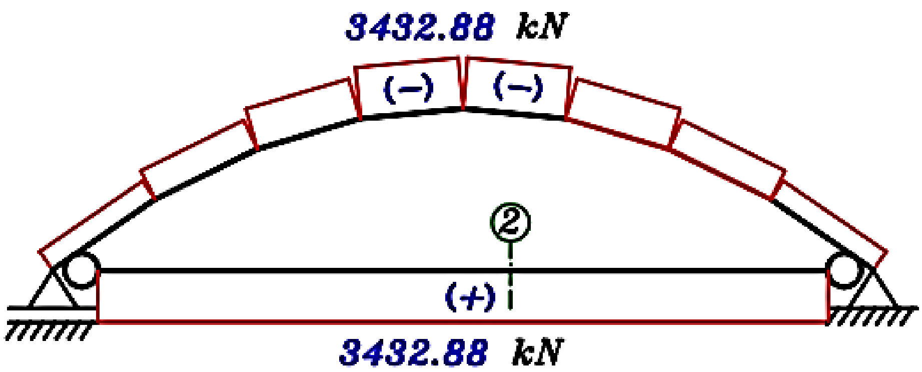
$$P = T = 0.95\ \frac{M_o}{h} = 0.95 * \frac{10840.7}{3.0} = 3432.88\ kN$$

$$M = 0.05\ M_o = 0.05\,(10840.7) = 542.03\ kN.m$$

B.M.D.



N.F.D.



* **Design of Arch Girder.**

Sec. 1 $b = 0.35\ m$, $t = 1.20\ m$

$$P = 0.95\ \frac{M_o}{h} = 0.95 * \frac{10840.7}{3.0} = 3432.88\ kN$$

$$M = 0.05\ M_o = 0.05\ (10840.7) = 542.03\ kN.m$$

$$e = \frac{M}{P} = \frac{542.03}{3432.88} = 0.158\ m \quad \therefore \frac{e}{t} = \frac{0.158}{1.2} = 0.13 < 0.5 \xrightarrow{use} I.D.$$

$$\zeta = \frac{1.2 - 0.2}{1.2} = 0.83 \xrightarrow{use} \text{ECCS Design Aids Page } 4-24$$

$$\left.\begin{aligned} \frac{P_U}{F_{cu}\ b\ t} &= \frac{3432.88 * 10^3}{25 * 350 * 1200} = 0.327 \\ \frac{M_U}{F_{cu}\ b\ t^2} &= \frac{542.03 * 10^6}{25 * 350 * 1200^2} = 0.043 \end{aligned}\right\} \rho = 1.0$$

$$\mu = \rho * F_{cu} * 10^{-4} = 1.0 * 25 * 10^{-4} = 2.5 * 10^{-3}$$

$$A_s = A_s` = \mu * b * t = 2.5 * 10^{-3} * 350 * 1200 = 1050\ mm^2$$

$$A_{s\,total} = A_s + A_s` = 2100\ mm^2$$

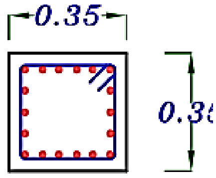
Check $A_{s\,min} = \frac{0.8}{100} * b * t = \frac{0.8}{100} * 350 * 1200 = 3360\ mm^2 > A_{s\,total}$

. Take $A_s = A_s` = \frac{A_{s\,min}}{2} = \frac{2520}{2} = 1680\ mm^2$ $5 \phi 22$

* Design of Tie.

Sec. ② $(350 * 350)$

$18\phi28$



Neglect o.w. of Tie.

$$T = 0.95\,\frac{M_o}{h} = 0.95 * \frac{10840.7}{3.0} = 3432.88 \text{ kN}$$

$$A_s = \frac{T}{F_y \backslash \delta_s} = \frac{3432.88 * 10^3}{360 \backslash 1.15} = 10966 \text{ mm}^2 \qquad 18\phi28$$

* Design of the hangers. $(350 * 350)$

Take $o.w._{(hanger)} = 3.50 \text{ kN}$ (U.L.)

$$T = o.w._{(hanger)} + R_1$$

$$= 3.50 + 162.96 = 166.46 \text{ kN}$$

$$A_s = \frac{T}{F_y \backslash \delta_s} = \frac{166.46 * 10^3}{360 \backslash 1.15} = 531.7 \text{ mm}^2 \qquad 8\phi12$$

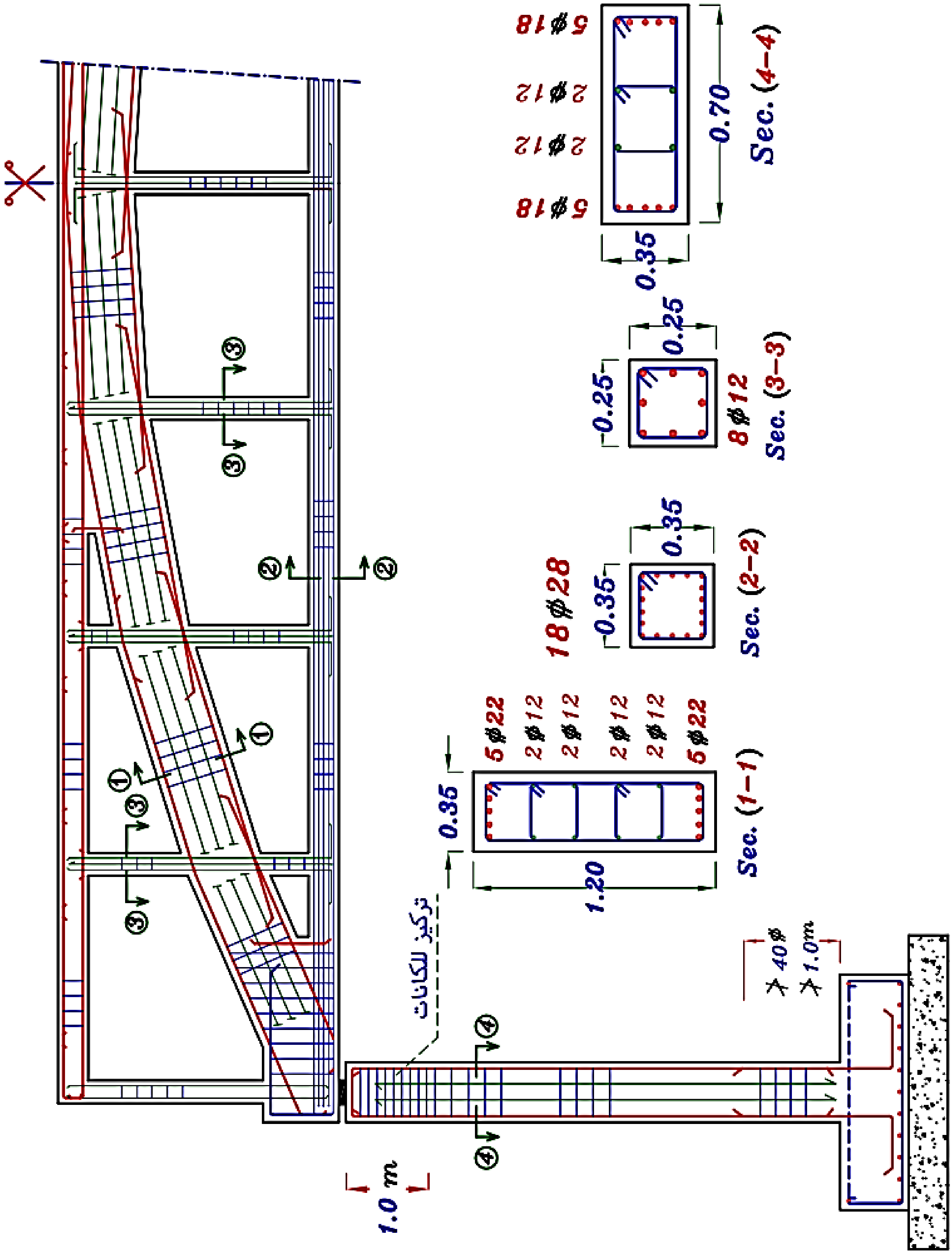
* Design the Post. $(350 * 350)$

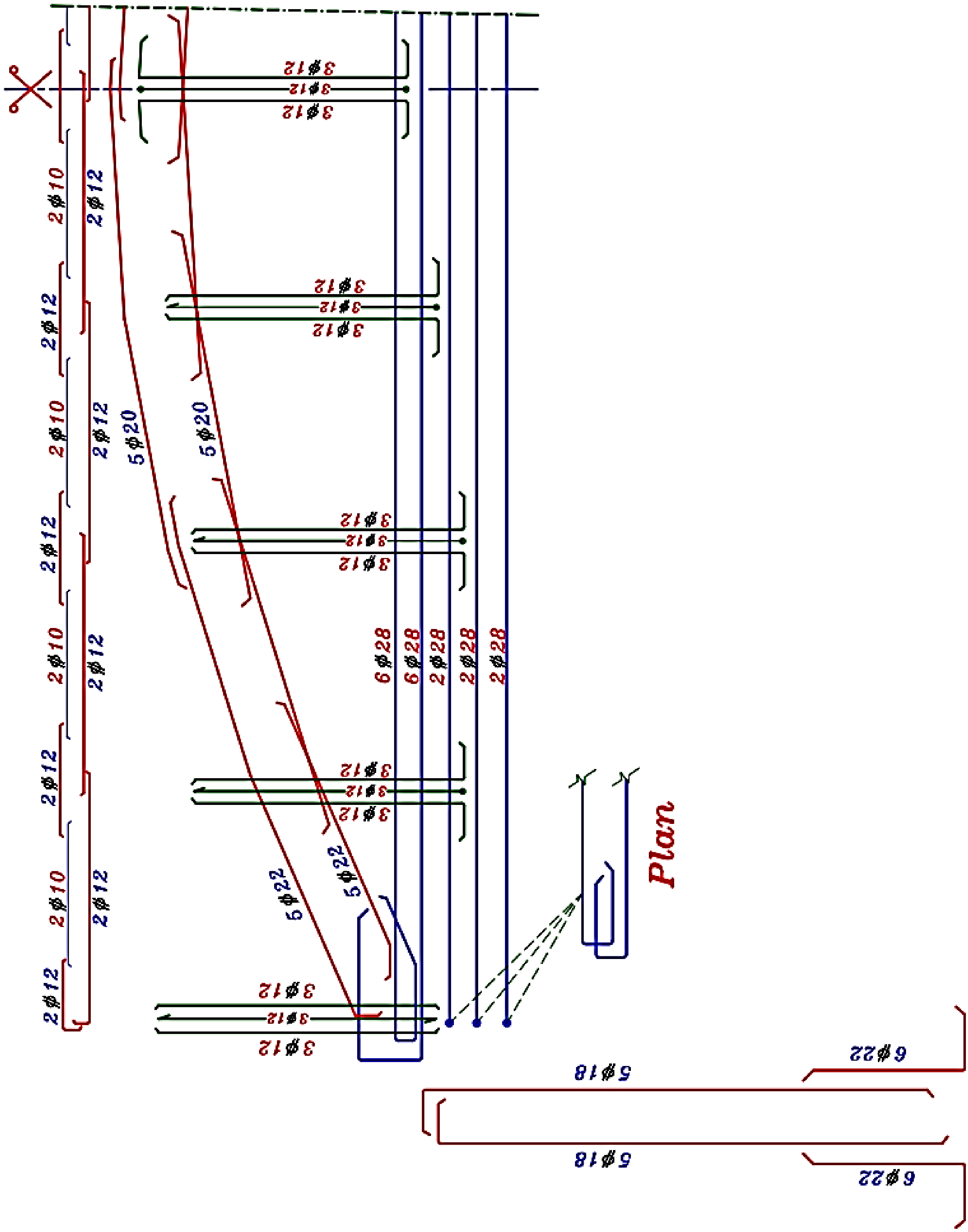
Take $o.w._{(Post)} = 3.50 \text{ kN}$ (U.L.)

$$P = o.w._{(Post)} + R_1$$

$$= 3.50 + 162.96 = 166.46 \text{ kN}$$

$$A_s = 8\phi12$$


Sec. (1–1)
Sec. (2–2)
Sec. (3–3)
Sec. (4–4)
5ϕ22
2ϕ12
2ϕ12
2ϕ12
2ϕ12
5ϕ22
0.35
1.20
18ϕ28
0.35
0.35
8ϕ12
0.25
0.25
5ϕ18
2ϕ12
2ϕ12
5ϕ18
0.35
0.70
1.0 m
40ϕ
1.0m
تركيز للكانات


3Ø12
2Ø10
2Ø12
5Ø20
5Ø22
6Ø28
2Ø28
Plan
5Ø18
6Ø22

Question No. 4

Using <u>arch slab system</u> to cover the following area, that shown in figure.

<u>It's required to:</u>

1- Complete analysis and design for different elements.

2- Details of reinforcements for arch slab and its supports.

<u>Data:</u>

Fcu = 30 N/mm^2

Fy = 360 N/mm^2

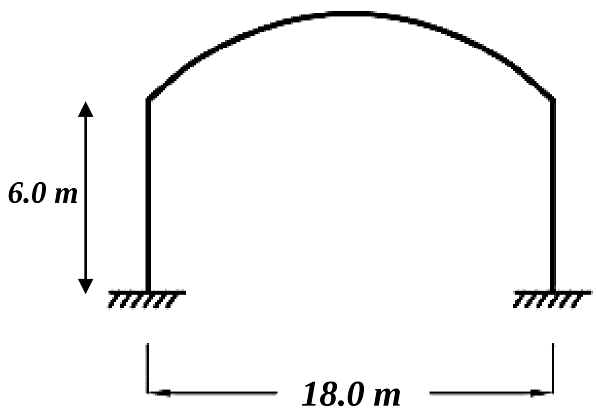
L.L $_{(UL)}$ = 1.60 KN/m^2 (H.P)

D.L $_{(UL)}$ = 5.40 KN/m^2 (H.P)

Foundation level = -2.0 m

Spacing between columns = 6.0 m

Clear height of column = 5.0 m



Solution

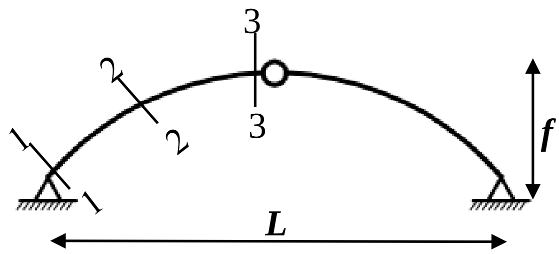
1- Concrete Dimensions for beams & slabs

$$f = \frac{18}{6 \to 8} = 2.50\,m$$

$$t_s = 10\,cm \;@\, \sec(3-3)$$

$$t_s = 12\,cm \;@\, \sec(2-2)$$

$$t_s = 14\,cm \;@\, \sec(1-1)$$

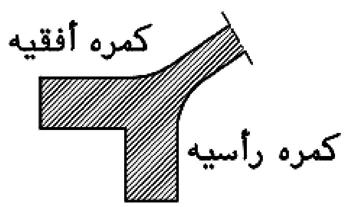


Statical System

3 – Hinge Arch

<u>- Horizontal beam (b x t)</u>

b = 250 mm & t = 600 mm



<u>- Vertical beam (b x t)</u>

b = 250 mm & t = 600 mm

<u>- Hangers & Ties (b x b)</u>

b = 250 mm

<u>- Spacing (S)</u>

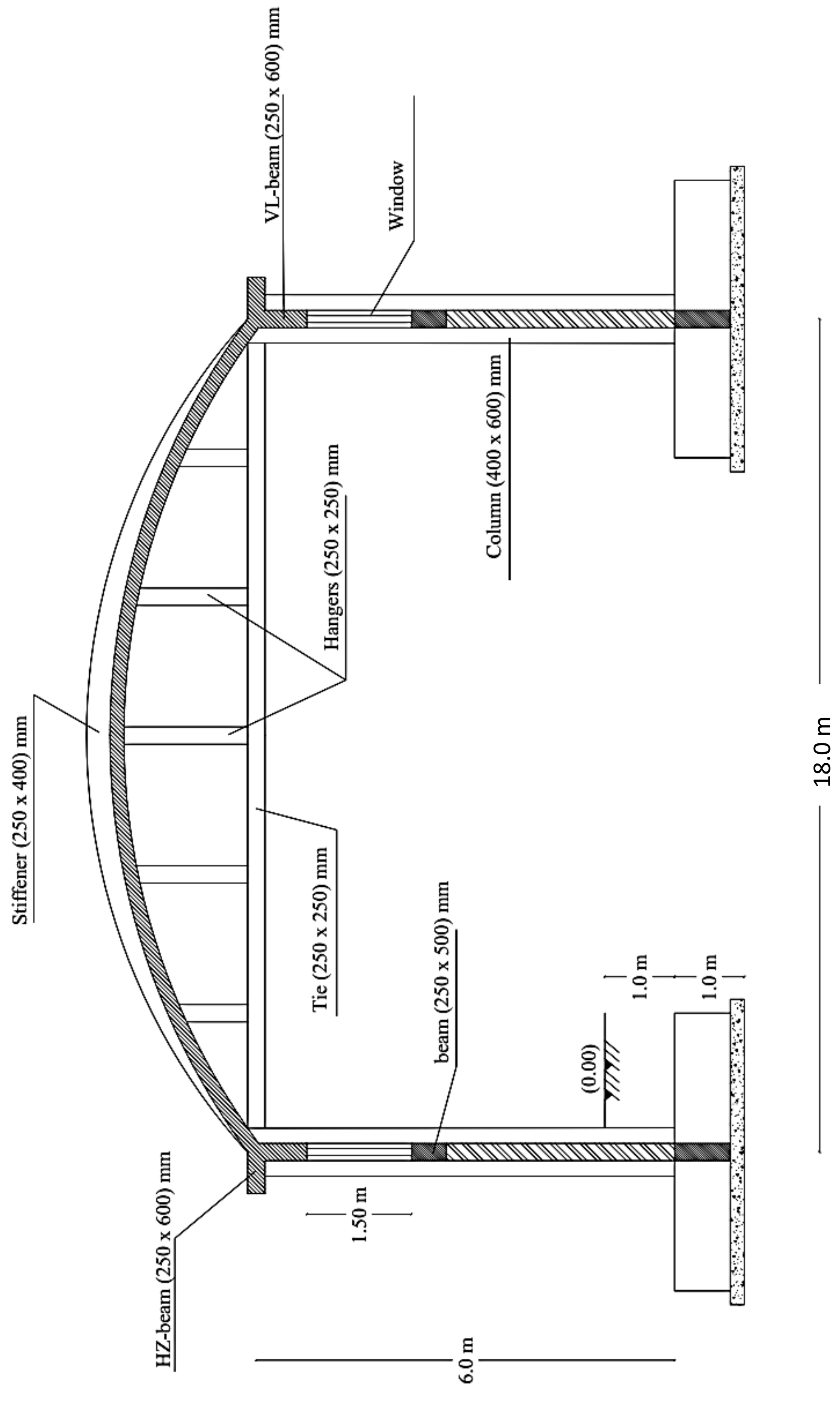
S = 6.0 m

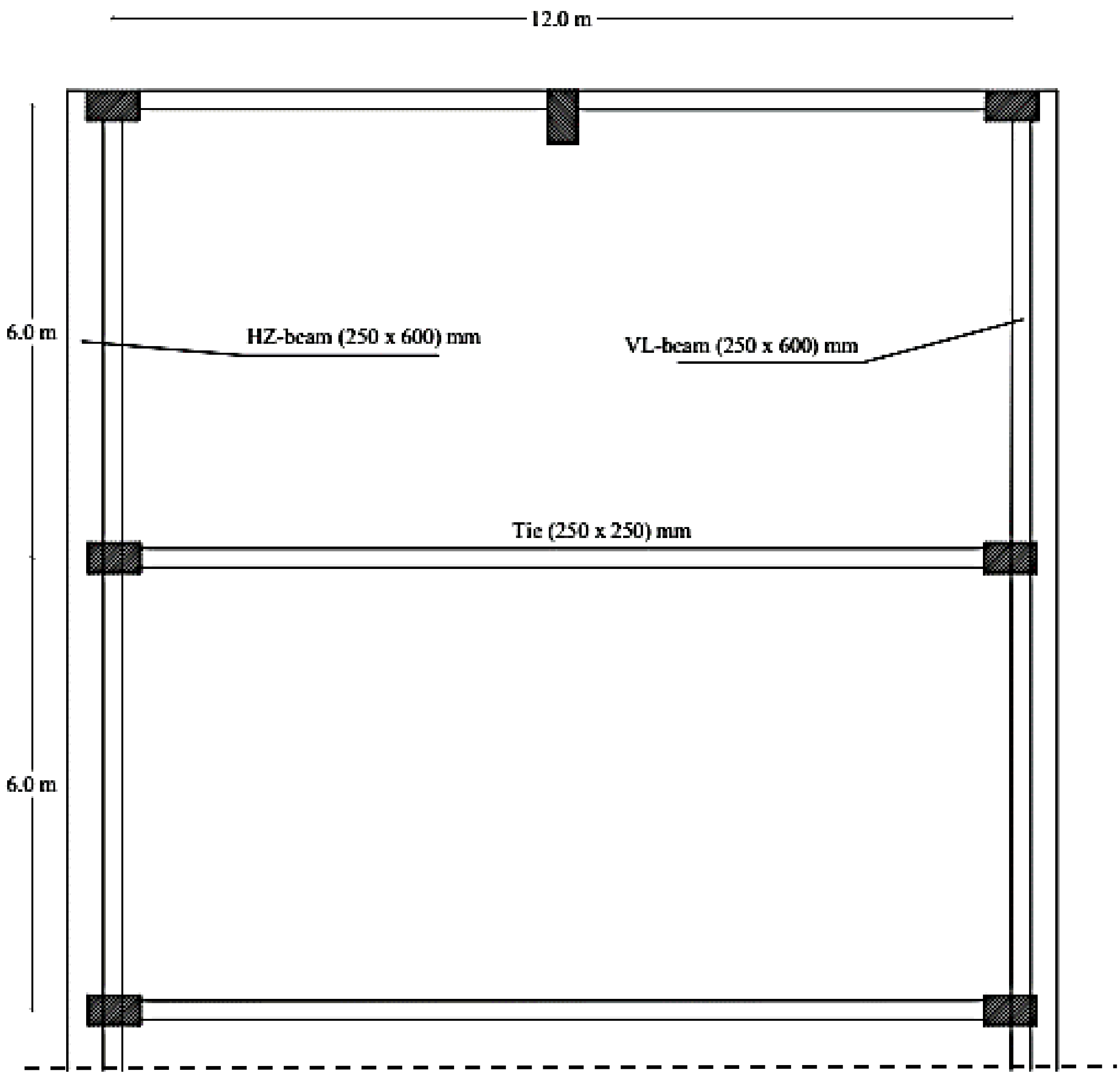
<u>- Distance between hangers (a)</u>

a = 3.0 m

<u>- Column (b_c x t_c)</u>

$b_c = 400$ mm & $t_c = 6 / (10 \rightarrow 12)$ take $t_c = 0.60$ m = 600 mm





Plan

2- Loads of Slabs

- Dead Load

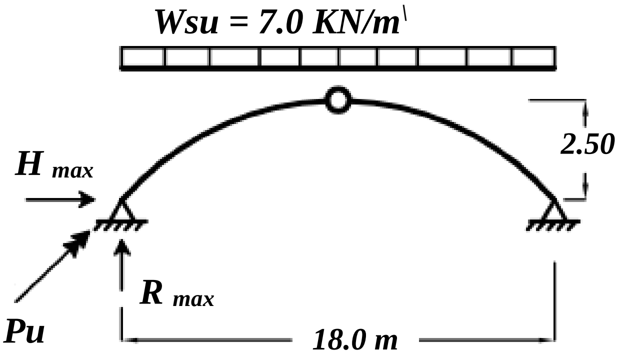
$$Wsu_{(D.L)} = 5.40\ KN / m^2$$

- Live Load

$$Wsu_{(L.L)} = 1.60\ KN / m^2$$

$$Wsu = Wsu_{(D.L)} + Wsu_{(L.L)} = 5.40 + 1.60 = 7.0\ KN/m^2$$

- Section (1) at support

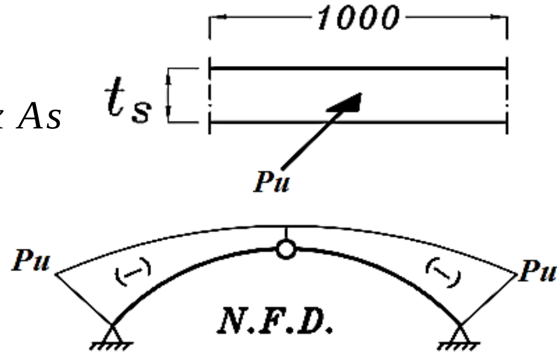


M = 0 & Pu = Nu

$$R_{\max} = \frac{W_{su}\ x\ L}{2} = \frac{7.0 x\ 18}{2} = 63KN\ / m'$$

$$H_{\max} = \frac{M}{f} = \frac{W_{su}\ x\ L^2}{8f} = \frac{7.0 x\ 18^2}{8 x\ 2.5} = 113.4KN\ / m'$$

$$P_u = \sqrt{H_{\max}^2 + R_{\max}^2} = \sqrt{113.4^2 + 63^2} = 129.725KN$$



$$Pu\ x\ 10^3 = 0.35 x\ fcu\ x\ Ac + 0.67 x\ fy\ x\ As$$

$$129.725 x\ 10^3 = 0.35 x\ 30 x\ 1000 x\ 140 + 0.67 x\ 360 x\ As$$

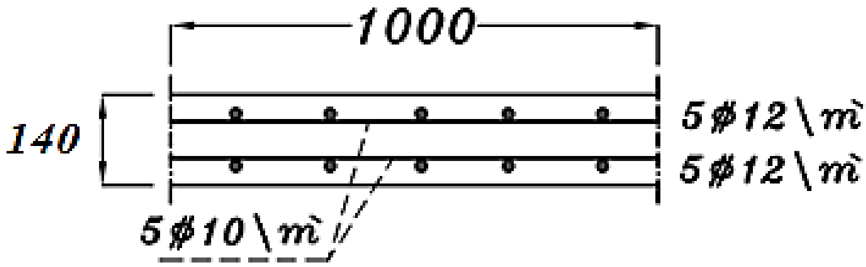
$$As = -5556.70\ mm^2$$

$$A_{s\ (\min)} = \frac{0.8}{100} x\ b\ x\ t_s$$

$$A_{s\ (\min)} = \frac{0.8}{100} x\ 1000 x\ 140 = 1120\ mm^2$$

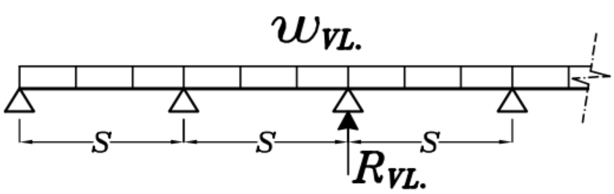
$$As_{total} = As_{\min} = 10\phi12 / m'$$

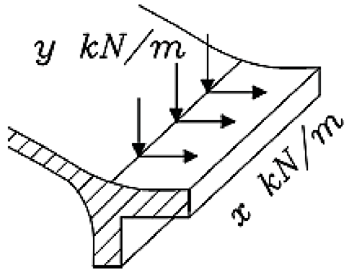
$$As = As' = 5\phi12 / m'$$



4- Design for vertical beams & horizontal beams

- Design of Vertical beam





$$o.w.t_{(V.L-beam)}\ 1.4x\ 25x\ 0.25x\ 0.60 = 5.25\,KN\ /m'$$

$$o.w.t_{(H.Z-beam)}\ 1.4x\ 25x\ 0.25x\ 0.60 = 5.25\,KN\ /m'$$

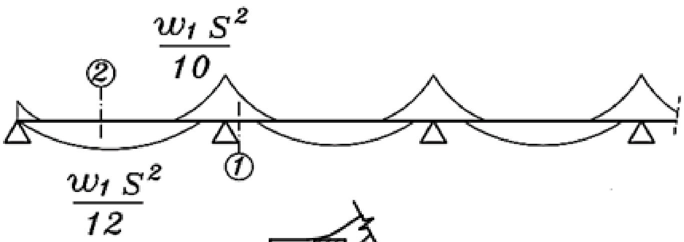
$$Y = R_{\max} = 63\,KN\ /m'$$

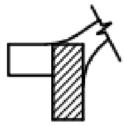
$$W_{VL} = o.w.t_{(V.L-beam)} + o.w.t_{(H.Z-beam)} + Y$$

$$W_{VL} = 5.25x\ 2 + 63 = 73.50\,KN\ /m'$$

$$R_{VL} = W_{VL}\ x\ S$$

$$R_{VL} = 73.50x\ 6 = 441\,\text{KN}$$





- Section (1)   (Rec – section)

$$d = t - 50\,mm = 600 - 50\,mm = 550\,mm$$

$$M_1 = \frac{W_{VL}\ x\ S^2}{10} = \frac{73.50x\ 6^2}{10} = 264.60\,KN.m$$

$$550 = c_1\sqrt{\frac{264.60x\ 10^6}{30x\ 250}} \xrightarrow{get} C_1 = 2.93 \xrightarrow{from\ chart} J = 0.734$$

$$As_1 = \frac{264.60x\ 10^6}{360x\ 0.734x\ 550} = 1820.66\,mm^2$$

$$As_{\min} = \frac{1.1}{360}x\ 250x\ 550 = 420.14\,mm^2$$

$$As_1 > As_{\min}$$

$\underline{Use\ 5\ \phi\ 22}$

$$n = \frac{b-25}{\phi+25} = \frac{250-25}{22+25} = 5\,bars$$

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- Section (2) (Rec – section)

$$M_2 = \frac{W_{VL}\ x\ S^2}{12} = \frac{73.50x\ 6^2}{12} = 220.50KN.m$$

$$550 = c_1\sqrt{\frac{220.50x\ 10^6}{30x\ 250}} \xrightarrow{get} C_1 = 3.21 \xrightarrow{from\ chart} J = 0.76$$

$$As_2 = \frac{220.50x\ 10^6}{360x\ 0.76x\ 550} = 1465.30\,mm^2$$

$$As_2 > As_{min}$$

$$Use\ \ 4\ \phi 22$$

- Section (3) (Rec – section)

$$M_3 = \frac{W_{VL}\ x\ S^2}{24} = \frac{73.50x\ 6^2}{24} = 110.25KN.m$$

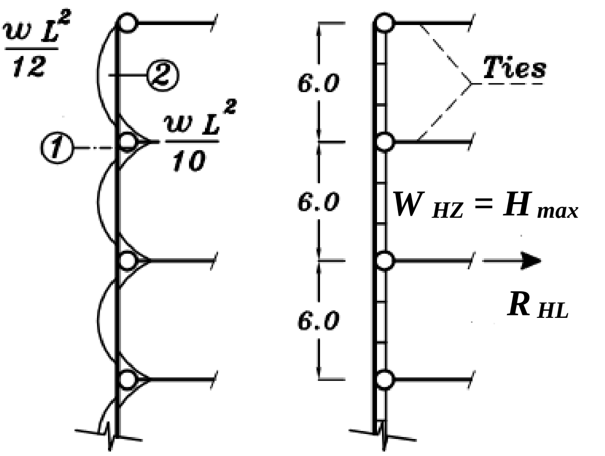
$$550 = c_1\sqrt{\frac{110.25x\ 10^6}{30x\ 250}} \xrightarrow{get} C_1 = 4.54 \xrightarrow{from\ chart} J = 0.819$$

$$As_3 = \frac{110.25x\ 10^6}{360x\ 0.819x\ 550} = 680\,mm^2$$

$$As_3 > As_{min}$$

$$Use\ \ 4\phi 16$$

- Design of horizontal beam



$$W_{HZ} = H_{max} = \frac{Wsu\ x\ L^2}{8f}$$

$$W_{HZ} = 113.40\,KN\ /m'$$

$$R_{HL} = W_{HZ}\ x\ S$$

$$R_{HL} = 113.40x\ 6 = 680.40KN$$

- Section (1) (Rec – section)

$$d = 600 - 50\,mm = 550\,mm$$

$$M_1 = \frac{W_{HZ}\ x\ S^2}{10} = \frac{113.40\,x\ 6^2}{10} = 408.24\,KN.m$$

$$550 = c_1\sqrt{\frac{408.24\,x\ 10^6}{30\,x\ 250}} \xrightarrow{get} C_1 = 2.35 < 2.78$$

$$Take\ c_1 = 3.0 \xrightarrow{from\ chart} J = 0.743$$

$$d = 3.0\sqrt{\frac{408.24\,x\ 10^6}{30\,x\ 250}} \rightarrow d = 700\,mm$$

$$As_1 = \frac{408.24\,x\ 10^6}{360\,x\ 0.743\,x\ 700} = 2180.35\,mm^2$$

$$As_{\min} = \frac{1.1}{360}\,x\ 250\,x\ 550 = 420.14\,mm^2$$

$$As_1 > As_{\min}$$

$\underline{Use\ \ 6\phi\ 22}$

- Section (2) (Rec – section)

$$M_2 = \frac{W_{HZ}\ x\ S^2}{12} = \frac{113.40\,x\ 6^2}{12} = 340.8\,KN.m$$

$$700 = c_1\sqrt{\frac{340.8\,x\ 10^6}{30\,x\ 250}} \xrightarrow{get} C_1 = 3.28 \xrightarrow{from\ chart} J = 0.767$$

$$As_2 = \frac{340.8\,x\ 10^6}{360\,x\ 0.767\,x\ 700} = 1763.21\,mm^2$$

$$As_2 > As_{\min}$$

$\underline{Use\ \ 5\phi\ 22}$

- Section (3) (Rec – section)

$$M_3 = \frac{W_{HZ}\ x\ S^2}{24} = \frac{113.40\,x\ 6^2}{24} = 170.1\,KN.m$$

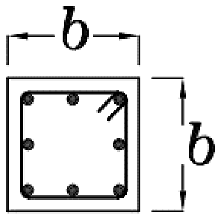
$\underline{Use\ \ 4\ \phi\ 16}$

5- Design of Tie (b x b)

$$T_{tie} = 1.10 \, x \; R_{HL}$$

$$T_{tie} = 1.10 \, x \; 680.40 = 748.44 \, KN$$

$$As = \frac{T_{tie} \; x \; 10^{3}}{Fy \big/ \gamma_s} \quad , \gamma_s = 1.15$$



$$As = \frac{748.44 \, x \; 10^{3}}{360 \big/ 1.15} = 2390.85 \, mm^{2}$$

$\underline{Use \;\; 8 \; \phi \; 22}$

6- Design of Hangers (b x b)

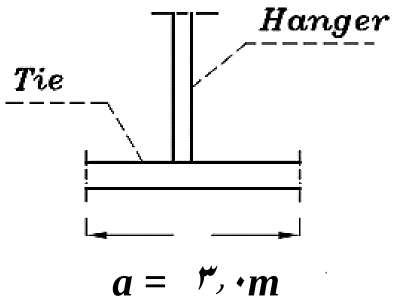
$$T = o.w.t_{\;hanger} + o.w.t_{\;(tie)} \; x \; a$$

$$o.w.t_{\;hanger} = 1.4 \, x \; \gamma_c \; x \; b \; x \; b \; x \; f$$

$$o.w.t_{\;hanger} = 1.4 \, x \; 25 \, x \; 0.25 \, x \; 0.25 \, x \; 2.50 = 5.50 \, KN$$

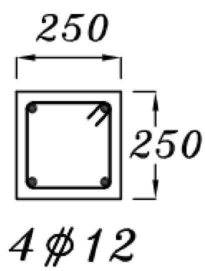
$$o.w.t_{\;(tie)} = 1.4 \, x \; \gamma_c \; x \; b \; x \; b$$

$$o.w.t_{\;(tie)} = 1.4 \, x \; 25 \, x \; 0.25 \, x \; 0.25 = 2.1875 \, KN \; / \, m'$$



$$T = 5.50 + 2.1875 \, x \; 3.0 = 12.10 \, KN$$

$$As = \frac{T \; x \; 10^{3}}{Fy \big/ \gamma_s} \quad , \gamma_s = 1.15$$



$$As = \frac{12.10 \, x \; 10^{3}}{360 \big/ 1.15} = 38.653 \, mm^{2}$$

$\underline{Use \;\; 4 \; \phi \; 12}$

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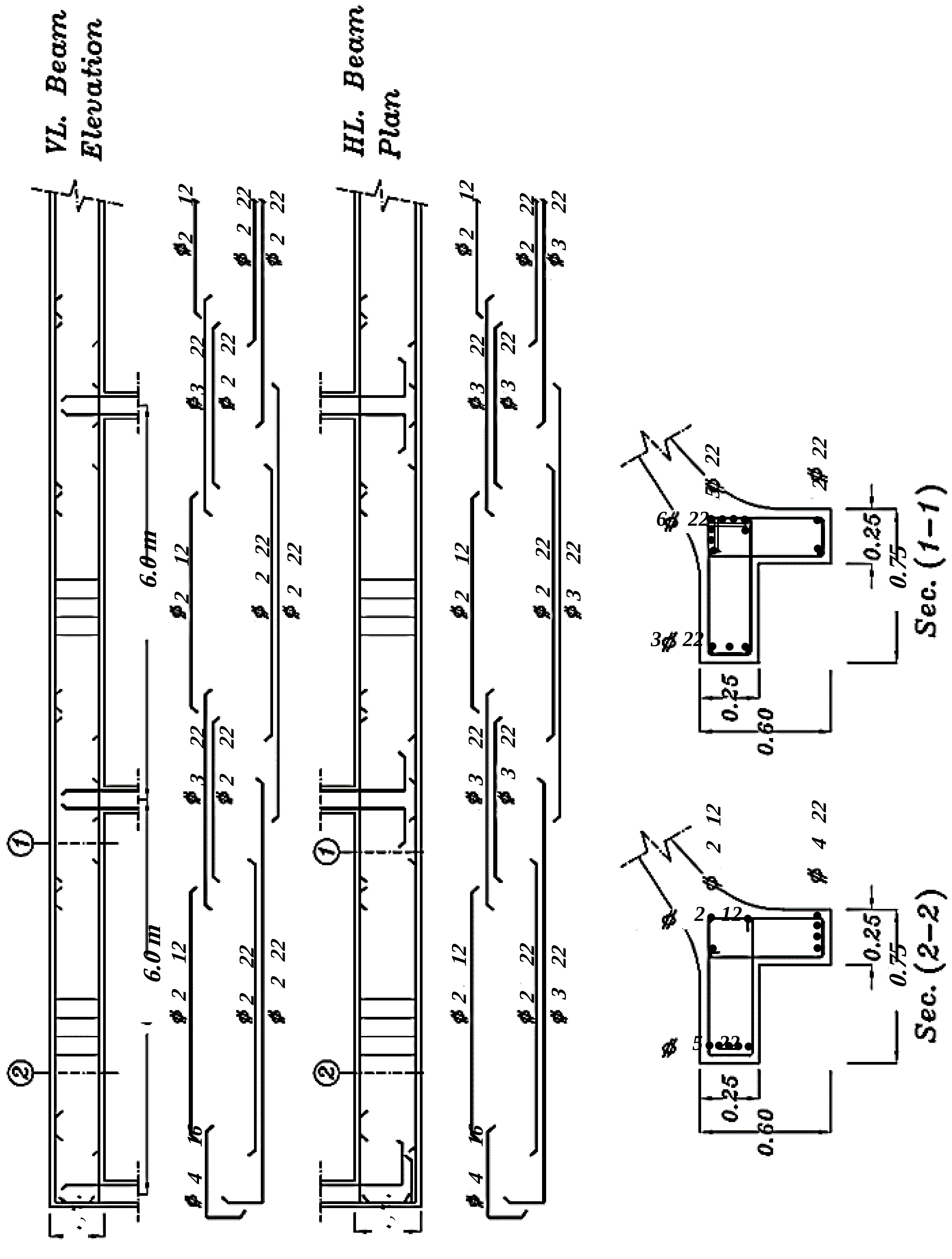
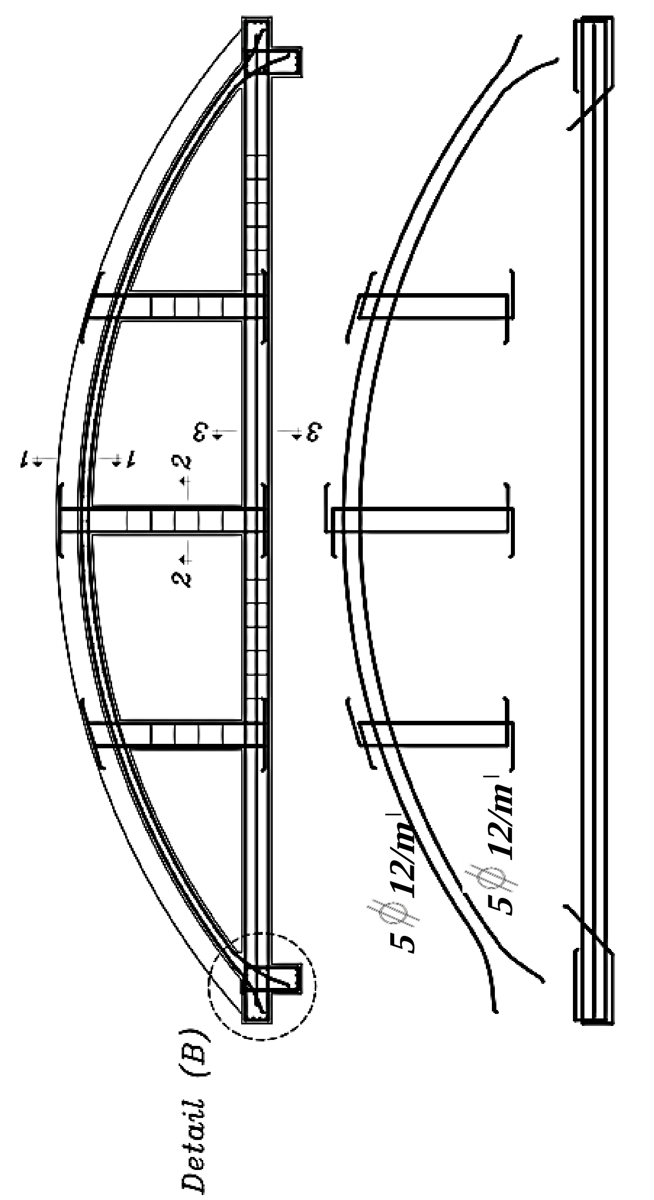
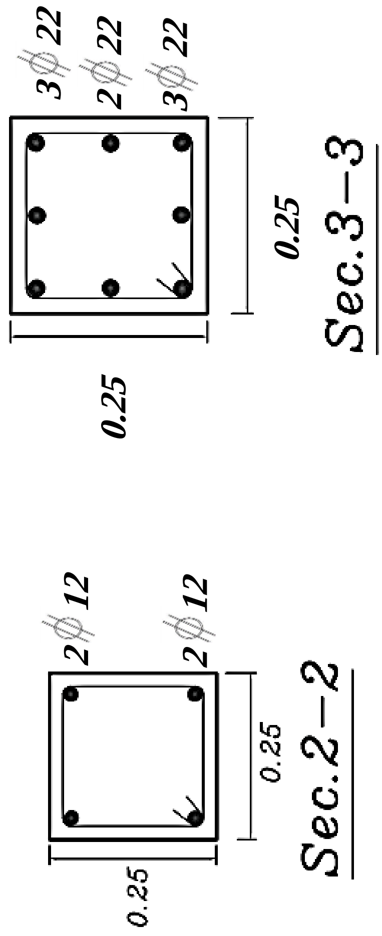


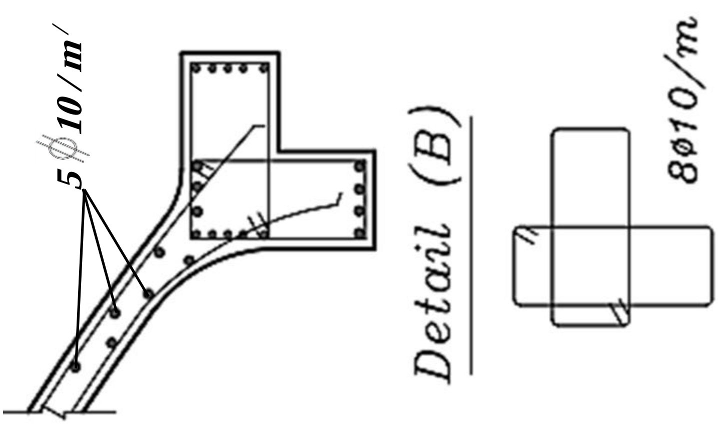
VL. Beam
Elevation
HL. Beam
Plan
6.0 m
6.0 m
Sec. (1-1)
Sec. (2-2)
0.25
0.60
0.75



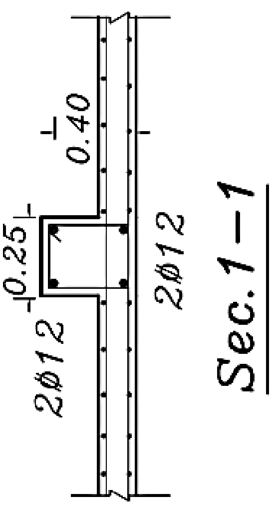
5Φ12/m
5Φ12/m
Detail (B)



3Φ22
2Φ22
3Φ22
0.25
0.25
Sec.3−3
2Φ12
2Φ12
0.25
0.25
Sec.2−2



5Φ10/m
8Ø10/m
Detail (B)



0.40
0.25
2Ø12
2Ø12
Sec.1−1