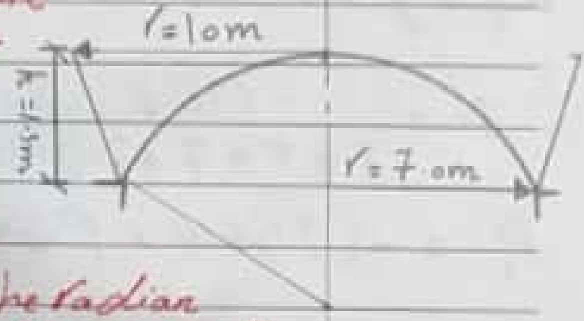
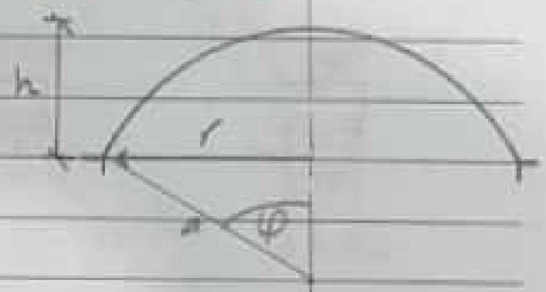
lecture (5)

Solved Example for Dome & Cone



EX:- The given Cone-Dome structure is supposed to cover a Parliament hall with diameter of 14.0m and top diameter 20.0m. By Assuming that $f_{cu} = 30\ N/mm^2$ and $f_y = 350\ N/mm^2$, estimate the radial and meridian forces, design critical sections and draw R.F.T.



1 for Dome:-

a- Prop. of Area:-

1- $a = \frac{r^2 + h^2}{2h} = 17.08$

2- $\varphi = \sin^{-1} r/a = 24° 11' 41''$

3- $t_{s_{crown}} = 120\ mm$

4- $t_{s_{foot}} = 140\ mm$

5- $S.A = 2\pi a h = 160.9\ m^2$

6- $H.A = \pi r^2 = 153.9\ m^2$

b- Loads:-

$g = \gamma_c * t_s + F.C = 3 \sim 3.5 = 3\ KN/m^2$

$P = 0.75 \sim 1 = 1\ KN/m^2$

c- Straining Actions:- (T & N)

@ Crown:- $N = T = -(g + P)\frac{a}{2} = -(3+1) * \frac{17.08}{2} = -34.16\ KN$

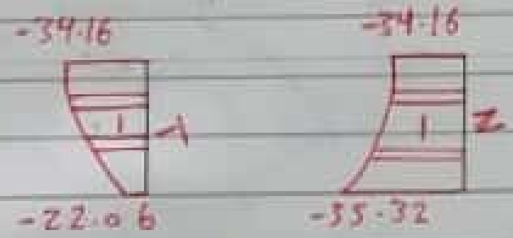
@ Footing:- $N = \frac{-W_t}{2\pi r \sin\varphi}$

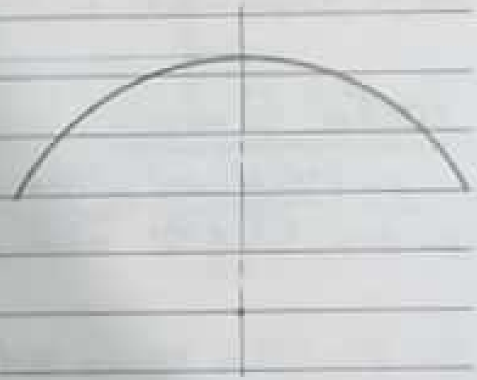
$W_t = g * S.A + P * H.A = 3 * 160.9 + 1 * 153.9 = 636.6$ KN

$\therefore N = \frac{-636.6}{2 * \pi * 7 * \sin(24° 11' 41'')} = -35.32$ KN

$P_r = -[g \cos\varphi + P \cos^2\varphi] = -3.57$ KN/m²

$\therefore T = P_r * a - N = -3.57 * 17.08 - (-35.32) = -22.06$ KN/m'





d- Design of critical section:-

Max Comp = -34.16 KN/m'

$P_u = 0.35 * 1000 * 170 * 30 = 1760$ KN

$\therefore P_u \ggg N_u \quad \therefore$ Safe

$\therefore$ use 5 Φ10/m'

$x = 0.6\sqrt{a * t} = 0.93 \simeq 1.0$ m

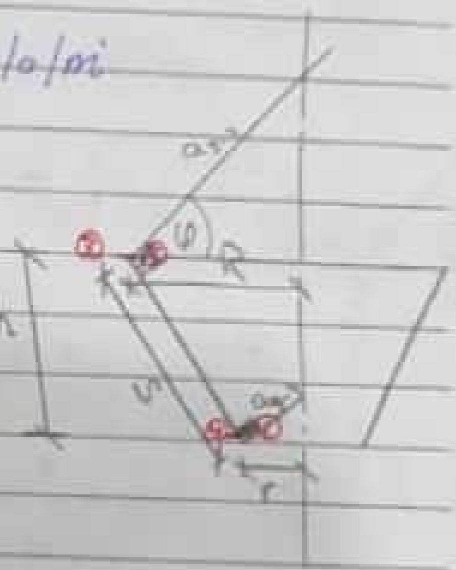
$\therefore M = (g+P) * \frac{x^2}{2} = 2$ KN.m

@ Footing $M = 2$ KN.m , $N = 35.32$ KN
$M_u = 3$ KN.m , $N_u = 53$ KN

$\therefore e = \frac{M}{N} = \frac{3}{53} = 0.057\ m < 0.5t$

$\therefore$ Design as N only

$\therefore P_u \ggg N_u$ $\therefore$ use 5 Φ 10/m



[2] For Cone:-

a- Prop of Area:-

@ Section 3-3:-

1- $\varphi = \tan^{-1}\frac{h}{R-r} = \tan^{-1}\frac{1.5}{10-7}$
$= 26°\ 33'\ 54''$

2- $a_{3-3} = \frac{R}{\sin\varphi} = \frac{10}{\sin 26°33'54''} = 22.36\ m$

@ Section 4-4:-

1- $\varphi = 26°\ 33'\ 54''$

2- $a_{4-4} = \frac{R}{\sin\varphi} = 15.65\ m$

i- $S = \sqrt{(R-r)^2 + h^2} = \sqrt{(10-7)^2 + 1.5^2} = 5.35\ m$

ii- S.A $= \pi \cdot r \cdot S = \pi * (R+r) * S = 178.9\ m^2$

iii- H.A $= \pi R^2 - \pi r^2 = 160.22\ m^2$

iv- $t_s = 120\ mm$

b- Loads:-

$g = 3\ KN/m^2$ $P = 1\ KN/m^2$

c- Straining Action:-

@Crown:- $N = \frac{-W_t}{2\pi r \sin\phi}$: $W_t = 0.0$

$\therefore N = 0.0$

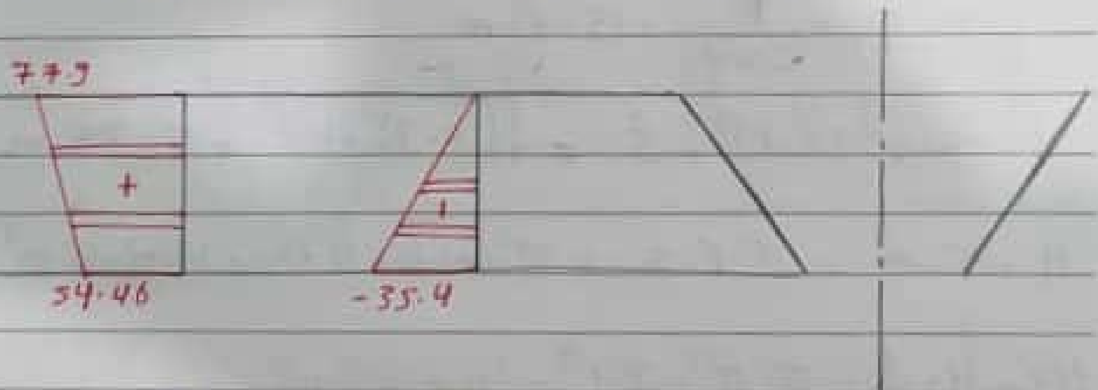
$T = P_r * a$: $P_r = g \cos\phi + P \cos^2\phi$
$= +3.48 \ KN/m^2$

$\therefore T = +3.48 * 22.36 = 77.9 \ KN/m'$

@footing:- $W_t = g * S.A + P * H.A$
$= 3 * 178.9 + 1 * 160.22 = 696.9 \ KN$

$\therefore N = -35.4 \ KN/m'$

$T = P_r * a = +3.48 * 15.65 = 54.46 \ KN/m'$

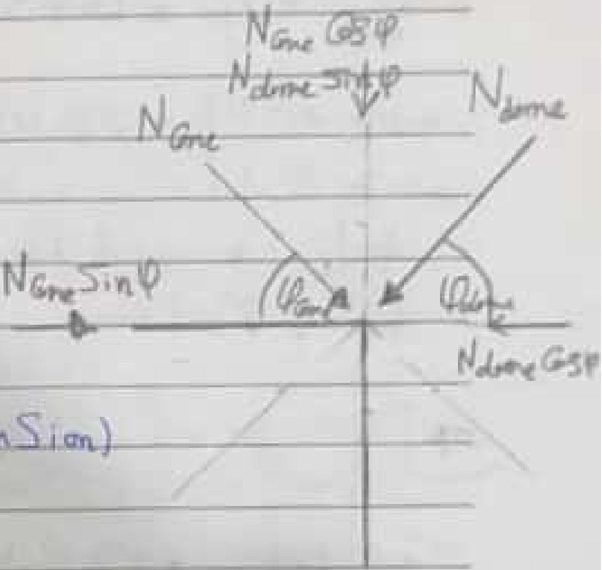


d- Design of critical section:-

Max Comp $= -35.4 \rightarrow N_u = 53.1 \ KN/m'$
Max tens $= +77.9 \rightarrow T_u = 117 \ KN/m'$

$P_u = 1260 \ KN \ggg N_u$ → safe for Comp
use 5 Φ10/m'

$$A_s = \frac{T_u * 10^3}{f_y / \gamma_s} = \frac{117 * 10^3}{350/1.15} = 384.4 = 5\phi12/m'$$



➡ Design of Ring Support:

a. for Horizontal beam:

$H = N_{dome} \cos\varphi - N_{cone} \sin\varphi$

$= 32.2 - 31.7 = 0.5 \ KN/m'$ (Tension)

$\therefore H_{ult} = 1.5 * 0.5 = 0.75 \ KN/m'$

$\therefore T_{ult} = H_{ult} * \frac{D}{2} = 0.75 * \frac{14}{2} = 5.25 \ KN$

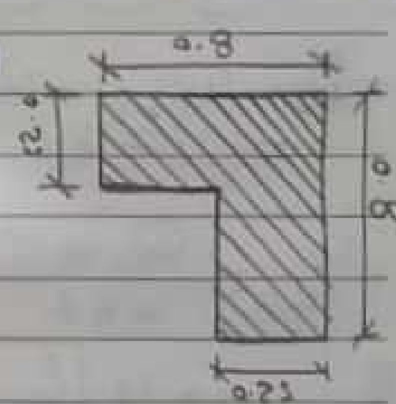
$\therefore A_s = \frac{T_u * 10^3}{f_y / \gamma_s} = 4\phi12/m'$

b - for Vertical beam:

$V = N_{dome} \sin\varphi + N_{cone} \sin\varphi =$

$= 30.3 \ KN/m' \rightarrow V_{ult} = 45.45 \ KN/m'$

No. of support $= \frac{\text{b.all}}{5 \sim 8} = \frac{\pi * 14}{5 \sim 8} = 9 \sim 6 = 8$ Supports



$o.W = \gamma_c * A_c = 25 * [0.25 * 0.8 + 0.25 * 0.55]$

$= 8.4 \ KN/m'$

$\therefore W_v = o.W * 1.4 + V_{ult}$

$= 11.8 + 45.45 = 57.26 \ KN/m'$

$\therefore P_T = \text{Perimeter} * W_v = 2518.5 \ KN$

Load on each Column = $\frac{P_T}{8}$ = 315 KN

$\therefore Q_{max} = \frac{P_T}{16} = 157.5$ KN

$\therefore$ +ve B.M = 0.0042 $P_T r$ = + 74 KN.m

$\therefore$ -ve B.M = -0.0083 $P_T r$ = -146.32 KN.m

$\therefore M_t = 0.0006\, P_T r$ = 10.58 KN.m

$\phi_o = 9° \; 33'$

⇒ Design of B.M :-

Sec 1-1 +ve B.M = 74 KN.m

$\therefore d_1 = C_1 \sqrt{\frac{M_u * 10^6}{f_{cu} * B}} \Rightarrow 750 = C_1 \sqrt{\frac{74*10^6}{30*250}} \Rightarrow C_1 = 7.55$

$\therefore J = 0.826 \rightarrow A_s = \frac{M_u * 10^6}{f_y * J * d} = \frac{74*10^6}{350*0.826*750}$

$= 341 \text{ mm}^2 = 4 \Phi 12$

$A_{s_{min}} = \frac{1.1}{f_y} * b * d = 589.3 \text{ mm}^2 = 8 \Phi 18$

Sec 2.2 use 5Φ18

⇒ Design of shear :-

$Q_u = Q_{max} - W_u * [C/2 + d/2] = 157.5 - 57.26 \left[\frac{0.5}{2} + \frac{0.75}{2}\right]$
$= 121.7$ KN

$\therefore q_{shu} = \frac{Q_u * 10^3}{b * d} = 0.65 \text{ N/mm}^2$

$q_{cu} = 0.16 \sqrt{\frac{f_{cu}}{\gamma_c}} = 0.72 \text{ N/mm}^2$
un Crack

$\therefore$ use 5 Φ10 /m'

→ Design of torsion:-

$M_t = 10.58$ KN m $\varphi_o = 9° 33'$

$Q_u = Q_{max} * \frac{\varphi - \varphi_o}{\varphi}$ $\because \varphi = \frac{360}{8} = 45°$

$= 157.5 * \frac{45 - 9° 33'}{45} = 124 KN$

$q_{sh} = \frac{Q_u * 10^3}{b * d} = 0.66 N/mm^2 < q_{cu}$

$q_t = \frac{M_{tmax} * 10^6}{2 * 0.85 * \frac{A_{oh}^2}{P_h}}$ $\because b' = (250 - 2*15) = 230 mm$
$d' = (800 - 2*50) = 700 mm$

$\therefore A_{oh} = b' * d' = 230 * 700 = 161000 mm^2$
$P_h = 2(b' + d') = 2*[230 + 700] = 1860 mm$

$\therefore q_t = \frac{10.58 * 10^6}{2*0.85 * \frac{(161000)^2}{1860}} = 0.45 N/mm^2$

$0.06 \sqrt{\frac{f_{cu}}{\gamma_c}} = 0.26$ $\rightarrow q_t > 0.06 \sqrt{\frac{f_{cu}}{\gamma_c}}$

$\therefore$ use closed stirrups & longitudinal bars.

* for closed stirrups:-

$A_{str} = \frac{M_{tu} * 10^6 * S}{1.7 * b' * d' * (f_y / \gamma_s)}$

$\therefore A_{str} = \frac{10.58 * 10^6 * 200}{1.7 * 230 * 700 * 350/1.15} = 25.4$

$A_{str_{min}} = \frac{0.4}{f_y} * b * S = \frac{0.4}{350} * 250 * 200 = 57.14$

$\therefore$ use $5 \Phi 10/m'$

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* for long. bars :-

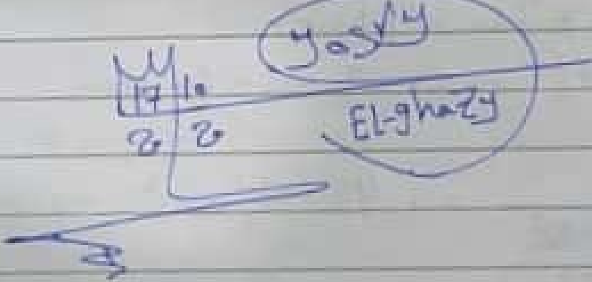
$$A_{s_l} = \frac{A_{str}}{s} * 2(b' + d') * \frac{f_{y\,str}}{f_{yl}} = \frac{25.4}{200} * 2 * (230+700) * \frac{350}{350}$$

$= 236.22\ mm^2$

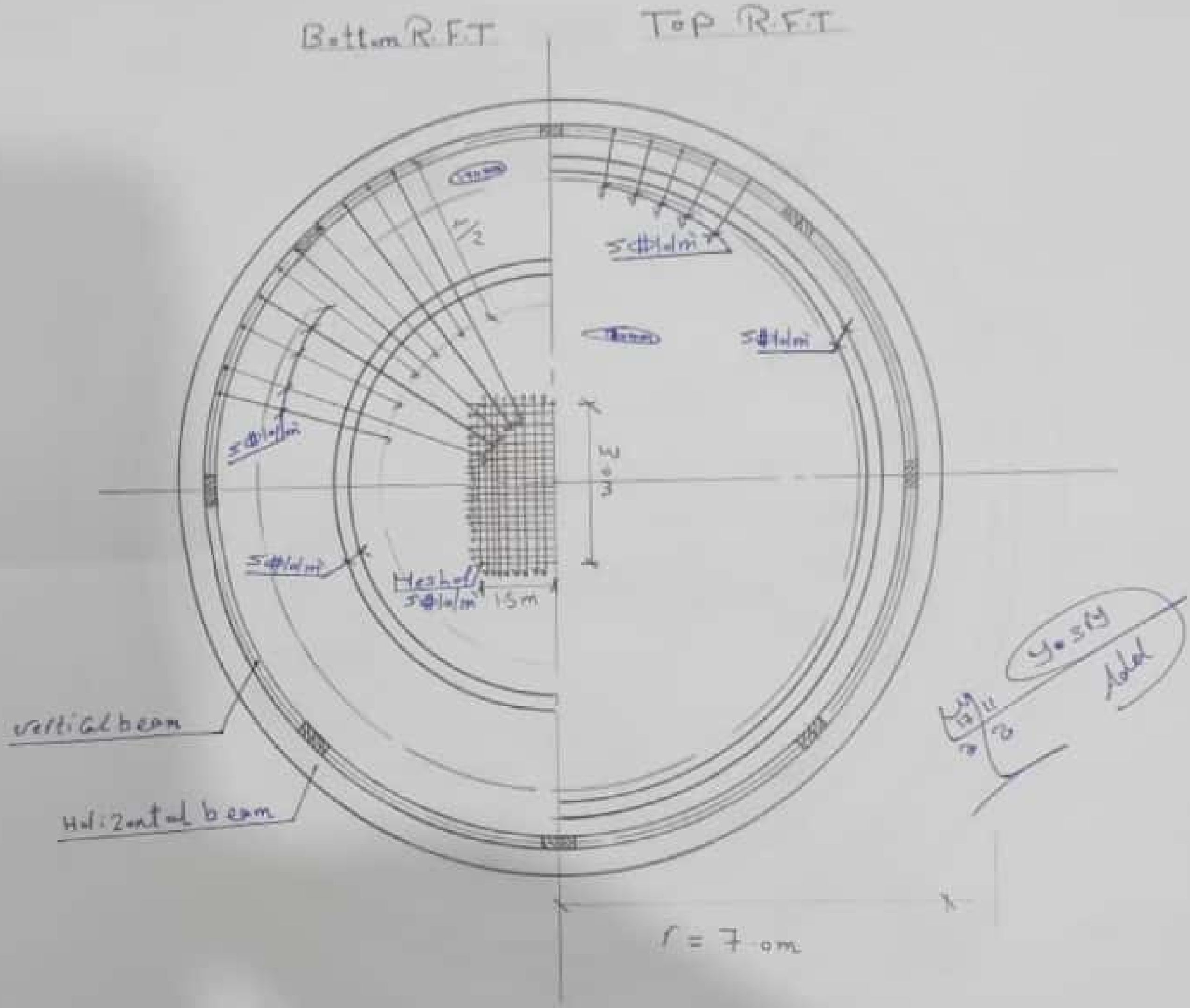
$$A_{s_{min}} = \frac{0.4\sqrt{\frac{f_{cu}}{\gamma_c}}}{f_y/\gamma_s} * A_{cr} - \frac{2A_{str}}{s} * (b' + d') * \frac{f_{yl}}{f_{y\,str}}$$

$$= \frac{0.4 * \sqrt{30/1.5}}{350/1.15} * 250 * 800 - \frac{2 * 28.4}{200} * 970 * 1$$

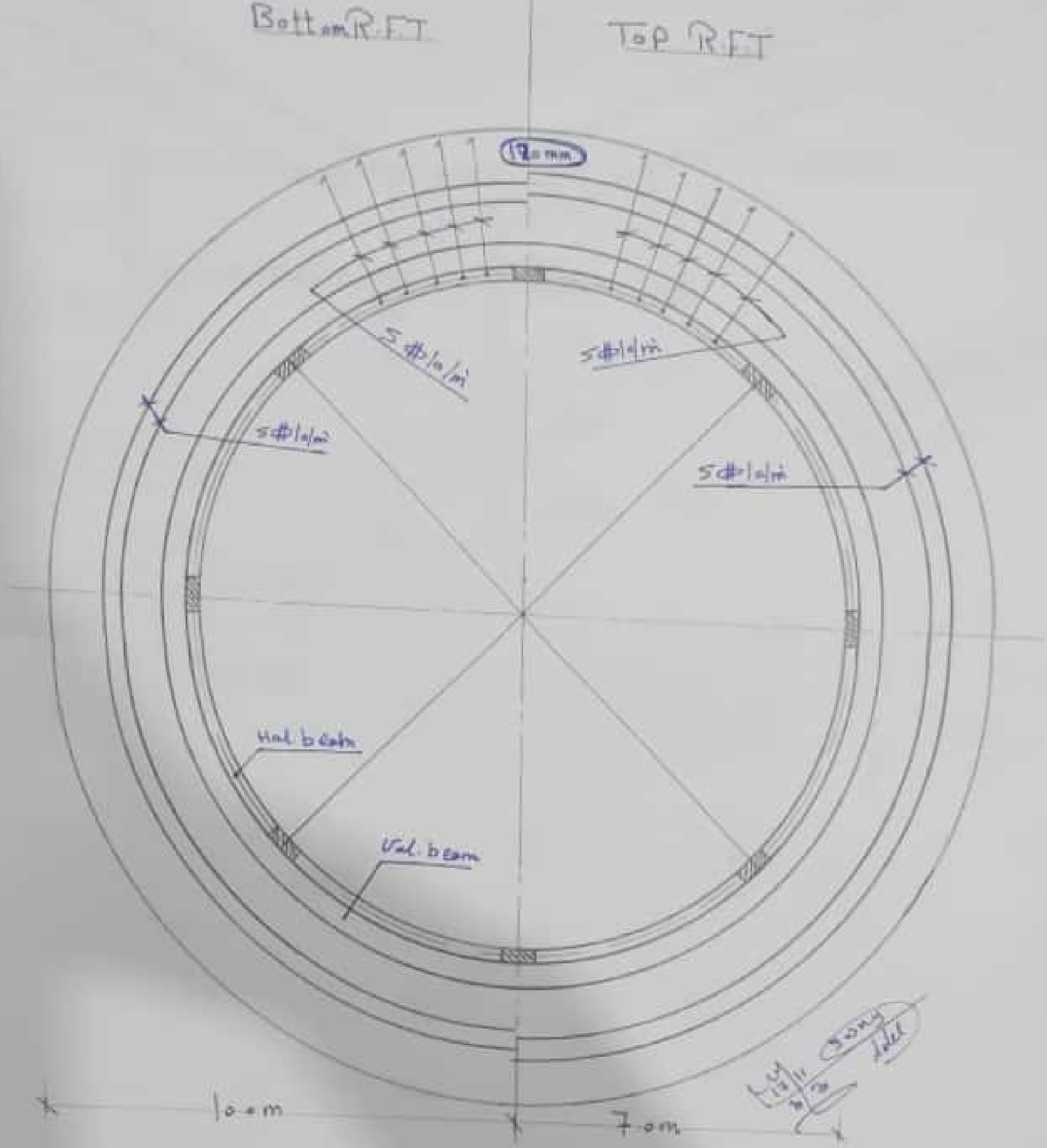
$= 939.3\ mm^2 = 5\ \Phi 16 = 9\ \Phi 12$

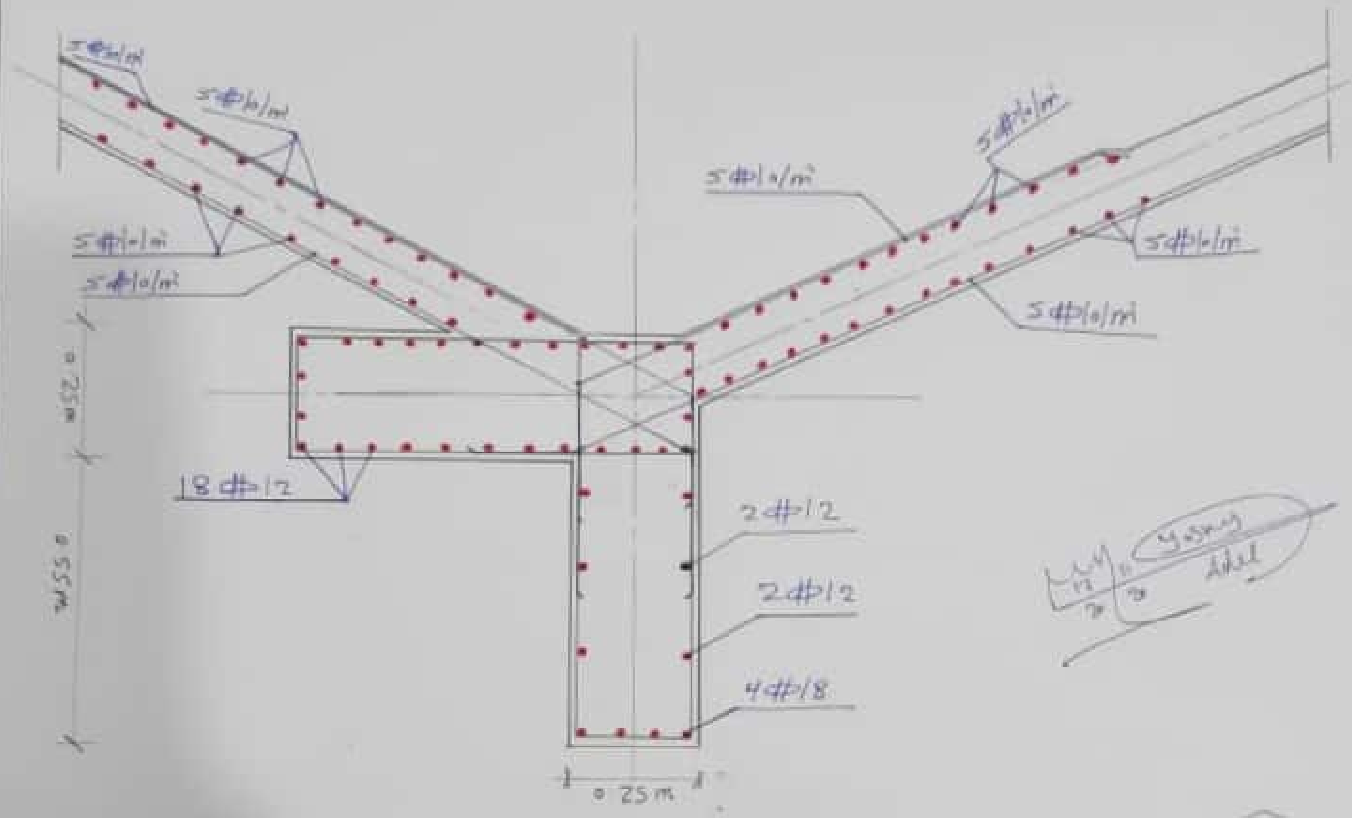


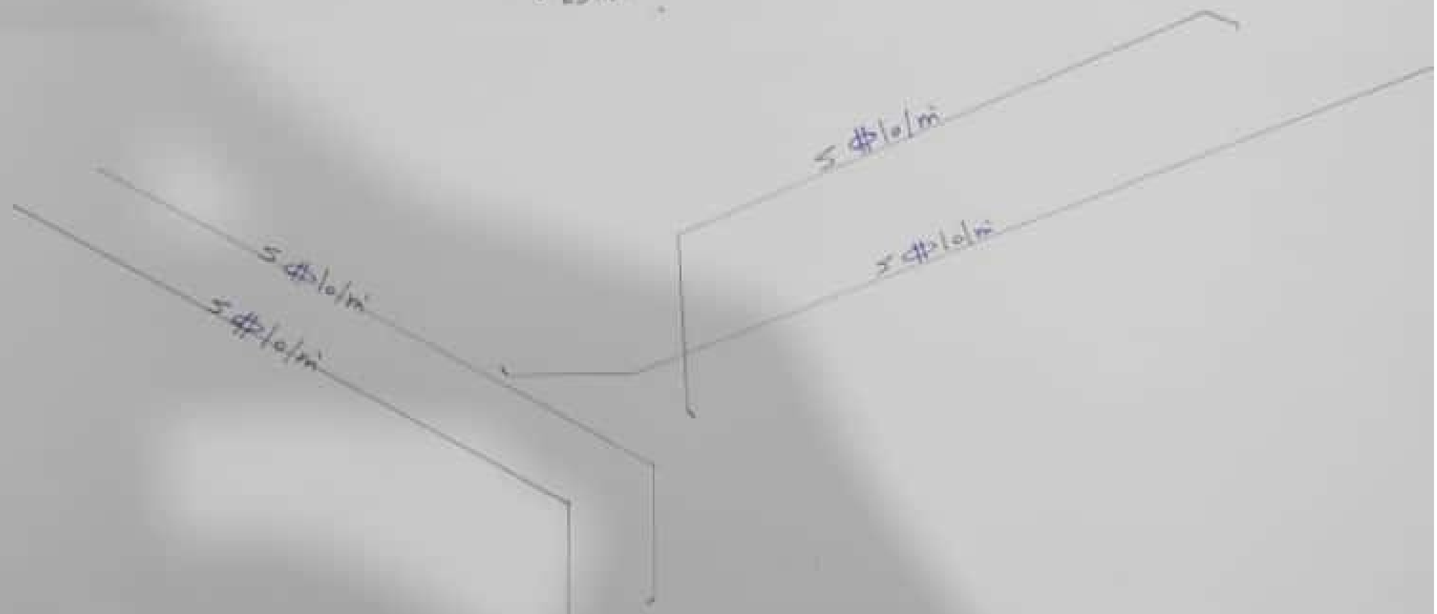
For Dome Part



For Cone Part







closed stirrups.