4th Year Civil Eng.

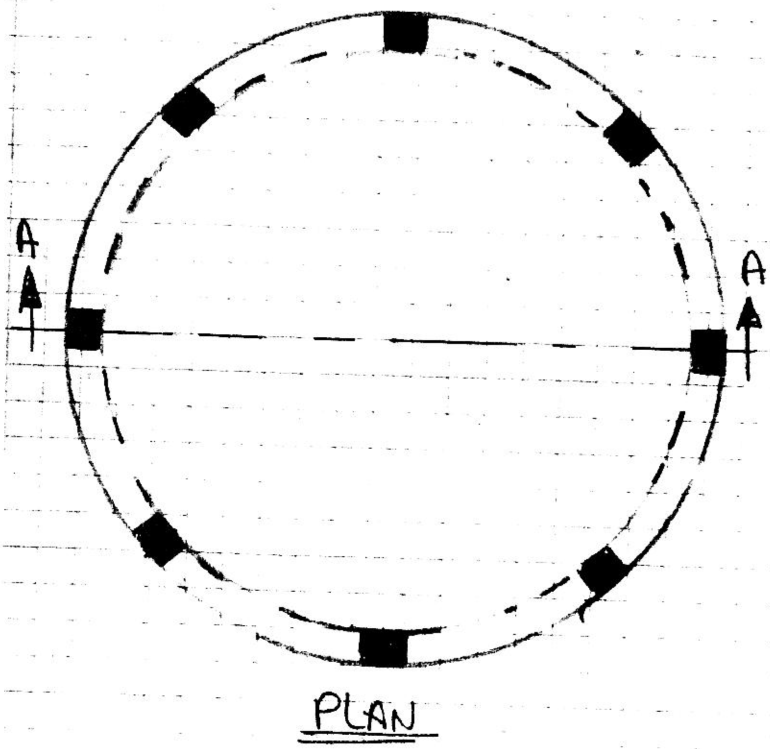
Concrete

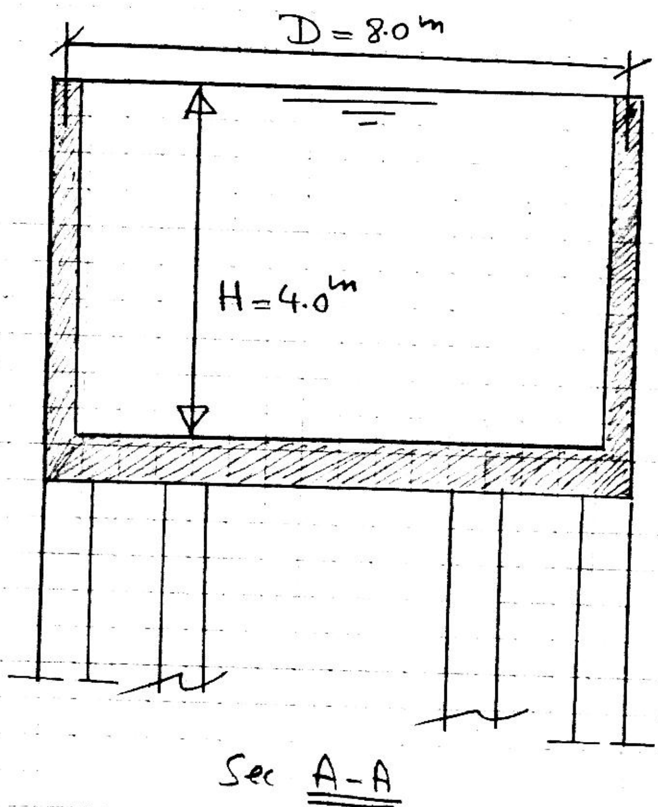
12

#Circular Tanks#

[Elevated Tank]

Ex : Design the shown Elevated circular tank. If $f_{cu} = 30$ MPa & $f_y = 360$ MPa.





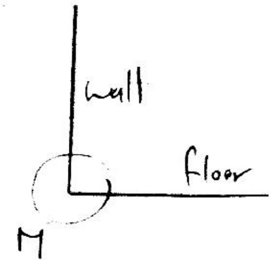
Elevated tank Supported on Outer Perimeter.
→ Statically Indeterminate tank.

Assume $t_w = 0.4 \gamma_w H R = 0.4 * 1.0 * 4 * 4 = 6.4^{cm} \not< 20^{c}$

$t_w = 20^{cm}$

Assume $t_f = t_w + 10 = 30^{cm}$

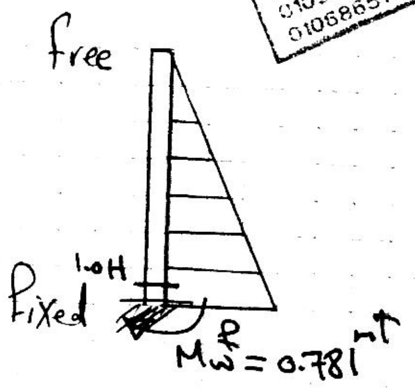
Use the Moment Distribution Method to determine the moment between wall & Floor.



Fixed End Moments and Stiffness :-

wall M_w^f $\frac{H^2}{D.t_w} = \frac{(4)^2}{8*(0.2)} = \boxed{10.0}$

Table VII



$M_w^f = Coeff * \gamma_w * H^3$

$M_w^f = \boxed{-0.0122} * 1.0 * (4)^3$

$M_w^f = \boxed{-0.781 \ mt/m'}$

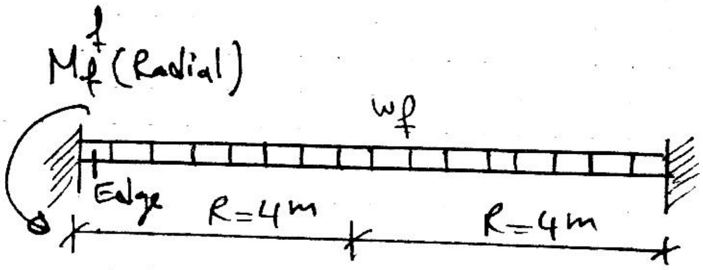
K_{wall} table XX

$K_{wall} = Coeff * \frac{E t_w^3}{H} = \boxed{1.011} * \frac{E*(0.2)^3}{4}$

$K_{wall} = \boxed{2.02*10^{-3} E}$

Floor M_f^f

P.127 Design Aids



$w_f = \gamma_c t_f + \gamma_w H_w$

$w_f = 2.5*0.3 + 1.0*4.0 = \boxed{4.75 \ t/m^2}$

$M_f^f \text{ (Radial)} = 0.125 \, w_f R^2 = 0.125 * (4.75) * (4)^2$

$\boxed{M_f^f = 9.5 \ mt/m'}$

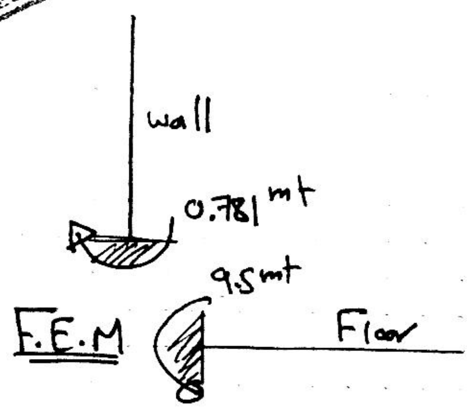
K_{floor} table XIX

▷ Circular plate without Central Support

$K_{floor} = \boxed{0.104} * \frac{E t_f^3}{R} = 0.104 * \frac{E*(0.3)^3}{(4.0)}$

$\boxed{K_{floor} = 0.702*10^{-3} E}$

Moment Distribution :-



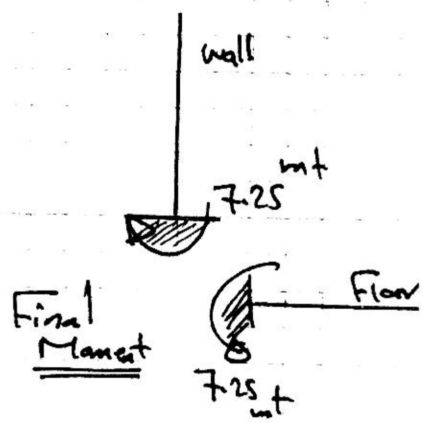
- $D.F_{wall} = \dfrac{K_{wall}}{K_{wall} + K_{floor}}$

$D.F_{wall} = \dfrac{2.02}{2.02 + 0.702} = \boxed{0.742}$

- $D.F_{Floor} = 1 - D.F_{wall} = \boxed{0.258}$

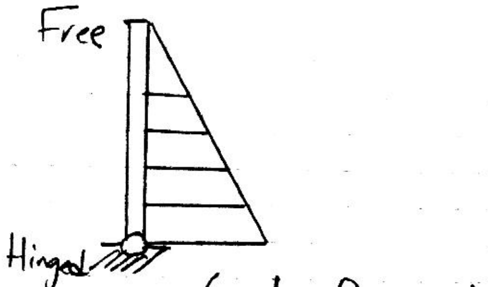
مع عقارب الساعة (+)

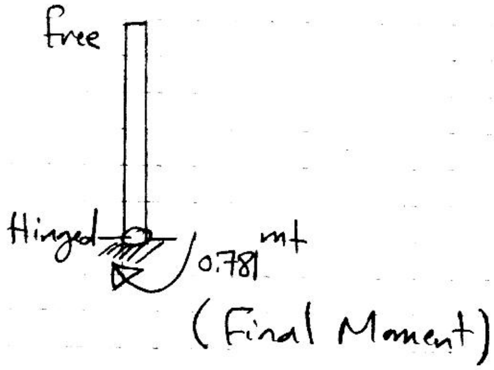
	Wall	Floor
D.F	0.742	0.258
F.E.M	+0.781	−9.5 mt
Dist. Moment	+8.719 +6.47	
Final Moment	+7.25 mt	−7.25 mt



Straining Actions :- Wall

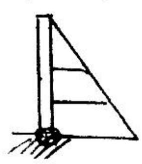
تم اعتبار الـ Hinged at Base ونؤثر عليه (M_{final}) بالإضافة إلى الـ (Water Pressure).

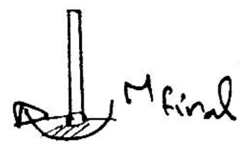




Wall H.L Dir (Ring tension)

$T = T_1$ (water Pressure) $+ T_2$ (Final M.)





→ T_1 (table II) $= Coeff * \gamma_w HR$

$$T_1 = Coeff * 1.0 * 4.0 * 4.0 = \boxed{Coeff * 16}$$

→ T_2 (table VI) $= Coeff * \frac{MR}{H^2}$

$$T_2 = Coeff * \frac{-725 * 4.0}{(4.0)^2} = \boxed{-Coeff * 1.8125}$$

Section	Water Pressure		Final Moment		T
	Coeff ①	T_1	Coeff ②	T_2	
0.3H	+0.311	+4.976	−0.94	+1.7	+6.679
0.4H	+0.428	+6.848	−0.73	+1.323	+ 8.17
0.5H	+0.552	+8.832	+0.82	−1.486	+7.34
0.6H	+0.666	+10.656	+4.79	−8.68	+1.97
0.7H					
0.8H					
0.9H					

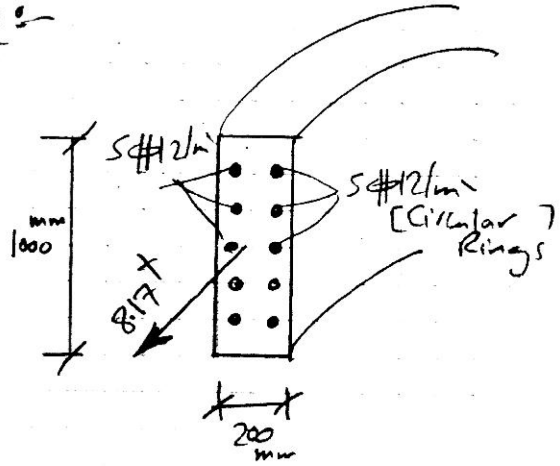
$T_{max} = \boxed{8.17\ t}$ @ 0.4H

Design of Section of Ring tension:-

- **Check tensile Stresses:-**

$$f_{ct} = \frac{T}{bt} = \frac{8.17 * 10^4}{1000 * 200}$$

$$f_{ct} = 0.41\ N/mm^2$$



$$\frac{f_{ctr}}{\eta} = \frac{0.6\sqrt{30}}{1.7} = 1.933\ N/mm^2$$

$$f_{ct} < \frac{f_{ctr}}{\eta} \quad \text{(ok Safe)}$$

- **A_s** $\quad T_u = 1.4\,T = 11.438\ t$

$$A_s = \frac{T_u}{f_y / \gamma_s} = \frac{11.438 * 10^4}{(0.85 * 360)/1.15} = \boxed{430\ mm^2}$$

$A_s/\text{side} = \frac{A_s}{2} = \boxed{215\ mm^2}$ Use 5Φ12/m' each side

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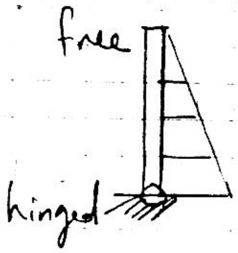
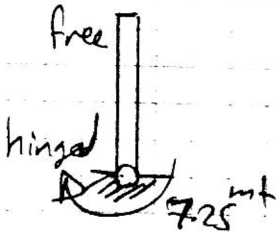
$V^{\underline{L}}$ Dir "Cantilever Action"

Moment

$M = M_1 \text{ (water Pressure)} + M_2 \text{ (Final moment)}$





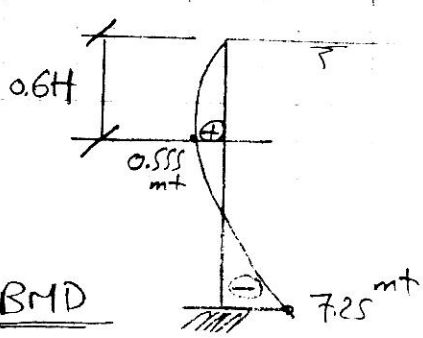
→ M_1 (table VIII) $= Coeff * \gamma_w * H^3$

$M_1 = Coeff * 1.0 * (4)^3 = \boxed{Coeff * 64}$

→ M_2 (table XI) $= Coeff * M$

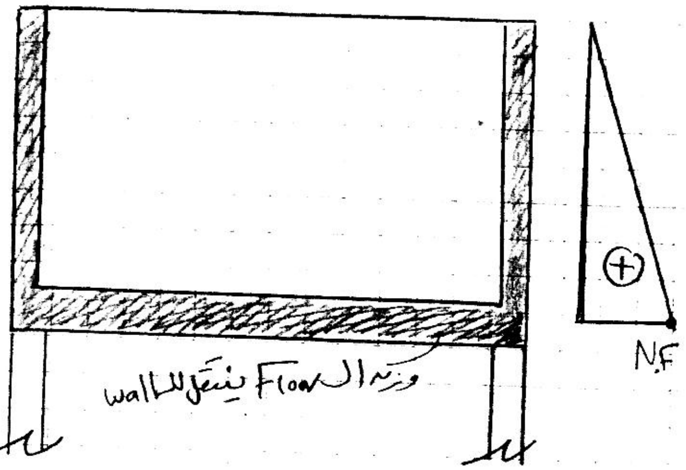
$M_2 = Coeff * -7.25 = \boxed{-Coeff * 7.25}$

Section	Water Pressure		Final Moment		M
	Coeff ①	M_1	Coeff ②	M_2	
0.3H					
0.4H					
0.5H	+0.0002	+0.0128	−0.053	+0.3842	+0.397
0.6H	+0.0011	+0.07	−0.067	+0.48	+0.555
0.7H	+0.0025	+0.16	−0.031	+0.2247	+0.384
0.8H					
0.9H					
1.0H	0.	0	+1	−7.25	−7.25



BMD

N.F (wall)



- If there is no exterior Circular Beam [wall directly on Columns]

→ N.f (wall) Caused by Floor weight

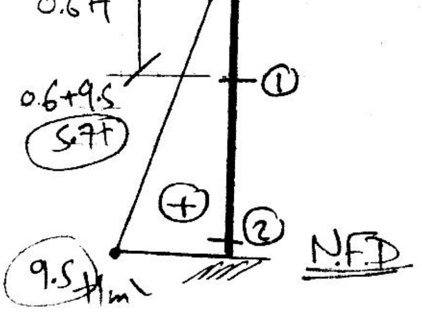
Tension

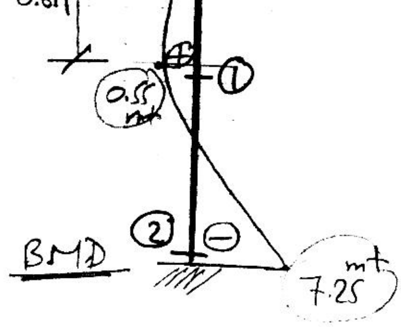
N.F "No exterior Circular Beam"

$$\text{Load from floor to wall}/m' = \frac{w_f * A_f}{\text{Perimeter of wall}}$$

$$N = \frac{4.75 * \pi \frac{(8)^2}{4}}{\pi (8)} = 9.5\ t/m'$$

$$T_{(wall)} = 9.5\ t/m'$$



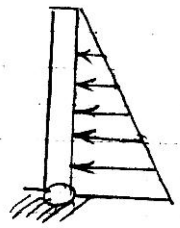


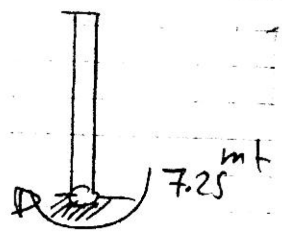
Critical sections of wall :-

Section	N	M	Type	t (mm)	A_s / m'
1	+5.7 t	0.55 mt	Air	200	
(2)	+9.5 t	7.25 mt	Water	200 [550]	6#16 / m'

Wall shear $\xrightarrow{\text{cause}}$ N.F on floor

$$V = V_1 \text{ (water pressure)} + V_2 \text{ (Final moment)}$$

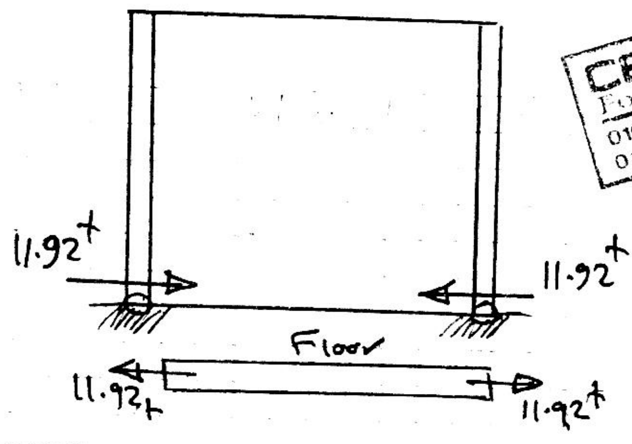




$$V = \text{Coeff} * \gamma_w H^2 + \text{Coeff} * \frac{M}{H}$$

$$V = \boxed{+0.087} * 1.0 * (4)^2 + \boxed{-5.81} * \frac{-7.25}{4.0}$$

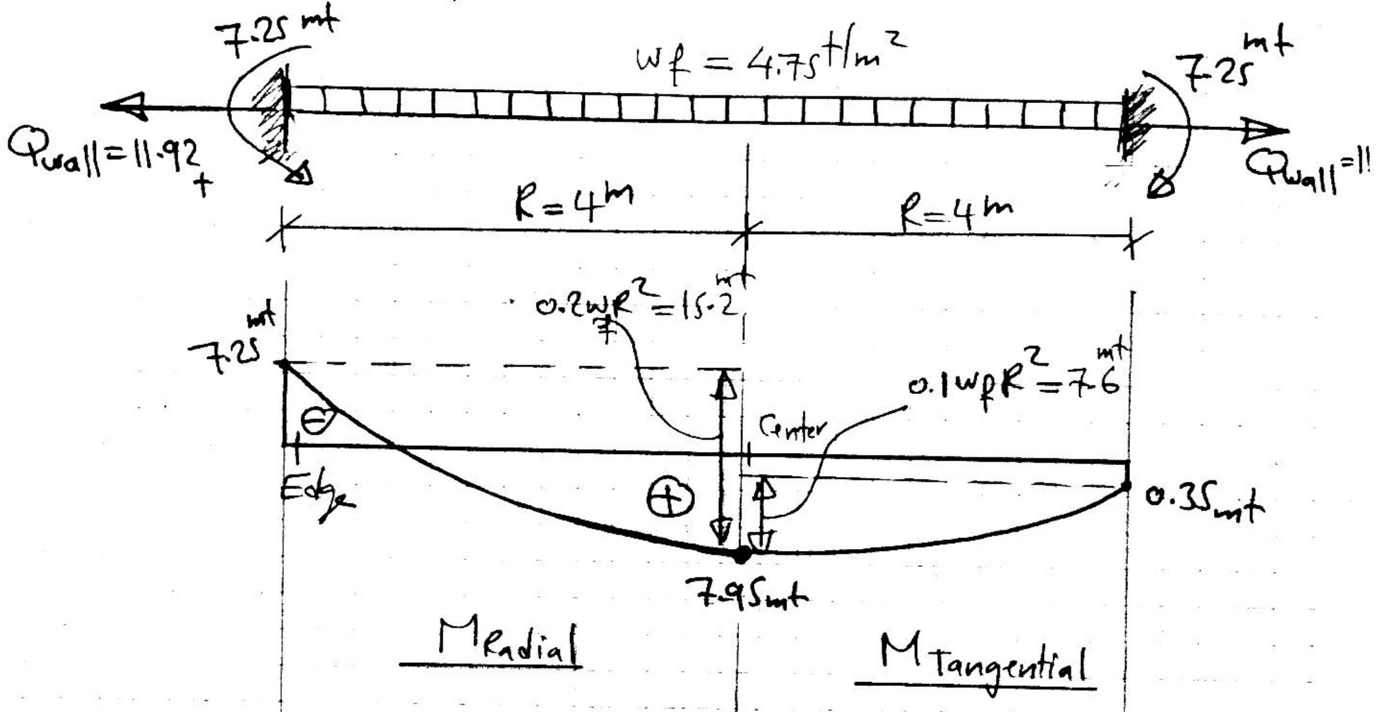
$$\boxed{V = +11.92^t}$$ act inward داخل الخزان



Floor :-

- Radial Moment
- Tangential Moment
- N.F.

Circular plate



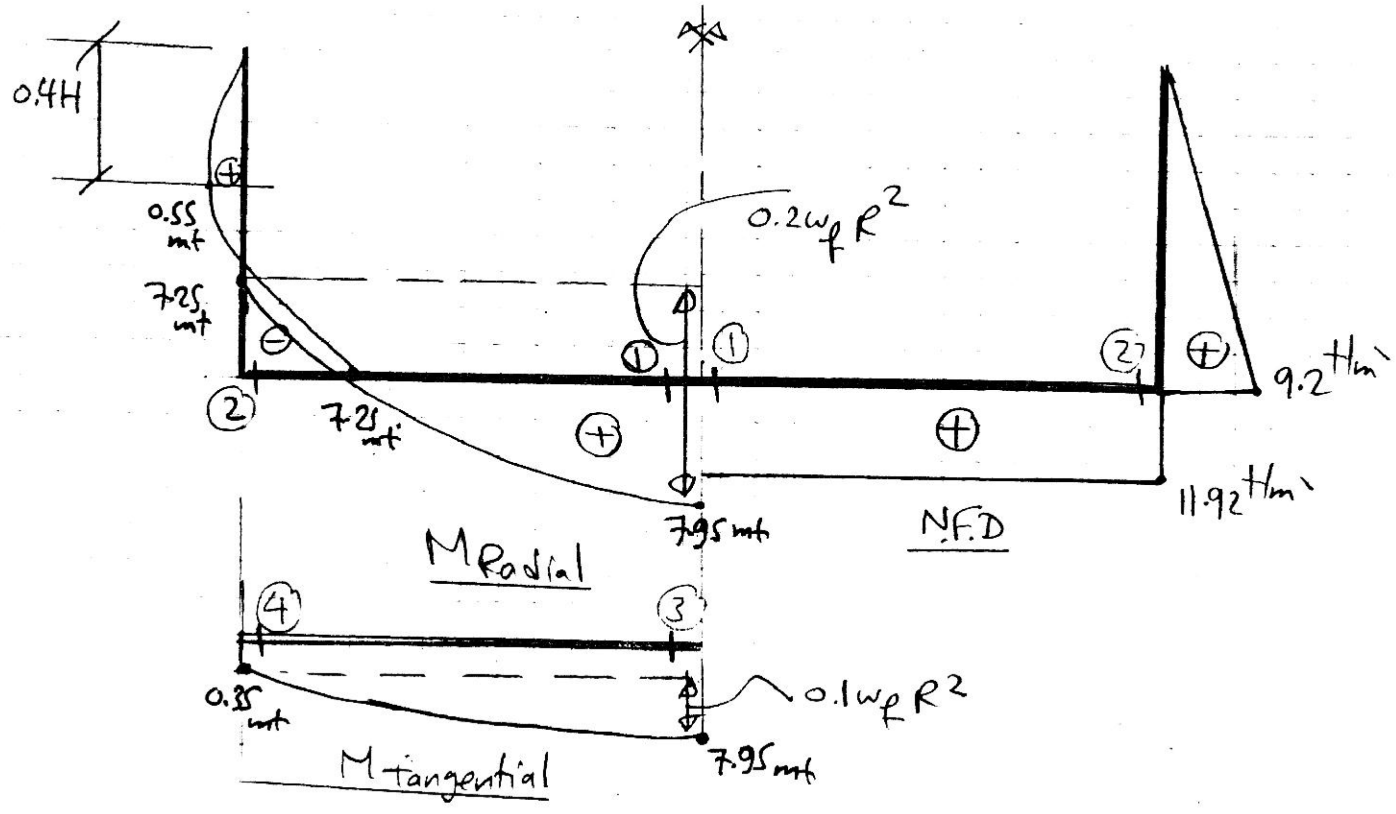
$M_{R\,[Edge]} = \boxed{-7.25\ mt}$

$M_{R\,[center]} = -7.25 + 0.2\, w_f R^2 = \boxed{+7.95\ mt}$

$M_T = M_R\ [center] = \boxed{+7.95\ mt}$

$M_{T\,[Edge]} = +7.95 - 0.1\, w_f R^2 = \boxed{+0.35\ mt}$

Moments & NF on tanks:-



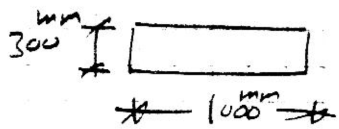
Critical sections for floor :-

Section	N (t)	M (mt)	Type	t (mm)	As /m'
1	+11.92	7.95 (M_e)	Air	300	7 Φ16 /m'
2	+11.92	7.25 (M_e)	water	300 [550]	6 Φ16 /m'
3	—	7.95 (M_T)	Air	300	7 Φ16 /m'
4	—	0.35 (M_T)	Air	300	min 5 Φ12 /m' 5 Φ10 /m'

Design of Critical section for wall & Floor :-

Sec (2) Floor $N = 11.92^{t}$ & $M = 7.25^{mt}$ [water-side]

- Check tensile stresses



$$f_{ct} = \frac{N}{bt} + \frac{6M}{bt^2}$$

$$f_{ct} = \frac{11.92*10^4}{1000*300} + \frac{6*7.25*10^7}{1000*(300)^2}$$

$$f_{ct} = 0.397 + 4.833 = \underline{5.23\ N/mm^2}$$

$$\frac{f_{ctr}}{\eta} \rightarrow t_u = 300\left[1 + \frac{0.397}{4.833}\right] = \underline{325\ mm}$$

$$\boxed{\eta \cong 1.5}$$

$$\frac{f_{ctr}}{\eta} = \frac{0.6\sqrt{30}}{1.5} = 2.19\ N/mm^2$$

$$f_{ct} > \frac{f_{ctr}}{\eta} \Rightarrow \underline{\text{Unsafe}}$$

Take $\boxed{t = 550\ mm}$

$$f_{ct} = \frac{11.92*10^4}{1000*550} + \frac{6*7.25*10^7}{1000*(550)^2}$$

$$f_{ct} = 0.216 + 1.438 = \underline{1.65\ N/mm^2}$$

$$f_{ct} < \frac{f_{ctr}}{\eta} \rightarrow \underline{\text{ok Safe}}$$

• **A_s**

$$e = \frac{M}{N} = \frac{7.25}{11.92} = 0.608\ m > \frac{t}{2} \quad (\text{Big ecc})$$

$$e_s = e - \frac{t}{2} + \text{Cover} = 0.608 - \frac{0.55}{2} + 0.04 = \boxed{0.37\ m}$$

$$M_{us} = N_u \cdot e_s = (1.4 * 11.92) * 0.37 = \boxed{6.228\ mt}$$

$$d = c_1 \sqrt{\frac{M_{us}}{f_{cu} \cdot b}} \rightarrow c_1 \rightarrow \boxed{J = 0.826}$$

$$A_s = \frac{M_{us}}{f_y \cdot J \cdot d} + \frac{N_u}{f_y / \gamma_s}$$

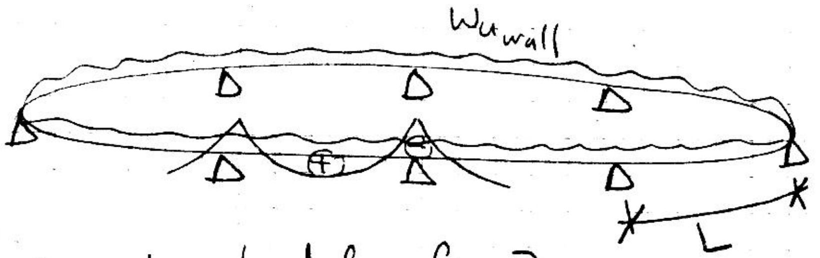
$$A_s = \frac{6.228 * 10^7}{(0.8 * 360) * 0.826 * 510} + \frac{(1.4 * 11.92) * 10^4}{(0.8 * 360)/1.15}$$

$$\boxed{A_s = 1179.7\ mm^2}$$

Use 6 #16 / m'

Design of wall as a beam :- [Beam action]

wall acts as a beam on columns if there is no outer circular Beam



$$Wu_{wall} = 1.4 [\text{own wt} + \text{load from floor}]$$

$$Wu_{wall} = 1.4 [\gamma_c \cdot t_w \cdot H + 9.5] = 1.4 [2.5 * 0.2 * 4 + 9.5]$$

$$Wu_{wall} = \boxed{15.68\ t/m'}$$

• Moments on Circular Beam :- Design Aids [P. 91]

$$M_{max}(-ve) = -0.0083\ Pr$$

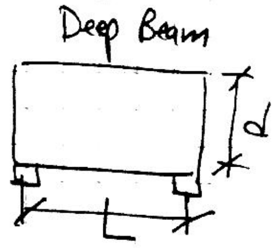
$$M_{max}(+ve) = +0.0042\ Pr$$

$$P = 2\pi r\, W_{wall} = 2*\pi*4*15.68 = \underline{394.08}\ t/m$$

- max M_{-ve} = $\boxed{-13.08\ mt}$
- max M_{+ve} = $\boxed{+6.62\ mt}$

Design of wall as a Deep Beam :-

If $\frac{L}{d} < 4 \rightarrow$ "Deep Beam"



$$\underset{\text{Span of Beam}}{L} = \frac{\pi D}{n_{c}} = \frac{\pi(8)}{8} = \boxed{3.14^{m}}$$

(n_c = no. of columns)

$$d = t - cover = 4.0 - 0.1 = 3.9\,m$$

$\rightarrow \frac{L}{d} = \frac{3.14}{3.9} = 0.8 < 4 \rightarrow$ "Deep Beam"

- ⊛ $\frac{L}{d} < 1.25$ [simple]
- ⊛ $\frac{L}{d} < 2.5$ [Continuous]

→ Design Using Empirical method

- ⊛ $\frac{L}{d} > 1.25$ [Simple]
- ⊛ $\frac{L}{d} > 2.5$ [Continuous]

→ Strut & Tie Model

$\rightarrow \frac{L}{d} < 2.5 \rightarrow$ "Empirical Method"

Empirical Method

$$\rightarrow T_u = \frac{M_u^{\ominus}}{y_{ct}}$$

$$\rightarrow y_{ct\,\ominus} = 0.37L \ngtr 0.87d$$

$$A_s = \frac{T_u}{F_y/\gamma_s}$$

- $y_{ct} = 0.37 * 3.14 = \underline{1.1618\,m} < 0.87*3.9 = 3.4_m$

$\boxed{OK}$

$$T_u = \frac{M_u \theta}{y_{ct}} = \frac{13.08}{1.1618} = \boxed{11.25\ t}$$

$$A_s = \frac{11.25 * 10^4}{(0.8 * 360)/1.15} = \underline{450\ mm^2}$$

 # Check $\boxed{A_{s_{min}}}$:-

$A_{s_{min}}$ = the least of

$\rightarrow \frac{0.255\sqrt{f_{cu}}}{f_y} bd \geq \frac{1.1}{f_y} b.d$

(3026.16 mm²)   (2383 mm²)

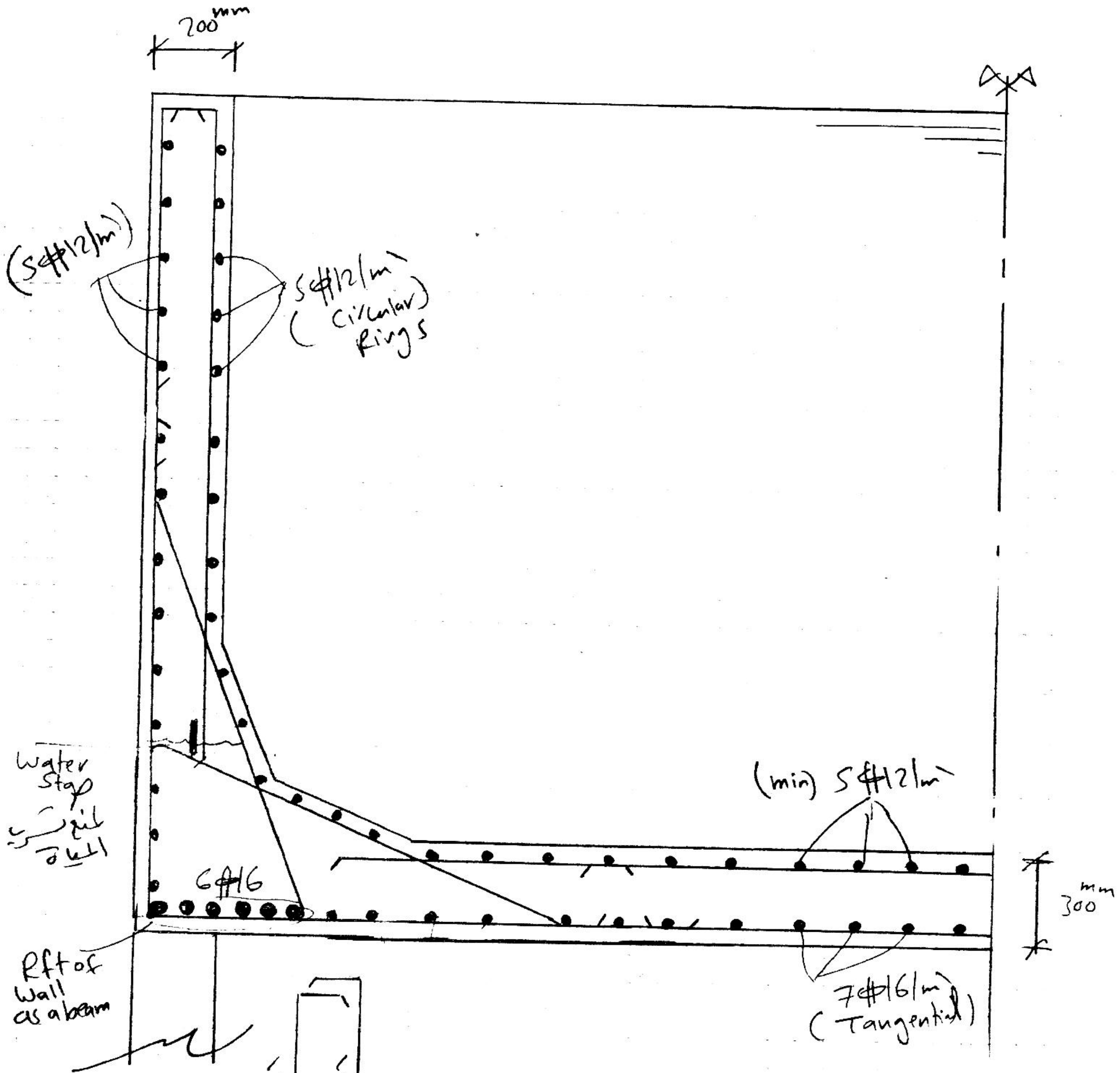
$\rightarrow 1.3 A_{s_{req}} = \underline{584.4\ mm^2}$

$$A_{s_{min}} \nless \frac{0.15}{100} bd \nless (1170\ mm^2)$$

$$\boxed{A_{s_{min}} = 1170\ mm^2}$$

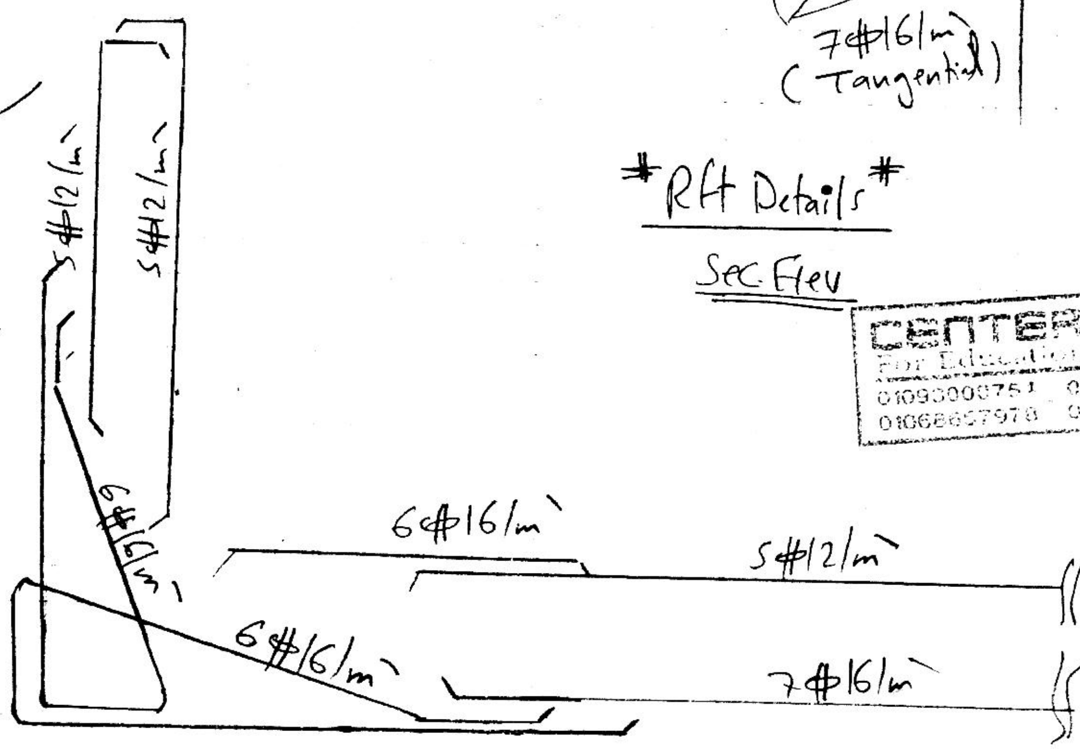
$$A_s = A_{s_{min}} = (1170\ mm^2)$$

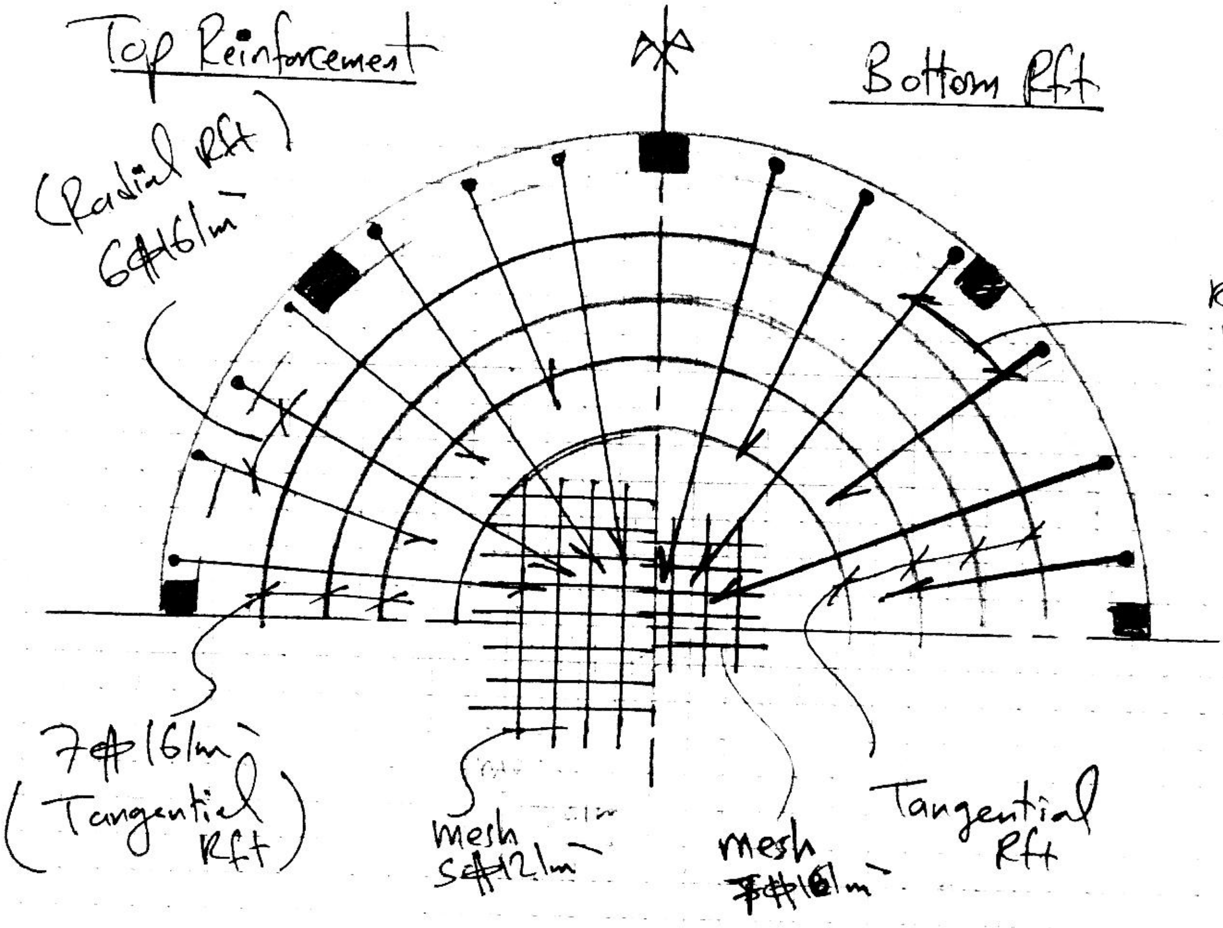
Use 6#16 * for wall as a beam #



Rft Details

Sec Elev





Top Reinforcement
Bottom Rft
(Radial Rft
6Φ16/m')
Radial
Rft
7Φ16/m'
(Tangential
Rft)
mesh
5Φ12/m'
mesh
7Φ16/m'
Tangential
Rft

PLAN