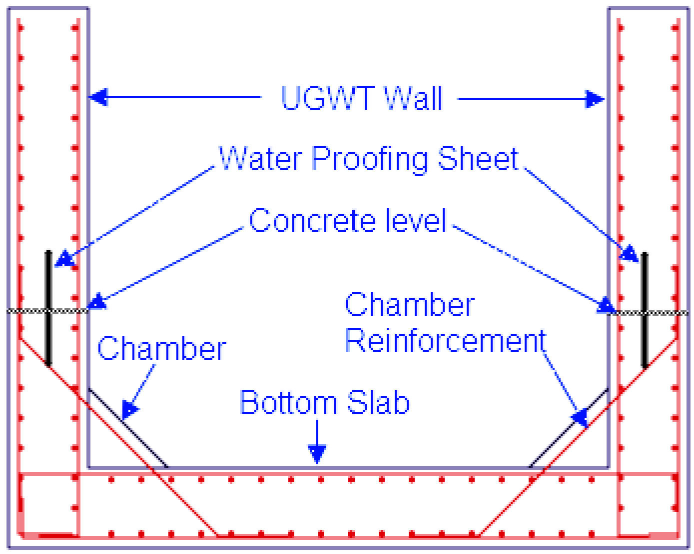
Design of Rectangular concrete Tank:

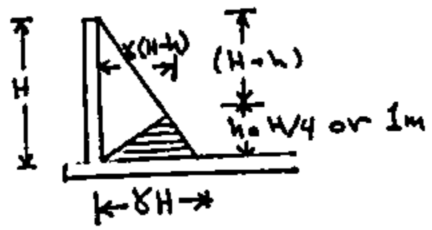


Under Ground Water Tank

Approximate Design Method

(a) For tanks of ratio $(L/B) < 2$

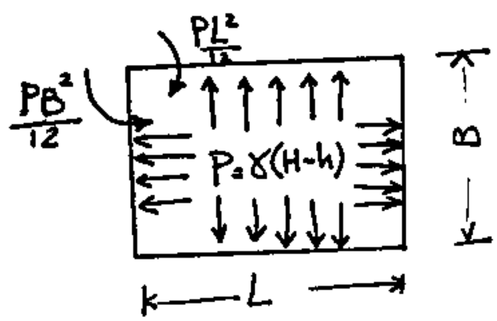
Refering to the Fig. below for the bottom height of $h = H/4$ or 1m (which ever is more), the bending is in vertical plane & this portion is designed as Cantilever:

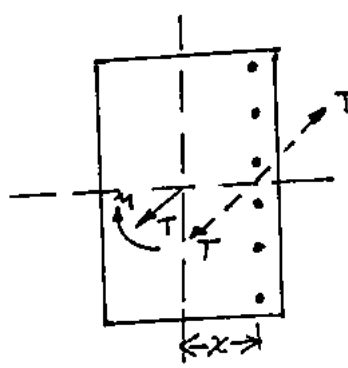


* عند ملئ الخزان بالماء فان الجدران تتعرض الى انحناء Bending في الاتجاهين ..
قد يكون هنا الانعطاف افقي ←

* وقد يكون انعطاف رأسي ويكون شكل Cantilever على ارضية الخزان.

* يجب تحديد اتجاه محور الانعطاف نتيجة ضغط المياه على الجدران ثم تحديد موضع واتجاه حديد التسليح الرئيسي في الجدران لغرض مقاومة العزوم.





The corners are designed for the maximum moment obtained after moment distribution with the intensity pressure $P = \gamma(H-h)$.

In the absence of moment distribution the bending moment may be computed by the following approximate expression

Bending moment at centre of span $= \left(\frac{PB^2}{16}\right)$ (producing

Bending moment at ends of span = $\left(\frac{PB^2}{12}\right)$ (producing tension on water face).

In addition to the bending moments, the walls are subjected to direct tension given by:-

Direct tension on long walls = $T_L = \gamma(H-h)\, B/2$
Direct tension on short walls = $T_b = \gamma(H-h)\, L/2$
Design moment = $(M - T.x)$

For B.M., $A_{st_1} = \left[\frac{M - Tx}{f_{st}.j.d}\right]$

$\therefore A_{st} = (A_{st_1} + A_{st_2})$

For direct tension $A_{st_2} = (T/f_{st})$

(b) Ratio of $(L/B) > 2$

In this case long walls are assumed to bend vertically & hence designed as cantilevers. Short walls are assumed to bend horizontally supported on long walls above H/4 or 1 m from bottom.

Bending moment for long walls = $\left(\frac{\gamma H^3}{6}\right)$

B.M. for short walls (above 1m from base) = $\frac{\gamma(H-h)B^2}{16}$

Maximum cantilever moment for short wall = $\left(\frac{\gamma H h.h}{2*3}\right)$

$= \left(\frac{\gamma H.h^2}{6}\right)$

In addition direct pulls are considered for long & short walls.

A rectangular Reinforced Concrete water tank with an open top is required to store 80,000 liters of water. The inside dimensions of tank as 6m x 4m. The tank rests on walls on all the four sides. Design the side walls of the tank for the following data.

Free Board

$F.B. = 15cm$, $j = 0.84$, $n = 13$, $f_c = 7MPa$

$f_{st} = 125MPa$ (on faces away from water face), $f_{st} = 100MPa$ (on faces near water face)

Solution :-

* Height of water $= \left(\frac{80,000 * 10^3}{600 * 400}\right) = 335cm = 3.35m$

Height of side walls $= (335 + 15) = 350cm = 3.5m$

$(L/B) = 6/4 = 1.5 < 2$

$\therefore$ Walls designed as continous slab subjected to water pressure above $(H/4)$ or $(1m)$ from bottom.

$\therefore P = \gamma(H - h) = (10 * 2.5) = 25 kN/m^2$

* Moments in Side walls:-

The moments in side walls is determined by moment distribution.

Fixed end moments:

Long Walls

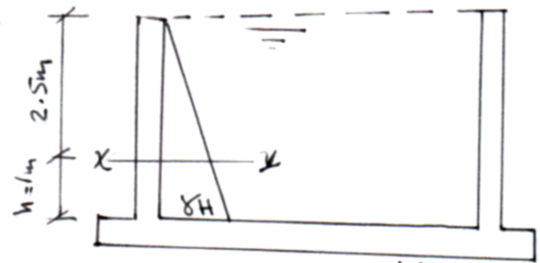
$\left(\frac{P.L^2}{12}\right) = \left(\frac{25*6^2}{12}\right) = 75 kN.m$

$\left(\frac{P.L^2}{8}\right) = \left(\frac{25\times6^2}{8}\right) = 112.5 kN.m$

Short Walls

$\left(\frac{PB^2}{12}\right) = \left(\frac{25*4^2}{12}\right) = 34 kN.m$

$\left(\frac{PB^2}{8}\right) = \left(\frac{25*4^2}{8}\right) = 50 kN.m$



$\gamma H = (10 \times 3.5) = 35\ kN/m^2$

Tank Dimensions

0.6	0.4
+34	-75
+24.6	+16.4
+58.6	-58.6

0.4	0.6
+75	-34
-16.4	-24.6
+58.6	-58.6

$\frac{EI}{L}$, EI → متساوي للجدارين *

* L مختلف

Distribution Stiffness Factor

DF

for Long wall

$$DF_{\text{Long wall}} = \frac{K}{2K} = \frac{\frac{EI}{6}}{\frac{EI}{6} + \frac{EI}{4}} = \frac{EI}{EI}\left(\frac{\frac{1}{6}}{\frac{4+6}{24}}\right)$$

$$DF_{\text{Long wall}} = \frac{4}{10} = 0.4$$

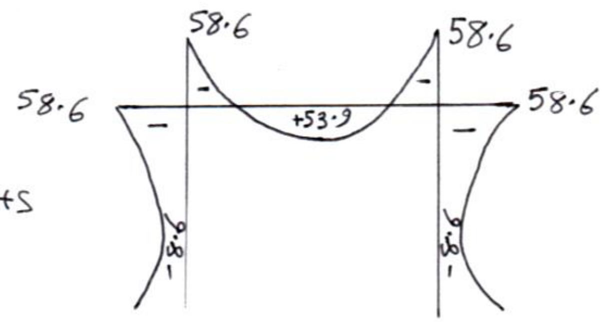
$$DF_{\text{short wall}} = \frac{\frac{EI}{4}}{\frac{EI}{4} + \frac{EI}{6}} = \frac{\frac{1}{4}}{\frac{10}{24}} = \frac{6}{10} = 0.6$$

Moment at support = 58.6 kN.m

Moment at centre (Long walls) = (112.5 − 58.6) = 53.9 kN.m

Moment at centre (Short walls) = (50 − 58.6) = −8.6 kN.m

Bending Moments



* Design of Long & Short Walls :-

Maximum moment = 58.6 kN.m

$$d_{req.} = \sqrt{\frac{M_{max}}{0.5\,K\,j\,b\,f_c}} \quad , r = \frac{100}{7} = 14.286 \, , \; K = \frac{n}{n+r} = \frac{13}{13+14.3} = 0.476$$

$$d_{req.} = \sqrt{\frac{58.6 * 10^6}{0.5 * 0.476 * 0.84 * 1000 * 7}} = 204.63 \text{ mm}$$

(at xx)

Adopt overall depth = 250 mm

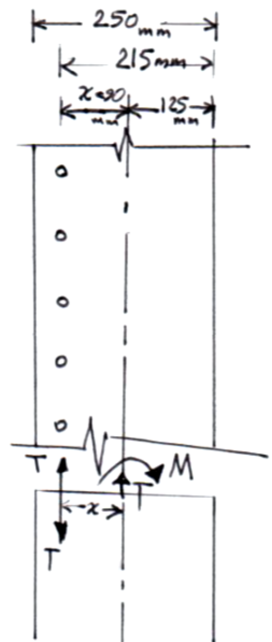
Use Effective depth = 215 mm

Direct tension in Long wall = $T = \left(\frac{P*B}{2}\right) = \left(\frac{25*4}{2}\right) = 50$ kN

Direct tension in short wall = $T = \left(\frac{P*L}{2}\right) = \left(\frac{25*6}{2}\right)$

$T = 75$ kN

$$A_{st}\text{ (Long wall corners)} = \left[\frac{M - T*x}{f_{st} \cdot j \cdot d}\right] + \frac{T}{f_{st}}$$



Net Moment $= (M - T * x)$

T = Pull in Steel

Fig. (Moments in Cross Section)

Refering to the Fig. above

$$\therefore A_{st} = \left[\frac{(58.6*10^6) - (50*10^3*90)}{100*0.84*215}\right] + \left[\frac{50*10^3}{100}\right]$$

$= 3495\ mm^2$

Use ϕ 20mm bar for reinforcement.

Spacing of 20mm ϕ bars $= \frac{1000}{3495/314} \simeq 90\ mm\ c/c$

- Center of Span (Long Walls)

$$A_{st} = \left[\frac{(53.9*10^6 - 50*10^3*90)}{125*0.84*215}\right] + \left[\frac{50*10^3}{125}\right] = 2588.26\ mm^2$$

∴ Half the bars from inner face at support are bent twoards outer face at center providing an area of: $\frac{3495}{2} = 1748\ mm^2$

For remaining area $(2588 - 1748) = 840\ mm^2$

Provide ϕ 16 mm with spacing $= \frac{1000}{840/201} = 239\ mm\ c/c$

Use ϕ 16mm @ 200 mm c/c

Short Walls :- (corners)

$$A_{st} = \left[\frac{(58.6 * 10^6) - (75 * 10^3 * 90)}{100 * 0.84 * 215}\right] + \left(\frac{75 * 10^3}{100}\right) = 3620\ mm^2$$

Use ϕ 20mm with spacing $= \frac{1000}{\frac{3620}{314}} = 86\ mm\ c/c$

Use ϕ 20 mm @ 80 mm c/c (50% of bars bend twoards outer face at center)

At the center of short walls

$$A_{st} = \left[\frac{(-9 * 10^6) - (75 * 10^3 * 90)}{100 * 0.84 * 215}\right] + \left(\frac{75 * 10^3}{100}\right) = 122\ mm^2$$

$S = \frac{1000}{\frac{122}{314}} = 2573\ mm\ c/c$ ∴ (The bars which bends from the corner is enough)

- Design for Cantilever Moment (For 1m height from bottom).

Cantilever moment $= (3.5 * 10 * \frac{1}{2} * \frac{1}{3}) = 5.833\ kN.m$

$$\therefore A_{st} = \left(\frac{5.833 * 10^6}{100 * 0.84 * 215}\right) = 323\ mm^2$$

(f_{st}, j, d)

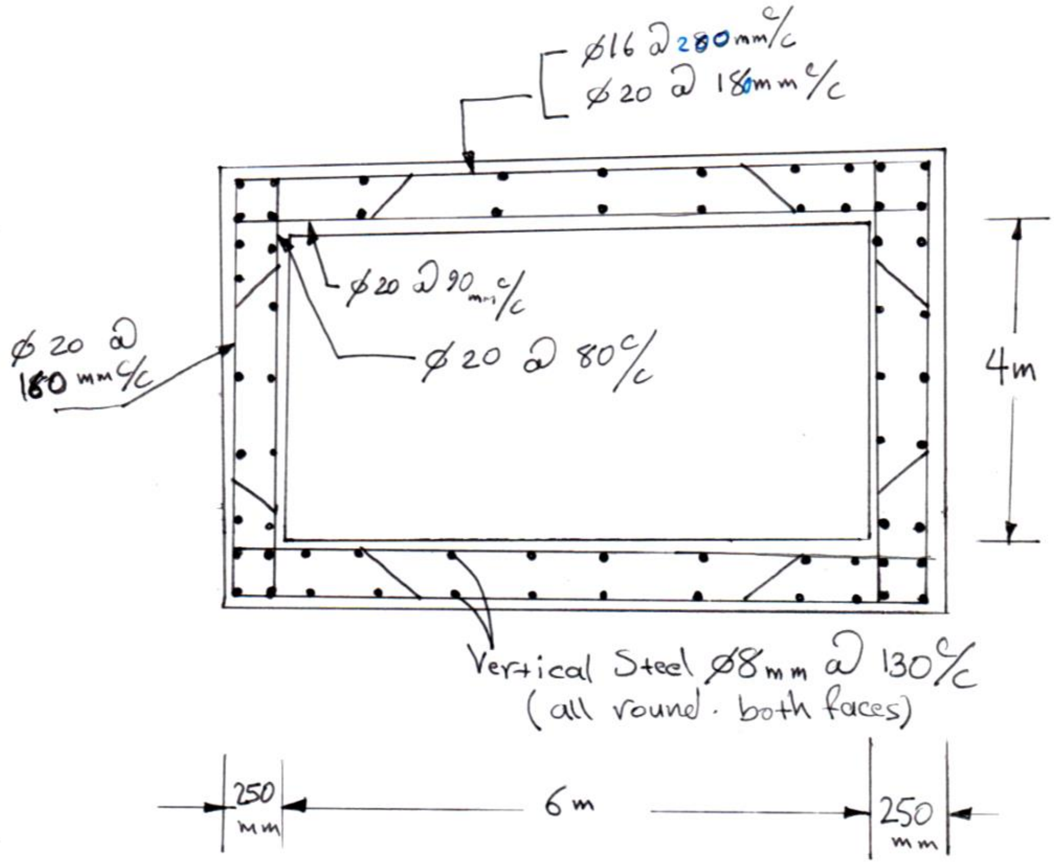
$$\text{Minimum steel} = 0.3\% = \left(\frac{0.3}{100} * 1000 * 250\right) = 750\ mm^2$$

$$\text{Steel on each face} = \left(\frac{750}{2}\right) = 375\ mm^2$$

$$\text{Spacing of 8mm bars} = \left(\frac{1000}{\frac{375}{50}}\right) = 130\ mm\ c/c$$

$$A_b = \left(\frac{\pi}{4} * (8)^2\right) = 50\ mm^2$$

Use ø 8mm c/c on both sides



Reinforcement Details in Water Tank (L/B < 2)