RECTANGULAR WATER TANK

Q. Design a rectangular Water tank of size 5m × 4m × 3m deep resisting from ground. Use M25 concrete and Fe250 mild Steel.

Ans: Size of tank = 5m × 4m × 3m.

Grade of Concrete = M25

From IS 456 : 2000, Table 21,

$\sigma_{cbc} = 8.5 \ N/mm^2$.

$\therefore m = \dfrac{280}{3\sigma_{cbc}} = \dfrac{280}{3 \times 8.5} = 10.98 \simeq 11$

For Fe250, $\sigma_{st} = 115 \ N/mm^2$.

$\therefore k = \dfrac{m\sigma_{cbc}}{m\sigma_{cbc} + \sigma_{st}} = \dfrac{11 \times 8.5}{11 \times 8.5 + 115}$

$= 0.448$

Lever arm depth factor, $j = 1 - k/3$

$= 1 - \dfrac{0.448}{3} = 0.850$

$\therefore R = \frac{1}{2}\sigma_{cbc} \times j \times k$

$= \frac{1}{2} \times 8.5 \times 0.85 \times 0.448 = 1.618 \ N/mm^2$.

In this problem, $L/H = 5/4 = 1.25 < 2$

Horizontal frame action :-

The critical section is at a height $h = H/4$ at 1m. whenever more, hence in this time = 1 m.

$P_x = \gamma(H-1) = 9.81 \times (3-1) = 19.6 \ kN/m^2$.

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Fixed end moments are :

i) $\frac{PL^2}{12} = \frac{19.6 \times 5^2}{12} = 40.83$ kN-m in long wall.

ii) $\frac{PB^2}{12} = \frac{19.6 \times 4^2}{12} = 26.133$ kN-m in short wall.

Thickness of short and long wall are maintained same distribution factor are shown.

Number	Stiffness	Total	Distribution
Short Wall	$\frac{4EI}{4} = EI$	1.8EI	0.556
Long wall	$\frac{4EI}{5} = 0.8EI$		0.444

Due to symmetry are balancing wall take care of moment distribution as shown in table below :

Short Wall			Long Wall
	0.556	0.444	
	− 26.133	40.883	
	− 8.20	− 6.55	
	− 34.333	34.333	

Correct moment, 34.333 kN = 34.33×10^6 N

Section outside effective thickness required for balance section

$$d = \sqrt{\frac{m}{R.b}} = \sqrt{\frac{34.33 \times 10^6}{1.618 \times 1000}} = 146 \text{ mm}.$$

Section is to be sufficiently under reinforce. Hence, let us keep overall thickness of 200 mm with effective cover of 35 mm.

$$d = 200 - 35 = 165 \text{ mm}.$$

Direct pull on long and short walls are given by.

$$T_L = P_x \times B/2 = 19.6 \times 4/2 = 39.2 \text{ kN},$$

$$T_B = P_x \times L/2 = 19.6 \times 5/2 = 49 \text{ kN}.$$

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Eccentricity of Reinforcement from centre of wall

$$x = \frac{200}{2} - 35 = 65 \text{ mm.}$$

Design moment at Corner $= M - Tx$

$$= 34.33 - 39.2 \times 0.065$$
$$= 31.785 \text{ kN·m.}$$

Hence at corner, horizontal reinforcement required for bending resistance,

$$A_{st_1} = \frac{M}{\sigma_{st} \cdot jd} = \frac{31.785 \times 10^6}{115 \times 0.85 \times 165} = 1970 \text{ mm}^2.$$

Using 20 mm bars direct tension

$$A_{st_2} = \frac{T}{\sigma_{st}} = \frac{34.33 \times 1000}{115} = 341 \text{ mm}^2.$$

Total $A_{st} = A_{st_1} + A_{st_2} = 2311 \text{ mm}^2$.

Using 20 mm bars spacing required,

$$s = \frac{\pi/4 \times 20^2}{2311} \times 1000 = 136 \text{ mm}.$$

Provide 20 mm bars at 130 c/c, it is to be provided on water face.

Reinforcement at middle of long walls.

Bending moment $= \frac{P_x L^2}{8}$ - moment at corner

$$= \frac{19.6 \times 5^2}{8} - 34.35 = 26.917 \text{ kN-m.}$$

Design moment $= M - T_0$

$$= 26.917 - 34.2 \times 0.065 = 24.369 \text{ kN-m}$$

$$A_{st_1} = \frac{24.369 \times 10^6}{115 \times 0.85 \times 16.5} = 1511 \text{ mm}^2.$$

$$A_{st2} = \frac{39.2 \times 1000}{115} = 341 \text{ mm}^2.$$

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Total $A_{st} = A_{st1} + A_{st2} = 1852 \text{ mm}^2$.

Using 20 mm bars spacing

$$s = \frac{\frac{\pi}{4} \times 20^2}{1852} \times 1000 = 169 \text{ mm}.$$

Hence also bars maybe provided at 130 mm c/c.
So that bars may be bent and used.

Reinforcement for short wall,

$$M = 34.333 - T$$
$$= 34.333 - 49 \times 0.065 = 31.198 \text{ kN-m}.$$

$$A_{st1} = \frac{31.198 \times 10^6}{115 \times 0.85 \times 165} = 1931 \text{ mm}^2.$$

$$A_{st2} = \frac{49 \times 1000}{15} = 926 \text{ mm}^2.$$

Total $A_{st} = A_{st1} + A_{st2} = 2357 \text{ mm}^2$.

Using 20 mm bars spacing

$$s = \frac{\frac{\pi}{4} \times 20^2}{2357} \times 1000 = 133 \text{ mm}.$$

Hence using 20 mm bars at 130 mm c/c.

Bending moment at ~~corne~~ centre of wall

$$= \gamma(H-h) \times \frac{4^2}{8} - \text{moment at ends}$$
$$= 9.81 \times (3-1) \times \frac{4^2}{8} - 34.333$$
$$= 1.867 \text{ kN-m}.$$

Reinforcement in vertical direction:

Cantilever moment $= \gamma H \cdot \frac{h^2}{6} = 9.81 \times 3 \times \frac{1^2}{6}$

$$= 4.9 \text{ kN-m}.$$

Signature :

$$A_{st} = \frac{M}{\sigma_{st}\, jd} = \frac{49 \times 10^6}{115 \times 0.85 \times 165} = 304 \text{ mm}^2.$$

minimum Reinforcement $= \frac{0.3}{100} \times 200 \times 1000$

$= 600 \text{ mm}^2.$

Provide 304 mm² area on each face, so that using 10 mm bars.

$$s = \frac{\pi/4 \times 10^2}{304} \times 1000 = 258 \text{ mm}.$$

Provide 10 mm bars 250 mm c/c on both face.

Base slab – Provide base slab of thickness 150 mm with 8 mm bars at 220 mm c/c in both direction at top and section of slab. A lean concrete bed of 100 mm may be provided in bottom slabs