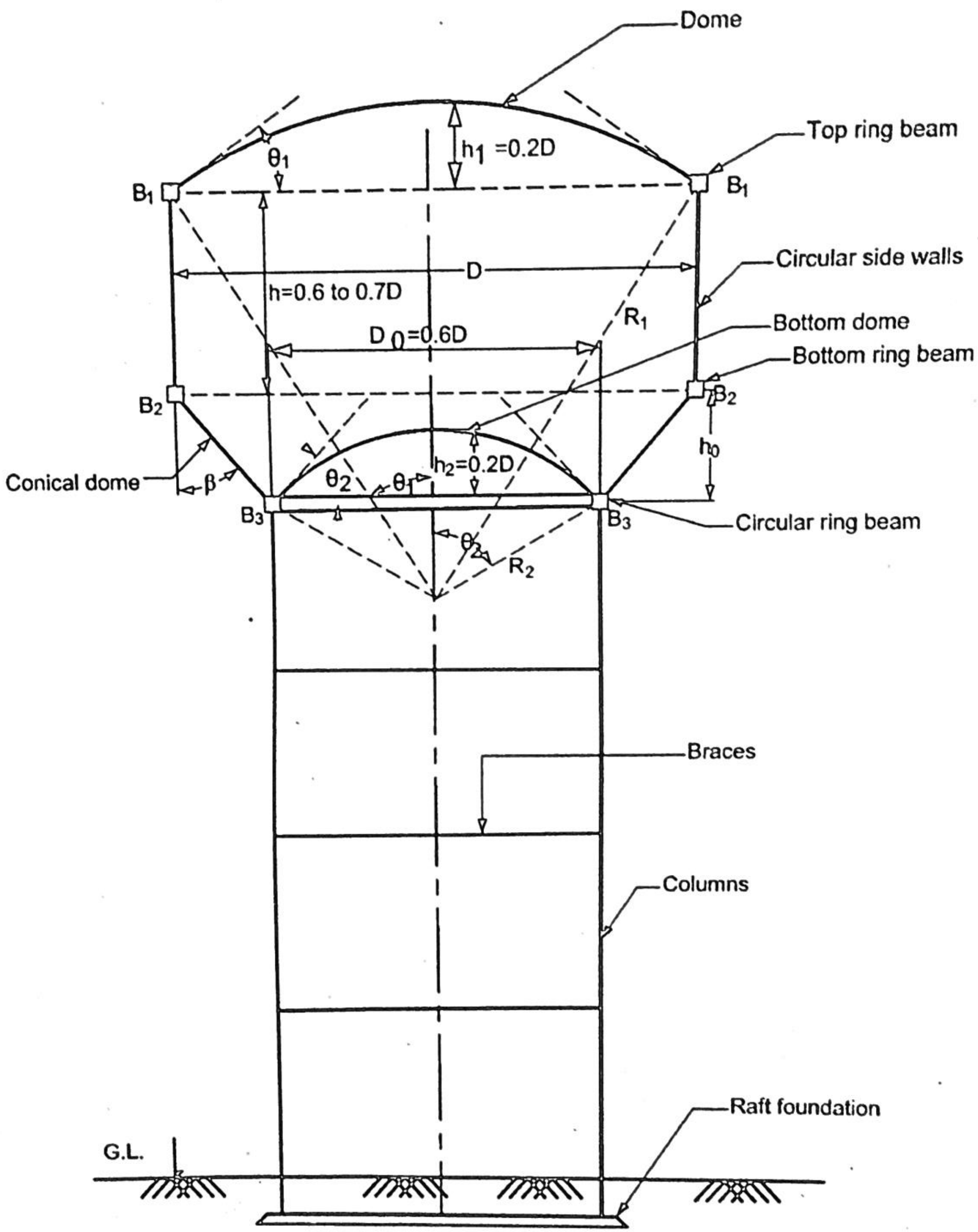
Design Of Intze Water Tank

Example

Fix the basic dimensions of elevated intze water tank to store 6 lacs litre water. Design and detail all structural components. Take live load = 1.5 kN/m^2. Use M30 grade concrete and Fe415 grade steel.



Dome
Top ring beam
h_1 =0.2D
θ_1
B_1
B_1
Circular side walls
D
h=0.6 to 0.7D
R_1
Bottom dome
D_0=0.6D
Bottom ring beam
B_2
B_2
h_0
h_2=0.2D
Conical dome
β
θ_2
θ_1
B_3
B_3
Circular ring beam
θ_2
R_2
Braces
Columns
Raft foundation
G.L.

* Solution :-

(1) Dimensions :

→ Let, Dia. of tank $(D) = 12$ m.

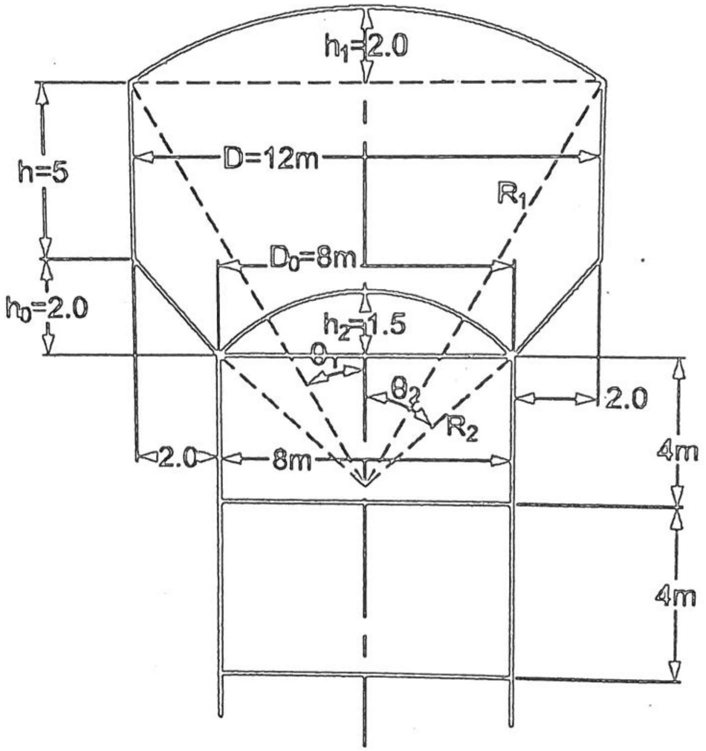
Dia. of lower R.B $(D_0) = 8$ m. (OR $0.6 \times 12 = 7.2$ m).

Rise of top Dome $(h_1) = 2$m (OR $0.2 \times 12 = 2.4$ m)

Rise of Bottom Dome $(h_2) = 1.5$ m (OR $0.2 \times 12 = 2.4$ m).

Height of conical dome $(h_0) = 2$ m.

Height of cylindrical portion $(h) = ?$



∴ Capacity of tank

$$= \left(\frac{\pi}{4} \times D^2 \times h\right) + \frac{\pi}{12} \times h_0 \left(D^2 + D_0^2 + D \cdot D_0\right) - \frac{\pi}{3} \times h_2^2 \left(3R_2 - h_2\right)$$

$$\therefore 600 = \left(\frac{\pi}{4} \times 12^2 \times h\right) + \frac{\pi}{12} \times 2 \times \left(12^2 + 8^2 + 12 \times 8\right) - \frac{\pi}{3} \times 1.5^2 \times \left(3 \times 6.08 - 1.5\right)$$

$$\therefore 600 = (113.09 \times h) + (159.17) - (39.44)$$

$$\therefore h = 4.24 \text{ m or say } h = 5 \text{ m.}$$

$$R_2 = \frac{(D/2)^2 + h^2}{2 \times h}$$

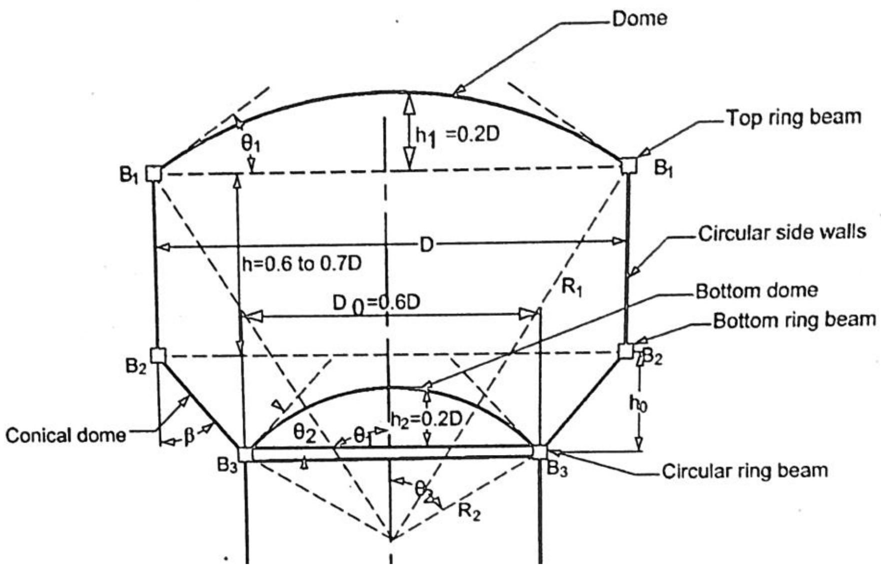
$$= \frac{(8/2)^2 + 1.5^2}{2 \times 1.5}$$

$$= 6.08 \text{ m.}$$

(2) Design of Top Dome :-

(i) Meridional force.

(ii) Hoop force.



i: Meridional force : (T_1)

$$T_1 = \frac{wR}{1+\cos\theta}$$

∴ w = Total load

→ S.W of dome = $0.1 \times 25 = 2.5\ KN/m^2$.

→ L.L = $1.5\ KN/m^2$.

$4\ KN/m^2$.

$$\rightarrow R_1 = \frac{(D/2)^2 + h_1^2}{2 \times h_1}$$

∵ h = 2 m.

$$\therefore R = \frac{(12/2)^2 + 2^2}{2 \times 2} = 10\ m.$$

$\rightarrow \sin\theta = \dfrac{D/2}{R} = \dfrac{6}{10} = 0.6$

$\therefore \theta = 36.86^{\circ}$

$\therefore \cos\theta = 0.80.$

$\Rightarrow T_1 = \dfrac{4 \times 10}{1 + 0.80} = 22.22 \text{ KN/m}.$

$\therefore$ Meridional stress $= \dfrac{22.22 \times 10^3}{1000 \times 100} = 0.22 \text{ N/mm}^2 < 5$

$\therefore$ <u>O.K</u>

ii Hoop force :

$$T_2 = wR_1\left[\cos\theta - \frac{1}{1+\cos\theta}\right]$$

$$= 4\times10\left[0.80 - \frac{1}{1+0.80}\right]$$

$$= 9.78 \text{ kN/m}.$$

→ Hoop stress $= \dfrac{9.78\times10^3}{1000\times100} = 0.0978 \text{ N/mm}^2 < 8$ ∴ OK.

∴ Provide nominal reinf. (0.24 %)

$$\therefore A_{st} = \frac{0.24}{100}\times1000\times100 = 240 \text{ mm}^2.$$

∴ Provide 8 mm ϕ @ 200 mm c/c.

③ Design of top Ring Beam (B_1) :

→ Horiz. component of meridional force (T_1)

$w = T_1 \cos\theta = 22.22 \times \cos\theta = 17.77$ KN/m.

∴ Total Hoop tension in beam,

$= \frac{w \times D}{2} = \frac{17.77 \times 12}{2} = 106.62$ KN.

∴ Ast for hoop tension $= \frac{106.62 \times 10^3}{130} = 820$ mm².

∴ Provide 12 ϕ @ 130 mm c/c. (Ast = 869 mm²)

$$\Rightarrow \sigma_{ct} = \frac{T}{A_g + (m-1) A_{st}}$$ | IS: 456-2000, Pg-80.

$$\therefore \frac{106.62 \times 10^3}{bD + (m-1) A_{st}} \le 1.5$$ | let $b = 300$ mm.

$$\therefore \frac{106.62 \times 10^3}{300 \times D + (9.33-1) \times 869} \le 1.5$$

$$\therefore 106.62 \times 10^3 \le 450D + 10858.15$$

$$\therefore 212.80 \le D$$

$\therefore$ Provide $D = 300$ mm.

$\therefore$ Size of beam = 300 mm × 300 mm.

→ Provide 8 ϕ - 2 legged stirrups.

$$\therefore S_v = \frac{0.87 \times f_y \times A_{sv}}{0.4 b}$$

IS: 456-2000, Pg - 48.

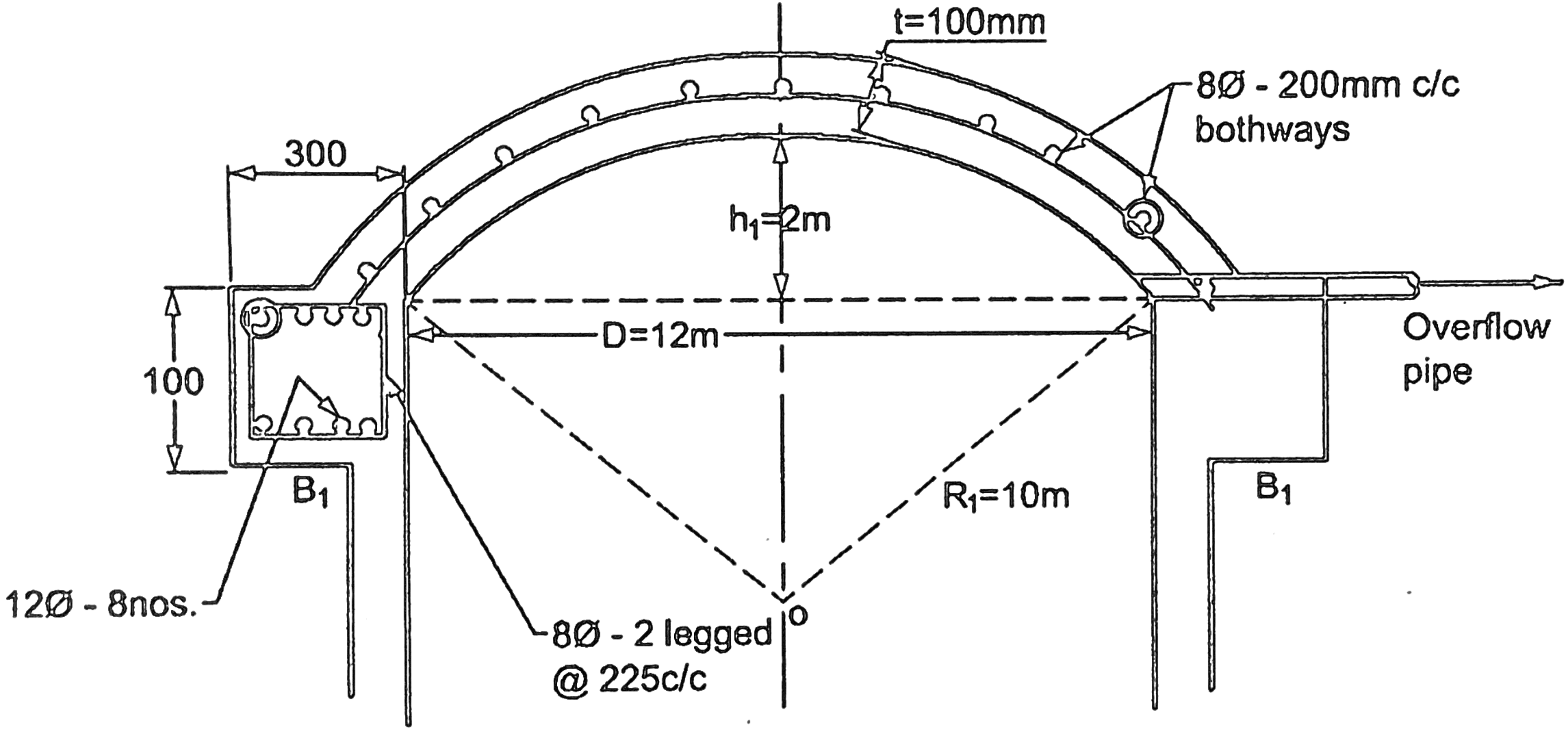
(i) $0.75D = 0.75 \times 300 = 225$

(ii) 300 mm.

$$\because A_{sv} = 2 \times \frac{\pi}{4} \times 8^2 = 100 \text{ mm}^2$$

$$\therefore S_v = \frac{0.87 \times f_y \times 100}{0.4 \times 300} = 300 \text{ mm.}$$

$\therefore$ Provide 8 ϕ - 2 legged vert. stirrups @ 225 c/c.



t=100mm
8Ø - 200mm c/c
bothways
300
h1=2m
100
D=12m
Overflow
pipe
B1
B1
R1=10m
12Ø - 8nos.
8Ø - 2 legged
@ 225c/c
o

(4) Design of Cylindrical Wall :-

$$T = \frac{\gamma_w \times h \times D}{2} = \frac{10 \times h \times 12}{2} = 60h \text{ kN/m.}$$

$$A_{st} = \frac{T}{130} = \frac{60h}{130} \times 10^3 = 461.54\,h \text{ mm}^2.$$

Depth from top (h) m	Area required A_{st}, mm² (461.54 h)	Area on each face mm² (230.76 h)	Reinforcement Provided on both faces (horizontal)
1	461.54	230.76	8 ϕ @ 210 c/c (A_{st} = 239 mm²)
2	923.0	461.54	10 ϕ @ 170 c/c (A_{st} = 462 mm²)
3	1384.62	692.31	10 ϕ @ 110 c/c (A_{st} = 714 mm²)
4	1846.16	923	12 ϕ @ 120 c/c (A_{st} = 942 mm²)
5	2322.70	1161.35	16 ϕ @ 170 c/c (A_{st} = 1183 mm²)

⇒ For thickness of wall :

$$\sigma_{ct} = \frac{T}{A_g + (m-1) A_{st}}$$

$T = 60 \times 5 = 300$ KN.

$A_g = 1000 \times t$.

$$\therefore \frac{300 \times 10^3}{1000 \times t + 22074.75} \leq 1.5$$

$\therefore 300 \times 10^3 \leq 1500t + 33112.17$

$\therefore 177.92 \leq t$

$\therefore$ Provide $t = 250$ mm. at base & 200 at top.

$$\therefore \text{Avg. } t = \frac{250 + 200}{2} = 225 \text{ mm.}$$

⇒ Distribution steel :-

→ Provide minimum steel (0.24 %)

$\therefore$ $Ast_{min} = \frac{0.24}{100} \times 1000 \times 225 = 540 \ mm^2$.

$\therefore$ Ast on each face $= \frac{540}{2} = 270 \ mm^2$.

$\therefore$ Provide $8\phi - 180$ mm c/c ($Ast = 279 \ mm^2$).

Thank You