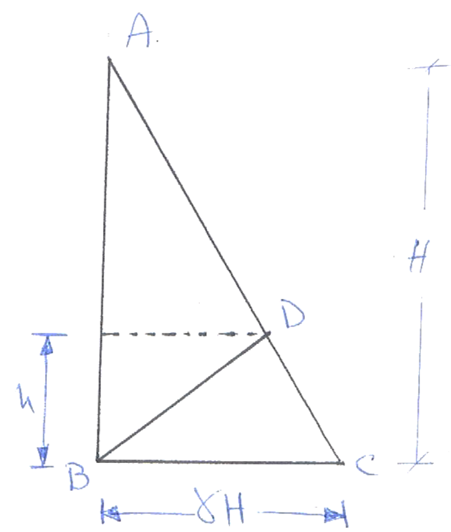
Case Two: Wall monolithic with the base:

In this method some portion of the tank at the base acts as a cantilever & some load at the bottom is taken by the cantilever effect.

The cantilever effect depends on the dimensions of tank & the thickness of wall.

i- for $\frac{H^2}{D.t}$ is between 6 to 12 the value of $h = \frac{H}{3}$ or (1m) which ever is more.



ii- for $\frac{H^2}{D.t}$ is between (12 to 30) the value $h = \frac{H}{4}$ or (1m) whichever is more.

Portion ABD is taken as pressure causing hoop tension & DBC is taken as cantilever load.

The max. hoop tension occurs at D.

Example :- $H = 3.65m$, $D = 11.3m$, $t = 0.16m$

$$\frac{H^2}{D.t} = \frac{3.65^2}{11.3 \times 0.16} = 7.369 > 6$$

$$\therefore h = \frac{H}{3} = \frac{3.65}{3} = 1.22 > 1m$$

hence $h = 1.22m$

Calculation for Reinforcement where the Hoop Force is Max:-

$T = \frac{PD}{2} = \frac{10\,(3.65-1.22)}{2} * 11.3 = 137.3\ kN$

$A_s = \frac{T}{f_s} = \frac{137.3*10^3}{80} = 1716.25\ mm^2$ use ϕ 12 mm

$S = \frac{1000}{(1716.25/\frac{\pi}{4}*12^2)} = 65.89\ mm\ c/c$

Use $S = 130\ mm\ c/c$ on both faces

Calculation of Max. B.M.:-

$B.M._{max} = \frac{1}{2}\gamma H \cdot h \cdot \frac{h}{3} = 9\ kN.m$

$M = A_s f_s \cdot jd \Longrightarrow d_{eff} = t - (cover + \frac{\phi}{2})$

$d = 160 - (40 + \frac{12}{2}) = 114\ mm$

$A_s = \frac{M}{f_s j d} = \frac{9*10^6}{80*0.85*114} = 1160.1 \simeq 1160\ mm^2$

Provide 12ϕ @ 97 mm c/c USE ϕ12 @ 90 mm c/c

Nominal vertical reinforcement:

$\frac{0.25}{100} * 160 * 1000 = 400\ mm^2$

Provide $\frac{1000}{(400/\frac{\pi}{4}*12^2)} = 282.74\ mm\ c/c$

Use 560 mm c/c in each face.

E.X.:- Design a circular tank with fixed base, for a capacity of $400 m^3$. The depth of water is to be 4.5m, including a free-board of 25cm. $f_c = 9 N/mm^2$, $f_{ct} = 1.2 N/mm^2$, $n = 9$, $f_s = 80 N/mm^2$. Bearing Capacity of soil $= 70\ kN/m^2$.

Solution:- effective depth $= 4.5 - 0.25 = 4.25 m$

$$V = \frac{\pi}{4} D^2 * 4.25 = 400 m^3$$

$D = 10.95$ Use $D = 11.0 m$

$t_{min} = ?$ $T = \frac{1}{2}\gamma h D = \frac{1}{2} \times 10 * 4.5 * 11 = 247\ kN/m$

$$A_{st} = \frac{T}{f_{st}} = \frac{247 \times 1000}{80} \simeq 3094 mm^2$$

$$t_{min} = \frac{1}{1000}\left[\frac{T}{f_{ct}} - (n-1) A_{st}\right] ; \quad n = \frac{E_s}{E_c} = \frac{200 \times 10^3}{4700\sqrt{f_c}}$$

اذا لم يعطى n

$$= \frac{1}{1000}\left[\frac{247 * 1000}{1.2} - (9-1) * 3094\right]$$

$= 181 mm$ use $t = 185 mm$

$$\frac{H^2}{Dt} = \frac{(4.25)^2}{11 * 0.185} = 8.876 \quad (\text{between } 6-12)$$

$$\therefore \frac{4.250}{3} = 1.4166 > 1 m$$

$\therefore h = 1.416 m$

Design of Walls for hoop tension:-

$$\text{Max. hoop tension} = \frac{\gamma (H-h) D}{2} = \frac{10(4.25 - 1.42) * 11}{2} = 155.65\ kN$$

Area of steel

$$A_s = \frac{T}{f_s} = \frac{155.65 \times 10^3}{80} = 1945.625 \ mm^2$$

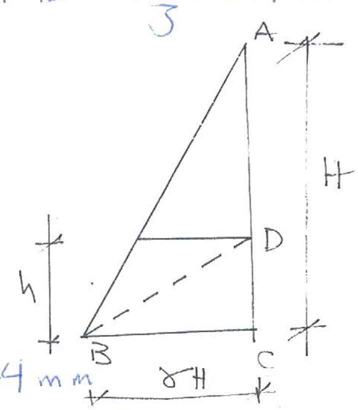
Use ϕ 12mm $A_b = 113 mm^2$

$$S = \frac{1000}{1946/113} = 58 \simeq 60 mm \ c/c$$

for both faces use $S = 120 mm \ c/c$

Design for Cantilever Action:-

$$M_{max} = \frac{1}{2} \gamma H \cdot h \cdot \frac{h}{3} = \frac{1}{2} * 10 * 4.25 * 1.42 * \frac{1.42}{3} = 14.28 kN \cdot m/m$$



$$M = \frac{1}{2} f_c k d b j d$$

$$k = \frac{n}{n+r} = \frac{9}{9 + \frac{80}{9}} = 0.5$$

$$j = 1 - \frac{k}{3} = 1 - \frac{0.5}{3} = 0.83$$

$$d = \left(\frac{2 * 14.28 * 10^6}{9 * 0.5 * 1000 * 0.83}\right)^{\frac{1}{2}} = 87.44 \ mm$$

Thickness of the wall $t = 87.44 + 40 + \frac{12}{2} = 133.44 mm < 185 mm$ ∴ OK

$$M = A_s f_s j d \Longrightarrow A_s = \frac{M}{f_s j d} = \frac{14.28 * 10^6}{80 * 0.83 * (185 - (40+6))} = 1547 mm^2/m$$

$$S = \frac{1000}{1547/113} = 73 \ mm \ c/c$$

∴ use ϕ12mm @ 70mm c/c

nominal Vertical Reinforcement = (0.2 – 0.3)% of gross concrete area:-

Use 0.3% ⟹ $A_{s\,secondary} = \frac{0.3}{100} * 185 * 1000 = 555\ mm^2/m'$

for two faces $A_s = \frac{555}{2} = 277.5\ mm^2/m'$

$S = \frac{1000}{277.5/113} = 407.2$ ⟹ use $S = 400\ mm\ c/c$ for both faces.

Design of Base Slab :-

Critical case when tank is empty

Load from wall $= \pi(11 + 0.185) * 4.5 * 0.185 * 24$
$= 644.28\ kN$

Intensity of soil Pressure $= \frac{644.28}{\frac{\pi}{4} * (12.34)^2} = 5.39\ kN/m^2$

Max. B.M. $= \frac{3}{16} q$