DSS

SEC-B WATER TANKS

Q1 Design a "Rectangular tank" of capacity 1,10,000 litres of water supported over a 12 m high staging. Columns are supported over concrete pedestal of M15 concrete. The Bearing capacity of soil is 100 kN/m². Design the wind pressure may be assumed to be 1.05 kN/m². Plates of 1.25 width and 8.75 m length are available.

Sol. (I) Tank :-

Capacity of Tank = 1,10,000 litres

$= 110 \, m^3$

Let us assume the height of Tank 2.4 m and free Board of 15 cm.

$$\text{Plan area of Tank} = \frac{110}{(2.4 - 0.15)} = 48.89 \, m^2$$

Plates in the bottom of the tank will be placed with their width (1.25 m) Parallel to the longer Direction of Tank. These plates will be bent up and made vertical and butt joined to the side plates.

Hence, width of the Tank :-

$= 8.75 - 2(0.85 + 0.471) + 2 \times 0.3$

$= 6.7 m$

as the plates will be a curve of 30 cm Radius consuming $\frac{\pi \times 2 \times 30}{4} = 47.1 cm$ length of plate on each end.

$\therefore$ Length of Tank $= \frac{48.89}{6.7}$

$= 7.29 m$

Provide 6 plates giving a length of $6 \times 1.25 = 7.5 m$

In addition to these provide one corner plate at each end of same Radius 30 cm.

$\therefore$ Length of Tank available $= 6 \times 1.25 + 2 \times 0.3$

$= 8.1 m$

$\therefore$ Provide a Tank of $8.1 \times 6.7 \times 2.4 m$ $(L \times B \times H)$.

(II) [Design of bottom plates]:-

Span of bottom plate = c/c Distance between Tee covers

$\Rightarrow 1.25\,m$

Consider unit width of plate

load of water $= wh = 9810 \cdot (2.4)$

$= 23544 \ N/m^2$

Assume self wt. of plate $= 1200 \ N/m^2$

Total wt. $= 23544 + 1200$

$= 24744 \ N/m^2$

Total wt. $= 24744 \times 1$

$= 24744 \ N/m$

Max. B.M $= \left[M = \frac{wl^2}{8} \right]$

$= \frac{24744 (1.25)^2}{8}$

$\Rightarrow 4832.8 \ N\text{-}m$

Moment of Resistance $= \left[\frac{1}{6} b t^2 \sigma_{bct} \right] \rightarrow (fix)\ (132)$

$= \frac{1}{6} \times (1000)\, t^2 \,(132)$

Hence, $\frac{1}{6} 1000\, t^2 (132) = 4832.8 \times 10^3$

$t = 14.82$

$[t = 16 \ mm]$

$\therefore$ Provide 16 mm thick plates for the Tank bottom, Thickness of side plates will also be kept 16 mm.

(III) [Tee - Covers] :-

Let us try ISNT 100 @ 150 N/m and 100x10 mm cover plate for Tee cover. The Tee-Covers act as continous Beams as well as stiffners. They transfer load from the plates to the longitudinal Beams.

The Tee sections will be placed at 1.25 m c/c spacing with their webs upward forming vertical stiffners, resting on longitudinal Beam provided at 1.22 m c/c.

load from one panel = 24744 x 1.25 x 1.22
= 37734.6 N

Assume self wt = 255.4 N
Total load = 37734.6 + 255.4
= 37990 N

$$\text{Max. B.M} = \frac{WL}{10}$$

$$= \frac{37990 \times 1.22}{10}$$

$$= (4634.78 \text{ N-m})$$

(IV) **[Stays]** :-

Stays will be provided in both the direction at the mid ht. of tank.

The stays will be placed at 1.25 m c/c in transverse direction and 1.22m c/c in longitudinal direction

Water pressure on the side walls for 1.25 m width = $\frac{wh^2}{2} \times$ width

$\left(\frac{1}{2}wh^2b\right)$ $= \frac{9810 (2.4)^2}{2}(1.25)$

$= 35316$ N

Overhang of tank from beam = 0.3 m

Wt. of water in overhang portion for a length of 1.25 m

$W_1 = 0.3 \times 1.25 \times 9810 \times 2.4$ (wabh)

$= 8829$ N

Wt. of plate for a length of 1.25 m

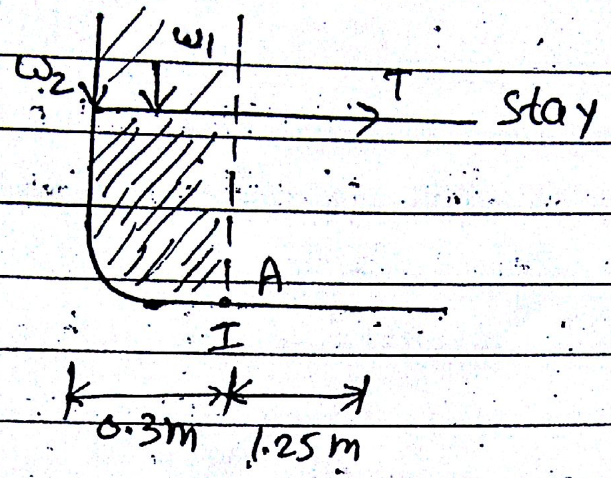
$W_2 = 0.016 \times 1.25 \times 2.4 \times 79000$

$= 3792$ N (ρbht)

where a = overhang portion of the tank

b = width , h = height

t = thickness , ρ = Density of steel



Taking the moments about hinge A,

$$T \times 1.20 = 35316 \times \frac{2.4}{3} + 8829 \times \frac{0.3}{2} + 3792 \times 0.3$$

$$(T = 25595.62\ N) \quad \text{Tension}$$

$$\left[A_{net} = \frac{T}{\sigma_{at}}\right]$$

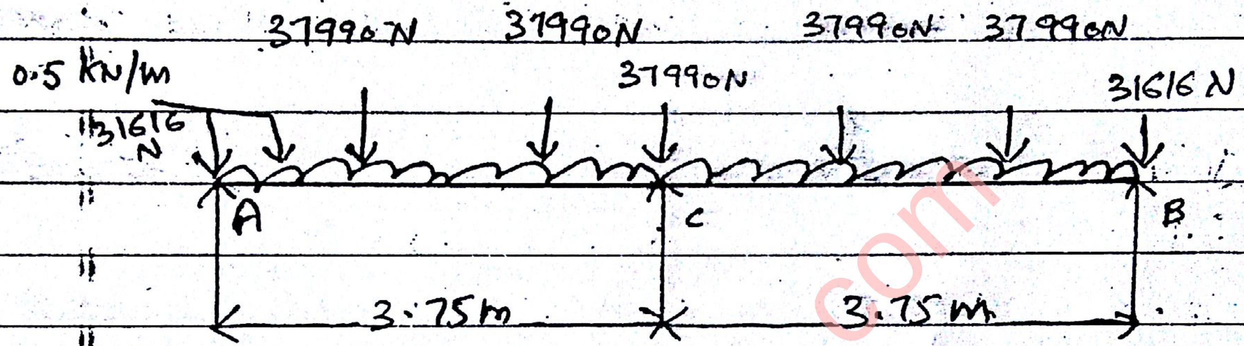
$$= \frac{25595.62}{120} \qquad (\sigma_{at} = 120)\ \text{Fix}$$

$$= \underline{213.30\ mm^2}$$

The longitudinal stays are provided with the same cross section as that for Transverse stays and will be provided above them.

(V) [Beams] :-

The span of the upper tie Beams will be 7.5 m and that of lower tie Beams will be 6.1 m .



<u>upper tie Beams</u> :-

(i) <u>Intermediate Beam</u> :-

load from Tee- Cover = 37990 N

load from end Tee Cover :-

$$= \frac{37990}{2} + 3792 + 8829 = 31616\ N$$

Assume self wt. of Beam = 0.5 kN/m.

Consider the spans AC and CB as separate Fixed Beam.

$$M_{FAC} = \frac{-37990}{(3.75)^2}\left[bh^2 + hb^2\right] - \frac{w(L_{AC})^2}{12}$$

$$= \frac{-37990}{(3.75)^2}\left[1.25(2.5)^2 + (2.5)(1.25)^2\right]$$

$$- \frac{500(3.75)^2}{1-}$$

$= (-32245 \text{ N-m})$

as w = self wt. of Beam
0.5 KN/m/ or (500 N/M)

$MF_{CA} = (+32245 \text{ N-m})$

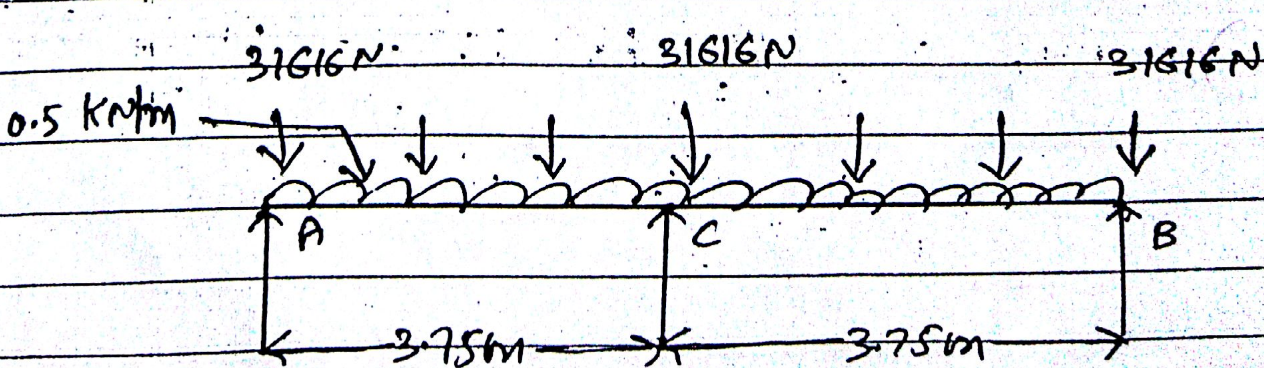
Applying moment Distribution method,

Joint	A	C		B
D.F		0.5	0.5	
Member	AC	CA	CB	BC
FEM	-32245	+32245	-32245	+32245
	+32245	+16122.5	-16122.5	-32245
	0	+48367.5	-48367.5	0

where, D.F = Distribution factor
FEM = Fixed end Moments

∴ Max B.M ⇒ 48367.5 N-m

(ii) [End Beam] :-



$$M_{FAC} = \frac{-31616}{(L_{AC})^2}\left[bh^2 + hb^2\right] - \frac{w(L_{AC})^2}{12}$$

$$\Rightarrow \frac{-31616}{(3.75)^2}\left[1.25(2.5)^2 + 2.5(1.25)^2\right] - \frac{500(3.75)^2}{12}$$

$$= (-25760.7 \text{ N-m})$$

$$M_{FCA} = (+25760.7 \text{ N-m})$$

Applying Moment Dist method,

$$\text{Max. B.M} = 25760.7 + \frac{25760.7}{2}$$

$\therefore$ Max B.M $\Rightarrow$ 38641.05 N-m

(VI) [Design of Supporting Tower] :-

Design wind pressure = 1.05 KN/m² (given)

Wind Force on Tank (P_1) :-

$= l\,[h + f_1] \times$ wind pressure

$= 8.1\,(2.4 + 0.325) \times 1.05 \times 10^3$

$= 23176.125$ N

This act at a height of :-

$= 12 + (f_1 + f_2) + \frac{h}{2}$

(12 ↓ given height)

$= 12 + (0.325 + 0.8) + 2.4 = 14.325$ m

Thus a force of 23176.125 N will act on Tank at a height of 14.325 m from the ground level.

<u>Wind force on Tower (P_2) :-</u>

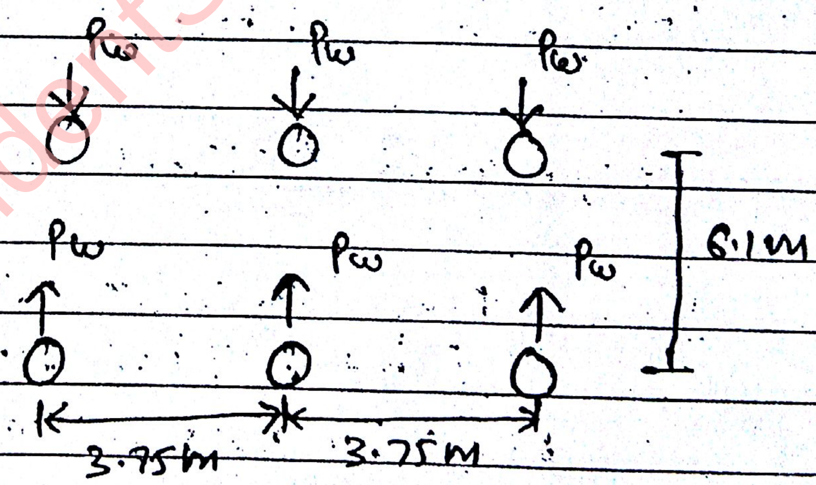
$= \frac{1}{5}$ [given ht. + f_2] × l × wind pressure

$= \frac{1}{5}$ [12 + 0.8] × 8.1 × 1.05 × 1000

= 21772.8 N

This act at a height of

$\frac{12+0.8}{2}$ = 6.4 m from ground



<u>B.M due to wind :-</u>

$M_w = P_1 (h_1) + P_2 (h_2)$

= 23176.125 (14.325) + 21772.8 (6.4)

= 471343.91 N-m

M_R = 3 P_w × 6.1

and, $M_R = M_w$

$3P_w \times 6.1 = 471343.91$

$$P_w = 25756.49 \text{ N}$$

↓

force in each column due to wind

Bracing :-

The column height is divided into three panels by the horizontal bracing. The Max. shear will be in lowest horizontal Brace.

Horizontal & Diagonal Braces are Provided.