UNIT - II

WATER TANKS:

Water tank are the liquid Storage (or) structure (or) container's, these tanks are usually storing water for human consumption

There are three type of reinf/ concrete water tank

(1) Tank resting On ground.
(2) Under ground water tank.
(3) elevated water tank.

Factors to be considered while designing water tanks.

(1) Strength.
(2) water tightness
(3) Overall Stability

The Concrete grade → (M20 . M30)

Design procedure for water tank:-

(1) for tank resting on ground with fixed base.

Step 1 :- Calculation of permissible stresses

Step 2 :- Design constants (K, j.)

Step 3 :- fixing of dimensions of the tank.

Step 4 :- Bending Moment, ring tension & Shear. $H^2/$ H → height for maximum bending moment

Step 5 :- $= Constant \times \omega H^3$

$\omega \rightarrow$ density of water

for maximum shear : $constant \times \omega H^2$

for maximum ring tension :

$$\frac{constant \times \omega \times H \times D}{2}$$

Step 5 :- Provision of steel reinforcement for hoop tension

$$Ast = T/\sigma_{st}$$

T = maximum ring tension

$\sigma_{st} \rightarrow$ permissible stress in steel

Step 6 :- Steel reinfo for bending moment

$$Ast = \frac{Maximum\ Moment}{\sigma_{st} \times j \times d.}$$

(d → internal dia.)

Step 7 :- Desing of vertical reinforcement.

minimum vertical reinf = 0.3 % of cross section area

Step 8:- Design of base slab of.

$Ast = 0.3\%$ of cross section area.

Step 9:- Maximum shear at base bar

check for shear.

Max shear stress : $\tau_v = V / jbd$.

—x—.

(ii) (For flexible Base.
circular tank)

Step 1:- Design Constant of permissible

Stress. $(\sigma_{ct}, \sigma_{st}, m)$

Step 2:- σ_{ct} = direct tensile stress in Concrete.

σ_{st} ⇒ direct tensile stress in Steel

m → Modular ratio

Step 2: Dimension of tank.

Step 3:- hoop tension of steel reinforcement

maxi hoop tension = $WHD/2$.

$Ast = \text{Maxi hoop tension} / \sigma_{st}$.

Step 4:- Thickness of wall.

t = thickness of wall

$$\frac{\frac{WHD}{2}}{1000t + (m-1)Ast} = \sigma_{ct}.$$

Step 5 reinforcement in tank wall

minimum reinforcement for tank wa

= 0.3 % of cross section

Minimum spacing :- should not be greater than 3 times of wall th

Step 6 :- Steel reinfor for hoop tensi

$$Ast = \frac{WHD/2}{100}$$

Distribution of temp reinforcement :-

= 0.3 % of cross section ar

Step 7 :- Design of tank floor slab

Ast = 0.3 % of cross section ar

Thickness = 150 mm.

1, Design a circular tank with a flexible base for a capacity of 5 lakh liter depth of water is to be 4 m & free board is 200 mm, use. M20 & fe 415 (grade I mild steel). permissible direct tensile stress in concrete = 1.2 N/mm² permissible stress in steel in direct tension = 115 N/mm²

Given :-

Capacity of tank = 5,00,000 liter

height of water = 4 m.

free board = 0.2 m.

f_{ck} = 20 N/mm². Grade I mild

(i) Step 1 design constant & permissible stress:

From IS 3370 part II [page No: 7 & 8]

table : 1.

permissible direct tensile stress = 1.2 N/mm² in concrete : σ_{ct} = 1.2 N/mm²

Table : 2.

permissible stress in steel in tension σ_{st} = 115 N/mm².

modular ratio, $m = \frac{280}{3\sigma_{cbc}}$

$= 280/3\times7$

$m = 13.3$

Step 2 :- Dimension of the tank :-

Volume = 500000 liter

$\pi/4 \times D^2 \times H = 500000/$ ...

$D = 12.6$ m.

The Overall height of the tank $= 4 + 0.2$

$H = 4.2$ m

Step 3:- Hoop tension & Steel reinf.:-

Maximum hoop tension $= \frac{WHD}{2}$.

w → density of water = 10.

$\Rightarrow = \frac{10 \times 4.2 \times 12.6}{2}$

$= 264.6$ KN.

Area of steel $= \frac{\text{max hoop tension}}{\sigma_{st}}$

$= 264.6 \times 10^3 / 115$

$= 2300.86\ mm^2$

Use 20mm ϕ bar.

$\Rightarrow$ A.ast $= \pi/4 \times 20^2 = 314.15$.

Spacing $= ast / Ast \times 1000$

$= 136.53$ mm.

$\simeq 130$ mm. c/c.

Provide 20m ϕ bar at 130 mm c/c for hoop tension :-

Step 4 : Thickness of wall:

if 't' is the thickness

$$\frac{\frac{wHD}{2}}{1000t + (m-1)\,Ast} = \sigma ct.$$

$$\Rightarrow \frac{\frac{10 \times 4.2 \times 12.6}{2}}{1000t + (m-1)\,2300} = 1.2.$$

$$\frac{(264.6 \times 10^3)}{1000t + (13.3-1)2300} = 1.2.$$

$t = 192.18$ mm.

$t \simeq 195$ mm.

Step 5 reinf in tank wall :

at top Mini reinforcement = 0.3 % cross section

$= 0.3 \times b \times (t)$

$= 0.3/100 \times 1000 \times 195$

$= 585 \text{ mm}^2$

Use 20 mm ϕ bar's.

• Spacing = $ast/Ast \times 1000$

$\Rightarrow 314.15/585 \times 1000$

$= 537.00$ mm c/c.

Minimum Spacing $\ngtr$ 3 time of the wall thickn

$= 3 \times 195$

$= 585$ mm.

Hence adopt spacing as 585 mm c/c.

Provide 20 mm ϕ bar at 585 mm c/c.

Step 6: Steel reinforcement for hoop tension:

At 2 m.

$$A_{st} = \frac{\frac{wHD}{2}}{100}$$

$$= \frac{\frac{10 \times 2 \times 12.6}{2}}{100}$$

$$= 1.26\ m^2$$

$$= 1260\ mm^2.$$

Use 20 mm ϕ

$$\text{Spacing} = \frac{ast}{A_{st}} \times 1000$$

$$= \frac{314.18}{1260} \times 1000$$

$$= 249.3\ mm \simeq 240\ mm\ c/c$$

Distribution of temperature reinf.

$\Rightarrow$ 0.3% of $b \times t$

$$= \frac{0.3}{100} \times 1000 \times 195$$

use 10 mm ϕ = 585 mm²

$$\text{Spacing} \Rightarrow S = \frac{ast}{A_{st}} \times 1000$$

$$= \frac{78.53}{585} \times 1000$$

$$= 134.23$$

$$\simeq 130\ mm\ c/c.$$

Provide 10 mm ϕ bar at di 130 mm c/c

Step 6: Steel reinforcement for hoop tension:

At 2 m.

$$Ast = \frac{\frac{wHD}{2}}{100}$$

$$= \frac{\frac{10 \times 2 \times 12.6}{2}}{100}$$

$$= 1.26\ m^2$$

$$= 1260\ mm^2.$$

Use 20 mm ϕ

$$Spacing = \frac{ast}{Ast} \times 1000$$

$$= \frac{314.78}{1260} \times 1000$$

$$= 249.3\ mm \simeq 240\ mm\ c/c$$

Distribution of temperature reinf.

$$\Rightarrow 0.3\%\ of\ b \times t$$

$$= \frac{0.3}{100} \times 1000 \times 195$$

use 10 mm ϕ = 585 mm^2

$$Spacing \Rightarrow S = \frac{ast}{Ast} \times 1000$$

$$= \frac{78.53}{585} \times 1000$$

$$= 134.23$$

$$\simeq 130\ mm\ c/c.$$

Provide 10 mm ϕ bar at dia 130 mm c/c

Step 4 : Design of floor slab :

A_{st} =

Provide nominal thickness of slab 150mm and mini

area of steel = 0.3% of cross section

$$\Rightarrow \frac{0.3}{100} \times 1000 \times 150$$

A_{st} = 450 mm^2 = 225

Provide half the reinforcement in each face.

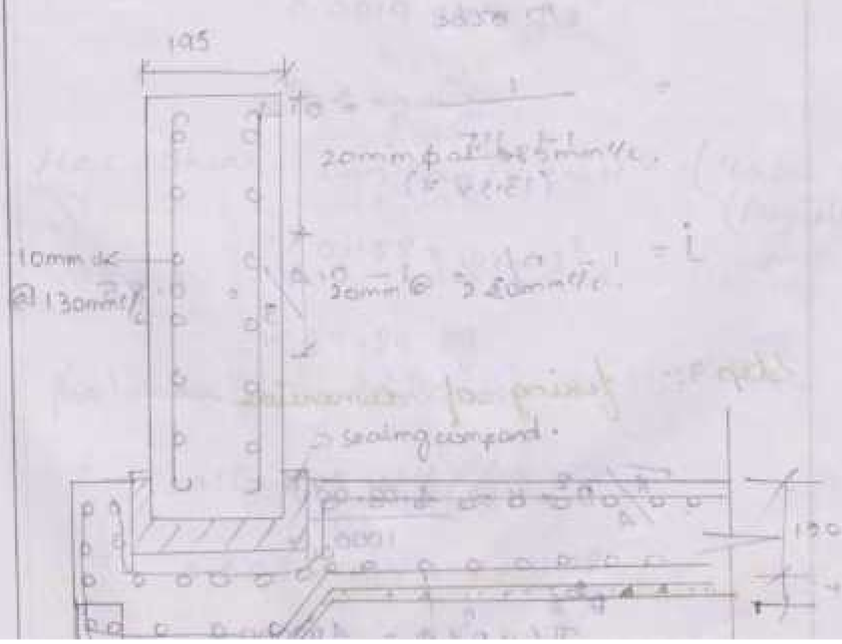
Use 8mm φ

$$\text{Spacing} = \frac{a_{st}}{A_{st}} \times 1000$$

$$= \frac{\pi/4 \times 8^2}{225} \times 1000$$

$$= 223.24 = 220 \text{ mm c/c}$$

Provide 8 mm φ bar at 220 mm c/c or in both direction.



design a circular tank with fixed base for capacity of 4 lak. depth of water is to be 4 m, free board is 200mm, use m20 & grade I mild steel:-

(i) Given:-

(ii) Step 1. Calculation of permissible stress :-

Permissible stress in concrete $\sigma ct = 1.2 N/mm^2$.

$\sigma st = 115 N/mm^2$.

$\sigma cbc = 7 N/mm^2$.

$$m = \frac{280}{3\sigma cbc} = 13.3,$$

$$n = \frac{1}{1 + \frac{\sigma st}{m\, \sigma cbc}}$$

$$= \frac{1}{1 + \frac{115}{(13.3 \times 7)}} = 0.4$$

$$j = 1 - n/3 = 1 - 0.4/3 = 0.85$$

Step 3:- fixing of dimension:-

$$\pi/4\, D^2 \times H = \frac{4,00,000}{1000}$$

$D^2 =$

$D = 11.28\,m.$ $1\,kg = 10\,N.$

Over all height $H = 4 + 0.2$

$\boxed{H = 4.2\,m.}$

(A) Bending moment & ring tension & shear.

(Provide, Adopt thickness of tank wall and base slab as 160mm

$\Rightarrow \frac{H^2}{Dt}$

(Part-4) IS 3370

$\Rightarrow$ page No: 35 (0.6H)

Maximum ring tension acting at 0.6 H.

$= 0.6H = 2.52.$

$H^2/Dt = \frac{4.2^2}{11.28 \times 0.16}$ (for bending moment (0.9 for - Ring tension & Shear $\rightarrow$ 0.6 H)

$= 9.7 \simeq 10.$

Refering IS 3370 part 4 in table 10.

for Max BM = Constant $\times wH^3$. (+0.0019)

$= 0.0019 \times 10 \times 4.2^3$

$= 1.4$ kgm/m.

Max. Shear = Constant $\times wH^2$. (table 11) (pag No: 37)

$= 0.158 \times 10 \times 4.2^2$

$= 27.87$ kg.

for max ring tension:-

$=$ Constant $\times wH\, D/2$

$= 0.608 \times 10 \times 4.2 \times \frac{11.28}{2} =$

Step5: provision of steel reinforcement for hoop tension.

$$A_{st} = \frac{T}{\sigma_{st}} = \frac{144.02\times10^3}{115}$$

$$= 1252.3\ mm^2.$$

Use 20 mm ϕ bar.

$$\Rightarrow \frac{\pi}{4}\times 20^2 = 314.15$$

Spacing No. of bars $= \frac{A_{st}}{a_{st}}$

$$= \frac{1252.3}{314.15}$$

$$= 3.9 \simeq 4 \#$$

Spacing:- $\frac{a_{st}}{A_{st}} \times 1000$

$$= \frac{\frac{\pi}{4}\times20^2}{1252.2} \times 1000$$

$$= 250.8 mm \simeq 250 mm\ c/c.$$

Provide 20mm ϕ bars at 250 mm c/c

Step6. check for thickness of wall.

$$\tau_a = V/jbd.$$

$$\frac{T}{1000t + (m-1)A_{st}} = \sigma_{ct}$$

$$\frac{(144.02 \times 10^3)}{1000t + (13.3-1)(1252.3)} = 1.21$$

$t = 104.6 < 160mm.$

Hence Safe.

Step 7 :- Steel reqd for B.M :-

$$A_{st} = \frac{\text{Max Moment}}{\sigma_{st}\, j\, d} = \frac{1.4 \times 10^6}{115 \times 0.85 \times 130}$$

$d = D - d'$

$= 160 - 30$

$d = 130mm$

$= 110 mm^2$

use 12 m ϕ

$$\text{Spacing} = \frac{ast}{A_{st}} \times 1000$$

$$= \frac{113.0}{110} \times 1000$$

adopt min spacing $= 1027mm.$ as 300 mm c/c.

Provide 12 mm ϕ bars at 300 mm c/c as steel reinf for B.M.

Step 8: Vertical reinf.

Min $A_{st} = 0.3\%\, bD$

$= \frac{0.3}{100} \times 1000 \times 160$

use 10mm ϕ $= 480 mm^2.$

Spacing $= ast/A_{st} \times 1000$

Step 9 :- Design of bare slab:-

Area of steel = 0.3% bD

$= \frac{0.3}{100} \times 1000 \times 160$

$= 480 mm^2$.

Area at each face = $\frac{480}{2}$

$= 240 mm^2$

Provide 8 mm φ bars.

Spacing = $\frac{ast}{Ast} \times 1000$

$= \frac{\pi/4 \times 8^2}{240} \times 1000$

$= 209 mm \simeq 200 mm$ c/c.

at junction use 12 mm φ bars.

Spacing $= \frac{\pi/4 \times 12^2}{280} \times 1000$

$= 471 mm$

$\simeq 450 mm$ c/c

Provide 8 mm φ bars at 200 mm c/c in both ways and at junction provide 12 mm φ bar's at 450 mm c/c.

Step 10 :- check for shear.

$$\tau_v = \frac{V}{bdj}$$

$$= \frac{27.87 \times 10^3}{1000 \times 130 \times 0.85}$$

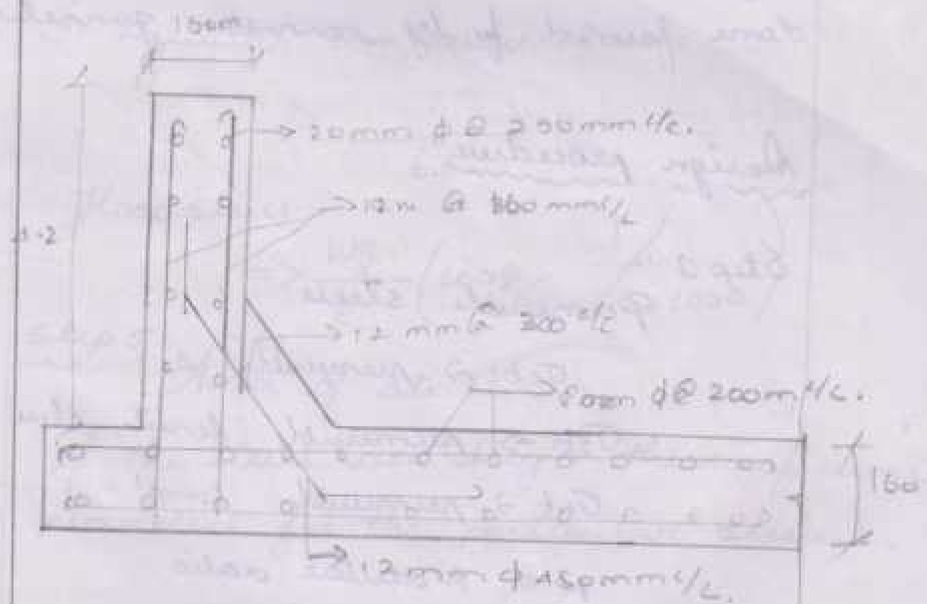
$$= 0.25 \ N/mm^2.$$

From IS 456 : 2000

$$\tau_c = 1.7 N/mm^2$$

$$\tau_v < \tau_c$$

Hence it is safe against shear.



Design of Domes:-

(i) Concrete domes are generally built + prepared to cover circular tank and for roof of larger span. Structure which are circular in shape.

(2) Spherical domes are supported by ring beams at base

(iii) Reinf./ made up of wire mesh and concrete is placed in the contrary ring. Over preformed frame works (or) dome formed for by concrete gunneting

Design procedure:-

Step 1 :-
Permissible stress

σ_{cbc} → permissible s

σ_{st} → permissible tensile stress

σ_{ct} → permissible compt.

M → Modular ratio

$$M = \frac{280}{\sigma_{cb} \times 3}.$$

step 2 Dimension of dome:-

If R = radius of dome.

$(R - x)^2 = R^2 - r^2$ ↳ radius of at base

(x ⇒ rise)

step 3 :- load calculation

(i) self weight

(ii) live load. (roof = 4 kN)

(iii) weight of finish

Total load.

step 4 :- stress in dome :-

(i) Meridian thrust $\left(T = \frac{WR}{1 + \cos\theta}\right.$.

W ⇒ load, R ⇒ Radius

(ii) Meridian Compressive stress :

$\Rightarrow \frac{T}{bt}$.

Hoop stress -

$\Rightarrow \frac{WR}{t}\left(\cos\theta - \frac{1}{1+\cos\theta}\right)$

step 5 :- Area of steel :-

If the stress are high the reinforcement provided for the particular stress.

If the stress are low the nominal reinf/. should be provided

Nominal reinf/. = 0.3 b × D.

Step 6:- Design of ring beam.

(i) horizontal component of thrust

$T_h = T \cos\theta$

Hoop tension in ring beam =>

$$\Rightarrow \frac{T \cos\theta D}{2}.$$

Area of reinforcement:

$$\Rightarrow A_{st} = \frac{\text{hoop tension}}{\sigma_{st}}.$$

1, Reinforced concrete dome of 6m base width (or) base diameter with a rise of 1.25 m is to be designed for for a water tank. The vol of including finishes on dome may be taken as 2 kN/m² adopt M20 grade & grade 1 mild steel bars. design the dome & ring beam.

(B) The permissible tensile stress in steel = 115 N/mm²

(i) Given:-

base width = 6 m. rise 1.25 m

live load = 2 kN/m²

σ_{st} = 115 N/

Step 1 :- permissible stress :-

Page No : 80.

$\Rightarrow \sigma_{st} = 115\ N/mm^2$.

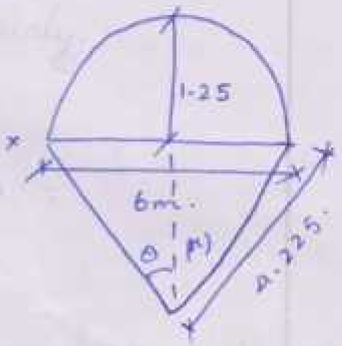
$\sigma_{ct} = ?$

$\sigma_{cbc} = 7\ N/mm^2$

$\sigma_{ct} = 2.8\ N/mm^2$.

$m = \frac{280}{3 \times \sigma_{cbc}} = \frac{280}{3 \times 7} = 13.3$.

2. Dimension of dome.



$\Rightarrow (R - rise)^2 = R^2 - r^2$

$\Rightarrow (R - 1.25)^2 = R^2 - 3^2$.

$\Rightarrow \Rightarrow$ $\boxed{R = 4.225\ m}$

3. load calculation

* Adopt thickness of the dome as 100 mm.

Self weight of dome $= 0.1 \times 25 \times 1$

$= 2.5\ kN/m^2$.

live load $= 2\ kN/m^2$

Total $= 4.5\ kN/m^2$.

4. Stress in dome:

(i) Meridian thrust $T = \frac{wR}{1 + \cos\theta}$.

$\sin\theta = Opp/hyp. = 3/4.225$

$\boxed{\sin\theta = 0.71}$ $\sin^{-1}(0.71) = \theta$

$\Rightarrow \cos\theta = 0.704.$

$$T = \frac{4.5 \times 4.225}{1+.704}$$

$= 11.15\ kN/m.$

iii. Meridian Compression stress

$\Rightarrow T/bt$

$= 11.15 / 0.1 \times 1 = 111.5\ kN/m.$

ii hoop stress

$$= \frac{wR}{t}\left(\cos\theta - \frac{1}{1+\cos\theta}\right).$$

$$= \frac{4.5 \times 4.225}{0.1}\left(\cos 45^\circ.14' - \frac{1}{1+\cos 45^\circ.14'}\right)$$

$= 22.27\ kN/m^2.$

Step 5:- Area of steel :-

Hence stress are minimum provide minimum Ast

$\Rightarrow 0.3\ \%\ b \times D$

$= \frac{0.3}{100} \times 1000 \times 100$

use 8mm ϕ bar.

$\Rightarrow$ Spacing $= \frac{\pi/4 \times 8^2}{300} \times 1000$.

$= 167$

$\simeq 160$ mm c/c.

Provide 8 mm ϕ at 160 mm c/c both meridionly and circumferencialy.

Step 6: Design of ring beam:

(i) horizontal component.

$T_h = T \cos\theta$.

$= 11.15 \times \cos 45^\circ 14'$

$T_h = 7.849$ kN/m

(ii) Hoop tension in ring beam.

$\Rightarrow \frac{T \cos\theta \, D}{2}$

$= \frac{11.15 \times 0.704 \times 6}{2}$

$= 23.54$ kN/m.

(iii) Area of reinforcement

$A_{st} = \frac{\text{hoop tension}}{\sigma_{st}}$.

$= \frac{23.54 \times 10^3}{115} = 204.52$ mm^2.

Use 8mm

No. of bar => $\frac{Ast}{ast}$

$= \frac{204.5}{\frac{\pi}{4} \times 8^2}$

$= 4.06$

≈ 4 # of bar's.

Area of beam:

Allowable stress in concrete = $\frac{\text{hoop tension}}{Ac + (m\, Ast)}$.

$\sigma_{ct} = (2.8) = \frac{(23.53 \times 10^3)}{Ac + (13.3 \times (4\, \frac{\pi}{4} \times 8^2))}$

201.06.

$Ac = 5730.5\, mm^2$.

Adopt minimum width of beam as 150mm

=> $Ac = b \times d$.

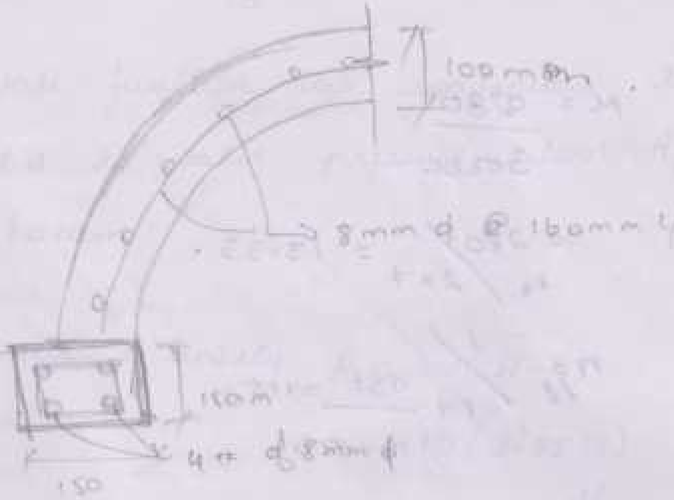
$5730 = 150 \times d$.

$d = 5730/150$

$d = 38.2$

d = 38 mm

Calculated depth is minimum So adapt Size area of beam => 150×150mm width



1, Design a reinf-/. rectangular concrete water ta[nk]
with an Open top for a capacity of 80,000 lit[re]
The inside dimens of the tank may taken a[s]
6m × 4m during the side wall of the tank
using M_{20} & Fe 250 grad I mild steel bar's.

Given

Capacity of tank = 80,000 litre

Size = 6m × 4m.

M_{20} fe 250 grade I ms bar:

IS 3370 - II

page No: 8

Step 2 :- permissible stress:-

σst = 115 N/mm² (liquid retaining near the f[ace])

σst = 125 N/mm² (liquid retaining away from the face)-

σcbc = 7.1

$m = \frac{280}{3\sigma_{cbc}}$

$= \frac{280}{3 \times 7} = 13.33$

$n = \frac{1}{1 + \frac{\sigma_{st}}{m \times \sigma_{cbc}}} = 115$

$= 0.45$

$j = 1 - n/3 = 1 - 0.45/3$

$= 0.85$

II Dimension of tank :-

Capacity = Volume.

$\Rightarrow \frac{80000}{10^3} = b \times d \times h$. (for rect)

$\Rightarrow h = \frac{80000}{10^3 \times 6 \times 4}$

$= 3.33 \simeq 3.35 m$.

$H = h +$ free board.

$= 3.35 + 0.2$

$= 3.55 m$.

Step :3 Moment in side wall :-

$l/a = 6/4 = 1.5 < 2$

$L/B > 2 \Rightarrow$ cantilever

The wall function as continuous slab subjected to water pressure above H/4 (or) 1 from bottom:-

Pressure intensity $p = w(H-h)$

$= 10(3.55-1)$

$= 25.5\ kN/m^2$.

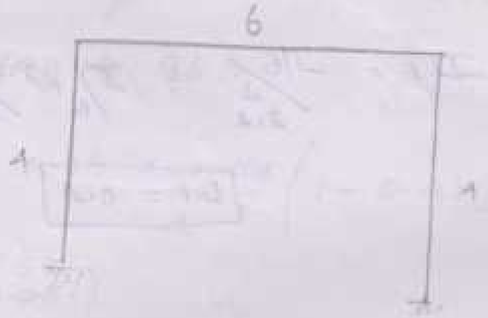
The moment is determined by moment distribution method.

Fixed end moment for 4m span

$\Rightarrow \frac{pl^2}{12}$

$= \frac{25.5 \times 4^2}{12}$

$= 34\ kNm$.



$\Rightarrow$ at centre:-

$pl^2/8 = \frac{25.5 \times 4^2}{8} = 51\ kN.m$.

For 6m span:-

$pl^2/12 = \frac{25.5 \times 6^2}{12} = 76.5\ kN.m$.

at centre: $pl^2/8 = \frac{25.5 \times 6^2}{8}$

$= 114.75\ kNm$.

Stiffness ratio:

$$K = I/L \Rightarrow I/4$$

$$K = I/6$$

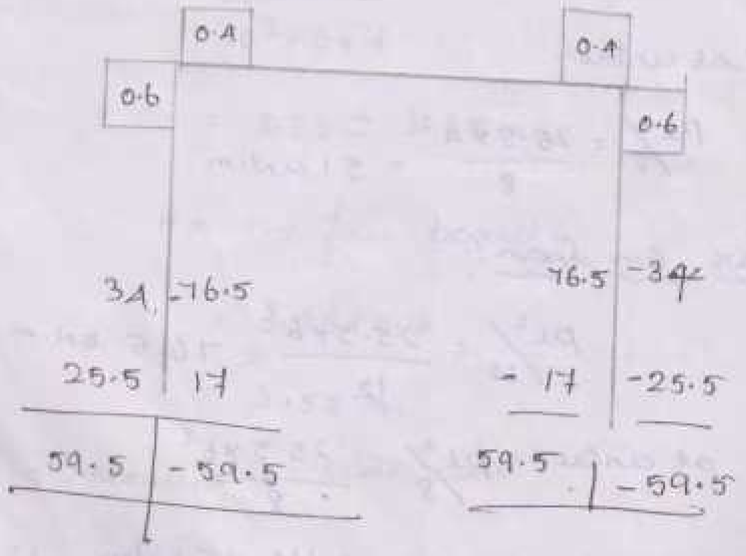
$$\Sigma K = I/4 + I/6 = 0.41 I.$$

$$\Rightarrow D = \frac{I/4}{0.41 I} \quad \frac{I}{2.4}$$

$$\boxed{D.F = 2.4/4 = 0.6.}$$

$$D.F = \frac{I/6}{\frac{I}{2.4}} = I/6 \times 2.4/I$$

$$\boxed{D.F = 0.4}$$



Moment at Support = 59 kN-m.

Moment at centre = (114.7 - 59)

= 55.7.

Moment centre (Shorter Span).

= (51 - 59.5)

= - 8.5 kN.m.

Step 4:

Design of shorter long column.

Adopt maximum moment for the design

Max design moment = 59.5 kN.m.

IS 456 page No: 96 :-

$(M_u\ lim) = 0.36 \frac{x_{u\,max}}{d}\left(1 - 0.42 \frac{x_{u\,max}}{d}\right) b$

$\left(\frac{x_{u\,max}}{d} = 0.53\right)$

$(59.5 \times 10^6) = (0.36 \times 0.53)\left(1 - 0.42 \times 0.53\right) \times (1000 \times d \times 20$

d = 141.6 ≃ 150mm.

d' = 40m.

D = 150 + 40

≃ 190mm.

Overall all think as wall of tank as 190m

Direct tension on the long wall.

$= 10(2.55)6/2$

$= 76.5\ KN/m^2$

Direct tension on short wall.

$T = \omega(H-h)B/2$

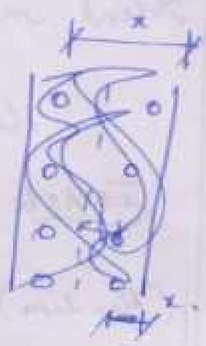
$= 10(3.55-1)4/2$

$= 51\ KN/m^2$

Area of steel reqd:-

$A_{st} = A_{st1} + A_{st2}$.

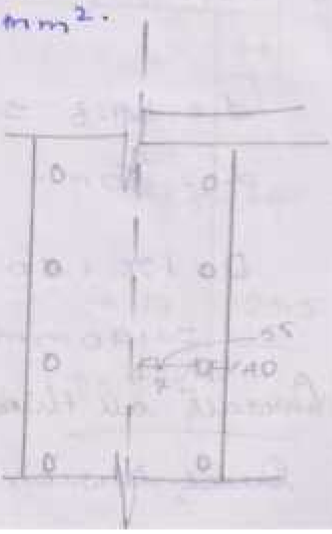
For $\sigma_{st} = 115\ N/mm^2$.



$$A_{st1} = \frac{M - Tx}{\sigma_{st}\, j\, d}$$

$$= \frac{(59.5\times10^6) - (76.5\times10^3\times\frac{55}{40})}{115\times0.85\times150}$$

$= 3771.0\ mm^2$.



$Ast_2 = T/\sigma st = \frac{(76.5 \times 10^3)}{(115)}$

$= 665.22\ mm^2.$

$Ast = Ast_1 + Ast_2$

$= 3771.01 + 665.22$

$= 4436.23\ mm^2.$

(5)

$\sigma st = 125\ N/mm^2.$

$\Rightarrow Ast_1 = \frac{(59.5 \times 10^6) - (76.5 \times 10^3 \times 53)}{(125 \times 0.85 \times 150)}$

$= 3469.3\ mm^2$

$Ast_2 = T/\sigma st$

$= \frac{76.5 \times 10^3}{125} = 612\ mm^2$

$Ast = Ast_1 + Ast_2$

$= 3469.3 + 612$

$= 4081.33\ mm^2.$

Adopt greater Ast.

use 22 mm φ bar.

Spacing $= \frac{ast}{Ast} \times 1000$

$= \frac{\pi/4 \times 22^2}{4436.23} \times 1000$

Provide half of the bars from the inner face at support are bent towards outer surface at centre providing at area of $\frac{4436.23}{2} = 2218.115$

$A_{st} = 2218.15\ mm^2$

Use 20mm ϕ bars.

$$Spacing = \frac{\pi/4 \times 20^2}{2218.15} \times 1000$$

$$= 141.6 \simeq 140mm\ c/c$$

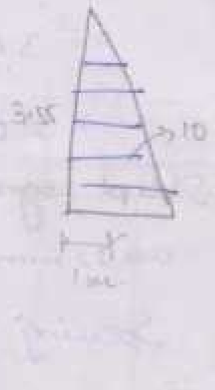
Provide 20 mm ϕ bar at 140mm c/c

Step 5:

Steel for cantilever moment:

cantilever moment $= (1/2 \times 1 \times 3.55 \times 10)\ 1/3$

$= 5.9\ KNm.$



$$A_{st} = \frac{M}{\sigma_{st}\ j\ d}$$

$$= \frac{(5.9 \times 10^3)}{(115 \times 0.85 \times 150)}$$

$= 402.38\ mm^2.$

Minimum Ast for cantilever is 0.3% b×D

$\Rightarrow \left(\frac{0.3}{100} \times 1000 \times 150\right)$

$= 570\ mm^2$.

Use 8mm ϕ.

Spacing $\Rightarrow \frac{\pi/4 \times 8^2}{570} \times 1000$

$= 88\ mm \simeq 100\ mm$ c/c.

Reinforcement on each face on the wall = 5
$= 285\ mm^2$.

Use 8mm ϕ bar.

$\Rightarrow$ Spacing $= \frac{\pi/4 \times 8^2}{285} \times 1000$

$= 176.3\ mm^2$

$\simeq 170\ mm$ c/c.

Provide 8mm ϕ bars on each face of the wall.

Step 6: Rft for slab.

Adopt nominal thickness of slab as 200 mm. minimum Ast

$= 0.3\%$ of $b \times D$

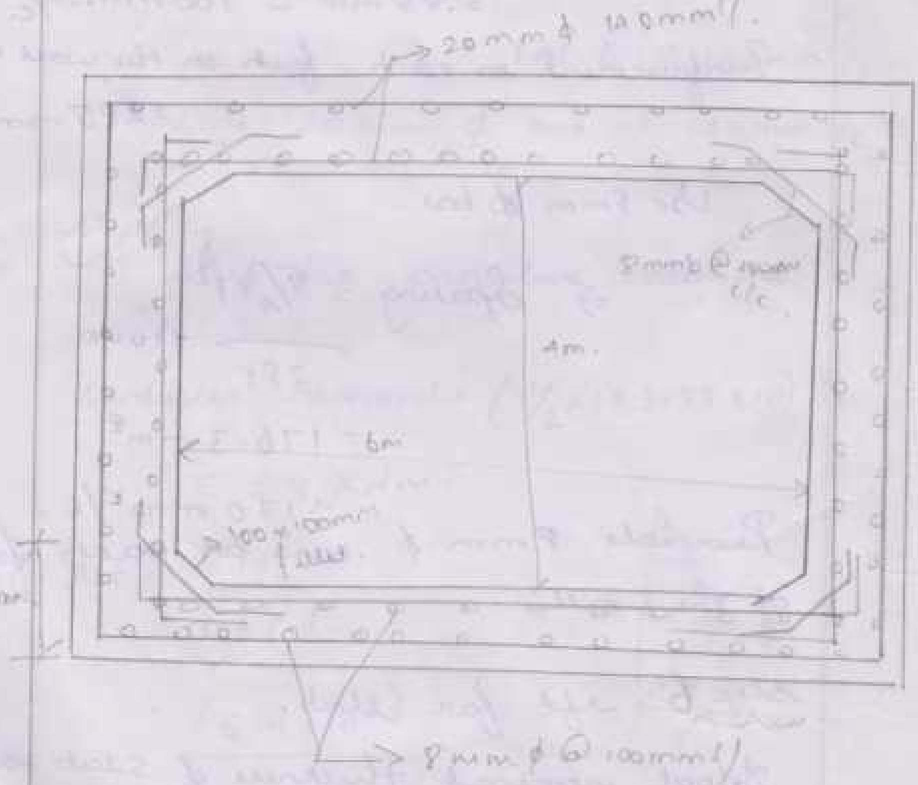
$= \frac{0.3}{100} \times 1000 \times 200$

Use 10 mm ϕ bars

$$\text{Spacing} = \frac{\pi/4 \times 10^2}{600} \times 100$$

$$= 130 \text{ mm c/c}$$

Provide 10 mm ϕ bar at 130 mm in both ways.



C.S of the tank above the base slab.

1, Design a reinforced (RC) water tank of in dimension 10 × 3 m × 3. The tank is to be pl underground. The soil surrounding tank likely to get wet. The angle repose is 30° at dry condition and 6° at wet. Take density of soil as 20 KN/m², adopt M20 grade I mild steel bar's.

Given:-

Size = 10 m × 3 m × 3m.

Angle of repose @ dry state = 30°

@ wet state = 6°

Unit wt of soil = 20 kN/m²

M_{20} + grade I ms bars.

(i) Step 1 permissible & design const.

Tension due to bending (Page No: 1 IS 3370 part II)

$\sigma_{ct} = 1.7 N/mm^2$.

$\sigma_{cbc} = 7 N/mm^2$.

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

design constan

$m = \frac{280}{3\sigma_{cbc}} = 13.33$.

$j = 1 - n/3$

$n = \frac{1}{1 + \frac{\sigma_{st}}{m\sigma_{cbc}}} = \frac{1}{1 + 115/13.3 \times 7} = 0.447$

$n = j = 1 - n/3$

$= 1 - 0.45/3$

$\boxed{j = 0.85}$

$Q = \frac{1}{2} \sigma_{cbc} \, n \cdot j$

$= \frac{1}{2} \times 7 \times 0.45 \times 0.85 = 1.33.$

$\boxed{Q = 1.33}$

Step 2: Design of tank wall:

Maximum bending moment occur for the case of empty tank and surrounding soil is water logged.

$L/B = 10/3 = 3.33 > 2$

∴ The long walls are designed as Cantilever

Pressure exerted by wet soil

$$P = \gamma_H \left[\frac{1 - \sin\phi}{1 + \sin\phi} \right)$$

$$= 20 \times (3) \left(\frac{1 - \sin 6}{1 + \sin 6} \right).$$

$\boxed{P = 48.64 \ kN/m^2}$

Moment calculation :-

Maximum moment at case of tension the water face :-

$$Max.\ BM = \frac{Ph^2}{33.5}$$

$$= \frac{48.64 \times 3^2}{33.5}$$

away.

$$= 13.07\ kNm.$$

For water face.

$$Max.\ B.M = \frac{ph^2}{15} = \frac{48.64 \times 3^2}{15}$$

$$= 29.18\ kN.m.$$

Thickness of the wall.

$$M = \frac{6ct\ bD^2}{6.}$$

$$(29.19 \times 10^6) = \frac{1.7 \times (1000) 3 \times D^2}{6.}$$

$$D = 320.9.$$

$$\simeq \boxed{320\ mm. = D}$$

$\Rightarrow d' = 40$; $d = 320 - 40 = 280 mm.$

Area of Steel for long wall :-

$$Ast = \frac{Max.B.M}{\sigma_{st} \times j \times d.}$$

$$= \frac{29.18 \times 10^6}{115 \times 0.85 \times 280}$$

$$= 1066.13\ mm^2$$

$= 188 \simeq 180 mm\ c/c$

Provide 16 mm ϕ bar at 180 mm c/c on Outerface of the wall.

Area of steel for innerface :

$$A_{st} = \frac{Max \cdot BM}{\sigma_{st}\ jd}$$

$$= \frac{13.07 \times 10^6}{(115 \times 0.85 \times 280)}$$

$$= 477.5 mm^2$$

Use 12 mm ϕ bar.

$$S = \frac{ast}{A_{st}} \times 1000$$

$$= 236.85$$

$$\simeq 230 mm\ c/c$$

Provide, 230 mm c/c at innerface :

Horizontal reinforcement in long wall :

Area of steel => 0.3 % of b×D

$$= \frac{0.3}{1000} \times 1000 \times 320$$

$$= 960 mm^2$$

Use 10 mm ϕ bars.

$S = \frac{ast}{Ast} \times 1000$

$= \frac{ast}{Ast} \times 1000$

$= 81.8mm \simeq 100mm\ c/c$

Provide 10 mm of bar at 100mm c/c as horizontal reinf.

Step 3 :- Design of short wall.

Intensity of earth pressure.

$P = 48.64\ KN/m^2$.

Max. B.M $= \frac{ph^2}{12}$

$= \frac{48.64 \times 3^2}{12}$

$= 36.48\ KN \cdot m$.

Effective span = clear span + 2(thickness/2)

$= 3 + 2\left(\frac{.320}{2}\right)$.

$= 3.320m$.

$\simeq 3.32m$.

effective depth

$d = \sqrt{\frac{M}{Qb}}$.

$= \sqrt{\frac{(36.48 \times 10^6)}{(1.33 \times 1000}}$

$= 165.61 < 280mm$.

adopt = d = 280mm.

Area of reinf for short wall.

$$A_{st} = M / \sigma_{st}\, j d.$$

$$= \frac{(36.48\times10^6)}{(115\times0.85\times280)}$$

$$= 1332.94\ mm^2$$

Use 16mm.

$$S = \frac{a_{st}}{A_{st}} \times 1000$$

$$= 150\ mm$$

⇒ use 16mm ϕ at 15 mm c/c on both ways.

The spacing may be increase upto 300mm c/c towards the top

Vertical reft.

$$A_{st} = 0.3/100 \times b \times D.$$

$$= 0.3/100 \times (1000) \times (320)$$

$$= 960mm^2$$

Use 10 mmϕ

⇒ S = 100 mm c/c.

Step 1 : Design of roof slab:

adopt: thickness of roof slab as 150 mm.

tk = 150mm.

load calculation

* Selfweight of slab = 1 × 0.15 × 1 × 25

= 3.75 kN.

live load = 2.5 kN

floor finish = 0.5 kN/m²

6.75 kN/m².

Moment calculation

$M = wl^2/8 = \frac{6.75 \times 3.32^2}{8} = 9.3$ kNm.

Check for depth:

$d = \sqrt{M/Qb}$

$= \sqrt{\frac{(9.3 \times 10^6)}{(1.33 \times 1000)}}$

$= \sqrt{6992.48} = 83.62 \simeq 100$ mm

depth required < provided.

Hence it is Safe.

Area of reinforcement.

D = 150 −

d = 150 − 25

d = 125

$Ast = M / \sigma st\, j\, d$

$= \frac{(9.3 \times 10^6)}{(115 \times 0.85 \times 125)}$ = ~~328.82~~ mm²

= [illegible] mm².

Use 10 mm ϕ

$S = \frac{ast}{Ast} \times 1000 = 103.19$ mm

$\simeq 100$ mm.

Provide 10 mm ϕ bar at 100 mm c/c as roof slab.

Distribution steel

$\Rightarrow Ast = \frac{0.3}{100} \times b \times D$

$= \frac{0.3}{100} \times 1000 \times 150$

$= 450\ mm^2$

Use 8 mm² ϕ bar.

$S = \frac{ast}{Ast} \times 1000 = 111.70$

$\simeq 110$ mm c/c.

Provide 8 mm ϕ bar at 110 mm c/c as distribar :-