

Course Outcome: The student will be able to

1. Understand the behavior and failure modes of different concrete members
2. Analyze and apply the results in designing various concrete members of structure
3. Apply the knowledge & Skills in practical problems
4. Understand the relevant software used and use the same in analysis & design of concrete members.

Unit – I

Design of circular **water tank** with roof slab/dome resting on ground by approximate methods/IS code method (by working stress method)
Design of rectangular water tank with one-way roof resting on ground by approximate methods/IS code method (by working stress method)

Unit – II

Analysis and design of **columns** subjected to bi-axial moments. Design of long columns. Design of isolated footings, for uni-axial moment, for square, rectangular & circular.

Unit – III

Moment **Redistribution**: Analysis and design of fixed beam, propped cantilever, two span symmetric continuous beams.

Unit – IV (With LSM)

Design of RCC Cantilever and counter-fort **retaining wall**.

Unit – V

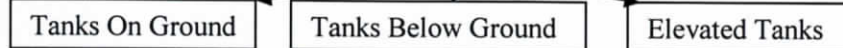
Analysis and design of **portal frames** (Single bay single storey) hinged or fixed base. Design of **stair case** (Dog-legged and open well)

Unit – VI

Design of **combined footing**

- i) Rectangular
- ii) Strap beam
- iii) trapezoidal footing
- iv) Raft footing.

Unit – I Water Tanks



IS Code Provisions: → IS 3370 (Part II) 1965
Min Grade of Concrete M20

Permissible stresses

	Concrete			Steel		
	σ_{cbc}	σ_{ct}	τ		Mild	Tor
M20	7.0	1.2	1.7	Direct tension	115	150
M25	8.5	1.3	1.9	Bending tension – liquid faces	115	150
M30	10.0	1.5	2.2	Bending tension- away from liquid	115	150
M35	11.5	1.6	2.5	Bending tension- $t \geq 225\text{mm}$ & face away from liquid	125	150
M40	13.0	1.7	2.7			

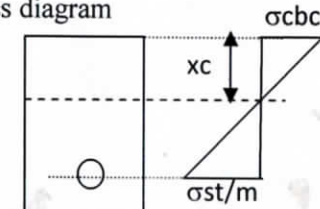
Minimum Reinforcement: In each of two mutually perpendicular directions
 i) For thickness ≤ 100 mm 0.3% of concrete section
 ii) For thickness ≥ 450 mm 0.2% of concrete section
 iii) For thickness between 100 to 450 mm – varies linearly from 0.3% to 0.2%
 (for HYSD bars; it may be reduced by 20% → 0.24% - 0.16%)

For thickness ≥ 225 mm two layers of reinforcing steel shall be placed.
 Min cover 25 mm/ ϕ of bar (more), Additional 12 mm → presence of sea water
 Design constants for **balanced section** using WSM

Depth of Critical Neutral axis, x_c ; From Stress diagram

$$\frac{x_c}{d} = \frac{d-x}{d} = \frac{d}{\sigma_{cbc} + \sigma_{st}/m}$$

$$\frac{x_c}{d} = \frac{\sigma_{cbc}}{\sigma_{cbc} + \sigma_{st}/m} = \frac{m \times \sigma_{cbc}}{m \times \sigma_{cbc} + \sigma_{st}} = \frac{280}{280 + 3 \sigma_{st}}$$



Lever arm, $jd = (d - x/3)$

Compressive force, $C = (b \times x_c) \times \sigma_{cbc}/2$

Tensile force, $T = A_{st} \times \sigma_{st}$

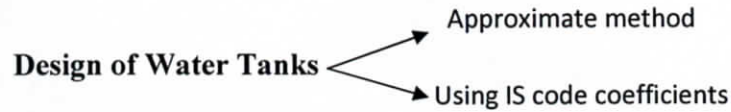
Moment of resistance ;

$$MR = C \times jd = [b \times x_c \times \sigma_{cbc}/2] \times [d - x_c/3] = Qbd^2$$

$$Q = x_c \times (1 - x_c/3d) \times (\sigma_{cbc}/2)$$

OR

$$MR = T \times jd = [A_{st} \times \sigma_{st}] \times [d - x/3]$$



Abbreviation:-

- D → Diameter of cylindrical tank
- H → Depth of water
- R → Radius of spherical dome

a) Flexible Base

Question 1: Design a circular water tank with **flexible connection** at base for a capacity of 400,000 liters. The tank rests on a firm level ground. The total height of tank including a free board of 200 mm should not exceed 3.5m. The tank is open at top. Use M 20 concrete and Fe 415 steel. Draw to a suitable scale:

1: Dimension of tank

Depth of water $H = 3.5 - 0.2 = 3.3$ m
 Volume $V = 400 = \pi \frac{D^2}{4} \times 3.3$;
 Diameter of tank, $D = 12.42$ m, say 13m

2. Assumption of Thickness of wall:

Assume the thickness of wall, $t \approx 30H + 50 \approx 149 \rightarrow 160$ mm

3: Design of Cylindrical (Vertical) wall

Max hoop tension at bottom $= \gamma H D/2 = 10 \times 3.3 \times 13/2 = 214.5$ kN

Area of steel $= T/\sigma_{st} = 214500/150 = 1430$ mm²

- Check for Minimum Area of Reinforcement, $A_{st \min} \rightarrow$
- 100mm --- 0.24%
 - 450mm --- 0.16%
 - 160mm --- $0.24 - (0.08/350) \times 60 = 0.226\%$ of A_g
 $= 0.00226 \times 1000 \times 160 = 361.6$ mm²

Hence, provide hoop reinforcement of 1430 mm²

Spacing of 12 mm diameter bar $\rightarrow 1000 \times 113/1430 = 79$ mm c/c
 Provide **12φ @ 75 c/c** as hoop tension steel

4: Check for tensile stress in concrete, σ_{ct}

Modular ratio $m = 13.33$

$$\text{Stress in concrete, } \sigma_{ct} = \frac{T}{A_e} = \frac{T}{A + (m-1)A_{st}}$$

$$= \frac{214,500}{160 \times 1000 + 12.33 \times 1430} = 1.19 < 1.2 \text{ N/mm}^2 \text{ Safe}$$

5: Curtailment of hoop steel:

	Max. H T	$A_{st} = T/\sigma_{st}$	Spacing
Top 1.1 + 0.2 m	71.5 kN	476	12φ @ 225 c/c
Middle 1.1m	143 kN	953	12φ @ 150 c/c
Bottom 1.1m	214.5 kN	1430	12φ @ 75 c/c

Max spacing $\rightarrow 3T = 3 \times 160 = 480$ m

6: Vertical reinforcement:

For temperature and shrinkage, provide distribution steel @ 0.226 %
 i.e., 361.6 mm².

Spacing of 10 mmφ $\rightarrow 1000 \times 78.5 / 361.6 = 217$ mm c/c ≈ 200 mm c/c

7: Tank floor:

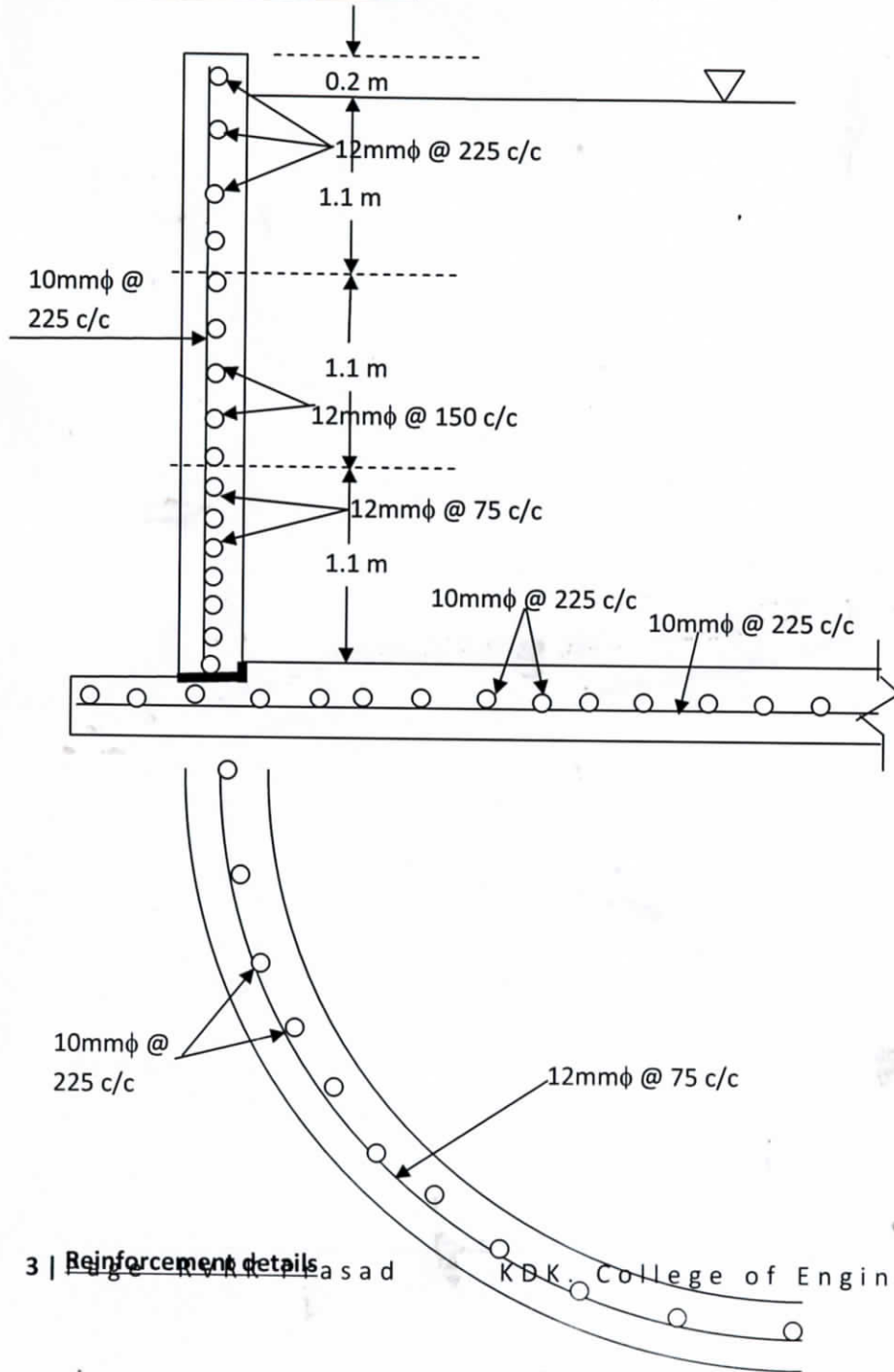
As the slab rests on firm ground, provide thickness of slab as 150 mm.

Minimum Area of Reinforcement, \rightarrow

- 100mm --- 0.24%
- 450mm --- 0.16%
- 150mm --- $0.24 - (0.08/350) \times 50 = 0.229\%$ of A_g
 $= 0.00229 \times 1000 \times 150 = 343.5$ mm²
 Try 10 φ, Spacing $\rightarrow 1000 \times 78.5 / 343.5 = 228$

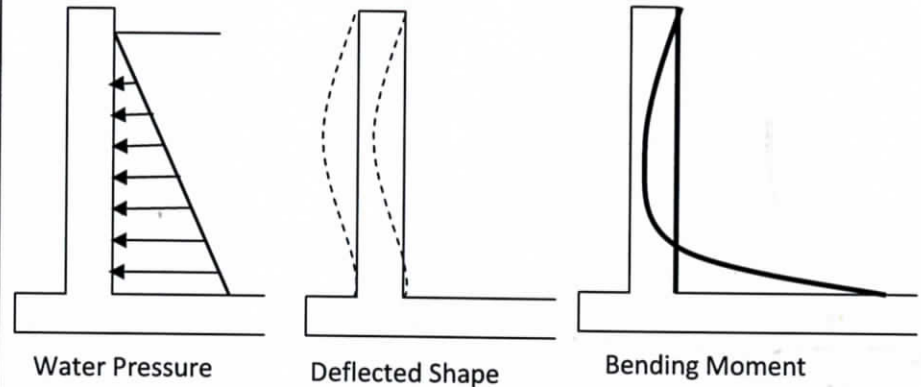
Provide 10 mm diameter bars at 225 c/c in both directions

8: Detailing of Reinforcement:



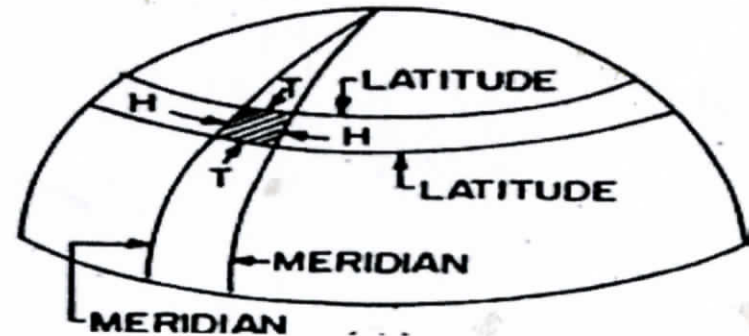
b) Restrained at base

In this type the pressure is borne partially by cantilever action and partially by hoop action



Approximate method of design of Circular tanks with fixed at base

H^2/Dt	Cantilever action
>12	Bottom 1/4 of wall or 1m (more) taken as cantilever wall
6-12	Bottom 1/3 of wall or 1m (more) taken as cantilever wall
<6	Entire height may be designed as cantilever wall fixed at base



Roof Dome

Meridional Force/Thrust, $N_\phi = \frac{wR}{1+\cos\theta}$
 Circumferential Force, $N_\theta = wR \left(\frac{1}{1+\cos\theta} - \cos\theta \right)$

Approximate method

Question 2: A cylindrical water tank, resting on unyielding ground, has a capacity of 400,000 liters. The total height of tank wall is limited to 3.5m. Free board is 200 mm. The wall and the base slab are cast integrally. Design the tank including the roof dome using M25 Grade concrete and Fe415 Type steel. Use approximate method for design.

1. Design constants: WSM

$$\sigma_{cbc} = 8.5, \sigma_{st} = 150$$

$$m = \frac{280}{3 \times 8.5} = 10.98 \approx 11; \quad xc/d = \frac{280}{280 + 3 \times 150} = 0.384$$

$$j = 1 - 0.384/3 = 0.872$$

$$Q = 0.5 \sigma_{cbc} (x) (j) = 0.5 \times 8.5 \times 0.384 \times 0.872 = 1.423$$

2. Dimensions:

$$H = 3.5 - 0.2 = 3.3 \text{ m}$$

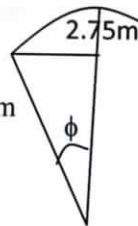
$$V = \pi \frac{D^2}{4} \times 3.3 = 400; \quad \text{Diameter of tank, } D = 12.42 \text{ m say } 12.5 \text{ m.}$$

3. Design of roof dome

$$\text{Rise, } h \rightarrow 12.5/5 = 2.5 \text{ to } 12.5/4 = 3.125 \text{ Provide } 2.75 \text{ m}$$

$$\text{Radius of dome, } R = \frac{D^2/4 + h^2}{2h} = \frac{12.5^2/4 + 2.75^2}{2 \times 2.75} = 8.48 \text{ Say } 8.5 \text{ m}$$

$$\cos \phi = (8.5 - 2.75) / 8.5 = 0.68$$



Assume thickness of dome = 75mm.

$$\text{DL } 0.075 \times 1 \times 1 \times 25 = 1.875 \text{ kN/m}^2$$

$$\text{LL } 0.75 - 3.45 (2.75/12.5)^2 = 0.583 \text{ kN/m}^2 \quad (\text{NBC 1970 Gr II Tab2})$$

$$\text{Total } 2.458 \approx 2.5 \text{ kN/m}^2$$

$$\text{Meridional Force/Thrust, } N\phi = \frac{wR}{1 + \cos\phi} = \frac{2.5 \times 8.5}{1 + 0.68} = 12.65 \text{ kN}$$

$$\text{Meridional Stress} = 12,650 / (1000 \times 75) = 0.168 \text{ N/mm}^2 \ll 8.5 \text{ N/mm}^2$$

$$\text{Circumferential Force, } N\theta = wR \left(\frac{1}{1 + \cos\phi} - \cos\phi \right)$$

$$= 2.5 \times 8.5 \left(\frac{1}{1.68} - 0.68 \right) = -1.80 \text{ kN (Tension)}$$

$$\text{Stress} = -1.8 \times 1000 / (1000 \times 75) = -0.024 \text{ N/mm}^2 \gg -1.3 \text{ N/mm}^2$$

Area of steel : Provide nominal steel = 0.24%

$$= 0.0024 (75 \times 1000) = 180 \text{ mm}^2$$

Try 8mm ϕ , spacing = $1000 \times 50 / 180 = 277$

Provide 8 mm ϕ @ 250 mm c/c # (both ways)

4. Design of Roof ring beam:

$$\text{Horizontal thrust from top dome} = \text{Meridional thrust} \times \cos \phi = 12.65 \times 0.68 = 8.6 \text{ kN}$$

$$\text{Hoop tension} = 8.6 \times 12.5 / 2 = 53.75 \text{ kN}$$

$$\text{Area of steel required} = 53750 / 150 = 358.3 \text{ mm}^2$$

Try 10 mm ϕ , No. of bars = $358.3 / 78.5 = 4.56$ bars say 6 No.

Tensile stress = 1.3 N/mm² \rightarrow for M25

$$1.3 = \frac{53750}{(A + 9.98 \times 358.3)}; \quad A = 37,770 \text{ mm}^2$$

Let the depth of beam = 150mm, $b = 37,770 / 150 = 251.8$ say 300 mm

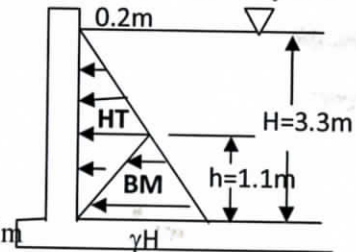
Provide a beam of 300 x 150 mm

Provide nominal shear reinforcement of 6 mm ϕ @ 90 mm c/c [0.75 x 120]

5. Cylindrical Wall:

5a) Assumption: Thickness of the wall, $t \approx 30H + 50 = 149$ say 150 mm

$$\frac{H^2}{Dt} = \frac{3.3^2}{12.5 \times 0.15} = 7.3$$



$$H/3 = 3.3/3 = 1.1 \text{ or } 1 \text{m (higher)} \rightarrow h = 1.1 \text{m}$$

5b) Design for Hoop Tension: Max hoop tension at 2.3 m below FSL,

$$\text{HT} = \gamma h^2 D/2 = 10 \times 2.2 \times 12.5/2 = 137.5 \text{ kN}$$

$$\text{Area of steel, } A_{st} = T / \sigma_{st} = 137,500 / 150 = 917 \text{ mm}^2$$

Check for Minimum Area of Reinforcement, $A_{st \text{ min}} \rightarrow$

$$100 \text{ mm} \text{ --- } 0.24\%$$

$$450 \text{ mm} \text{ --- } 0.16\%$$

$$150 \text{ mm} \text{ --- } 0.24 - (0.08/350) \times 50 = 0.229\% \text{ of } A_g$$

$$= 0.00229 \times 1000 \times 150 = 343.5 \text{ mm}^2$$

Spacing of 12 mm diameter bar = $1000 \times 113 / 917 = 123.7 \text{ mm c/c}$

Provide #12 @ 120 c/c as hoop rings

$$\text{Stress in concrete, } \sigma_t = \frac{T}{A + (m-1)A_{st}} = \frac{137,500}{150,000 + 9.98 \times 917} = 0.86 < 1.3$$

Curtailment of hoop reinforcement

Height	Hoop Tension	Ast= T/σst	Reinforcement
Top 1.3m	68.75 kN	458 mm ²	12φ @ 225 c/c
Middle 1.1m	137.5 kN		12φ @ 120 c/c
Bottom 1.1m	137.5 kN		12φ @ 120 c/c

5c) Bending moment: $\gamma Hh^2/6 = 10 \times 3.3 \times 1.1^2/6 = 6.655 \text{ kNm}$

Effective depth required = $\sqrt{6.655 \times 10^6 / (1.423 \times 1000)} = 68.4 < 120$
 $d = 150 - 25 - 10/2 = 120 \text{ mm}$

Area of steel, $A_{st} = M / (\sigma_{st} \times j \times d) = 6.655 \times 10^6 / (150 \times 0.872 \times 120) = 424 \text{ mm}^2$

Try 8 mmφ bars, spacing = $1000 \times 50 / 424 = 117.92$ say 110 mm c/c

5d) Shear force: $\gamma H^2/2 = 10 \times 3.3^2/2 = 54.45 \text{ kN}$

Shear stress, $\tau = V / (b \times j \times d) = 54,450 / (1000 \times 0.872 \times 120) = 0.52 < 1.9$

6: Tank floor:

As the slab rests on firm ground, Provide 150 mm thick & minimum steel @ 0.229% of $A_g = 343.5 \text{ mm}^2$

Try, 8 mm diameter bars, spacing = $1000 \times 50 / 343.5 = 145.56 \approx 140$

Provide 8 mmφ @ 140 c/c.

7. Haunch:

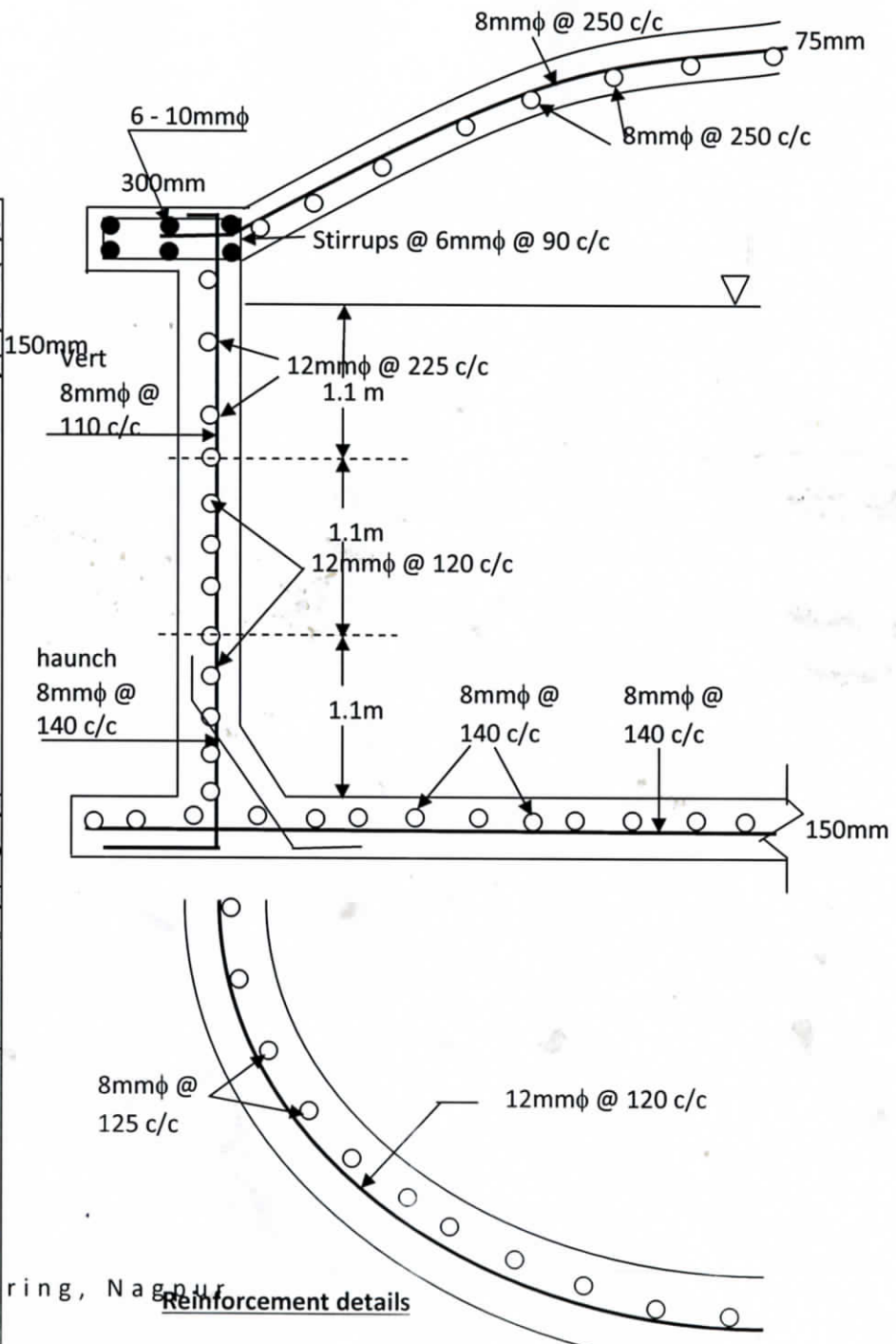
Provide a haunch of 150 x 150 mm at bottom all around the tank

Provide haunch reinforcement of 8mm φ @ 140 c/c

8: Detailing of Reinforcement:

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IS Code method:

Question 3: A cylindrical water tank, resting on unyielding ground, has a capacity of 400,000 liters. The total height of tank wall is limited to 3.5m. Free board is 200 mm. The wall and the base slab are cast integrally. Design the tank including the roof dome using M20 Grade concrete and Fe415 Type steel. Use IS Code method for design.

1. Design constants: WSM

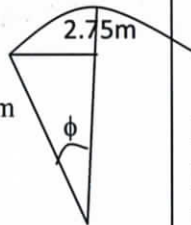
$\sigma_{cbc} = 8.5, \sigma_{st} = 150$
 $m = \frac{280}{3 \times 8.5} = 10.98 \approx 11; xc/d = \frac{280}{280 + 3 \times 150} = 0.384$
 $j = 1 - 0.384/3 = 0.872$
 $Q = 0.5 \sigma_{cbc} (x) (j) = 0.5 \times 8.5 \times 0.384 \times 0.872 = 1.423$

2. Dimensions:

$H = 3.5 - 0.2 = 3.3 \text{ m}$
 $V = \pi \frac{D^2}{4} \times 3.3 = 400; \text{ Diameter of tank, } D = 12.42 \text{ m say } 12.5 \text{ m}$

3. Design of roof dome

Rise, $h \rightarrow 12.5/5 = 2.5$ to $12.5/4 = 3.125$ Provide 2.75 m
 Radius of dome, $R = \frac{D^2/4 + h^2}{2h} = \frac{12.5^2/4 + 2.75^2}{2 \times 2.75} = 8.48$ Say 8.5 m
 $\cos \phi = (8.5 - 2.75) / 8.5 = 0.68$



Assume thickness of dome = 75mm.
 DL $0.075 \times 1 \times 1 \times 25 = 1.875 \text{ kN/m}^2$
 LL $0.75 - 3.45 (2.75/12.5)^2 = 0.583 \text{ kN/m}^2$ (NBC 1970 Gr II Tab2)
 Total $2.458 \approx 2.5 \text{ kN/m}^2$
 Meridional Force/Thrust, $N\phi = \frac{wR}{1 + \cos\theta} = \frac{2.5 \times 8.5}{1 + 0.68} = 12.65 \text{ kN}$
 Meridional Stress = $12,650 / (1000 \times 75) = 0.168 \text{ N/mm}^2 \ll 8.5 \text{ N/mm}^2$

Circumferential Force, $N\theta = wR \left(\frac{1}{1 + \cos\theta} - \cos\theta \right)$
 $= 2.5 \times 8.5 \left(\frac{1}{1.68} - 0.68 \right) = -1.80 \text{ kN}$ (Tension)
 Stress = $-1.8 \times 1000 / (1000 \times 75) = -0.024 \text{ N/mm}^2 \gg -1.3 \text{ N/mm}^2$

Area of steel : Provide nominal steel = 0.24%
 $= 0.0024(75 \times 1000) = 180 \text{ mm}^2$

Try 8mm ϕ , spacing = $1000 \times 50 / 180 = 277$
 Provide 8 mm ϕ @ 250 mm c/c # (both ways)

4. Design of Roof ring beam:

Horizontal thrust from top dome = Meridional thrust $\times \cos \phi$
 $= 12.65 \times 0.68 = 8.6 \text{ kN}$
 Hoop tension = $8.6 \times 12.5 / 2 = 53.75 \text{ kN}$
 Area of steel required = $53750 / 150 = 358.3 \text{ mm}^2$
 Try 10 mm ϕ , No. of bars = $358.3 / 78.5 = 4.56$ bars say 6 No.
 Tensile stress = 1.3 N/mm² \rightarrow for M25

$1.3 = \frac{53750}{(A + 9.98 \times 358.3)}; A = 37,770 \text{ mm}^2$

Let the depth of beam = 150mm, $b = 37,770 / 150 = 251.8$ say 300 mm
 Provide a beam of 300 x 150 mm

Provide nominal shear reinforcement of 6 mm ϕ @ 90 mm c/c [0.75x120]

5. Cylindrical Wall:

5a) Assumption: Thickness of the wall, $t \approx 30H + 50 = 149$ say 150 mm

$\frac{H^2}{Dt} = \frac{3.3^2}{12.5 \times 0.15} = 7.3$

5b) Codal Coefficients

Max HT @ 0.6 H = $\alpha (wHr); \alpha \rightarrow 0.514 + (0.575 - 0.514) \times 1.3 / 2 = 0.554$
 Max BM @ Base = $\beta (wH^3); \beta \rightarrow 0.0187 - (0.0187 - 0.0146) \times 0.65 = 0.01604$
 Max SF @ Base = $\gamma (wH^2); \gamma \rightarrow 0.197 - (0.197 - 0.174) \times 0.65 = 0.182$

5c) Design for Hoop Tension:

Max hoop tension at 0.6H = 1,98 m below FSL,
 HT = $\alpha (wHr) = 0.554 \times 10 \times 3.3 \times 6.25 = 114.263 \text{ kN}$
 Area of steel, $A_{st} = T / \sigma_{st} = 114,263 / 150 = 761.75 \text{ mm}^2$

Check for Minimum Area of Reinforcement, $A_{st \text{ min}} \rightarrow$

100 mm --- 0.24%
 450 mm --- 0.16%
 150 mm --- $0.24 - (0.08/350) \times 50 = 0.229\%$ of A_g
 $= 0.00229 \times 1000 \times 150 = 343.5 \text{ mm}^2$

Spacing of 12 mm diameter bar = $1000 \times 113 / 761.75 = 149 \text{ mm c/c}$

Provide #12 @ 140 c/c as hoop rings

Stress in concrete, $\sigma_t = \frac{T}{A + (m-1)A_{st}} = \frac{114,263}{150,000 + 9.98 \times 761.75} = 0.73 < 1.3$

HT @ 0.3 H, $\alpha = 0.344 - 0.009 \times 1.3 / 2 = 0.339; HT = 0.339 \times 10 \times 3.3 \times 6.25$

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Curtailment of hoop reinforcement

Height	Hoop Tension	Ast= T/σst	Reinforcement
Top 0.99 +0.2m	69.92 kN	466 mm ²	12φ @ 240 c/c
Middle 0.99m	114.263 kN		12φ @ 140 c/c
Bottom 1.32 m	114.263 kN		12φ @ 140 c/c

5d) Bending moment: $=\beta (wH^3) = 0.01604 \times 10 \times 3.3^3 = 5.7643 \text{ kNm}$
 Effective depth required $= \sqrt{5.7643 \times 10^6 / (1.423 \times 1000)} = 63.6 < 120$

$d = 150 - 25 - 10/2 = 120 \text{ mm}$

Area of steel, $A_{st} = M / (\sigma_{st} \times j \times d) = 5.7643 \times 10^6 / (150 \times 0.872 \times 120) = 367$
 Try 8 mmφ bars, spacing = $1000 \times 50 / 367 = 136$ say 125 mm c/c

5e) Shear force: $\gamma (wH^2) = 0.182 \times 10 \times 3.3^2 = 19.82 \text{ kN}$
 Shear stress, $\tau = V / (b \times j \times d) = 19,820 / (1000 \times 0.872 \times 120) = 0.189 < 1.9$

6: Tank floor:

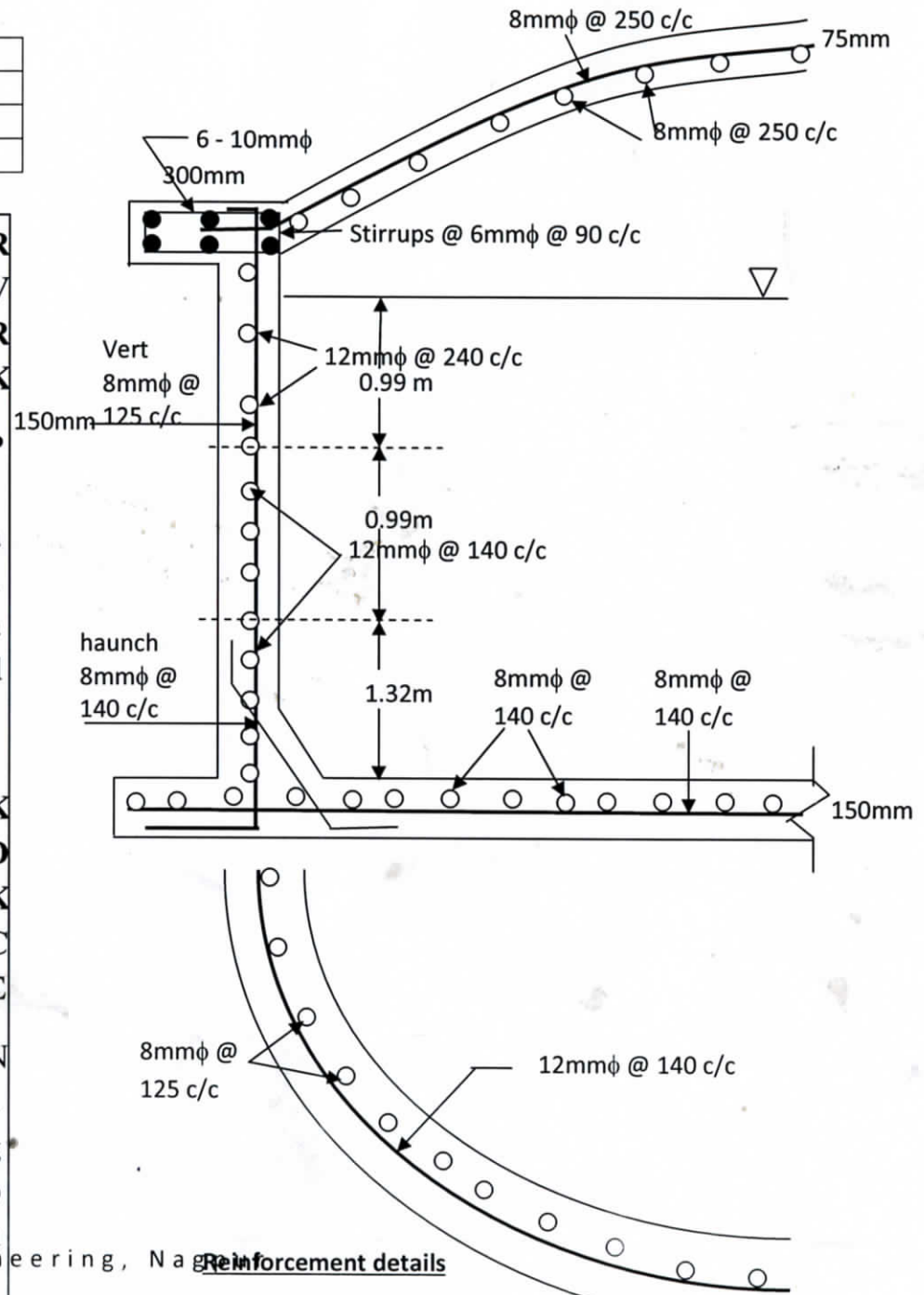
As the slab rests on firm ground, Provide 150 mm thick & minimum steel @ 0.229% of $A_g = 343.5 \text{ mm}^2$
 Try, 8 mm diameter bars, spacing = $1000 \times 50 / 343.5 = 145.56 = 140$
 Provide 8 mmφ @ 125 c/c.

7. Haunch:

Provide a haunch of 150 x 150 mm at bottom all around the tank
 Provide haunch reinforcement of 8mm φ @ 140 c/c

8: Detailing of Reinforcement:

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Rectangular water tank

Question 4. Design a rectangular water tank 5m x 4m with depth of storage 3m, resting on ground and whose walls are rigidly joined at vertical and Base. Free at top. Assume M20 concrete and Fe415 grade steel. Sketch the details of reinforcement in the tank using IS Code method:

1. Design constants:

$$m = 280/3\sigma_{cbc} = 13.333$$

$$\text{Design constants, } x/d = 280/(280+3\sigma_{st}) = 0.384$$

$$\text{Lever arm, } jd = 1 - x/3d = 1 - 0.384/3 = 0.87$$

$$Q = 0.5\sigma_{cbc} (x/d) (1 - x/3d) = 1.17$$

2. Codal coefficients

i) Long wall:

$$L/a = 5/3 = 1.67 \approx 1.75;$$

$$\text{at } y=0, x/a=1, M_x = -0.074;$$

$$\text{at } y=b/2, x/a=1/4, M_y = -0.052$$

$$\text{Max vert. moment} = M_x \gamma a^3 = -19.98$$

$$\text{Max hor. moment} = M_y \gamma a^3 = -14.04$$

$$T_{\text{long}} = \gamma ab/2 = 60 \text{ kN}$$

ii) Short wall:

$$B/a = 4/3 = 1.33 \approx 1.5;$$

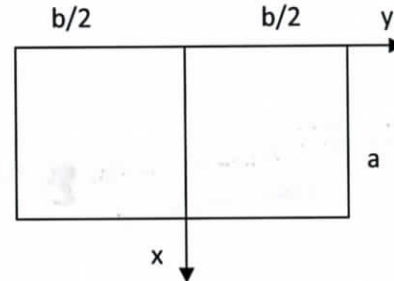
$$\text{at } y=0, x/a=1, M_x = -0.06;$$

$$\text{at } y=b/2, x/a=1/4, M_y = -0.044$$

$$\text{Max vert. moment} = M_x \gamma a^3 = -16.2$$

$$\text{Max hor. moment} = M_y \gamma a^3 = -11.88$$

$$T_{\text{short}} = \gamma aL/2 = 75 \text{ kN}$$



3. Thickness of Wall :

$$\text{Depth, } d = \sqrt{\frac{M}{Qb}} = \sqrt{\frac{19.98 \times 10^6}{1.17 \times 1000}} = 132 \text{ mm}$$

$$\text{Thickness} = 132 + 25 + 12/2 = 163 \approx 170 \text{ mm (d=139)}$$

4. Vertical reinforcement:

Minimum Area of Reinforcement, $A_{st \text{ min}} \rightarrow$

$$100 \text{ mm} \quad \text{---} \quad 0.24\%$$

$$450 \text{ mm} \quad \text{---} \quad 0.16\%$$

$$170 \text{ mm} \quad \text{---} \quad 0.24 - (0.08/350) \times 70 = 0.224\% \text{ of } A_g$$

$$= 0.00224 \times 1000 \times 170 = 380.8 \text{ mm}^2$$

R Long wall (Vert) = $\frac{M}{\sigma_{st} \times jd} = \frac{19.98 \times 10^6}{150 \times 0.87 \times 139} = 1110 \text{ mm}^2$
 V Provide 12 mm ϕ , $S_p = 1000 \times 113/1110 = 102$ say 100 mm/c - [b]
 R Short wall (Vert) = $\frac{M}{\sigma_{st} \times jd} = \frac{16.2 \times 10^6}{150 \times 0.87 \times 139} = 890 \text{ mm}^2$
 K Provide 12 mm ϕ , $S_p = 1000 \times 113/890 = 126$ say 125 mm/c - [c]

P Minimum steel $\rightarrow 1000 \times 50 / (380/2) = 263$ say 250 c/c - [d]

5. Horizontal reinforcement:

r Horizontal moment: They are producing unbalanced moments

$$kL = 1/5; kS = 1/4 \rightarrow \text{DF } .44 \text{ \& } .56$$

a Moment distribution at the joint of long and short walls

	0.44	0.56
s	-14.04	11.88
a	0.95	1.21
d	-13.09	13.09

K Tension in Walls: at H/4 or 1 m (higher) $\rightarrow 3/4$ or 1 \rightarrow 1 m from bottom

$$\text{Tension in Long wall} = 2 \times 10 \times 4/2 = 40 \text{ kN}$$

$$\text{Tension in Short wall} = 2 \times 10 \times 5/2 = 50 \text{ kN}$$

$$\text{Net BM, } M' = M - T_x; x = d - D/2 = 139 - 85 = 54 \text{ mm}$$

$$M'_{\text{Long}} = 13.09 - 40 \times 0.054 = 10.93 \text{ kNm}$$

$$M'_{\text{Short}} = 13.09 - 40 \times 0.054 = 10.39 \text{ kNm}$$

$$A_{st} = (T/\sigma_{st}) + (M'/\sigma_{st} jd)$$

$$\text{Long wall, } A_{st} = 40,000/150 + 10.93 \times 10^6 / (150 \times 0.87 \times 139) = 869 \text{ mm}^2$$

$$\text{Short wall } A_{st} = 50,000/150 + 10.39 \times 10^6 / (150 \times 0.87 \times 139) = 906 \text{ mm}^2$$

$$\text{Provide 12 mm } \phi, S_p = 1000 \times 113/906 = 123 \text{ say 120 mm/c - [a]}$$

6. Base slab:

g The base slab is assumed to be resting on firm ground, provide a nominal thickness of 150 mm.

$$\text{Min area of steel} = 0.24 - 0.08(50/350) = 0.228$$

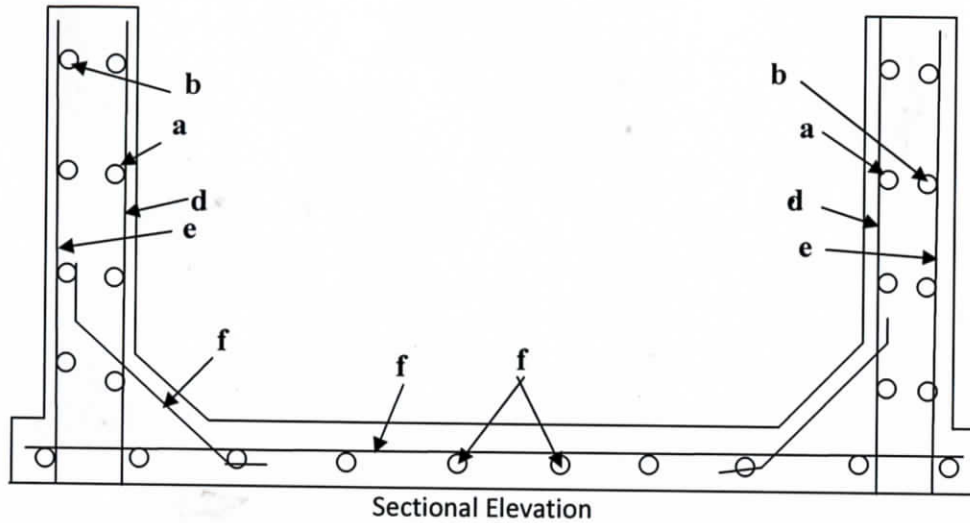
$$A_{st} = 0.00228 \times 1000 \times 150 = 343 \text{ mm}^2$$

$$\text{Provide 8 mm } \phi, S_p = 1000 \times 50/343 = 145 \text{ say 140 mm/c # [d]}$$

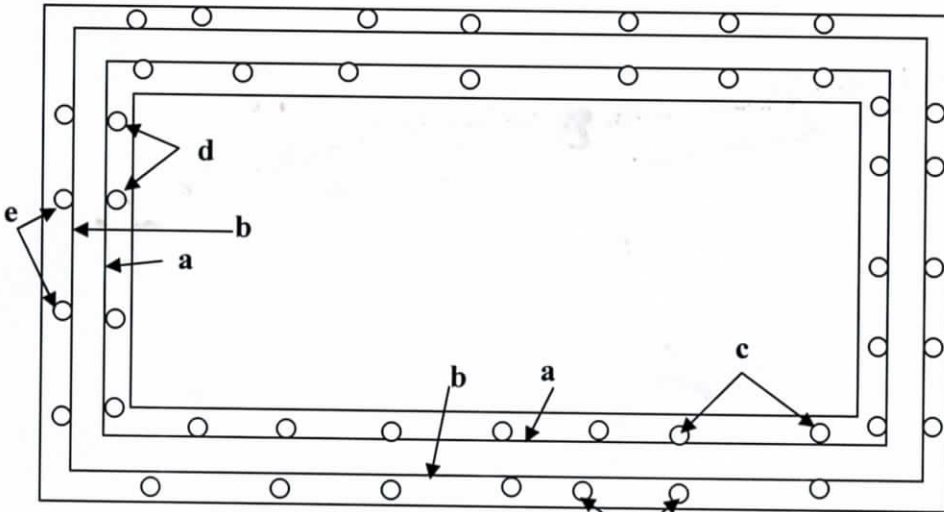
7 Haunch:

r Provide a haunch of 150 x 150 all around at the base

Provide haunch reinforcement of 8 mm ϕ @ 140 c/c



Sectional Elevation



Sectional Plan

- [a] – Horizontal reinforcement - 12 mm ϕ @ 120 c/c
- [b] - Minimum steel horizontal – 8 mm ϕ @ 250 c/c
- [c] – Vertical reinforcement - 12 mm ϕ @ 100 c/c
- [d] – Vertical reinforcement - 12 mm ϕ @ 125 c/c
- [e] – Minimum steel, vertical – 8mm ϕ @ 250 c/c
- [f] – base & haunch reinforcement - 8 mm ϕ @ 140 c/c

Questions from the previous papers:

Winter 15

R
V Q (1) [14M] :

OR

R
Q (2) [14M] :

Summer 16

K Q (1) [14M] : Design the cylindrical Wall of a Circular Water Tank for a capacity of 400,000 liters. The tank is fixed at base and free at top. The depth of water is to be 4 m and take free board as 0.4m. Use M 25 Grade Concrete and Fe 415 types Steel. Design for Hoop Tension, Bending Moment, and provide requisite distribution steel. Design by using IS code or by approximate method. Detail the design by neat Diagram.

OR

P
r
a
s
a
d Q (2) [14M] : Design the wall of a Square Water Tank for a capacity of 75 m³. The tank is fixed at base and free at top. The depth of water is 3m and the free board is 0.3 m. Use M25 Grade concrete and Fe 415 type Steel. Design for both longitudinal and lateral bending, and provide required distribution steel. Design by using IS Code or by approximate method. Detail the design by neat diagram.

Winter 16

D
K
C Q (1) [14 M] : Design the cylindrical wall of circular water tank for a capacity 3,50,000 liter. The tank is fixed at base and free at top. The depth of water is to be 3.5 m and take free board as 0.35 m use M20 grade of concrete and Fe 415 type of steel. Draw reinforcement details.

OR

E
N
a Q (2) [14M] : Design the wall of square water tank of size 6m x 6m x 3m (L x B x D) for a capacity of 85 m³ . The tank is fixed at base and free at top Use M25 grade of concrete and Fe 415 grade of steel. Draw the reinforcement Details.

Summer 17

g
p
u
r Q(1) [13M] :A cylindrical water tank of capacity of 500,000 liters resting on a firm ground and having a rigid joint at the base. The depth of water is to be 4 m including a free board of 200mm. Design the roof dome and circular wall of the tank. Use M 20 Grade Concrete and Fe 415 types Steel.

OR

Q (2) [13M] : Design the rectangular water tank 6m x 5m with depth of storage 3.5m, resting on firm ground whose walls are fixed at base and free at top. Design the walls of water tank by using IS code method or approximate method. Adopt M20 grade of concrete and Fe 415 type of steel