Design Problem No.2:

Design a circular water tank to hold 5,50,000 liters of water. Assume rigid joints between the wall and base slab. Adopt M20 concrete and Fe 415 steel. Sketch details of reinforcements.

Solution:

Step 1: Dimension of tank

Volume of tank V=550 m^3

Assume H= 4.5

A=550/4.5 = 122.22 m^2

D= $\sqrt{(4 \times 122.22/\pi)}$ = 12.47 ≈12.5 m

Step 2: Analysis for hoop tension and bending moment

One meter width of the wall is considered and the thickness of the wall is estimated as t=30H+50 = 185 mm. The thickness of wall is assumed as 200 mm.

$$\frac{H^2}{Dt} = \frac{4.5^2}{12.5 \times 0.2} = 8.1 \approx 8$$

Referring to table 9 of IS3370 (part IV), the maximum coefficient for hoop tension = 0.575

T_{max}=0.575 x 10 x 4.5 x 6.25 =161.72 kN

Referring to table 10 of IS3370 (part IV), the maximum coefficient for bending moment = -0.0146 (produces tension on water side)

M_{max}= 0.0146 x 10 x 4.5^3=13.3 kN-m

Step 3: Design of section:

For M20 concrete σ_{cbc}=7, For Fe415 steel σ_{st}=150 MPa and m=13.33 for M20 concrete and Fe415 steel

The design constants are:

$$k = \frac{m\sigma_{cbc}}{m\sigma_{cbc} + \sigma_{st}} = 0.39$$

j=1-(k/3)=0.87

Q= ½ σ_{cbc}jk = 1.19

Effective depth is calculated as $d = \sqrt{\frac{M}{Qb}} = \sqrt{\frac{13.3\text{x}10^6}{1.19\text{x}1000}} = 105.7\text{mm}$

Let over all thickness be 200 mm with effective cover 33 mm $d_{provided}$=167 mm

$$A_{st} = \frac{M}{\sigma_{st}\, jd} = \frac{13.3\text{x}10^6}{150\text{x}0.87\text{x}167} = 610.27\text{mm}^2$$

Spacing of 16 mm diameter bar = $\frac{201\text{x}1000}{610.27} = 329.36\text{mm c/c}$ (Max spacing 3d=501mm)

Provide #16@300 c/c as vertical reinforcement on water face

Hoop steel: $A_{st1} = \frac{T}{\sigma_{st}} = \frac{161.72\text{x}10^3}{150} = 1078.13\text{mm}^2$

Spacing of 12 mm diameter bar = $\frac{113x1000}{1078.13} = 104 mm c/c$

Provide #12@100 c/c as hoop reinforcement on water face

Actual area of steel provided $A_{st} = \frac{113x1000}{100} = 1130 mm^2$

Step 4: Check for tensile stress:

$$\sigma_c = \frac{T}{1000t + (m-1)A_{st}} = \frac{161.72x10^3}{1000x200 + (13.33-1)x1130} = 0.76 N/mm^2$$

Permissible stress = $0.27\sqrt{f_{ck}}$=1.2 N/mm^2 > σ_c Safe

Step 5: Distribution Steel:

Minimum area of steel is 0.24% of concrete area

A_{st}=(0.24/100) x1000 x 200 = 480 mm^2

Spacing of 8 mm diameter bar = $\frac{50.24x1000}{480} = 104.7. mm c/c$

Provide #8 @ 100 c/c as vertical and horizontal distribution on the outer face.

Step 5: Base slab:

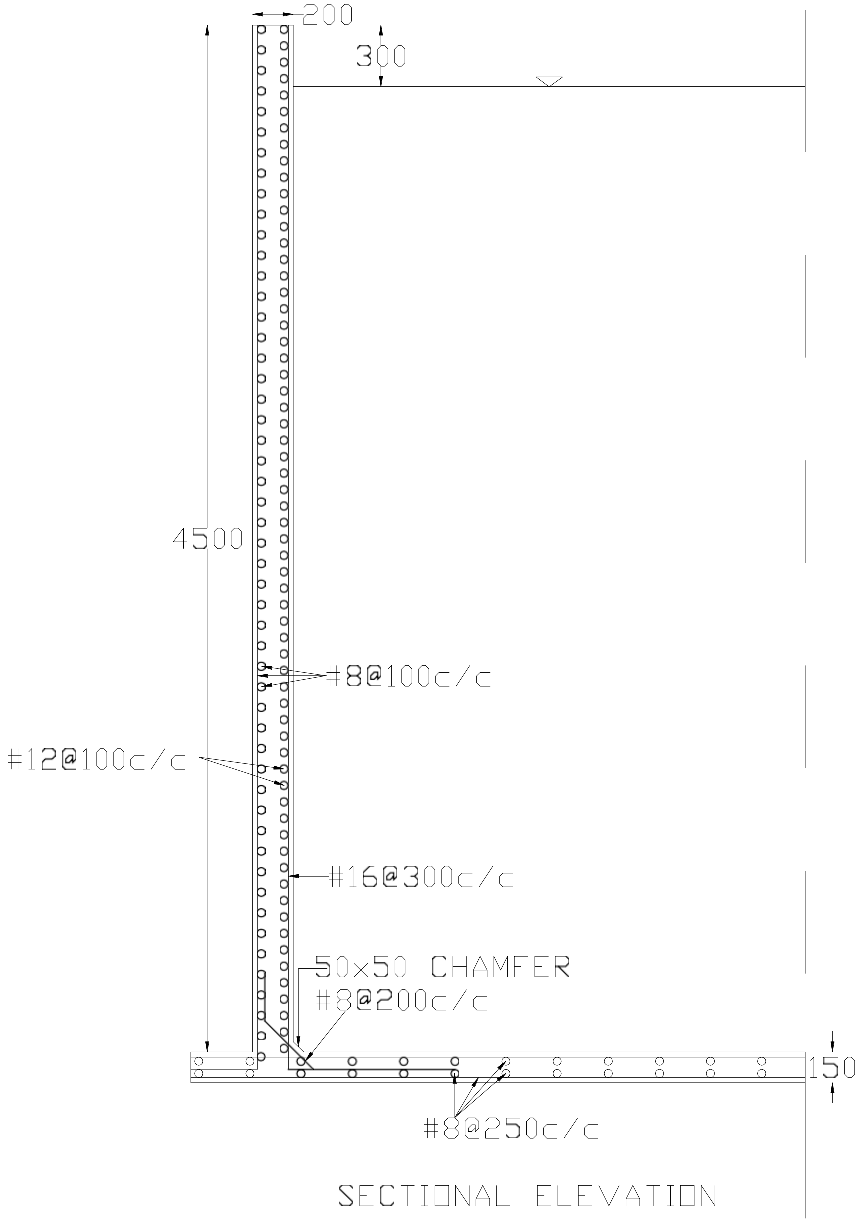
The thickness of base slab shall be 150 mm. The base slab rests on firm ground, hence only minimum reinforcement is provided.

A_{st}=(0.24/100) x1000 x 150 = 360 mm^2

Reinforcement for each face = 180 mm^2

Spacing of 8 mm diameter bar = $\frac{50.24x1000}{180} = 279. mm c/c$

Provide #8 @ 250 c/c as vertical and horizontal distribution on the outer face.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#16@300c/c
50x50 CHAMFER
#8@200c/c
150
#8@250c/c
SECTIONAL ELEVATION