UNDERGROUND RECTANGULAR TANKS - HEMISPHERICAL BOTTOMED STEEL WATER TANK

3.3 Design the closed rectangular water tank

Example 3

Design the closed rectangular water tank with internal dimension of 6 x 3x 3m below the ground level. The nature of soil is always dry and its unit weight 18kN/m^2 and angle of repose 28º. Draw the reinforcement detail.

Given data:

Internal dimension = 6x3x3m

unit weight = 18kN/m^2

angle of repose = 28º

nature of soil = dry

Solution:

Step 1:Design of constants

The tank with the dimension of 6x3x3m and 200mm free board

6x3x2.8 = 50.4m^3

= 50400 liters capacity

Let useM20 grade concrete anf Fe 415 steel

permissible direct tensile stress of concrete,

$$\sigma_{ct} = 1.2 \text{ Mpa}$$

permissible bending tensile stress of concrete,

$$\sigma_{cbt} = 1.6 \text{ Mpa}$$

permissible bending compressive stress of concrete,

$$\sigma_{cbc} = 7.0 \text{ Mpa}$$

modular ratio,   m   = 280/3

               σ_{cbc} = 280/3(7)

               = 13.33

permissible tensile stress of steel σ_{st} = 150MPa

 N.A depth coefficient ,   n   = 1/ 1+ σ_{st}/m σ_{cbc}

Lever arm coefficient   j   = 1 – n/3

               = 0.872

         K   = ½ σ_{cbc} nj

               = ½ x7x0.3835x0.872

               = 1.170

Step 2:Design of walls

        (i) Testing condition (tank full of water without support of surrounding soil)
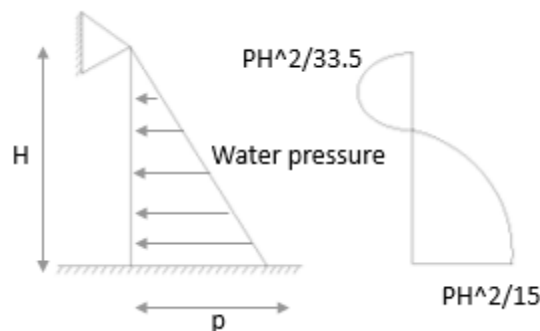
        (ii) Empty tank condition

(i)   Only water pressure acting on the tank wall from inside.

    Maximum water pressure,   P   =γH

               = 10x3

               = 30kN/m^2

Bending moment @ water face

$$PH^2/15 = 30 \times 3^2/15$$

$$= 18 \text{kNm/m}$$

Bending moment @ away from water face

$$PH^2/33.5 = 30 \times 3^2/33.5$$

$$= 8.8 \text{kNm/m}$$

Thickness of wall required for avoiding crack can be determined by,

$$\sigma_{cbt} \times 1/6 \times b \times D^2 = M$$

$$1.6 \times 1/6 \times 1000 \times D^2 = 18 \times 10^6$$

$$D = 260 \text{mm}$$

Let provide 300m wall thickness.

(ii) Empty tank condition

Active earth pressure coefficient

$$K_a = 1 - \sin \phi / 1 + \sin\phi$$

$$= 1 - \sin 28° / 1 + \sin 28°$$

$$= 0.361$$

Maximum earth pressure

$$P = K_a \, \gamma_s \, H$$

$$= 0.361 \times 18 \times 3$$

$$= 19.5 \text{kN/m}^2$$

Bending moment @ base (away from water face)

$$PH^2/15 = 19.5 \times 3^2/15$$

$$= 11.7 \text{kNm} /\text{m}$$

Calculating area of steel

Maximum bending moment @ water face

$$= 18 \text{kNm}$$

Maximum bending away from water face

$$= 11.7 \text{kNm}$$

Minimum required steel $\quad = 0.24 - 300/350 \times 0.08$

$$= 0.17$$

$A_{st\ min} \quad = 0.17/100 \times 1000 \times 300$

$$= 510 \text{mm}^2$$

$$= 255 \text{mm}^2 \text{ on each face}$$

Vertical reinforcement required @ water face

$$= M/\sigma_{st}\ j\ d$$

$$= 18 \times 10^6/150 \times 0.874 \times 250$$

$$= 528 \text{mm}^2$$

Provide 12mmφ @ 200mm c/c ,($A_{st\ pro} = 565 \text{mm}^2$) vertical reinforcement on inner face of tank.

Vertical reinforcement away from water face

$$= 11.7 \times 10^6/150 \times 0.874 \times 250$$

$$= 343 \text{mm}^2$$

Provide 12mm φ@ 300mm c/c spacing ($A_{st\ pro} = 377 \text{mm}^2$) on outer face of tank.

Provide 10mm φ@ 200mm c/c as horizontal bars on the both face of wall.

Step 3 :Design of roof slab

Assume thickness of roof slab is 150mm

Loading:

(i) Self weight of slab = 0.15x24

= 3.8kN/m^2

(ii) live load = 1.5kN/m^2

(iii) finishing = 0.15kN/m^2

total = 5.25kN/m^2

c/c dimension of the slab = 3.3x6.3m

Design of oneway slab

The max bending moment in slab = 5.25x3.3^2/8

= 7.146kN

effective depth required   d = $\sqrt{\dfrac{7.1465\ X10^6}{1.012 X 1000}}$

d_{pro} = 150-40

=110mm

= 84mm <110mm

Area of steel requirement A_{st} = 7.1465x10^6/150x0.874x110

= 495.56mm^2

Provide 12mm ϕ @ 200mm c/c along both directions.

Step 4: Design of base slab

The BM @ base of wall will be same for the edge of base slab.

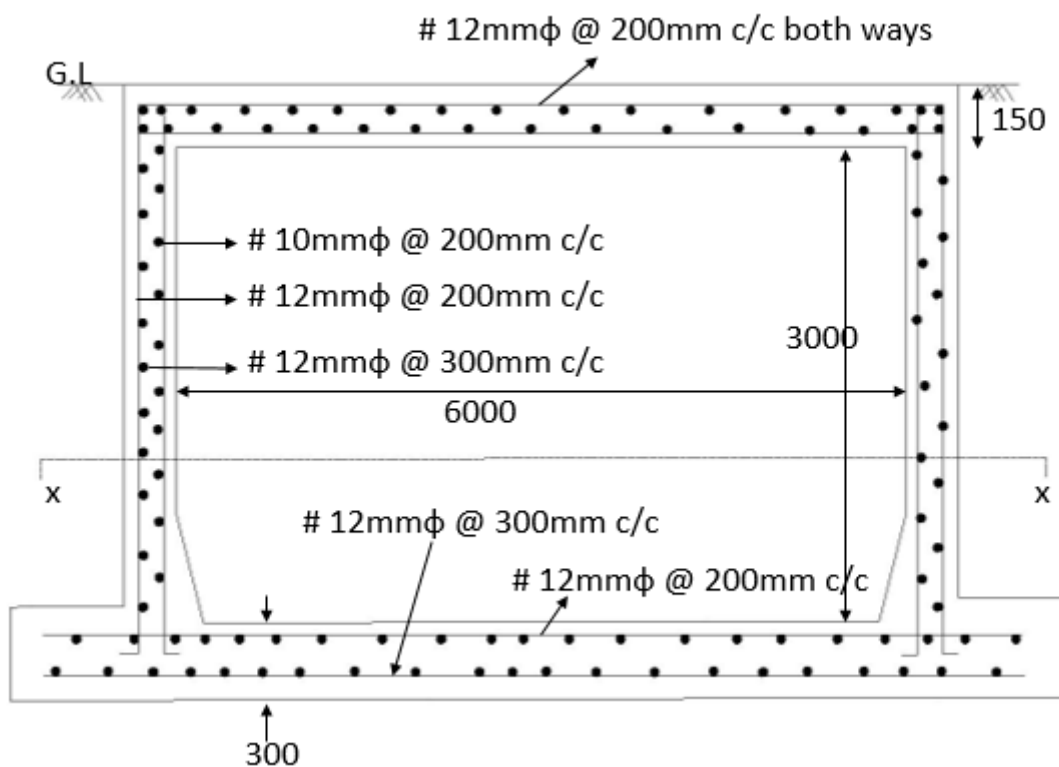Hence provide 300mm thickness with 12mm ϕ @ 200mm c/c at the top and 12mmϕ @

300mm c/c at the bottom.
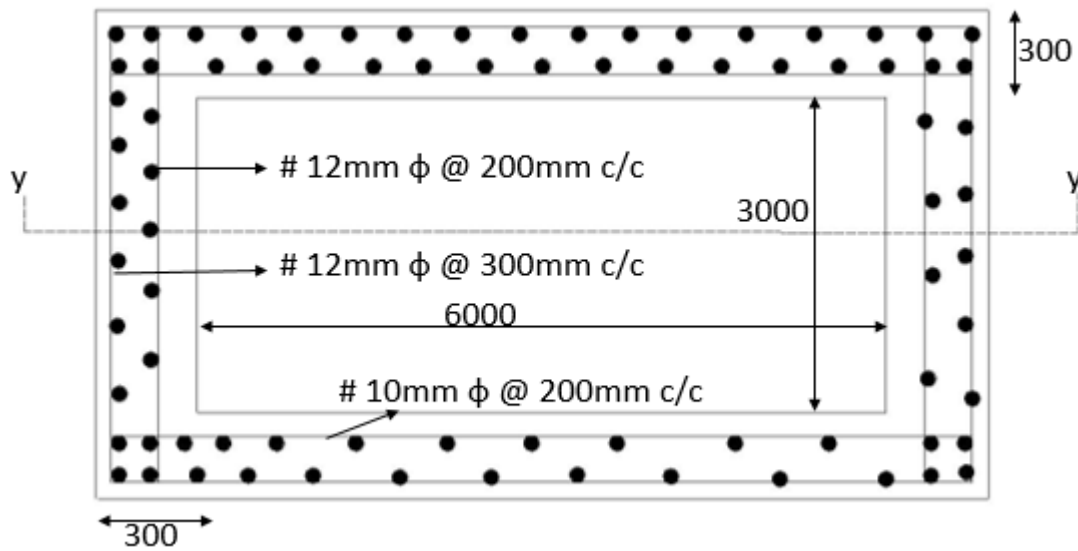
Reinforcement details

Fig.3.1 Cross section

Fig.3.2 Cross section