INTRODUCTION

Storage Reservoirs and Over Head Tanks are used to store water, liquid petroleum & similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product.

_In general there are three kinds of water tanks-

1.Tanks resting on ground

2.Underground Tanks

3.Elevated tanks

The tanks may have circular or rectangular section.

Tanks resting on ground & Underground may have flat bottom slab, while Elevated ones may have flat or Conical bottom.

TYPES OF WATER TANKS

WATER TANK

BASED ON PLACEMENT OF TANK

1. RESTING ON GROUND
2. UNDER GROUND
3. ELEVATED

BASED ON SHAPE OF TANK

1. CIRCULAR
2. RECTANGULAR
3. SPHERICAL
4. INTZ
5. CONICAL BOTTOM


HALTOM
CITY


BWSC

COMPARISON OF TANKS

RECTANGULAR TANK	CIRCULAR TANK	INTZE TANK	PRESTRESSED TANKS
For smaller capacities we go for rectangular tanks	For bigger capacities we go for circular tanks	Intze tank is constructed to reduce the project cost because lower dome in this construction resists horizontal thrust	For bigger tanks, prestressing is the superior choice resulting in a saving of up to 20%.

Rectangular water tank introduction

- Rectangular tanks are used when the storage capacity is small.
- Rectangular tanks should be preferably square in plan from point of view of economy.
- It is also desirable that longer side should not be greater than twice the smaller side.
- Moments are caused in two directions of the wall i.e., both in horizontal as well as in vertical direction.
- Exact analysis is difficult and are designed by approximate methods.
- When the length of the wall is more in comparison to its height, the moments will be mainly in the vertical direction, i.e., the panel bends as vertical cantilever

GENERAL REQUIREMENTS

1. **Concrete should be impervious-**

Concrete should be rich in cement content i.e. water-cement ratio should be low. The quantity of cement in mix should not be less than $3KN/m^3$, again to keep shrinkage low the quantity of cement should not exceed $5.3KN/m^3$.Generally M30 grade of concrete is used.

To avoid leakage problems, Limit State Method of Design should be avoided. IS:456-2000 is silent about permissible stresses in direct tension, hence from IS:3370, it is obvious that guidelines of previous version of IS:456 should be used which is based on Working Stress Method.

GENERAL REQUIREMENTS

2. CRACK DEVELOPMENT

1. Due to dimensional movements in concrete on account of temperature & moisture changes.
2. Due to differential expansion of thick members due to Heat of Hydration.
3. Cracks caused by Unequal Settlement

REMEDY

- Proper curing
- Provision of joints
- Reinforcements in each of 2 directions at right angles.
- Expansion & Shrinkage of concrete should be considered during its design.
- Subdivide the tank in smaller compartments with provision of necessary joints.

PERMISSIBLE STRESSES IN CONCRETE

GRADE OF CONCRETE	PERMISSIBLE STRESS IN DIRECT TENSION (N/mm^2)	PERMISSIBLE STRESS IN TENSION DUE TO BENDING (N/mm^2)	PERMISSIBLE STRESS IN SHEAR (N/mm^2)
M 15	1.1	1.5	1.5
M 20	1.2	1.7	1.7
M 25	1.3	1.8	1.9
M 30	1.5	2.0	2.2
M 35	1.6	2.2	2.5

PERMISSIBLE STRESSES IN STEEL

TYPE OF STRESS IN STEEL REINFORCEMENT	PERMISSIBLE STRESSES IN N/mm2	
	Plain round mild steel bars	High yield strength deformed bars(HYSD)
1)Tensile stresses in the members under direct tension(?s)	115	150
2) Tensile stress in members in bending(?st)		
On liquid retaining face of members	115	150
On face of away from liquid for members less than 225mm	115	150
On face away from liquid for members 225mm or more in thickness	125	190
3) Tensile stresses in shear reinforcement(?sv)		
For members less than225mm in thickness	115	150
For members 225mm or more in thickness	125	175

MINIMUM REINFORCEMENT REQUIRED

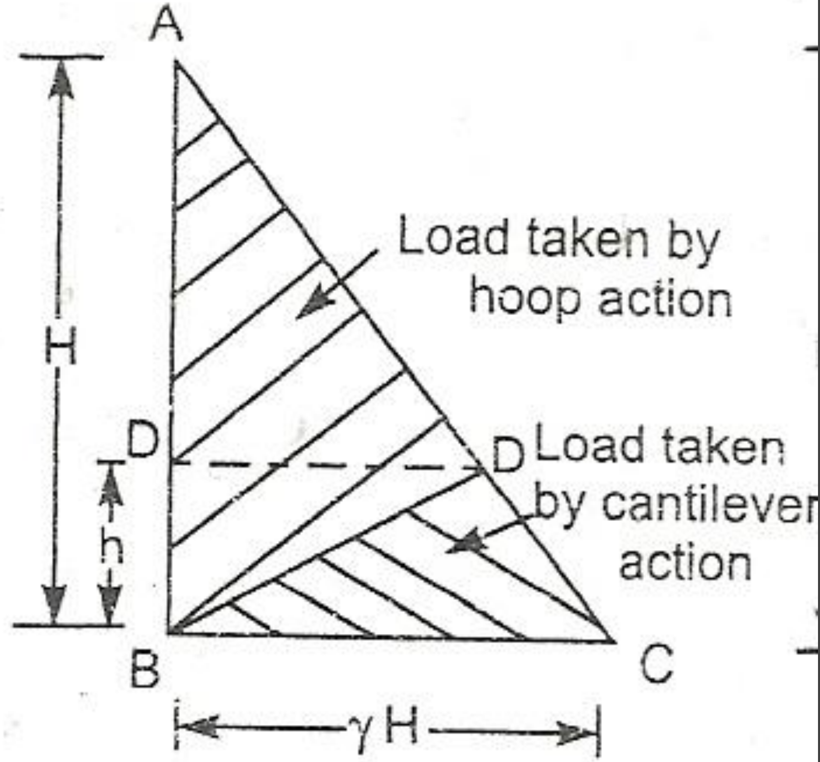
- For thickness up to 100mm, minimum % of reinforcement should be 0.3%
- For thickness from 100mm to 450mm, it may be reduced linearly to 0.2%
- i.e. P(min)= 0.3 up to 100mm thick sections
- P(min)= 0.3- 0.1*[(t-100)/(450-100)] where 't' lies b/w 100mm to 450mm
- Minimum reinforcement should be ensured in both directions.
- If thickness of section is more than 225mm, layer of bars are required near both face.

METHOD OF ANALYSIS

There are several analysis methods like Bending Theory, Plate Load theory, Finite Element analysis etc. But we commonly use "**Approximate Method of Analysis**" for water tanks. In this method, it is assumed that-

In case of Circular tanks, bottom 1/3rd Or 1m (whichever is greater) & for Rectangular tanks, Bottom 1/4th or 1m (whichever is greater) is predominantly under Cantilever action.

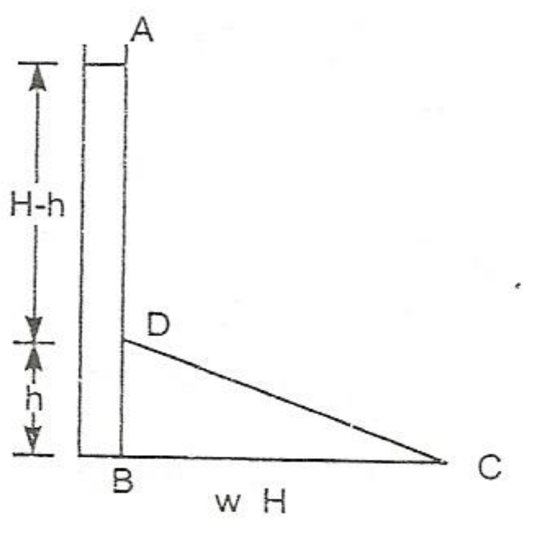
Rest of the Wall is resisting the Water Pressure by forces Developed in Horizontal direction.



(a) Load sharing

"APPROXIMATE METHOD OF ANALYSIS"

In this method, the bottom height of wall
BP is designed as a Cantilever Fixed at B &
subjected to Triangular load given by
Area DBC of Pressure Triangle.
Load at B= wH
Reinforcement for Cantilever Action is provided
Up to height 'h' from inner face of wall.



(b) Load for cantilever action

The advantage of this method over other sophisticated methods is that-

1. It is a simple method
2. It is more practical & gives a feel of the Structural Behaviour
3. "Confusion driven disasters " caused due to mistakes of Draughtsmen in understanding sign conventions & analysis steps of other complex methods can be avoided.

RECTANGULAR TANKS

INTRODUCTION-

- Rectangular Tanks are provided when capacity of liquid to be stored is small.
- For small capacities, circular tanks are uneconomical on account of curved shuttering thus Rectangular Tanks prove to be economical in this case.
- Unlike Circular tanks, rectangular tanks occupy entire available area, so it is easy to divide the tank in compartments & design.

DESIGN OF RECTANGULAR TANKS

- The components of a Rectangular Tank are-
  - 1.Side walls
  - 2.Base Slab
  - 3.Roof Slab

- The design of walls by Approximate method is broadly classified into two categories-

1. Tanks having ratio L/B <2
2. Tanks having ratio L/B >2

Tanks with ratio of L/B <2

- In this case, Tank is designed as a Horizontal slab all around (b/w corners) & subjected to triangular load due to hydrostatic pressure from 0 at top to H/4 or 1m above the base (whichever is more).
- From bottom junction to Height of H/4 or 1m (whichever is more), the wall is treated as a vertical cantilever fixed at base.
- Maximum Pressure(p) = w(H-h) at D.
- Maximum Cantilever Moment= [(1/2)(wH)(h)](h/3) at (h/3) from base
- The pressure(p) is resisted by the closed frame action of tank.
- The fixed end moments at A are ($pB^2/12$) & ($pL^2/12$) . Using Moment Distribution method, they can be Balanced.

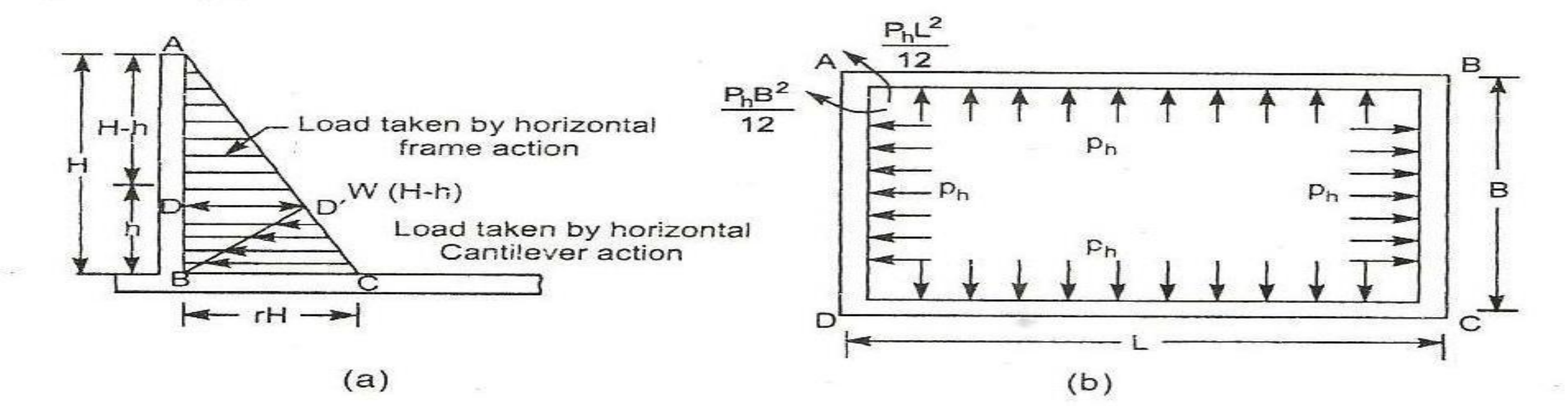
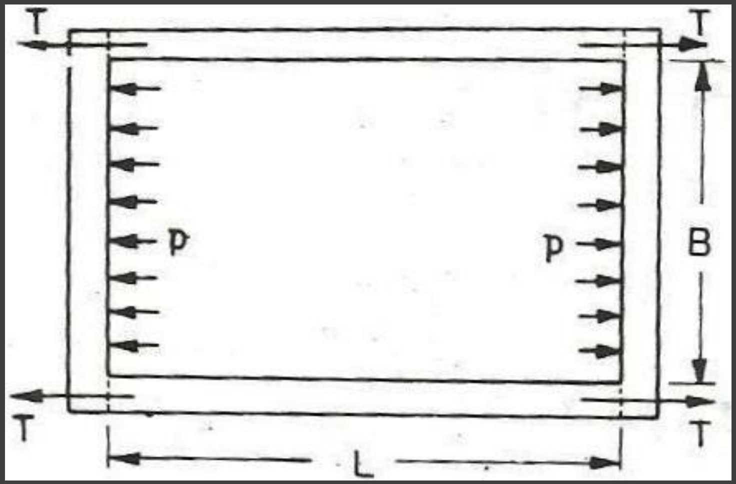


Fig. 13.6 *Pressure Diagram*

RectangularTanks with ratio L/B <2

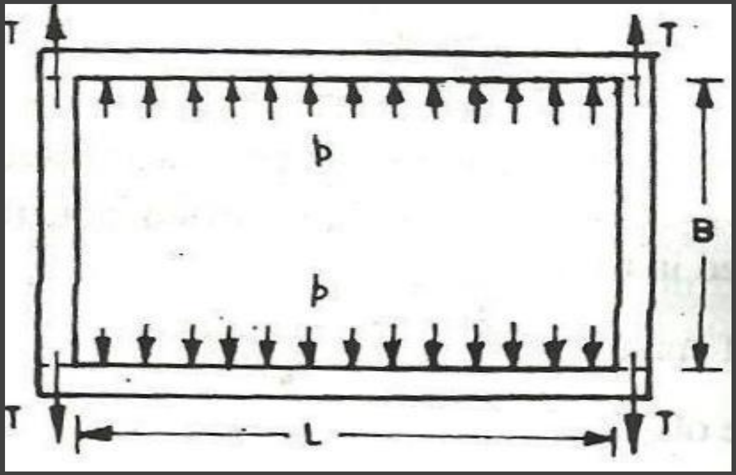
PULL ON LONG WALLS

- Since the short walls span b/w Long walls, above D, the water pressure on short walls gets transferred to Long walls as Tension.
- Considering 1 m high strip of short wall at height ‘h’
- Total Tension= w(H-h)*1*B
- Pull on each Long wall (T_l)
- T_l = (1/2)w(H-h)B



PULL ON SHORT WALLS

- In the similar fashion, Long walls support the short walls & water pressure gets transferred to short walls as Tension(pull).
- Considering 1 m High strip of Long walls at height ‘h’
- Total Tension= w(H-h)*1*L
- Pull on each short wall (T_B)
- T_B = (1/2)w(H-h).L



RECTANGULAR TANKS WITH RATIO L/B >2

- In this case, the Long walls are treated as vertical cantilever fixed at base & Short walls are treated as Horizontal slabs(bending horizontally) b/w Long walls.
- Maximum B.M in long walls= (1/2)wH*H*(H/3) = $wH^3/6$
- For short walls, Maximum BM at level P may be taken under-
- BM at ends of span= $[w(H-h)B^2]/12$
- BM at centre of span= $[w(H-h)B^2]/16$

PULL ON LONG & SHORT WALLS-

- Pull on Long wall (T_L)= 0.5w(H-h).B
- Pull on Short Wall (T_B)= w(H-h)*1
- Due to monolithic construction, it is

Assumed that water pressure on about 1m Of long wall adjacent to corner causes Tension in short wall.

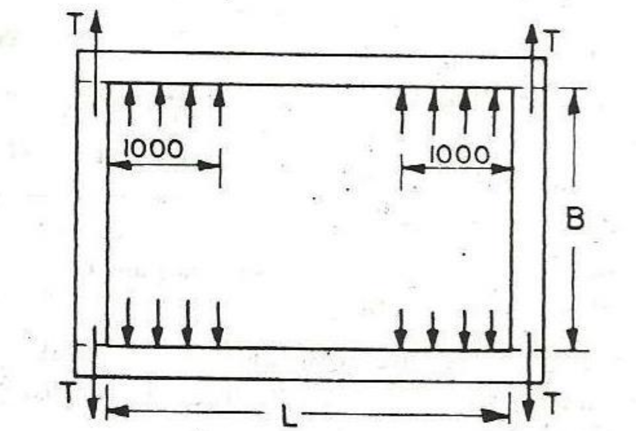
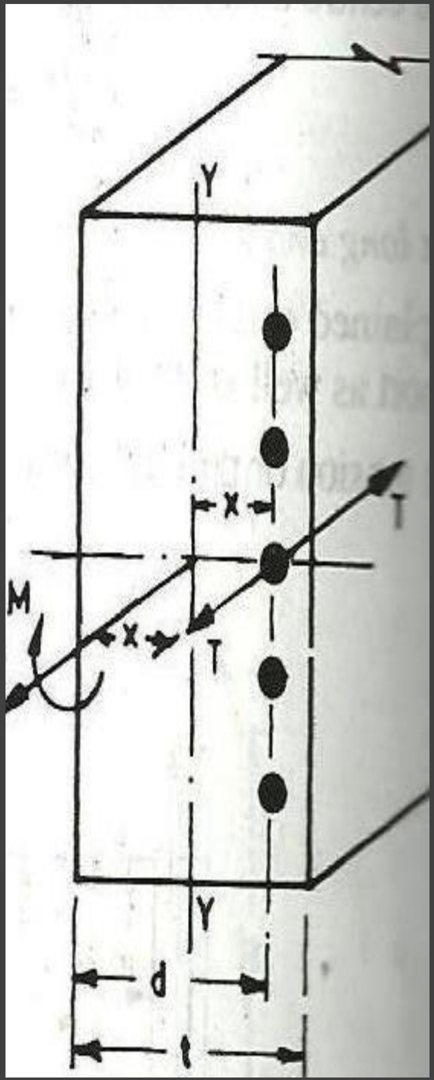


Fig. 32.4
Plan showing pressure causing pull is short walls

Tank wall section subjected to combined effect of BM & Tension

- Distance of main reinforcement from central axis= x
- The effect of Horizontal tensile forces is to reduce the net moment in the walls.
- Thus final horizontal design moment = M-Tx
- The BM reduces towards top above edge, hence spacing may be increased towards top
- Near corners, BM is on inner face & near centre it is on outer side.
- Area of steel for net BM (A_T)
- A_T = (M-Tx)/(Lever arm * safe stress in steel)
- Area of steel for pull (A)= T / safe stress in steel
- Total Area of steel= A_T + A



DESIGN OF CIRCULAR TANKS

- Design of circular tanks is simplest in nature.
- For same capacity, its construction requires less concrete than rectangular tanks, thus it is economical for large capacity storage.
- On account of circular shape, it can be made water tight easily as there are no sharp corners.

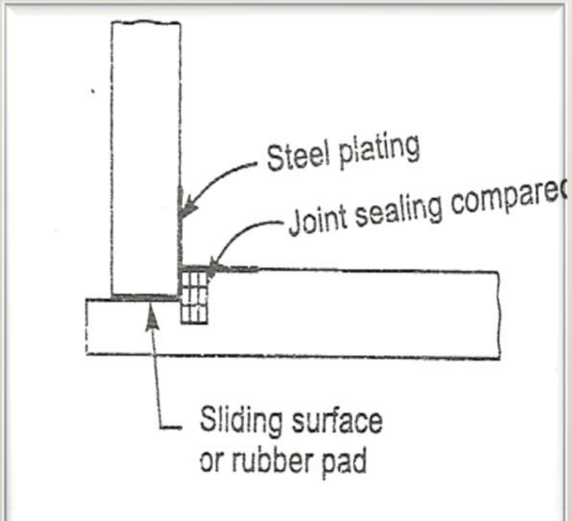
For purpose of design, circular tanks can be divided into following categories-

- 1. Tanks with sliding or flexible joint b/w floor & wall.
- **2**. Circular tank with rigid joint b/w floor & wall.

CIRCULAR TANK WITH FLEXIBLE JOINT b/w FLOOR & WALL

- In this case, the wall is free to move outward when internal water pressure is applied. Hence the wall is subjected to Hoop Stress 'T' only.
- $T = \gamma Hd/2$ ('d' is dia of tank)
- **Maximum Hoop Stress** $= \gamma(H-h)d/2$
- Maximum Hoop stress occurs

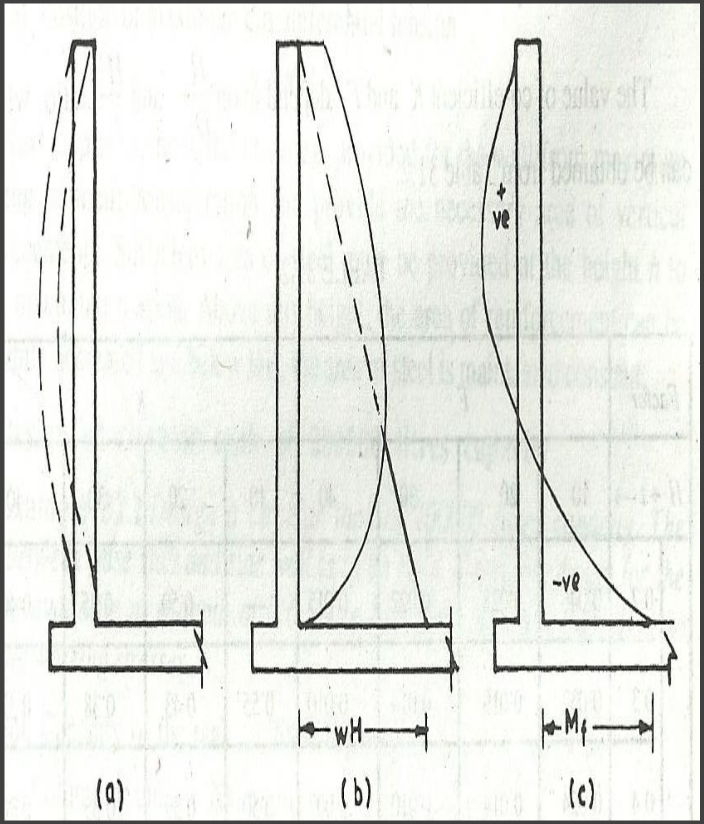
at H/3 or 1m whichever is more



(a) Sliding base

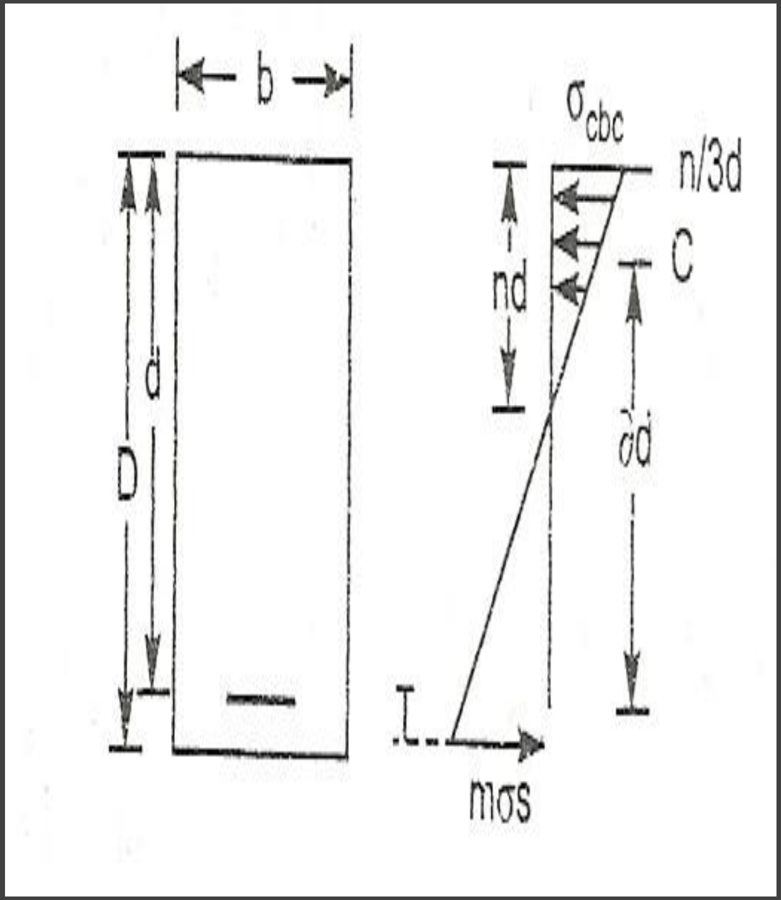
CIRCULAR TANK WITH RIGID BASE

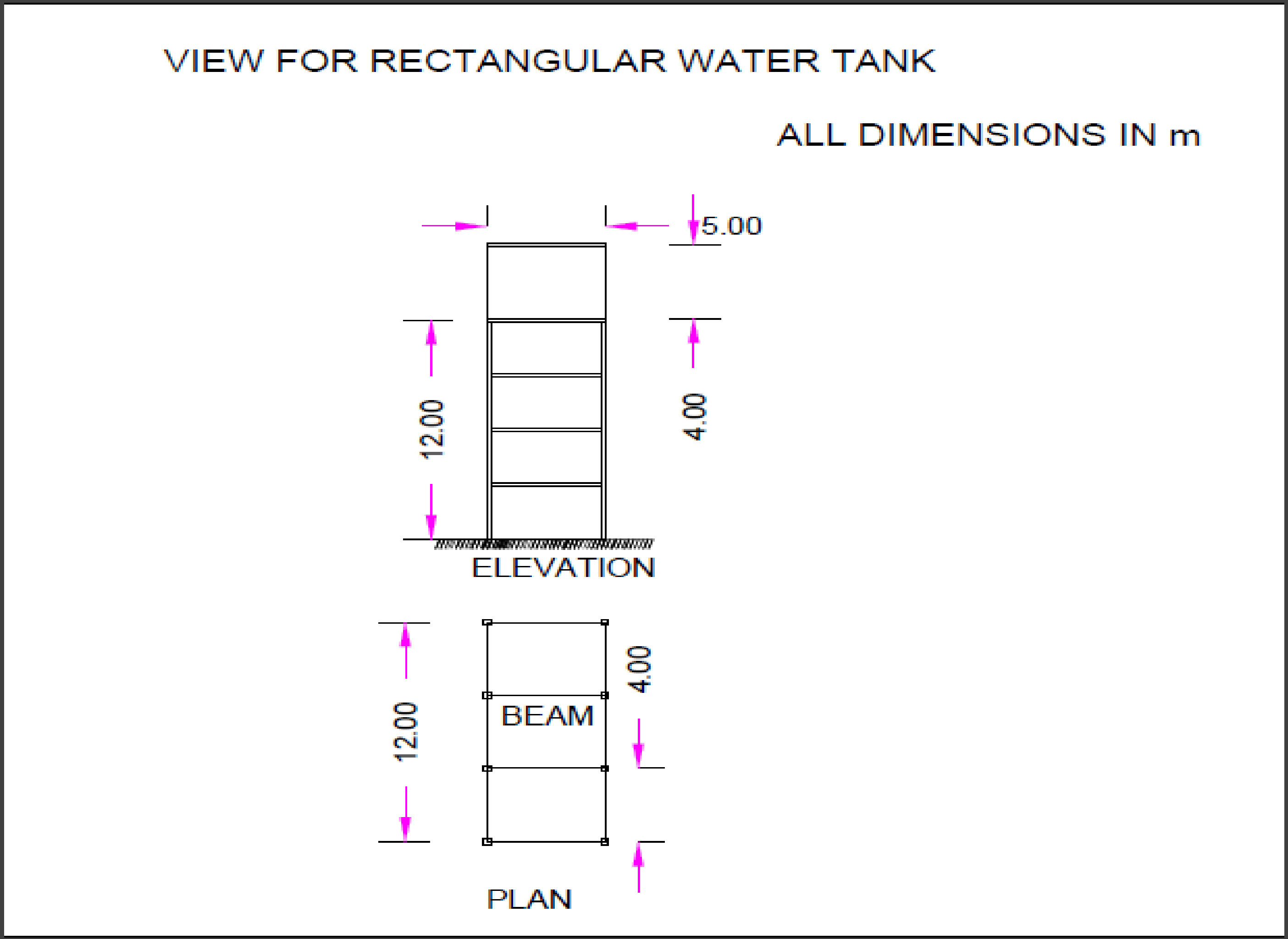
- Since the wall in this case is fixed with floor slab, circumferential elongation of wall is not possible at its Junction with floor slab & hence Hoop stress is 0 there & the entire Liquid pressure is resisted by Cantilever action.
- At a certain point D at a height h, above base slab , full Hoop Stress develops & cantilever effect is 0.
- At midway b/w D & base slab, liquid pressure is resisted partly by Hoop action & partly by Cantilever action
- Fig a shows likely deformation of wall
- Fig b shows Load distribution on wall
- Fig c shows B.M Diagram



DESIGN CONSTANTS

- **Depth of Neutral axis= nd**
- $n = m\sigma(cbc) / [m\sigma(cbc) + \sigma(st)]$
- Lever arm= jd
- $j = 1-(n/3)$
- Moment of Resistance = M
- $M = kbd^2$
- where $k = 0.5\sigma(cbc)jk$
- Equivalent concrete section
- $= A_c + mA_{st} = A_g + (m-1)A_{st}$
- m= modular ratio (Es/Ec)
- m also = $280/3\sigma(cbc)$





AUTO CAD DESIGN

DESIGN PROBLEM

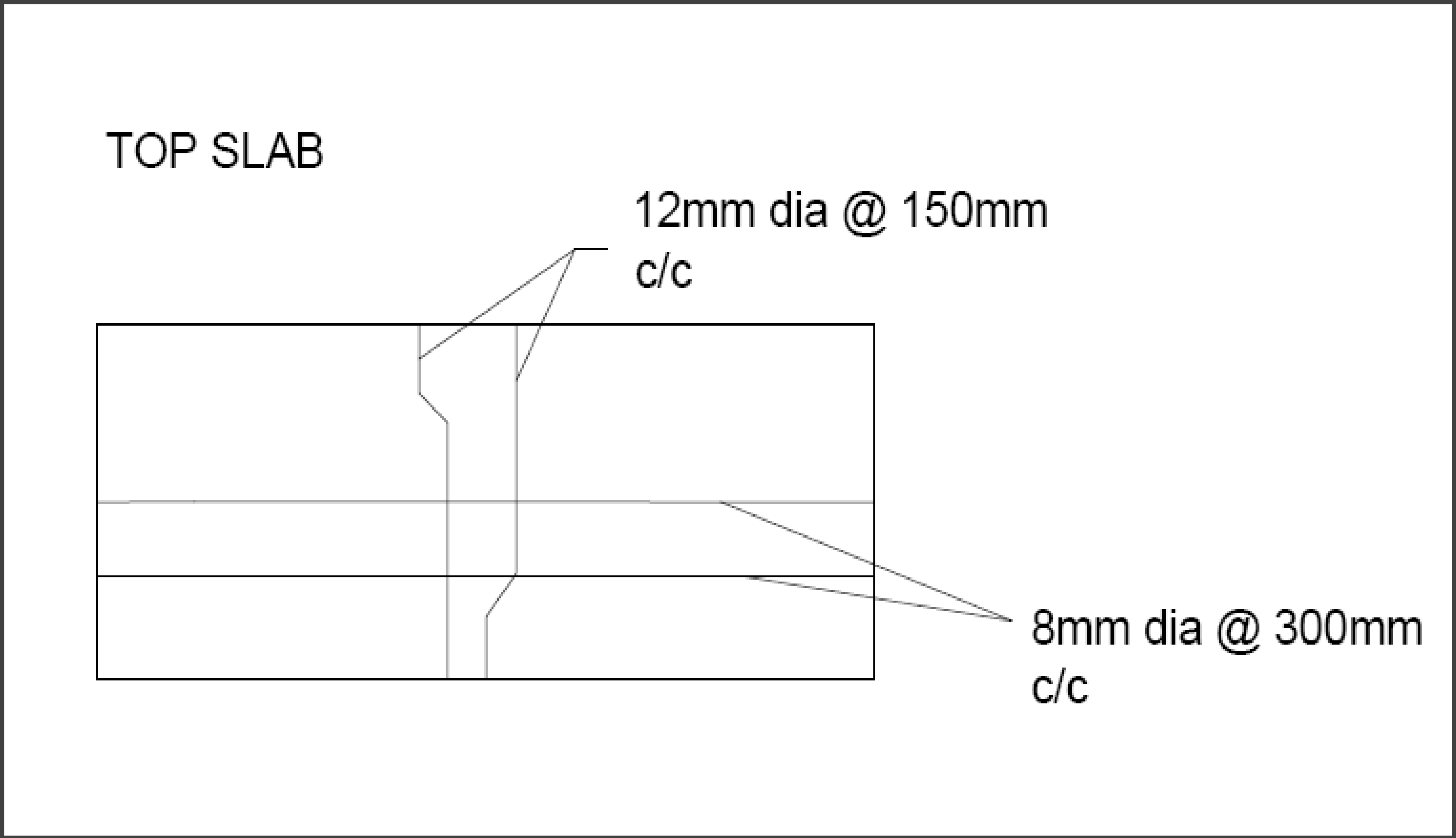
To design a tank (12m*5m*4m). The bottom of tank is 12m above the ground level. The tank is covered at top.SBC of soil=150KN/m2.Use M20 mix?

1)DESIGN OF ROOF SLAB:-

Reinforcement of slab

Specification	Size	Reinforcement details
Top slab ➢Long span ➢Short span	12m×5m	8mm Ø @300mm c/c 12mm Ø @1500mm c/c

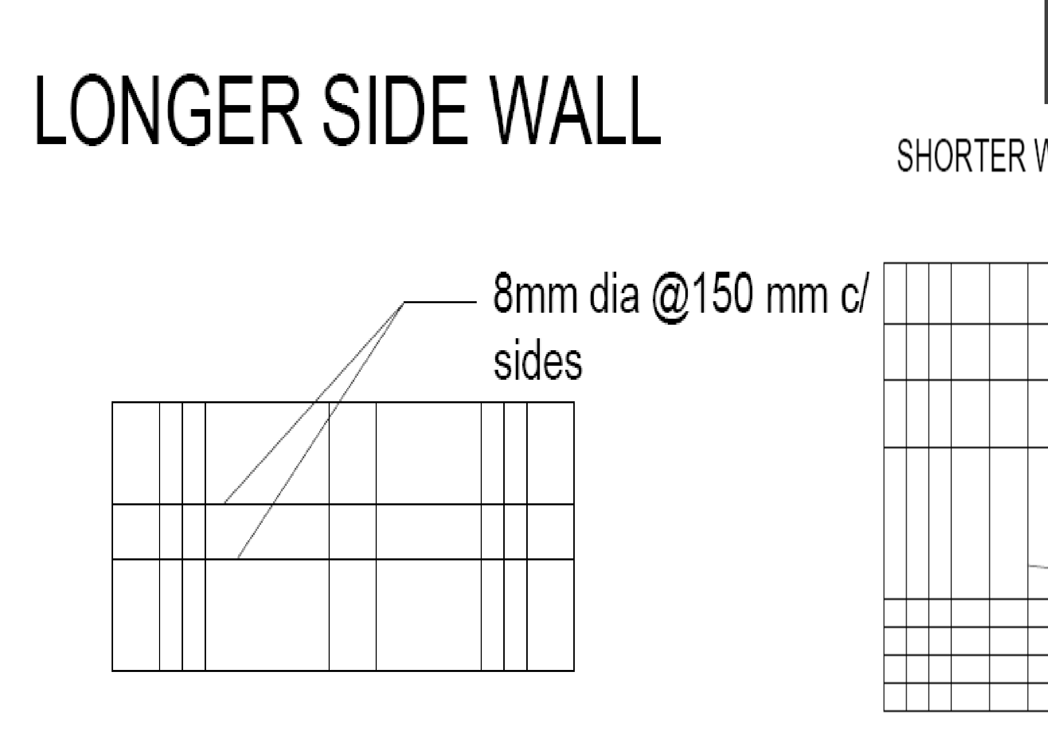
TOP SLAB REINFORCEMENT

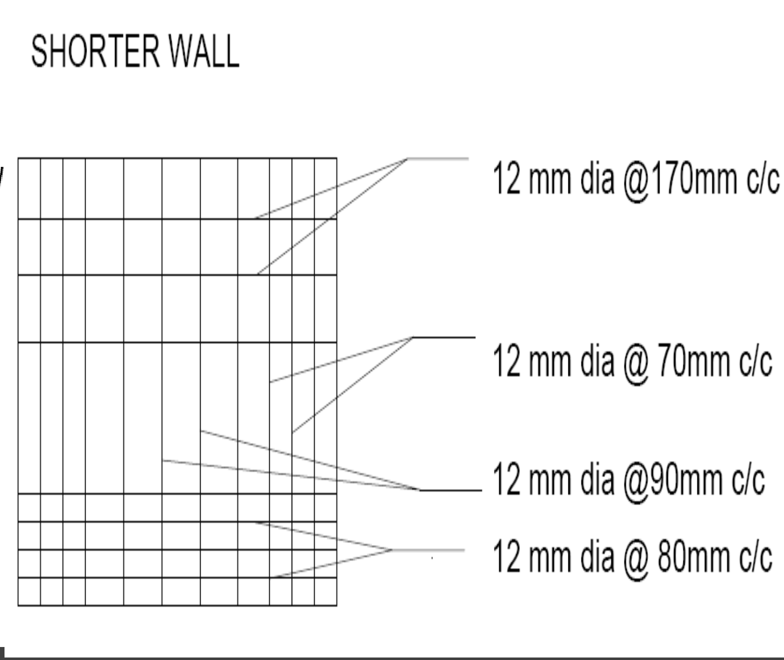


2) Design of Longer & SHORTER SIDE WALLS

Specification	Size	Reinforcement details
Longer side wall ➢ Long span ➢ Short span 1. +ve bending moment 2. -ve bending moment	12m×4m	 8mm Ø @300mm c/c 12mm Ø @90mm c/c 20mm Ø @110mm c/c
Shorter side wall ➢ Long span I. At top II. At bottom ➢ Short span I. At supports II. At middle	5m×4m	 12mm Ø @170mm c/c 12mm Ø @80mm c/c 12mm Ø @70mm c/c 10mm Ø @80mm c/c

REINFORCEMT IN LONG & SHORT WALLS



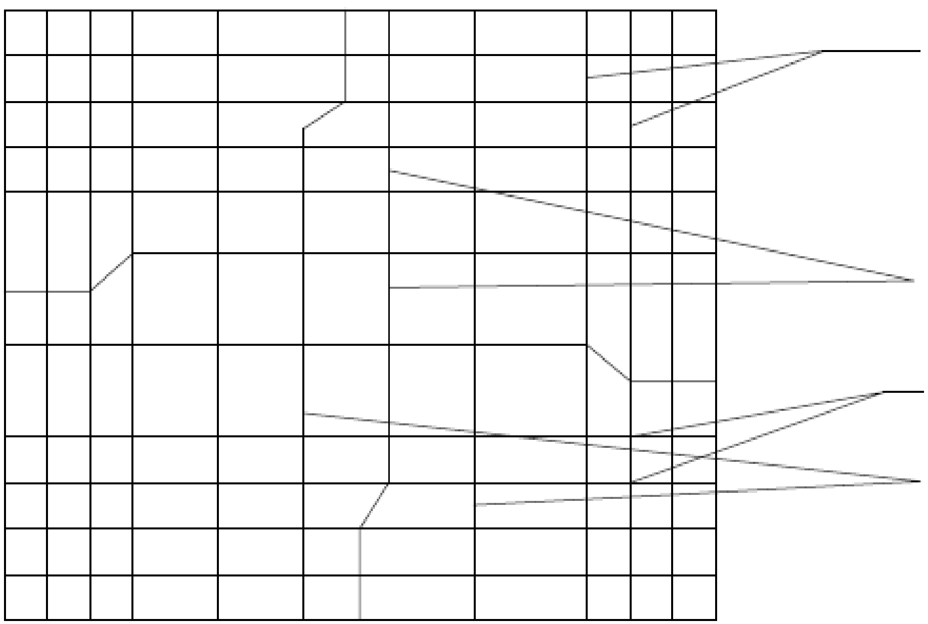


3)DESIGN OF BASE SLAB:-

Specification	Size	Reinforcement details
Base slab ➢ Short span I. -ve bending moment II. +ve bending moment ➢ Long span I. -ve bending moment II. +ve bending moment	5m×4m	 16mm Ø @80mm c/c 16mm Ø @110mm c/c 16mm Ø @110mm c/c 10mm Ø @220mm c/c

REINFORCEMENT IN BASE SLAB

BASE SLAB



4)Design of beams

Specification	Size	Reinforcement details
Beam I ➢ Main reinforcement ➢ Stirrups	480mm×300mm	 3 bars of 20mm Ø & 3 bars of 32 mm Ø 12mm Ø @50mm c/c (near support) 12mm Ø @80mm c/c (near middle)
Beam II ➢Main reinforcement ➢Stirrups	480mm×300mm	 3 bars of 20mm Ø 8mm Ø @300mm c/c
Beam III ➢Main reinforcement I. Span AB II. Span BC ➢ Stirrups	480mm×300mm	 3 bars of 12mm Ø 2 bars of 12mm Ø 8mm Ø @300mm c/c

CONCLUSION

1) Storage of water in tanks has become a necessity for drinking and washing purposes in the present day life.
2) For small capacities we go for rectangular water tanks & for large capacities we go for circular tanks.
3) The designed RCC rectangular tank can store water upto 240000 liters
4) In this design project we have analyzed the over head rectangular RCC water tank, through theoretical design and STAAD Pro program.
5) Although the stresses and bending moment are nearly equal but all the parameters used in the theoretical design cannot be fully adopted in the program design.