Design of Water Tank

A Project Submitted
In Partial Fulfillment of the Requirements
For the Degree of

Bachelor of Technology
In Civil Engineering

By

Nibedita Sahoo
10401010

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY ROURKELA
MAY 2008

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Under the Guidance of
Prof. S.K. Sahoo

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ROURKELA

CERTIFICATE

This is to certify that the project entitled “**DESIGN OF WATER TANK”** submitted by Miss Nibedita Sahoo [Roll no. 10401010] in partial fulfillment of the requirements for the award of bachelor of technology degree in Civil engineering at the National Institute of Technology Rourkela (deemed University) is an authentic work carried out by her under my supervision and guidance.

To the best of my knowledge the matter embodied in the project has not been submitted to any other university/institute for the award of any degree or diploma.

Date:

Prof. S.K Sahu
Department of Civil Engineering
National Institute of Technology
Rourkela - 769008

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Nibedita Sahoo
Roll No 10401010
B. Tech 8th Semester

CONTENTS

ABSTRACT

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage.

This project gives in brief, the theory behind the design of liquid retaining structure (circular water tank with flexible and rigid base and rectangular under ground water tank) using working stress method. This report also includes computer subroutines to analyze and design circular water tank with flexible and rigid base and rectangular under ground water tank. The program has been written as Macros in Microsoft Excel using Visual Basic programming language. In the end, the programs are validated with the results of manual calculation given in "Concrete Structure" book.

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

INTRODUCTION

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. Water or raw petroleum retaining slab and walls can be of reinforced concrete with adequate cover to the reinforcement. Water and petroleum and react with concrete and, therefore, no special treatment to the surface is required. Industrial wastes can also be collected and processed in concrete tanks with few exceptions. The petroleum product such as petrol, diesel oil, etc. are likely to leak through the concrete walls, therefore such tanks need special membranes to prevent leakage. Reservoir is a common term applied to liquid storage structure and it can be below or above the ground level. Reservoirs below the ground level are normally built to store large quantities of water whereas those of overhead type are built for direct distribution by gravity flow and are usually of smaller capacity.

1.1 OBJECTIVE

1. To make a study about the analysis and design of water tanks.
2. To make a study about the guidelines for the design of liquid retaining structure according to IS Code.
3. To know about the design philosophy for the safe and economical design of water tank.
4. To develop programs for the design of water tank of flexible base and rigid base and the underground tank to avoid the tedious calculations.
5. In the end, the programs are validated with the results of manual calculation given in “Concrete Structure” book.

CHAPTER 2

THEORY

2.1 DESIGN REQUIREMENT OF CONCRETE (I. S. I)

In water retaining structure a dense impermeable concrete is required therefore, proportion of fine and course aggregates to cement should be such as to give high quality concrete.

Concrete mix weaker than M20 is not used. The minimum quantity of cement in the concrete mix shall be not less than 30 kN/m^3.

The design of the concrete mix shall be such that the resultant concrete is sufficiently impervious. Efficient compaction preferably by vibration is essential. The permeability of the thoroughly compacted concrete is dependent on water cement ratio. Increase in water cement ratio increases permeability, while concrete with low water cement ratio is difficult to compact. Other causes of leakage in concrete are defects such as segregation and honey combing. All joints should be made water-tight as these are potential sources of leakage.

Design of liquid retaining structure is different from ordinary R.C.C, structures as it requires that concrete should not crack and hence tensile stresses in concrete should be within permissible limits.

A reinforced concrete member of liquid retaining structure is designed on the usual principles ignoring tensile resistance of concrete in bending. Additionally it should be ensured that tensile stress on the liquid retaining face of the equivalent concrete section does not exceed the permissible tensile strength of concrete as given in table 1. For calculation purposes the cover is also taken into concrete area.

Cracking may be caused due to restraint to shrinkage, expansion and contraction of concrete due to temperature or shrinkage and swelling due to moisture effects. Such restraint may be caused by –

(i) The interaction between reinforcement and concrete during shrinkage due to drying.

(ii) The boundary conditions.

(iii) The differential conditions prevailing through the large thickness of massive concrete.

Use of small size bars placed properly, leads to closer cracks but of smaller width. The risk of cracking due to temperature and shrinkage effects may be minimized by limiting the changes in moisture content and temperature to which the structure as a whole is subjected. The risk of cracking can also be minimized by reducing the restraint on the free expansion of the structure with long walls or slab founded at or below ground level, restraint can be minimized by the provision of a sliding layer. This can be provided by founding the structure on a flat layer of concrete with interposition of some material to break the bond and facilitate movement.

In case length of structure is large it should be subdivided into suitable lengths separated by movement joints, especially where sections are changed the movement joints should be provided.

Where structures have to store hot liquids, stresses caused by difference in temperature between inside and outside of the reservoir should be taken into account.

The coefficient of expansion due to temperature change is taken as 11 x 10^{-6}/° C and coefficient of shrinkage may be taken as 450 x 10^{-6} for initial shrinkage and 200 x 10^{-6} for drying shrinkage.

2.2 JOINTS IN LIQUID RETAINING STRUCTURES

2.2.1 MOVEMENT JOINTS. There are three types of movement joints.

(i)***Contraction Joint.*** It is a movement joint with deliberate discontinuity without initial gap between the concrete on either side of the joint. The purpose of this joint is to accommodate contraction of the concrete.

The joint is shown in Fig.2.1 (a).

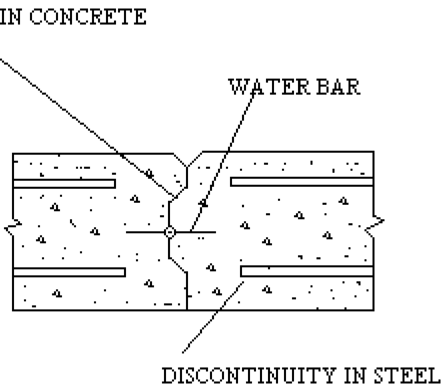


Figure 2.1(a)

A contraction joint may be either complete contraction joint or partial contraction joint. A complete contraction joint is one in which both steel and concrete are interrupted and a partial contraction joint is one in which only the concrete is interrupted, the reinforcing steel running through as shown in Fig.2.1(b).

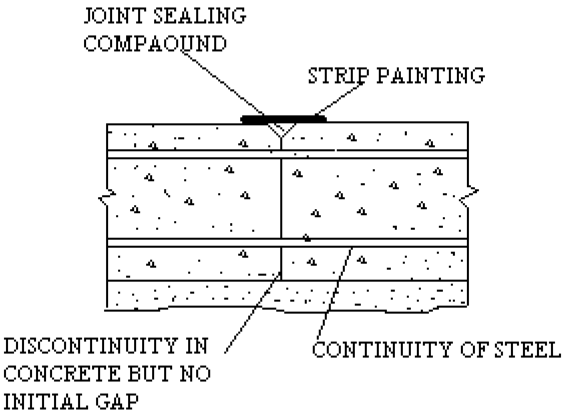


Figure 2.1(b)

(ii)***Expansion Joint.*** It is a joint with complete discontinuity in both reinforcing steel and concrete and it is to accommodate either expansion or contraction of the structure. A typical expansion joint is shown in Fig.2.2

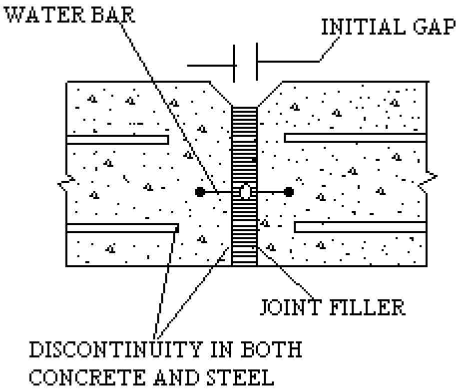


Figure 2.2

This type of joint requires the provision of an initial gap between the adjoining parts of a structure which by closing or opening accommodates the expansion or contraction of the structure.

(iii) ***Sliding Joint***. It is a joint with complete discontinuity in both reinforcement and concrete and with special provision to facilitate movement in plane of the joint. A typical joint is shown in Fig. 2.3

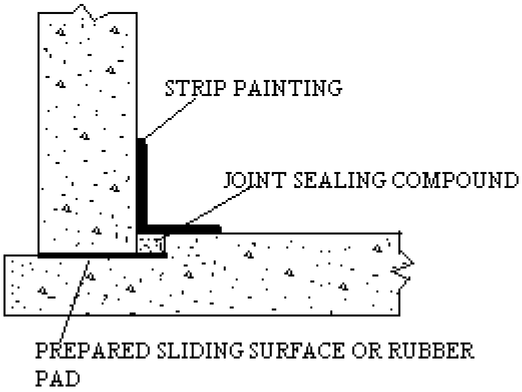


Figure 3.3

This type of joint is provided between wall and floor in some cylindrical tank designs.

2.2.2. CONTRACTION JOINTS

This type of joint is provided for convenience in construction. Arrangement is made to achieve subsequent continuity without relative movement. One application of these joints is between successive lifts in a reservoir wall. A typical joint is shown in Fig.3.4.

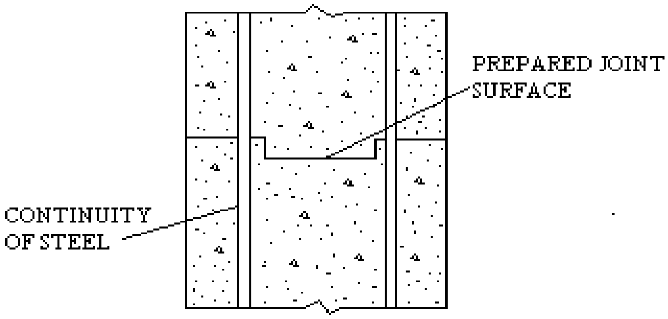


Figure 3.4

The number of joints should be as small as possible and these joints should be kept from possibility of percolation of water.

2.2.3 TEMPORARY JOINTS

A gap is sometimes left temporarily between the concrete of adjoining parts of a structure which after a suitable interval and before the structure is put to use, is filled with mortar or concrete completely as in Fig.3.5(a) or as shown in Fig.3.5 (b) and (c) with suitable jointing materials. In the first case width of the gap should be sufficient to allow the sides to be prepared before filling.

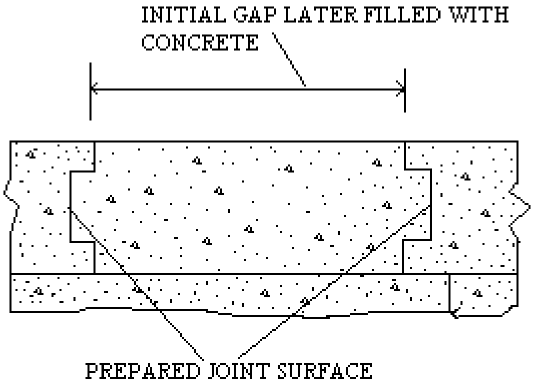


Figure 3.5(a)

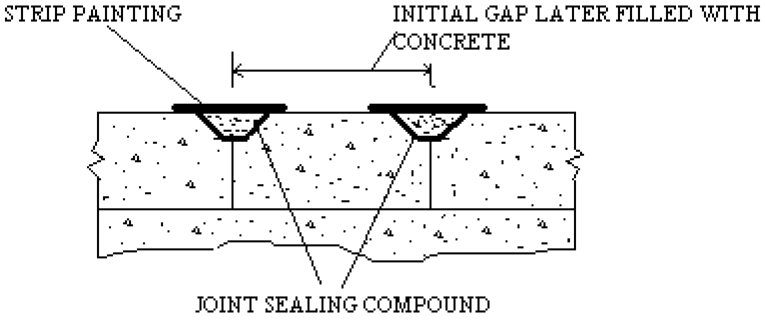


Figure 3.5(b)

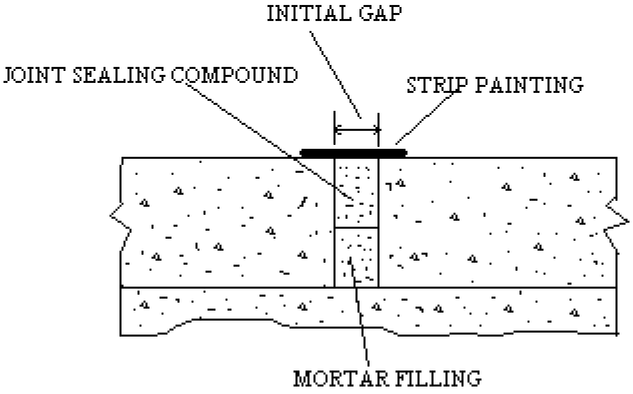


Figure 3.5(c)

2.2.4 SPACING OF JOINTS

Unless alternative effective means are taken to avoid cracks by allowing for the additional stresses that may be induced by temperature or shrinkage changes or by unequal settlement, movement joints should be provided at the following spacing:-

(a)In reinforced concrete floors, movement joints should be spaced at not more than 7.5m apart in two directions at right angles. The wall and floor joints should be in line except where sliding joints occur at the base of the wall in which correspondence is not so important.

(b)For floors with only nominal percentage of reinforcement (smaller than the minimum specified) the concrete floor should be cast in panels with sides not more than 4.5m.

(c)In concrete walls, the movement joints should normally be placed at a maximum spacing of 7.5m. in reinforced walls and 6m in unreinforced walls. The maximum length desirable between vertical movement joints will depend upon the tensile strength of the walls, and may be increased by suitable reinforcement. When a sliding layer is placed at the foundation of a wall, the length of the wall that can be kept free of cracks depends on the capacity of wall section to resist the friction induced at the plane of sliding. Approximately the wall has to stand the effect of a force at the place of sliding equal to weight of half the length of wall multiplied by the co-efficient of friction.

(d)Amongst the movement joints in floors and walls as mentioned above expansion joints should normally be provided at a spacing of not more than 30m between successive expansion joints or between the end of the structure and the next expansion joint; all other joints being of the construction type.

(e)When, however, the temperature changes to be accommodated are abnormal or occur more frequently than usual as in the case of storage of warm liquids or in uninsulated roof slabs, a smaller spacing than 30m should be adopted that is greater proportion of movement joints should be of the expansion type). When the range of temperature is small, for example, in certain covered structures, or where restraint is small, for example, in certain elevated structures none of the movement joints provided in small structures up to 45mlength need be of the expansion type. Where sliding joints are provided between the walls and either the floor or roof, the provision of movement joints in each element can be considered independently.

2.3 GENERAL DESIGN REQUIREMENTS (I.S.I)

2.3.1 Plain Concrete Structures. Plain concrete member of reinforced concrete liquid retaining structure may be designed against structural failure by allowing tension in plain concrete as per the permissible limits for tension in bending. This will automatically take care of failure due to cracking. However, nominal reinforcement shall be provided, for plain concrete structural members.

2.3.2. Permissible Stresses in Concrete.

(a) For resistance to cracking. For calculations relating to the resistance of members to cracking, the permissible stresses in tension (direct and due to bending) and shear shall confirm to the values specified in Table 1. The permissible tensile stresses due to bending apply to the face of the member in contact with the liquid. In members less than 225mm. thick and in contact with liquid on one side these permissible stresses in bending apply also to the face remote from the liquid.

(b) For strength calculations. In strength calculations the permissible concrete stresses shall be in accordance with Table 1. Where the calculated shear stress in concrete alone exceeds the permissible value, reinforcement acting in conjunction with diagonal compression in the concrete shall be provided to take the whole of the shear.

Table 1.Permissible concrete stresses in calculations relating to resistance to cracking

Grade of concrete	Permissible stress in KN/m^2 tension		shear
	Direct	Bending	
M15	1.1	1.5	1.5
M20	1.2	1.7	1.7
M25	1.3	1.8	1.9
M30	1.5	2.0	2.2
M35	1.6	2.2	2.5
M40	1.7	2.4	2.7

2.3.3 Permissible Stresses in Steel

(a) For resistance to cracking.

When steel and concrete are assumed to act together for checking the tensile stress in concrete for avoidance of crack, the tensile stress in steel will be limited by the requirement that the permissible tensile stress in the concrete is not exceeded so the tensile stress in steel shall be equal to the product of modular ratio of steel and concrete, and the corresponding allowable tensile stress in concrete.

(b) For strength calculations.

In strength calculations the permissible stress shall be as follows:

(i) Tensile stress in member in direct tension 1000 kg/cm^2

(ii) Tensile stress in member in bending on
liquid retaining face of members or face away from
liquid for members less than 225mm thick 1000 kg/cm^2

(iii)On face away from liquid for members 225mm or more
in thickness 1250 kg/cm^2

(iv)Tensile stress in shear reinforcement,
For members less than 225mm thickness 1000 kg/cm^2

For members 225mm or more in thickness 1250 kg/cm^2

(v)Compressive stress in columns subjected to direct load 1250 kg/cm^2

2.3.4. Stresses due to drying Shrinkage or Temperature Change.

(i)Stresses due to drying shrinkage or temperature change may be ignored provided that –

(a) The permissible stresses specified above in (ii) and (iii) are not otherwise exceeded.

(b) Adequate precautions are taken to avoid cracking of concrete during the construction period and until the reservoir is put into use.

(c) Recommendation regarding joints given in article 8.3 and for suitable sliding layer beneath the reservoir are complied with, or the reservoir is to be used only for the storage of water or aqueous liquids at or near ambient temperature and the circumstances are such that the concrete will never dry out.

(ii)Shrinkage stresses may however be required to be calculated in special cases, when a shrinkage co-efficient of 300×10^{-6}may be assumed.

(iii) When the shrinkage stresses are allowed, the permissible stresses, tensile stresses to concrete (direct and bending) as given in Table 1 may be increased by 33.33 per cent.

2.3.5. Floors

(i)Provision of movement joints.

Movement joints should be provided as discussed in article 3.

(ii) Floors of tanks resting on ground.

If the tank is resting directly over ground, floor may be constructed of concrete with nominal percentage of reinforcement provided that it is certain that the ground will carry the load without appreciable subsidence in any part and that the concrete floor is cast in panels with sides not more than 4.5m. with contraction or expansion joints between. In such cases a screed or concrete layer less than 75mm thick shall first be placed on the ground and covered with a sliding layer of bitumen paper or other suitable material to destroy the bond between the screed and floor concrete.

In normal circumstances the screed layer shall be of grade not weaker than M 10,where injurious soils or aggressive water are expected, the screed layer shall be of grade not weaker than M 15 and if necessary a sulphate resisting or other special cement should be used.

(iii) Floor of tanks resting on supports

(a)If the tank is supported on walls or other similar supports the floor slab shall be designed as floor in buildings for bending moments due to water load and self weight.

(b)When the floor is rigidly connected to the walls (as is generally the case) the bending moments at the junction between the walls and floors shall be taken into account in the design of floor together with any direct forces transferred to the floor from the walls or from the floor to the wall due to suspension of the floor from the wall.

If the walls are non-monolithic with the floor slab, such as in cases, where movement joints have been provided between the floor slabs and walls, the floor shall be designed only for the vertical loads on the floor.

(c)In continuous T-beams and L-beams with ribs on the side remote from the liquid, the tension in concrete on the liquid side at the face of the supports shall not exceed the permissible stresses for controlling cracks in concrete. The width of the slab shall be determined in usual manner for calculation of the resistance to cracking of T-beam, L-beam sections at supports.

(d)The floor slab may be suitably tied to the walls by rods properly embedded in both the slab and the walls. In such cases no separate beam (curved or straight) is necessary under the wall, provided the wall of the tank itself is designed to act as a beam over the supports under it.

(e)Sometimes it may be economical to provide the floors of circular tanks, in the shape of dome. In such cases the dome shall be designed for the vertical loads of the liquid over it and the ratio of its rise to its diameter shall be so adjusted that the stresses in the dome are, as far as possible, wholly compressive. The dome shall be supported at its bottom on the ring beam which shall be designed for resultant circumferential tension in addition to vertical loads.

2.3.6. Walls

(i)Provision of joints

(a)Where it is desired to allow the walls to expand or contract separately from the floor, or to prevent moments at the base of the wall owing to fixity to the floor, sliding joints may be employed.

(b)The spacing of vertical movement joints should be as discussed in article 3.3 while the majority of these joints may be of the partial or complete contraction type, sufficient joints of the expansion type should be provided to satisfy the requirements given in article

(ii)Pressure on Walls.

(a)In liquid retaining structures with fixed or floating covers the gas pressure developed above liquid surface shall be added to the liquid pressure.

(b)When the wall of liquid retaining structure is built in ground, or has earth embanked against it, the effect of earth pressure shall be taken into account.

(iii) Walls or Tanks Rectangular or Polygonal in Plan.

While designing the walls of rectangular or polygonal concrete tanks, the following points should be borne in mind.

(a)In plane walls, the liquid pressure is resisted by both vertical and horizontal bending moments. An estimate should be made of the proportion of the pressure resisted by bending moments in the vertical and horizontal planes. The direct horizontal tension caused by the direct pull due to water pressure on the end walls, should be added to that resulting from horizontal bending moments. On liquid retaining faces, the tensile stresses due to the combination of direct horizontal tension and bending action shall satisfy the following condition:

$$(t'/t) + (\sigma_{ct}' / \sigma_{ct}) \leq 1$$

t' = calculated direct tensile stress in concrete

t = permissible direct tensile stress in concrete (Table 1)

σ'_{ct} = calculated tensile stress due to bending in concrete.

σ_{ct} = permissible tensile stress due to bending in concrete.

(d)At the vertical edges where the walls of a reservoir are rigidly joined, horizontal reinforcement and haunch bars should be provided to resist the horizontal bending moments even if the walls are designed to withstand the whole load as vertical beams or cantilever without lateral supports.

(c)In the case of rectangular or polygonal tanks, the side walls act as two-way slabs, whereby the wall is continued or restrained in the horizontal direction, fixed or hinged at the bottom and hinged or free at the top. The walls thus act as thin plates subjected triangular loading and with boundary conditions varying between full restraint and free edge. The analysis of moment and forces may be made on the basis of any recognized method.

(iv) Walls of Cylindrical Tanks.

While designing walls of cylindrical tanks the following points should be borne in mind:

(a)Walls of cylindrical tanks are either cast monolithically with the base or are set in grooves and key ways (movement joints). In either case deformation of wall under influence of liquid pressure is restricted at and above the base. Consequently, only part of the triangular hydrostatic load will be carried by ring tension and part of the load at bottom will be supported by cantilever action.

(b)It is difficult to restrict rotation or settlement of the base slab and it is advisable to provide vertical reinforcement as if the walls were fully fixed at the base, in addition to the reinforcement required to resist horizontal ring tension for hinged at base, conditions of walls, unless the appropriate amount of fixity at the base is established by analysis with due consideration to the dimensions of the base slab the type of joint between the wall and slab, and , where applicable, the type of soil supporting the base slab.

2.3.7. Roofs

(i) Provision of Movement joints.

To avoid the possibility of sympathetic cracking it is important to ensure that movement joints in the roof correspond with those in the walls, if roof and walls are monolithic. It, however, provision is made by means of a sliding joint for movement between the roof and the wall correspondence of joints is not so important.

(ii)Loading

. Field covers of liquid retaining structures should be designed for gravity loads, such as the weight of roof slab, earth cover if any, live loads and mechanical equipment. They should also be designed for upward load if the liquid retaining structure is subjected to internal gas pressure.

A superficial load sufficient to ensure safety with the unequal intensity of loading which occurs during the placing of the earth cover should be allowed for in designing roofs.

The engineer should specify a loading under these temporary conditions which should not be exceeded. In designing the roof, allowance should be made for the temporary condition of some spans loaded and other spans unloaded, even though in the final state the load may be small and evenly distributed.

(iii)Water tightness. In case of tanks intended for the storage of water for domestic purpose, the roof must be made water-tight. This may be achieved by limiting the stresses as for the rest of the tank, or by the use of the covering of the waterproof membrane or by providing slopes to ensure adequate drainage.

(iv) Protection against corrosion. Protection measure shall be provided to the underside of the roof to prevent it from corrosion due to condensation.

2.3.8. Minimum Reinforcement

(a)The minimum reinforcement in walls, floors and roofs in each of two directions at right angles shall have an area of 0.3 per cent of the concrete section in that direction for sections up to 100mm, thickness. For sections of thickness greater than 100mm, and less than 450mm the minimum reinforcement in each of the two directions shall be linearly reduced from 0.3 percent for 100mm thick section to 0.2 percent for 450mm, thick sections. For sections of thickness greater than 450mm, minimum reinforcement in each of the two directions shall be kept at 0.2 per cent. In concrete sections of thickness 225mm or greater, two layers of reinforcement steel shall be placed one near each face of the section to make up the minimum reinforcement.

(b)In special circumstances floor slabs may be constructed with percentage of reinforcement less than specified above. In no case the percentage of reinforcement in any member be less than 0°15% of gross sectional area of the member.

2.3.9. Minimum Cover to Reinforcement.

(a)For liquid faces of parts of members either in contact with the liquid (such as inner faces or roof slab) the minimum cover to all reinforcement should be 25mm or the diameter of the main bar whichever is grater. In the presence of the sea water and soils and water of corrosive characters the cover should be increased by 12mm but this additional cover shall not be taken into account for design calculations.

(b)For faces away from liquid and for parts of the structure neither in contact with the liquid on any face, nor enclosing the space above the liquid, the cover shall be as for ordinary concrete member.

2.4 FLEXIBLE BASE CIRCULAR WATER TANK

For smaller capacities rectangular tanks are used and for bigger capacities circular tanks are used .In circular tanks with flexible joint at the base tanks walls are subjected to hydrostatic pressure .so the tank walls are designed as thin cylinder. As the hoop tension gradually reduces to zero at top, the reinforcement is gradually reduced to minimum reinforcement at top. The main reinforcement consists of circular hoops. Vertical reinforcement equal to 0.3% of concrete are is provided and hoop reinforcement is tied to this reinforcement.

STEP 1

DETERMINATION OF DIAMETER OF THE WATER TANK

Diameter=D=√(Q * 0.004) / ((H - Fb) * 3.14)

Where Q=capacity of the water tank

H=height of the water tank

Fb=free board of the water tank

STEP 2

DESIGN OF DOME SHAPED ROOF

Thickness of dome = t=100mm

Live load = 1.5KN/m^2

Self weight of dome = (t / 1000) * unit weight of concrete

Finishes load= 0.1KN/m^2

Total load = live load + self weight + finishes load

Central rise= r =1m

Radius of dome = R= ((0.5 * D) ^ 2 + r ^ 2) / (2 * r)

cosA = ((R - r) /R)

Meridional thrust = (total load * R) / (1 + cosA)

Circumferential thrust = total load * R * (cosA - 1 / (1 + cosA))

Meridional stress = meridional thrust / t

Hoop stress = circumferential thrust / t

Reinforcement in both direction = 0.3 * t* 10

Hoop tension = meridional thrust * cosA * D * 0.5

Reinforcement in top ring beam =As_topringbeam hoop tension / Ts

Cross section area of top ring beam

= (hoop tension / PST direct) - (m - 1) * As_topringbeam

STEP 3

DETERMINATION OF HOOP REINFORCEMENT

HTi = 0.5 * (w * (H - i) * D)

Asi = HTi / Ts

Where, HTi=hoop tension at a depth of i from the top

Asi=hoop reinforcement at a depth of i from the top

STEP 4

DETERMINATION OF THICKNESS OF CYLINDRICAL WALL

HT = 0.5 * (w * H * D)

t = 0.001 * (HT1 / PSTdirect - (m - 1) * As)

Where, t=thickness of the wall

HT=hoop tension at the base of tank

PSTdirect=permissible stress due to direct tension

As=hoop reinforcement at base

STEP 5

DETERMINATION OF VERTICAL REINFORCEMENT

Asv = (0.3 - 0.1 * (t - 100) / 350) * t * 10

Where, Asv= vertical reinforcement of the wall

t=thickness of the wall

STEP 6

DESIGN OF BASE

Thickness of base =150mm

Minimum reinforcement required=(0.3/100)*150*1000mm^2

2.5 RIGID BASE CIRCULAR TANK

The design of rigid base circular tank can be done by the approximate method. In this method it is assumed that some portion of the tank at base acts as cantilever and thus some load at bottom are taken by the cantilever effect. Load in the top portion is taken by the hoop tension. The cantilever effect will depend on the dimension of the tank and the thickness of the wall. For H^2/Dt between 6 to 12, the cantilever portion may be assumed at H/3 or 1m from base whichever is more. For H^2/Dt between 6 to 12, the cantilever portion may be assumed at H/4 or 1m from base whichever is more.

STEP 1

DETERMINATION OF DIAMETER OF THE WATER TANK

Diameter=D=√(Q * 0.004) / ((H - Fb) * 3.14)

Where Q=capacity of the water tank
H=height of the water tank
Fb=free board of the water tank

STEP 2

DESIGN OF DOME SHAPED ROOF

Thickness of dome = t=100mm

Live load = 1.5KN/m^2

Self weight of dome = (t / 1000) * unit weight of concrete

Finishes load= 0.1KN/m^2

Total load = live load + self weight + finishes load

Central rise= r =1m

Radius of dome = R= ((0.5 * D) ^ 2 + r ^ 2) / (2 * r)

cosA = ((R - r) /R)

Meridional thrust = (total load * R) / (1 + cosA)

Circumferential thrust = total load * R * (cosA - 1 / (1 + cosA))

Meridional stress = meridional thrust / t

Hoop stress = circumferential thrust / t

Reinforcement in both direction = 0.3 * t* 10

Hoop tension = meridional thrust * cosA * D * 0.5

Reinforcement in top ring beam =As_topringbeam hoop tension / Ts

Cross section area of top ring beam

= (hoop tension / PST direct) - (m - 1) * As_topringbeam

STEP 3

Assume the thickness of the wall=t = 0.15m

Find the value of H ^ 2 / (D * t)

(i) 6 < H ^ 2 / (D * t) < 12

Cantilever height=H/3 or 1m (which ever is more)

(ii) 12 < H ^ 2 / (D * t) < 30

Cantilever height=H/4 or 1m (which ever is more)

STEP 4

DETERMINATION OF REINFORCEMENT IN WALL

Maximum hoop tension=pD/2

Where, p=w*(H-cantilever height)

w=unit weight of water

Area of steel required=maximum hoop tension/σ_{st}

STEP 5

DETERMINATION OF REINFORCEMENT IN CANTILEVER HEIGHT

Maximum bending moment = 0.5 * (w * H) * (cantileverht ^ 2) / 3

Effective depth=t-40mm

Area of steel required=maximum bending moment/(j*effective depth* σ_{st})

STEP 6

DETERMINATION OF DISTRIBUTION STEEL IN WALL

Distribution steel provided = (0.3 - 0.1 * (t - 100) / 350) * t * 10

STEP 7

DESIGN OF BASE

Thickness of base =150mm

Minimum reinforcement required=(0.3/100)*150*1000mm^2

Reinforcement in top ring beam =As_topringbeam hoop tension / Ts

2.6 UNDER GROUND WATER TANK

The tanks like purification tanks, Imhoff tanks, septic tanks, and gas holders are built underground. The design principle of underground tank is same as for tanks are subjected to internal water pressure and outside earth pressure. The base is subjected to weight of water and soil pressure. These tanks may be covered at the top.

Whenever there is a possibility of water table to rise, soil becomes saturated and earth pressure exerted by saturated soil should be taken into consideration.

As the ratio of the length of tank to its breadth is greater than 2, the long walls will be designed as cantilevers and the top portion of the short walls will be designed as slab supported by long walls. Bottom one meter of the short walls will be designed as cantilever slab.

STEP 1

DETERMINATION OF DIMENSION OF THE TANK

Assuming length is equal to the three times of breadth.

Area of the tank = Q / H

B =√ (area of tank / 3)

L=3B

STEP 2

DESIGN OF LONG WALLS

1.first considering that pressure of saturated soil acting from outside and no water pressure from inside, calculate the depth and over all depth of the walls.

2. Calculate the maximum bending moment at base of long wall.

3. Calculate the area of steel and provide it on the outer face of the walls.

4. Now considering water pressure acting from inside and no earth pressure acting from outside, calculate the maximum water pressure at base.

5. Calculate the maximum bending moment due to water pressure at base.

6. Calculate the area of steel and provide it on the inner face of the walls.

7. Distribution steel provided = (0.3 - 0.1 * (t - 100) / 350) * t * 10

STEP 3

DESIGN OF SHORT WALLS

1. Bottom 1m acts as cantilever and remaining 3m acts as slab supported on long walls. Calculate the water pressure at a depth of (H-1) m from top.

2. Calculate the maximum bending moment at support and centre.

3. Calculate the corresponding area of steel required and provide on the outer face of short wall respectively.

4. Then the short walls are designed for condition pressure of saturated soil acting from outside and no earth pressure from inside.

STEP 4

Base slab is check against uplift.

STEP 5

Design of base is done.

2.7 PROGRAMS

2.7.1 Design of Flexible Base and Rigid Base Circular Tank

```
Sub circular_flexible_rigid()

Dim Q As Double 'capacity of the tank in lt.
Dim H As Double 'depth of the water tank in m.
Dim Fb As Double 'free board of the tank in m.
Dim D As Integer 'diameter of the tank in m.
Dim dsqr As Double
Dim HTi As Double 'maximum hoop tension at im from top in N/m^2
Dim HT1 As Double 'maximum hoop tension at 1m from top
Dim Asi As Double 'area of steel required at im from top
Dim w As Double 'density of water in N/m^3
Dim Ts As Double 'the permissible stress in reinforcemnt
Dim AST As Double 'allowable stress in tension
Dim fck As Double 'the compressive strength of concrete
Dim PSTdirect As Double 'permissible tension stress direct in N/mm^2
Dim PSTbending As Double 'permissible tension stress bending
Dim m As Double 'modular ratio of concrete
Dim t As Double 'thickness of wall
Dim Asv As Double 'vertical reinforcement
Dim Asvf As Double 'vertical reinforcement on each face
Dim n As Integer 'no.of rows
Dim diareinf As Integer 'diameter of the reinforcement in mm
Dim Sv As Integer 'spacing provided per m.
Dim verticalSv As Integer 'spacing provided per m on each face (vertical)
Dim AraSv As Double 'area of one bar
Dim assumedt As Double 'assumed thickness of the tank
Dim Hsqrbydt As Double
Dim cantileverht As Double 'ht of cantilever portion
```

```
Dim maxht As Double 'maximum hoop tension in rigid base tank design
Dim maxhtast As Double 'area of steel required due to hoop stress
Dim spacing As Integer 'spacing of steel on both face due to hoop stress
Dim maxbm As Double 'maximum bending moment in cantilever portion
Dim maxbmast As Double 'area of steel required for cantilever portion
Dim dst As Double 'distribution steel
Dim percentreinf As Double 'percentage of distribution steel
Dim dst_spacing As Integer
Dim t_roof As Double 'thickness of roof
Dim liveload As Double 'live load on dome
Dim self_wt As Double 'selfwt of dome
Dim finishes As Double 'wt of finishes
Dim total_load As Double 'total load on dome
Dim r As Integer 'central rise of the dome
Dim rad_dome As Double 'radius of dome
Dim cosA As Double
Dim mer_thrust As Double 'meridional trust
Dim circ_thrust As Double 'circumferential thrust
Dim mer_stress As Double 'meridional stress
Dim hoop_stress As Double 'hoop stress
Dim ast_dome As Double 'area of steel in dome
Dim hoop_tension As Double 'hoop tension in dome
Dim ast_topringbeam As Double 'area of steel in top ring beam
Dim d_base As Double 'depth of base slab
Dim ast_slab As Double 'minimum reinforcement provided in slab
Dim deff_wall As Double 'effective depth of the wall
Dim ast_cant As Double 'area of steel provided on cantilever portion

w = 10000
Ts = 100
```

```
Sheet2.Cells.Clear
Sheet3.Cells.Clear

Q = Sheet1.Cells(2, 2)
H = Sheet1.Cells(2, 3)
Fb = Sheet1.Cells(2, 4)
fck = Sheet1.Cells(2, 5)
m = Sheet1.Cells(2, 6)
diareinf = Sheet1.Cells(2, 7)
AraSv = (3.141 * diareinf ^ 2) / 4

If fck = 15 Then
PSTdirect = 1.1
PSTbending = 1.5

ElseIf fck = 20 Then
PSTdirect = 1.2
PSTbending = 1.7

ElseIf fck = 25 Then
PSTdirect = 1.3
PSTbending = 1.8

ElseIf fck = 30 Then
PSTdirect = 1.5
PSTbending = 2

ElseIf fck = 35 Then
PSTdirect = 1.6
PSTbending = 2.2
```

```
ElseIf fck = 40 Then
PSTdirect = 1.7
PSTbending = 2.4

End If

'design of flexible base
dsqr = (Q * 0.004) / ((H - Fb) * 3.14)
D = Sqr(dsqr)
Sheet2.Cells(1, 1).Value = "DIAMETER in m"
Sheet2.Cells(2, 1).Value = D
i = 0
n = 2
Asi = 0
increment:
If i < H Then
HTi = 0.5 * (w * (H - i) * D)
Asi = HTi / Ts
Sv = AraSv * 1000 / Asi
Sheet2.Cells(1, 3).Value = "AT DEPTH IN m FROM TOP"
Sheet2.Cells(n, 3).Value = (H - i)
Sheet2.Cells(1, 4).Value = "SPACING OF REINFORCEMENT PER 1m ON EACH FACE in mm"
Sheet2.Cells(n, 4).Value = Sv * 2
i = i + 1
n = n + 1
GoTo increment:

ElseIf i >= H Then
HT1 = 0.5 * (w * H * D)
```

```
t = 0.001 * (HT1 / PSTdirect - (m - 1) * Asi)
Asv = (0.3 - 0.1 * (t - 100) / 350) * t * 10
verticalSv = AraSv * 1000 / Asv

End If

Sheet2.Cells(1, 2).Value = "THICKNESS in mm"
Sheet2.Cells(2, 2).Value = t
Sheet2.Cells(1, 5).Value = "VERTICAL REINFORCEMENT SPACING ON EACH FACE in mm^2"
Sheet2.Cells(2, 5).Value = verticalSv
Sheet3.Cells(1, 1).Value = "DIAMETER in m"
Sheet3.Cells(2, 1).Value = D

'design of rigid base tank
assumedt = 150
Sheet3.Cells(1, 2).Value = "THICKNESS in mm"
Sheet3.Cells(2, 2).Value = assumedt
Hsqrbydt = H ^ 2 / (D * assumedt)
If 6 < Hsqrbydt < 12 Then
If H / 3 > 1 Then
cantileverht = H / 3
ElseIf H / 3 <= 1 Then
cantileverht = 1
End If

ElseIf 12 < Hsqrbydt < 30 Then
If H / 4 > 1 Then
cantileverht = H / 4
ElseIf H / 4 <= 1 Then
cantileverht = 1
```

```
End If

End If
maxht = w * 2 * (H / 3) * (D / 2)
maxhtast = maxht / Ts
spacing = AraSv * 1000 / maxhtast
Sheet3.Cells(1, 3).Value = "AT DEPTH IN m FROM TOP"
Sheet3.Cells(2, 3).Value = (H - cantileverht)
Sheet3.Cells(1, 4).Value = "SPACING OF REINFORCEMENT PER 1m
ON EACH FACE in mm"
Sheet3.Cells(2, 4).Value = spacing * 2

st = 150
cbc = fck / 3
m = 280 / (3 * cbc)
k = (m * cbc) / (m * cbc + st)
j = 1 - k / 3
qcrack = 0.5 * k * j * cbc
maxbm = 0.5 * (w * H) * (cantileverht ^ 2) / 3
deff_wall = assumedt - 40
ast_cant = maxbm * 10 ^ 6 / (j * st * deff_wall)
Sheet3.Cells(5, 1).Value = "Ast in cantilever portion in mm^2"
Sheet3.Cells(5, 2).Value = ast_cant

'distribution steel
percent_reinf = 0.3 - 0.1 * (assumedt / 1000 - 0.1) / 0.35
dst = percent_reinf * 0.15 * 1000 * 1000 / 100
dst_spacing = AraSv * 1000 / dst
Sheet3.Cells(7, 1).Value = "DISTRIBUTION STEEL"
Sheet3.Cells(7, 2).Value = dst
```

```
Sheet3.Cells(8, 1).Value = "SPACING OF REINFORCEMENT PER 1m ON EACH FACE in mm"
Sheet3.Cells(8, 2).Value = dst_spacing * 2

'design of dome shape roof
t_roof = 100
liveload = 1.5
selfwt = (t_roof / 1000) * 24
finishes = 0.1
total_load = liveload + selfwt + finishes
r = 1
rad_dome = ((0.5 * D) ^ 2 + r ^ 2) / (2 * r)
cosA = ((rad_dome - r) / rad_dome)
mer_thrust = (total_load * rad_dome) / (1 + cosA)
circ_thrust = total_load * rad_dome * (cosA - 1 / (1 + cosA))
mer_stress = mer_thrust / t_roof
hoop_stress = circ_thrust / t_roof
ast_dome = 0.3 * t_roof * 10
Sheet2.Cells(10, 1).Value = "DESIGN OF ROOF"
Sheet2.Cells(11, 1).Value = "CENTRAL RISE in m"
Sheet2.Cells(11, 2).Value = r
Sheet2.Cells(12, 1).Value = "THICKNESS in mm"
Sheet2.Cells(12, 2).Value = t_roof

'design of top ring
hoop_tension = mer_thrust * cosA * D * 0.5
ast_topringbeam = hoop_tension / Ts
ac_topringbeam = (hoop_tension / PSTdirect) - (m - 1) * As_topringbeam
Sheet2.Cells(13, 1).Value = "REINFORCEMNET IN DOME in mm^2"
Sheet2.Cells(13, 2).Value = ast_dome
Sheet2.Cells(15, 1).Value = "DESIGN OF TOP RING BEAM"
```

```
Sheet2.Cells(16, 1).Value = "c/s AREA OF RING BEAM in mm^2"
Sheet2.Cells(16, 2).Value = ac_topringbeam
Sheet2.Cells(17, 1).Value = "REINFORCEMENT IN RING BEAM in mm^2"
Sheet2.Cells(17, 2).Value = ast_topringbeam

'DESIGN OF BASE
d_base = 150
ast_slab = (0.3 / 100) * 150 * 1000
Sheet2.Cells(20, 1).Value = "DESIGN OF BASE"
Sheet2.Cells(21, 1).Value = "DEPTH OF SLAB in m"
Sheet2.Cells(21, 2).Value = d_base
Sheet2.Cells(22, 1).Value = "REINFORCEMENT in mm^2"
Sheet2.Cells(22, 2).Value = ast_slab

End Sub
```

2.7.2 Design of Underground Tank

```
Sub underground_tank()

Dim Q As Double
Dim H As Double
Dim angle As Double
Dim density As Double
Dim w_water As Double 'unit wt of water
Dim w_soil As Double 'unit wt of soil
Dim area_tank As Double
Dim Fck As Integer 'characteristic strength of concrete
Dim cbc As Integer
Dim m As Integer
Dim k As Double
Dim j As Double
Dim qcrack As Double
Dim L As Double
Dim B As Double
Dim p As Double 'earth pressure
Dim Ka As Double 'coeff of earth pressure
Dim maxBM_longwall As Double 'maxm B.M at base of long wall
Dim maxBM_longwall_soil As Double
Dim deff As Double 'effective depth required for wall
Dim avgd As Double 'average thickness of wall
Dim d As Integer 'provided depth of the wall
Dim steel_long_inner As Double 'area of steel provided on inner side of long wall
Dim steel_long_outer As Double 'area of steel provided on outer side of long wall
Dim distr_long As Double 'distribution steel in long wall
```

```
Dim maxBM_short_centre As Double 'bending moment at centre in short wall
Dim maxBM_short_support As Double 'bending moment at support in short wall
Dim t_short As Double
Dim t_avlble As Double
Dim T As Double 'tension in short wall
Dim steel_short As Double 'area of steel along short wall
Dim steel_short_support As Double 'area of steel at support short wall
Dim steel_short_centre As Double 'area of steel at centre short wall
Dim drct_comprsn As Double 'direct compression due to long wall
Dim Leff As Double
Dim Beff As Double
Dim wt_long As Double
Dim wt_short As Double
Dim wt_base As Double
Dim wt_earth_projection As Double
Dim upward_pr As Double
Dim downward_pr As Double
Dim fric_res As Double
Dim submrgd_earthpr As Double
Dim tot_fric_res As Double
Dim up_pr_1m As Double
Dim slf_wt As Double
Dim net_up_pr As Double
Dim wt_wall_proj As Double
Dim R As Double 'reaction
Dim d_base As Double 'thickness of base
Dim steel_base_support As Double 'steel in base
Dim BM_edge As Double
Dim distr_base As Double
```

```
Dim a As Double
Dim tot_pr_1mwall As Double
Dim assumed_d_roof As Double 'thickness of roof slab
Dim selfwt As Double 'selfwt of roof slab
Dim livewt As Double 'live load on roof slab
Dim finishes As Double 'finishes load on roof
Dim total_load As Double
Dim maxBM_roof As Double 'maxm BM on roof slab
Dim ast_roof As Double 'reinforcement of roof slab
Dim dst_roof As Double 'distribution reinforcement of roof slab
Dim d_roof As Double
Dim deff_roof As Double
Dim bm_short_support As Double
Dim bm_short_centre As Double
Dim as_short_support_outer As Double
Dim as_short_centre_outer As Double

Sheet2.Cells.Clear

Q = Sheet1.Cells(2, 1).Value
H = Sheet1.Cells(2, 2).Value
angle = Sheet1.Cells(2, 3).Value
w_soil = Sheet1.Cells(2, 4).Value
w_water = Sheet1.Cells(2, 5).Value
Fck = Sheet1.Cells(2, 6)

If Fck = 15 Then
PSTdirect = 1.1
PSTbending = 1.5

ElseIf Fck = 20 Then
```

```
PSTdirect = 1.2
PSTbending = 1.7

ElseIf Fck = 25 Then
PSTdirect = 1.3
PSTbending = 1.8

ElseIf Fck = 30 Then
PSTdirect = 1.5
PSTbending = 2

ElseIf Fck = 35 Then
PSTdirect = 1.6
PSTbending = 2.2

ElseIf Fck = 40 Then
PSTdirect = 1.7
PSTbending = 2.4

End If
st = 150
cbc = Fck / 3
m = 280 / (3 * cbc)
k = (m * cbc) / (m * cbc + st)
j = 1 - k / 3
qcrack = 0.5 * k * j * cbc

area_tank = Q / H
B = (area_tank / 3) ^ 0.5
L = 3 * B
Sheet2.Cells(1, 1).Value = "LENGTH"
```

```
Sheet2.Cells(2, 1).Value = L
Sheet2.Cells(1, 2).Value = "BREADTH"
Sheet2.Cells(2, 2).Value = B

'long wall
'tank full and no soil pressure
maxBM_longwall = (w_water * H ^ 3) / 6
deff = Sqr((maxBM_longwall * 6 * 10 ^ 6) / (1000 * PSTbending))

xyz:
d = deff + 10
steel_long_inner = maxBM_longwall * 10 ^ 6 / (j * deff * st)
avgd = (d + 150) * 0.5
distr_long = (0.3 - 0.1 * (avgd - 100) / 350) * 1000 * avgd / 100

'soil pressure only no water pressure

a = 3.14 * angle / 180
Ka = (1 - Sin(a)) / (1 + Sin(a))
p = w_water * H + (w_soil - w_water) * Ka * H
maxBM_longwall_soil = (p * H ^ 2) / 6
steel_long_outer = maxBM_longwall_soil * 10 ^ 6 / (j * (d - 50) * st)

Sheet2.Cells(1, 3).Value = "THICKNESS"
Sheet2.Cells(2, 3).Value = d
Sheet2.Cells(1, 4).Value = "LONG WALL"
Sheet2.Cells(2, 4).Value = "STEEL ALONG INNER SIDE"
Sheet2.Cells(2, 5).Value = steel_long_inner
Sheet2.Cells(3, 4).Value = "STEEL ALONG OUTER SIDE"
Sheet2.Cells(3, 5).Value = steel_long_outer
Sheet2.Cells(4, 4).Value = "DISTRIBUTION STEEL"
```

```
Sheet2.Cells(4, 5).Value = distr_long

'short wall
'tank full no eart pressure
maxBM_short_centre = (w_water * (H - 1) * B ^ 2) / 16
maxBM_short_support = (w_water * (H - 1) * B ^ 2) / 12
t_short = Sqr((maxBM_short_support * 6 * 10 ^ 6) / (1000 * PSTbending))
t_avlble = 150 + (d - 150) * (H - 1) / H
If t_short > t_avlble Then
GoTo xyz
ElseIf t_short < t_avlble Then
steel_short = (maxBM_short_support * 10 ^ 6) / (st * j * t_short)
T = w_water * (H - 1)
steel_short_support = (maxBM_short_support * 10 ^ 6 - T * 0.25 * t_short) / (st * j * t_short) + (T * 10 ^ 3) / st
steel_short_centre = (maxBM_short_centre * 10 ^ 6 - T * 0.25 * t_short) / (st * j * t_short) + (T * 10 ^ 3) / st
End If

Sheet2.Cells(6, 4).Value = "SHORT WALL"
Sheet2.Cells(7, 4).Value = "STEEL ALONG INNER SIDE"
Sheet2.Cells(8, 4).Value = "AT SUPPORT"
Sheet2.Cells(8, 5).Value = steel_short_support
Sheet2.Cells(9, 4).Value = "AT CENTRE"
Sheet2.Cells(9, 5).Value = steel_short_centre

'tank empty & earth pressure outside
drct_comprsn = w_water * H + (w_soil - w_water) * Ka * H
bm_short_support = (drct_comprsn * B ^ 2) / 12
as_short_support_outer = bm_short_support * 10 ^ 6 / (j * st * t_short)
```

```
bm_short_centre = (drct_comprsn * B ^ 2) / 16
as_short_centre_outer = bm_short_centre * 10 ^ 6 / (j * st * t_short)

Sheet2.Cells(7, 6).Value = "STEEL ALONG OUTER SIDE"
Sheet2.Cells(8, 6).Value = "AT SUPPORT"
Sheet2.Cells(8, 7).Value = as_short_support_outer
Sheet2.Cells(9, 6).Value = "AT CENTRE"
Sheet2.Cells(9, 7).Value = as_short_centre_outer
Sheet2.Cells(10, 6).Value = "DISTRIBUTION STEEL"
Sheet2.Cells(10, 7).Value = distr_long

'assume 30cm projection and 40cm as base thickness
'check against uplift
abc:
prj = 0.3
Leff = L + 2 * d / 1000 + 2 * prj
Beff = B + 2 * d / 1000 + 2 * prj
wt_long = 2 * (Leff - 2 * 0.3) * (avgd / 1000) * 24 * H
wt_short = 2 * B * (avgd / 1000) * 24 * H
wt_base = Leff * Beff * 0.4 * 24
wt_earth_projection = 2 * (Leff + B + 2 * avgd / 1000) * w_soil * H * 0.3
upward_pr = Leff * Beff * (H + 0.4) * 10
downward_pr = wt_long + wt_short + wt_base + wt_earth_projection

fric_res = 0.15 * (upward_pr - downward_pr)
submrgd_earthpr = (w_water + (w_soil - w_water) * Ka) * (H + 0.4)
tot_pr_1mwall = submrgd_earthpr * (H + 0.4) * 0.5
tot_fric_res = 2 * (Leff + B + 2 * avgd / 1000) * tot_pr_1mwall
If tot_fric_res > fric_res Then
Sheet2.Cells(1, 6).Value = "PROJECTION"
Sheet2.Cells(2, 6).Value = prj
```

```
ElseIf tot_fric_res <= fric_res Then
prj = prj + 0.1
GoTo abc
End If

‘design of base
up_pr_1m = (H + 0.4) * w_water
net_up_pr = up_pr_1m - 0.4 * 25
wt_wall_proj = avgd * H * 25 + H * w_soil
R = 0.5 * (net_up_pr * (B + 2 * avgd / 1000) - 2 * (avgd / 1000 * H * 25
+ H * w_soil * prj))
BM_edge = 0.5 * (net_up_pr * prj ^ 2) + (w_soil - w_water) * H * (H /
0.3 + 0.2) * 0.5 - 0.5 * w_soil * H * prj ^ 2
d_base = Sqr(BM_edge * 10 ^ 6 / (qcrack * 1000))
steel_base_support = BM_edge * 10 ^ 6 / (j * d_base * st)
distr_base = (0.3 - 0.1 * d_base / 350) * 1000 * d_base / 100

Sheet2.Cells(6, 1).Value = "BASE THICKNESS"
Sheet2.Cells(6, 2).Value = d_base
Sheet2.Cells(7, 1).Value = "REINFORCEMENT"
Sheet2.Cells(7, 2).Value = steel_base_support
Sheet2.Cells(8, 1).Value = "DISTRIBUTION STEEL"
Sheet2.Cells(8, 2).Value = distr_base

'Design of roof
assumed_d_roof = 100
selfwt = assumed_d_roof * 25 / 1000
livewt = 1.5
finishes = 0.1
total_load = selfwt + livewt + finishes
maxBM_roof = total_load * B ^ 2 / 8
```

```
d_roof = Sqr(maxBM_roof * 10 ^ 6 / (qcrack * B * 1000))

If assumed_d_roof / 2 > d_roof Then
ast_roof = maxBM_roof * 10 ^ 6 / (j * d_roof * st)
dst_roof = 0.15 * 10 * d_roof
Sheet2.Cells(10, 1).Value = "DESIGN OF ROOF"
Sheet2.Cells(11, 1).Value = "THICKNESS in mm"
Sheet2.Cells(11, 2).Value = d_roof + 20
Sheet2.Cells(12, 1).Value = "REINFORCEMNET IN ROOF in mm^2"
Sheet2.Cells(12, 2).Value = ast_roof
Sheet2.Cells(13, 1).Value = " DISTRIBUTION STEEL IN ROOF”
Sheet2.Cells(13, 2).Value = dst_roof

ElseIf assumed_d_roof < d_roof Then
deff_roof = assumed_d_roof - 20
ast_roof = maxBM_roof * 10 ^ 6 / (j * deff_roof * st)
dst_roof = 0.15 * 10 * assumed_d_roof
Sheet2.Cells(10, 1).Value = "DESIGN OF ROOF"
Sheet2.Cells(11, 1).Value = "THICKNESS in mm"
Sheet2.Cells(11, 2).Value = assumed_d_roof
Sheet2.Cells(12, 1).Value = "REINFORCEMNET IN ROOF in mm^2"
Sheet2.Cells(12, 2).Value = ast_roof
Sheet2.Cells(13, 1).Value = " DISTRIBUTION STEEL IN ROOF in mm^2"
Sheet2.Cells(13, 2).Value = dst_roof
End If

End Sub
```

CHAPTER 3

RESULT AND DISCUSSION

RESULTS

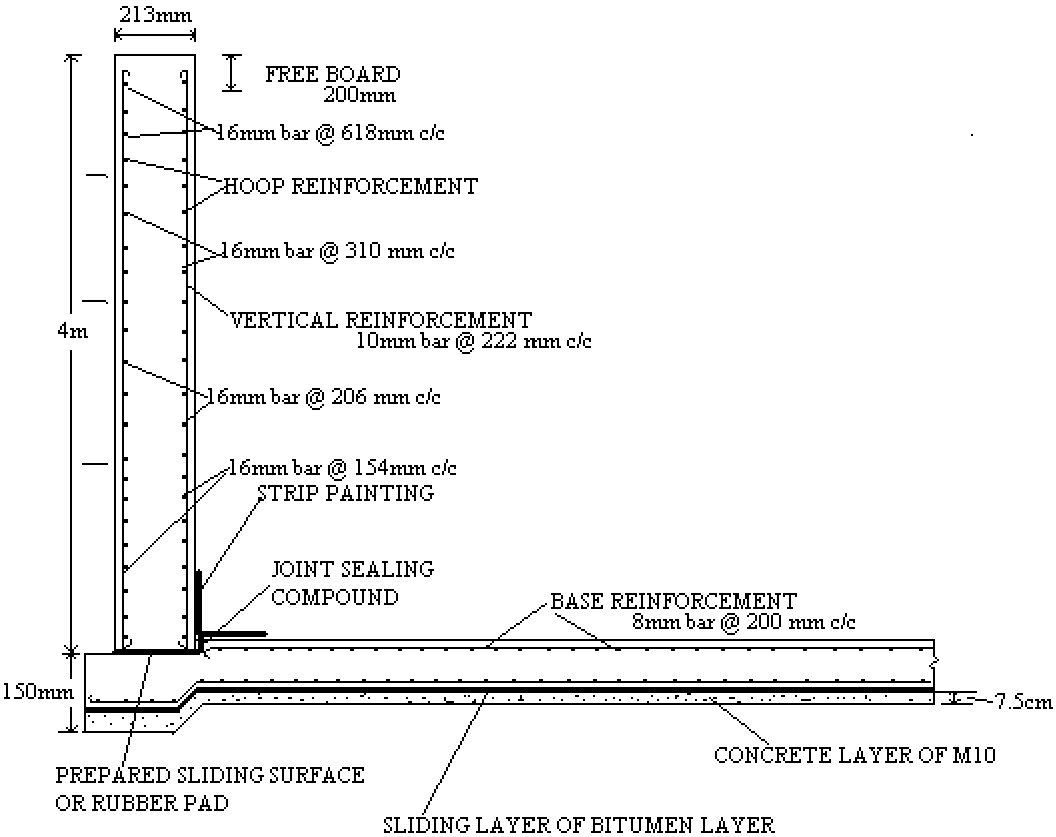
3.1 Design of Circular Tank with Flexible and Rigid Base

Capacity=	500000Litres.
Depth of the tank =	4m
Compressive strength of concrete=	M20
Free board=	0.2m
Diameter of bars used=	16mm

Table 2

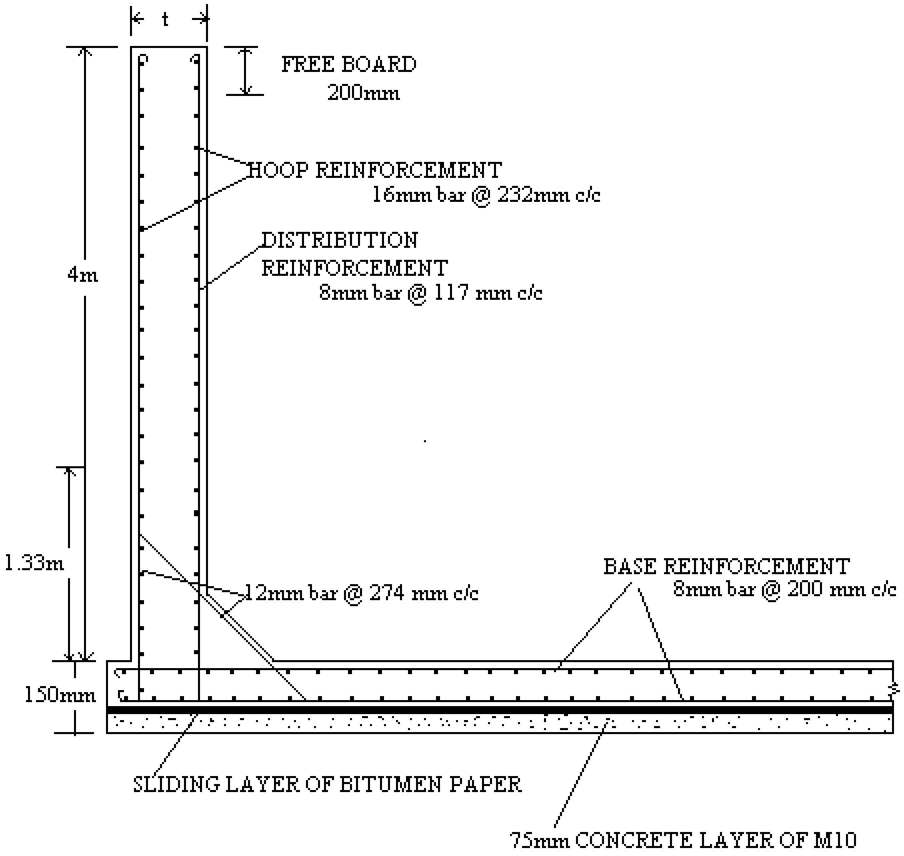
	THEORITICAL VALUES	PROGRAM VALUES
Diameter in m	13	13
Thickness of walls in mm	260	212.767
Thickness of roof in mm	100	100
Central rise of roof in m	1	1
Reinforcement in dome in mm^2	300	300
Cross section area of top ring beam		228.73
Reinforcement in ring beam		2744.711
Depth of base slab in mm	150	150
Reinforcement in base slab	450	450
Spacing of hoop reinforcement per 1m at depth m from top in mm		
4	140	154
3	200	206
2	300	310
1		618
Spacing of vertical reinforcement per 1m in both faces in mm	220	353

RIGID BASE		
	Theoretical	Program values
Thickness in mm	150	150
Reinforcement in cantilever portion	1284	823.6
Hoop reinforcement spacing on each face in mm	130	232
Spacing of distribution steel on both face in mm	429	428.57



Flexible base circular tank

Figure.3.1



Rigid base circular tank

Figure.3.2

3.2 Design of Underground Tank

Capacity=	192m^3
Depth of the tank =	4m
Compressive strength of concrete=	M20
Free board=	0.2m
Diameter of bars used=	16mm
Angle of repose of soil=	30 degree
Unit weight of soil=	16KN/mm^3
Unit weight of water=	10KN/ mm^3

DESCRIPTION		THEORITICAL VALUE	PROGRAM VALUE
Length (m)		12	12
Breadth (m)		4	4
Thickness of wall (mm)		650	624
Long wall	Steel along inner side (mm^2)	1390.52	1325.846
	Steel along outer side(mm^2)	1777.7	1700.875
	Distribution steel(mm^2)	867.34	843.66
Short wall	Steel along inner side at support(mm^2)	1145.45	1011.8544
	steel along inner side at centre(mm^2)	995.453	808.876
	Steel along outer side at support(mm^2)	1367.325	1299.19
	Steel along outer side at centre(mm^2)	1050.478	974.394
	distribution steel(mm^2)	967.45	843.66
Base thickness (mm)		400	373.38
Reinforcement in base (mm^2)		3547.56	3289.62

Distribution steel in base (mm^2)	834.59	721.82
Projection in both side of wall(m)	0.3	0.3
Roof thickness (mm)	100	62.125
Reinforcement in roof (mm^2)	433	1484.57
Distribution steel in roof(mm^2)	150	63.187

CHAPTER 4

CONCLUSION

CONCLUSION

Storage of water in the form of tanks for drinking and washing purposes, swimming pools for exercise and enjoyment, and sewage sedimentation tanks are gaining increasing importance in the present day life. For small capacities we go for rectangular water tanks while for bigger capacities we provide circular water tanks.

Design of water tank is a very tedious method. Particularly design of under ground water tank involves lots of mathematical formulae and calculation. It is also time consuming. Hence program gives a solution to the above problems.

There is a little difference between the design values of program to that of manual calculation. The program gives the least value for the design. Hence designer should not provide less than the values we get from the program. In case of theoretical calculation designer initially add some extra values to the obtained values to be in safer side.

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