EFFECT OF REVISION OF IS 3370 ON WATER STORAGE TANK

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ABSTRACT

Storage overhead tank are used to store water. BIS has brought out the revised version of IS 3370 (part 1& 2) after a long time from its 1965 version in year 2009. This revised code is mainly drafted for water tank. In this revision important is that limit state method is incorporated in design. This paper gives in brief, the theory behind the design of circular water tank using working stress method and limit state method. In the end comparative result of IS 3370 (1965) and IS 3370 (2009) is given.

1 . INTRODUCTION

As per Greek philosopher Thales ," water is source of every creation." In day to day life one can not live without water. Therefore water needs to be stored for daily used. Overhead water tank is the most effective storing facility used for domestic or even industrial purpose.

Depending upon the location of the tank the tanks can be name as overhead ,on ground and underground. The tanks can be made in different shapes usually circular and rectangular shapes are mostly used. The tanks can be made of RCC or even of steel. The overhead tanks are usually elevated from the roof top through the column. In most cases underground and on ground tanks are circular or rectangular in shape but the shape of the overhead tanks are influenced by the aesthetic view in surroundings and as well as the design of the construction. Steel tanks are also used specially in railway yards. Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. 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. The overhead tanks are supported by column which act as stage. This Overhead type are built for direct distribution by gravity flow and are usually of smaller capacity. After a long time IS 3370 is revised from its 1965 version. In this revision introduction of limit state design is the most important addition.

2 . 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 subjected to efficiently 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.

3. PROBLEM DESCRIPTION

To model any structure the main aim is to achieve the economy. Material saving results in saving in construction cost. However circularcylindrical tanks are more numerous than any other type because they are simple in design and can be easily constructed .

In present work total focus is given on preliminary analysis and design of Circular Cylindrical water tank by IS 3370: (1965) & IS 3370 :(2009) . The grade of Concrete used is M30 and grade of Steel used is Fe 415.The permissible concrete stresses in calculation relating to resistance to cracking (for direct tension) is 1.5 N/ mm^2 The value of permissible stress in Steel (in direct tension ,bending and shear) in IS 3370:(1965) σ_{st} is 150 N/mm^2 and in IS 3370:(2009) σ_{st} is 130 N/mm^2. The permissible concrete stresses in calculation relating to resistance to cracking for shear is 2.2 N/mm^2 The cylindrical water tank is basically divided in two parts; first is wall and base slab. Wall is design for maximum Hoop tension and maximum Bending moment and checked for bending tensile stress which govern the thickness of wall .Base slab is design for maximum bending moment and also checked for permissible tensile stress in concrete to make the tank leak proof.

4. ANALYSIS AND DESIGN OF CONTAINER WALL

4.1. Method of Analysis of Cylindrical wall

Following method are available for analysis of circular tank.

1. Reissner's method
2. Carpenter's method
3. Approximate method
4. I.S. code method

4.2. Design of cylindrical wall

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

(a) Wall of cylindrical tanks are either cast monolithically with the base or set in grooves and key ways. In either case deformation of wall under influence of liquid pressure is restricted at end above the base. Consequently, only part of 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 base slab and it is advisable to provide vertical reinforcement as if the wall were fully fixed at the base, in addition to the reinforcement required to resist horizontal ring tension for hinge at base , conditions of walls, unless the appropriate amount of fixity at the base is established by analysis with due consideration to the dimension of base slab the type of joint between the wall and slab and where applicable the type of soil supporting the base slab.

5. ALYSIS AND DESIGN OF BASE SLAB

5.1 Analysis of base slab

When the circular tanks are elevated and supported, the analysis and design of base slab depend upon the manner in which it is supported if the supporting tower consisting of columns placed below the tank walls, usually no separate curved beam is required over the column to support the tank. The tank wall itself act as a curved beam, as the depth of this beam is large only a few steel bar at its bottom and top is all that is required as a reinforcement for the beam section.

The base slab should however be suitably tied to the walls by the vertical rods embedded properly in the slab and the wall. When the flexible joint is provided between the wall and slab, a separate circular beam is required below the slab.

5.2 Design of base base

If the bottom of a circular tank is supported around its periphery, it can be designed as a circular slab simply supported at edges. Although circular slab are not so commonly used in building but they have wide application in water tanks. In applying this theory to R.C. slab poisson's ratio may be taken to zero. This slab when loaded deflected in form of a saucer and develops radial as well as circumferential stress. The convex face of slab has tensile stress and concave face of slab compressive stress. Hence R/F should be placed on the concave face near the surface to be more effective. The best form of R/F will be radial and circumferential to safe-guard the slab against circular and radial crack respectively. An alternative arrangement in form of mesh such that the intensity of reinforcement in either direction of the mesh is as required for the bigger of the radial and circumferential stresses. The radial and circumferential system of reinforcement become essential near the periphery of the slab if the stresses there are not negligible or if the slab is fixed at edges.

6. ANALYSIS AND DESIGN OF TOP DOME

A dome may be defined as a thin shell generated by the revolution of a regular curve about one of its axes. The shape of the dome depends on the type of the curve and the direction of the axis of revolution. In spherical and conoidal domes, surface is described by revolving an arc of a circle. The centre of the circle may be on the axis of rotation (spherical dome) or outside the axis (conoidal dome). Both types may or may not have a symmetrical lantern opening through the top. The edge of the shell around its base is usually provided with edge member cast integrally with the shell.

Domes are used in variety of structures, as in the roof of circular areas, in circular tanks, in hangers, exhibition halls, auditoriums, planetorium and bottom of tanks, bins and bunkers. Domes may be constructed of masonry, steel, timber and reinforced concrete. However, reinforced domes are more common nowadays since they can be constructed over large spans.

6.1. Analysis of top dome

Stresses to be considered in dome are Meridional thrust , Hoop stress

6.2. Design of top dome

The domes are designed for the total vertical load only. The term total vertical load include the weight of the dome slab and that of covering material ,if any over the slab the weight of any other load suspended from the slab and live load etc.

The minimum thickness of dome slab should not be less than 80 mm and the minimum percentage of steel should not be less than 0.3 %

7. ANALYSIS AND DESIGN OF TOP RING BEAM

The ring beam is necessary to resist the horizontal component of the thrust of the dome. To bear this horizontal component of meridional thrust a ring beam is provided at the base of dome

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7.1. Design of top ring beam

The ring beam takes hoop tension and transfer only vertical reaction to the supporting walls.

8. CRACKWIDTH IN MATURE CONCRETE

According to IS 3370:2009 following assessments has given

8.1. Assessment of crack width in flexure

The design surface crack width should not exceed the appropriate value i.e. 0.2 mm. Crack width can be calculated by following formula

W = (3 acr εm)/ 1+{2 (acr – Cmin) /(D-x)

W = design surface crack widt

acr = distance from the point considered to the surface of the nearest bar

εm = average strain at the level where the cracking is being considered.

Cmin = minimum cover to the tension steel

D = overall depth of the member

x = depth of neutral axis

8.2. Average strain in flexure

The average strain at the level where cracking is being considered is assessed by calculating the apparent strain using characteristic load and normal elastic theory. Where flexure is predominant but some tension exists at the section , the depth of the neutral axis should be adjusted. The calculated apparent strain , ε1 is then adjusted to take into account the stiffening effect of the concrete between cracks ε2.

$$\varepsilon m = \varepsilon 1 - \varepsilon 2$$

8.3. Stiffening effect of concrete in flexure

For a limiting design surface crack width of 0.2 mm

ε2 = bt (D-x)(a'-x) / 3 Es As (d-x)

where

ε1 = strain at the level considered

ε2 = strain due to the stiffening effect of concrete between cracks

bt = width of section at the centroid of the tension steel

D = overall depth of the member

x = depth of the member

Es = modulus of elasticity of reinforcement

As = area of tension reinforcement

d = effective depth

a' = distance from the compression face to the point at which the crack

8.4. Assesment of crackwidth in direct tension

In some reinforced concrete member like tankwall direct tension due to applied loading may act in combination with restrained to volume change cause by temperature and shrinkage. This can lead to significant cracking which should be controlled in the interest of serviceability. cracking due to direct tension is of somewhat more serious because it cause clear separation of concrete through the entire thickness of member.

9. CONCLUSION

The thickness of wall and depth of base slab is comes to different for IS 3370:(1965) and IS 3370:(2009) because of the value of permissible stress in Steel (in direct tension ,bending and shear) IS 3370:(1965) value of σ_{st} is 150 N/mm^2 and in IS 3370:(2009) σ_{st} is 130 N/mm^2. Design of water tank by Limit State Method is most economical as the quantity of material required is less as compared to working stress method Water tank is the most important container to store water therefore, Crack width calculation of water tank is also necessary.

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