A Review on Comparative Study of RCC Water Storage Tank With Old And New Provision

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Abstract- *Water is the life line facility that must remain functional following disaster. Most municipalities in India have water supply system which depends on elevated tanks for storage. Elevated water tank is a large elevated water storage container constructed for the purpose of holding a water supply at a height sufficient to pressurize a water distribution system. Water storage tanks are designed as per the provisions of IS 3370. As per the provisions of the code (IS 3370-1965), the designing of water tanks was permitted by working stress method only and on the philosophy of no cracking. This code has been revised in 2009. As per IS 3370:2009, use of limit state method has been permitted and provision for checking the crack width is also included in this code. Hence this study was undertaken to compare the provisions of IS 3370: 1965 and IS 3370: 2009. Prasad and Kamdi (2012) had given effect of revised IS 3370 on water tank and concluded that thickness of wall and width of base slab is different for both codes because the value of permissible stress in steel is different and also concluded design of water tank by LSM is most economical as the quantity of material required is less as compared to WSM. Bhandari and Karan Deep Singh (2014) gives the comparison of IS 3370:1965 and IS 3370:2009 for WSM and LSM and other aspects. Design of three different types of water tank with reference to the IS 3370:1965 and IS 3370:2009 with different capacities. After concluded the design of water tank is most economical in LSM as compared to WSM and the quantity of material required is less in LSM. Lodhi, Sharma, Garg (2014) Design of intzee water tank as per IS 3370:1965 without considering earthquake forces and after redesign the intzee water tank with same parameter as per IS 3370:2009 with considering earthquake forces and concluded that design of intzee water tank as per old IS code was unsafe in hoop tension. With considering earthquake forces in design of intzee water tank the thickness of cylindrical wall, conical dome and bottom dome is increased. As per new IS code required reinforcement is also increases. Jindal and Singhal (2012) compared the IS 3370:1965 and IS 3370:2009 code of practice for concrete structures for the storage of liquids. It gives the comparison of WSM and LSM.*

Keywords- Underground tanks1, Tanks resting on ground2, Overhead water tanks3

I. INTRODUCTION

1.1 *Basis of concrete water tank*

One of the vital considerations for design of tanks is that the structure has adequate resistance to cracking and has adequate strength. There is assumption as follows:-

I. The full section of concrete including cover and reinforcement is capable of resisting limited tensile stresses.
II. In strength calculation the tensile strength of concrete is ignored against structural failure.
III. In design adopts reduced value of permissible stresses in steel.

1.2 *Types of Water Tanks*

In this section, the types of water tanks are discussed in detail. There is different type of water tank depending upon the shape, position with respect to ground level etc. From the position point of view, water tanks are classified into three categories. Those are,

a) Underground tanks
b) Tanks resting on ground
c) Overhead water tanks

In most cases the underground and on ground tank are circular or rectangular in shape but the shape of the overhead tanks are influenced by the aesthetical view of the surroundings and as well as the design.

1.2.1 *Underground water tank*

An Underground storage tank (UST) is a storage tank that is placed below the ground level. Underground storage tanks fall into three different types:

1.2.1.1 Steel/aluminium tank, made by manufacturers in most states and conforming to standards set by the Steel Tank Institute.

1.2.1.2 Composite overwrapped a metal tank (aluminium/steel) with filament windings like glass fibre/aramid or carbon fibre or a plastic compound around the metal cylinder for corrosion protection and to form an interstitial space.

Tanks made from composite material, fibreglass/aramid or carbon fibre with a metal liner (aluminium or steel). Underground water storage tanks are used for underground storage of potable drinking water, wastewater & rainwater collection. So whether you call it a water tank or water cistern, as long as you are storing water underground III these are the storage tanks for you. Plastic underground water tanks (cistern) are a great alternative to concrete cisterns.

1.2.2 *Tanks resting on ground*

In this section, we are studying only the tanks resting on ground like clear water reservoirs, settling tanks, aeration tanks etc. are supported on ground directly. The wall of these tanks are subjected to pressure and the base is subjected to weight of water. These tanks are rectangular or circular in their shape.

1.2.3 *Overhead water tanks*

Overhead water tanks of various shapes can be used as service reservoirs, as a balancing tank in water supply schemes and for replenishing the tanks for various purposes. Reinforced concrete water towers have distinct advantages as they are not affected by climatic changes, are leak proof, provide greater rigidity and are adoptable for all shapes.
From the shape point of view, water tanks may be of several types. These are,

a) Circular tanks
b) Conical or funnel shaped tanks
c) Rectangular tanks

Circular tanks

Circular tanks are usually good for very larger storage capacities the side walls are designed for circumferential hoop tension and bending moment, since the walls are fixed to the floor slab at the junction. The co-efficient recommended in IS 3370 part 4 is used to determine the design forces. The bottom slab is usually flat because it's quite economical.

Rectangular tanks

The walls of Rectangular tank are subjected to bending moments both in horizontal as well as in vertical direction. The analysis of moment in the wall is difficult since water pressure results in a triangular load on them. The magnitude of the moment will depend upon the several factors such as length, breadth and height of tank, and conditions of the support of the wall at the top and bottom edge. If the length of the wall is more in compression to its height the moment will be mainly in vertical direction i.e. the panel will bend as a cantilever. If, however, height is larger in comparison to length, the moments will be in horizontal direction, and the panel will bend as a thin slab supported on the edges. The wall of the tank will thus be subjected to both bending moment as well as direct tension.

Detail Design

Working stress method of design, considered as the method of earlier times, has several limitations. However, in situations where limit state method cannot be conveniently applied, working stress method can be employed as an alternative. It is expected that in the near future the working stress method will be completely replaced by the limit state method. Though the choice of the method of design is still left to the designer as per cl. 18.2 of IS 456:2000.

Working Stress method incorporated limited cracking width in the liquid retaining structure and hence was the main reason why the Indian Standard IS: 3370 (1965) did not adopt the limit state design method. However, adopted limit state design method in 2009 with the following advantages – Limit State Method of design considers the materials according to their properties , treats load according to their nature , the structures also fails mostly under limit state and not in elastic state and limit state method also checks for serviceability. IS:3370-2009 recommends the use of Limit State Design method for designing water storing tanks with some specified precautions. It adopts the criteria for limiting crack width. This is done by considering ultimate limit state and restricting the stresses to **130 MPa** in steel so that cracking width is not exceeded. this is considered to satisfy the required condition. This precaution ensures us that the crack width remains less than 0.2 mm i.e. liquid storage is possible without any leakage due to cracking. This also suggests the difference between liquid storage structures and other structures. A thorough study through both the versions of IS:3370 reveals four methods of designs:

a. Working stress method in accordance IS 3370 (1965).
b. Working stress method in accordance IS 3370 (2009).

c. Designing by Ultimate Limit State and then checking cracking width by limit state of serviceability IS 3370 (2009).
d. Limit state design method by limiting steel stresses in accordance IS 3370 (2009) and checking cracking width under serviceability.

To prevent the leakage, IS 456 guidelines are recommended (based on working stress method.) The strength of the structure and imperviousness is achieved by employing rich concrete mix (recommended concrete mixes are M25 and M30.) imperviousness can be achieved by keeping a minimum clear cover of 40 mm and providing smaller diameter bars at closer intervals and good construction practices.

Major Variations in is 3370: 1965 and is 3370:2009

In IS 3370:1965 design criteria adopts working stress method and in revised version of IS3370:2009 adopts working stress method as well as limit state method with crack width theory.

Permissible Stresses in concrete

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. The permissible stresses due to bending apply to the face of the member in contact with the liquid.

For Strength Calculations – in strength calculations, the permissible concrete stresses in according to IS 456:2000. If the calculated shear stress in concrete alone exceed the permissible value, reinforcement acting in conjunction with diagonal compression in the concrete shall be provided to take the whole ofthe shear.

Permissible Stresses in steel

For Resistance to Cracking – The tensile stress in the steel will necessarily 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 permissible tensile stress in concrete. For Strength Calculation – In strength calculations, the permissible stresses in steel reinforcement shall be given in IS3370

$$S_{Max} = \frac{f_{ct}}{f_b} \times \frac{\emptyset}{2\rho}$$

Minimum reinforcement for water tank

The minimum reinforcement in walls, floors and roofs in each of two directions at right angles. For 100 mm thick section is 0.3% of the area concrete section and is reduced for 450 mm thick section is 0.2%. In concrete sections of thickness 225 mm or greater, two layers of reinforcing steel shall be placed one near each face of the section to make up the minimum reinforcement. For high strength deformed bars and not less than 0.64 percent for mild steel reinforcement bars. The minimum reinforcement can be further reduced to 0.24 percent for deformed bars and 0.40 percent for plain round bars for tanks having any dimension not more than 15 m. In wall slabs less than 200 mm in thicknesses. The calculated amount of reinforcement may all be placed in one face. For ground slabs less than 300 mm thick the calculated reinforcement should be placed in one face as near as possible to the upper surface consistent with the nominal cover. Bar spacing should generally not exceed 300 mm or the thickness of the section whichever is less.

Design on basis of crack width

According to IS 3370:2009 following assessment is given, To be effective in distributing cracking The amount of reinforcement provided needs to be at least as great as that given by the formula;

$$p_{crit} - \frac{f_{ct}}{f_y}$$

Where,

Pcrit = critical steel ratio, that is, the minimum ratio, of steel area to the gross area of the whole concrete section required to distribute the cracking;

fct = direct tensile strength of the immature concrete Maximum spacing of crack S Max shall be given by the formula:

Where, $\frac{f_{ct}}{f_b}$ = ratio of the tensile strength of the concrete (fct) to the average bond strength between concrete and steel which can be taken as 2/3 for immature concrete
ø = size of each reinforcing bar, and
ρ = steel ratio based on the gross concrete section.

The width of a fully developed crack due to drying shrinkage and 'heat of hydration' contraction in lightly reinforced restrained walls and slabs may be obtained from:

$$W_{Max} = S_{Max} \times \frac{\alpha}{2} \times T_1$$

Where,
α = coefficient of thermal expansion of mature concrete, = 1 x 10^{-5}
T1 = fall in temperature between the hydration peak and ambient. = 300
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III. CONCLUSIONS

Design of water tank as per IS 3370: 2009 by limit state method is most economical as compared to IS 3370:1965 by working stress method. Area of steel for reinforcement is decreases in LSM as per IS code. The thickness of wall is decreases in limit state method. The size of member of ring beam is also decreases in limit state method. The quantity of material required is less in limit state method as compared to working stress method. Crack width calculations done in limit state method.

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 σst is 150 N/mm2 and in IS 3370:(2009) σst is 130 N/mm2. 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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