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COMPARISION OF DESIGN OF WATER TANK AS PER IS 3370 (1967) AND IS 3370 (2009)

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ABSTRACT

Indian Standards for the design of liquid retaining structures have been recently revised in the year 2009. The earlier version allowed the design of water retaining structures by Working Stress Method only, But the revision of the code allows the Working stress method as well as Limit State method for designing RCC water tanks. The major modification in the revision is the introduction of Limit State Design Method for water tanks, which was not recommended by BIS in order to avoid cracks.Also, The permissible stresses in steel was reduced to 130 Mpa and the clause for minimum steel has alos been modified.

In this paper, Intz type tank was designed by adopting both Working Stress Method IS 3370 (1967) and IS 3370 (2009), and Limit State Design Method as per IS 3370 (2009) and the results are discussed in the end of this paper.It was observed that the steel requirements, for permissible stress in steel less than or equals to 130 MPa, is same for both the cases.

I INTRODUCTION

"*Water is the driver of Nature*", as quoted by *Leonardo da Vinci*. . Throughout history, wood, ceramic and stones were used as water tank material In day to day life one cannot live without water. Therefore water needs to be stored for daily use. A water tank or storage reservoirs and overhead tanks are used to store water, liquid petroleum, petroleum products and similar liquids. In general there are three kinds of water tanks-

1. Tanks resting on ground,
2. Underground tanks and
3. Elevated tanks.

The tanks resting on ground are supported directly on the leveled ground. The walls of these tanks are subjected to hydrostatic pressure only and the base of the tank is subjected to weight of liquid and upward soil pressure. The base performs no special structural function and can be designed with the minimum required steel.

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The tanks may also be classified broadly with respect to their cross sectional geometry as- rectangular tanks, circular tanks, and Intz type tank.

Rectangular tanks are designed where moderate capacity of water is to be stored.. Circular tanks are used where tank with greater capacity is required. For smaller or moderate capacities, they are not recommended with an economical point of view, as the formwork required for circular tanks is very costly.

The rectangular tanks should be preferably square in plan from point of view of economy. It is desirable that longer side should not be greater than twice the smaller side.

The structures can be designed by three methods, namely-

- Working stress method,
- Ultimate load method and
- Limit state method.

Ultimate load method is not recommended these days. Other two methods generally used have been discussed here.

Limit state design method has been found to be the best when designing the reinforced concrete structures over the elastic theory of design where the stress variation in concrete and steel are such that the stress-deformations are taken to be linear.

There are two limit states- *Limit State of Collapse* and *Limit State of Serviceability* which includes deflection and cracking. The structure is first designed under limit state of collapse and then checked under serviceability. Because of its superiority over other two methods, IS 456:2000 has been thoroughly updated in its fourth revision in 2000 taking into consideration the rapid development in the field of concrete technology and incorporating important aspects like durability etc. This standard has put greater emphasis to limit state method of design by presenting it in a full section (section 5), while the working stress method has been given in Annex B of the same standard. Accordingly, structures or structural elements shall normally be designed by limit state method. It is important to point out here that a structure designed through limit state method when fails, the failure will be in plastic stage and not in elastic stage. Therefore, the cracking and cracking width can be significant at the failure stage.

II DESIGN METHODS

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, IS:3370 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:

1. Working stress method in accordance IS 3370 (1965).
2. Working stress method in accordance IS 3370 (2009).
3. Designing by Ultimate Limit State and then checking cracking width by limit state of serviceability IS 3370 (2009).
4. 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 following good construction practices.

III RESULTS & DISCUSSIONS

The design of sections of the components have been discussed here. However the calculations from both methodologies has not been discussed in this paper.

TOP DOME

Meridional Thrust	-	22.17 kN/m
Circumferential Force	-	10.4 kN/m

Meridional Stress - 0.27 N/mm^2

Hoop Stress - 0.13 N/mm^2

Note : All the linear dimensions are in mm and area is in mm2

Top Dome	WSM		LSM	
	IS 3370 1967	**IS 3370 2009**	**Crack theory**	**Deemed to satisfy**
Thickness	100	100	100	100
Area of Steel	300	175	120	--

TOP RING BEAM

Hoop Tension - 108.37 kN

Top Ring Baem	WSM		LSM	
	IS 3370 1967	**IS 3370 2009**	**Crack theory**	**Deemed to satisfy**
Cross-sectional area	62917	92917	35480	35480
Area of steel required	787	835	453	835

CYLINDRICAL TANK WALLS

Hoop Tension at base of the wall (Max.) - 494kN/m

Hoop Tension at the top of the wall - 120 kN/m

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Cylindrical Tank Walls	WSM		LSM	
	IS 3370 1967	IS 3370 2009	Crack theory	Deemed to satisfy
Thickness at base	350	350	150	150
Area of steel at base	3730	3730	2000	3700
Thickness at Top	200	200	100	100
Area of steel at Top	800	930	500	930

BOTTOM RING BEAM

Total Hoop Tension – 804 kN

Bottom Ring Baem	WSM		LSM	
	IS 3370 1967	IS 3370 2009	Crack theory	Deemed to satisfy
Cross-sectional area	720000	720000	540000	540000
Area of steel required	5245	6148	3321	6148

CONICAL DOME

Meridional Thrust - 580 kN/m

Hoop Tension - 770 kN

Conical Dome	WSM		LSM	
	IS 3370	IS 3370	Crack	Deemed

	1967	2009	theory	to satisfy
Thickness	600	600	500	500
Area of Steel	5110	5900	3200	5890

BOTTOM SPHERICAL DOME

Meridional Thrust - 340kN/m

Meridional Stress - 1.127 N/mm2

Circumferential Force - 85 kN

Bottom Spherical Dome	**WSM**		**LSM**	
	IS 3370 1967	**IS 3370 2009**	**Crack theory**	**Deemed to satisfy**
Thickness	300	200	200	200

Comparison of design by adopting Working Stress Method as per IS:3370-1965 & IS:3370-2009

1. No change in size of the members in both the cases.
2. The Steel requirements is increased when designed as per IS 3370 (2009).
3. The steel requirement in case to Top Dome is decreased due to the modification in minimum steel clause in IS 3370 (2009) when compared to that of IS 3370 (1967)

Comparison of design by Limit State Methods as per IS:3370-2009

1. For both limit state of collaps as well as deemed to satisfy conditions
2. The Steel Requirements for deemed to satisfy case increased as the limiting stresses for steel is restricted to 130Mpa from 140Mpa.

Comparison of design by adopting Working Stress Method and Limit State MEthod IS:3370-2009

1. The size of members decreased considerably when designed by Limit State Method as per IS 3370 (2009)in comparison with Working Stress Method as per IS 3370 (1965) and IS 3370 (2009).

IV CONCLUSION

Based on the obtained results, following conclusions are arrived at:

1. The member size remained same when designed by Working Stress Method per both IS 3370 (1967) and IS 3370 (2009).
2. The Steel requirement increased when designed by Working Stress Method as per IS 3370 (2009), as the permissible stresses in steel were limited to 130 Mpa.
3. The member size were unchanged when designed by Limit State Method as per IS 3370 (2009) for both limit state of collapse as well as deemed to satisfy .
4. The size of members as well as the steel requirement of the structure were reduced when designed by using Limit State Method as per IS 3370 (2009), when compared with Working Stress Method as per IS 3370 (1967)

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