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ANALYTICAL AND SOFTWARE BASED COMPARATIVE ANALYSIS OF ON GROUND CIRCULAR WATER TANK

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ABSTRACT

This paper presents comparative study of analytical and software based methods used for the analysis of on ground concrete circular water tank.An analytical methos consider as per IS 3370 and as given by pca(portland cement association),which are also compare with the result of FE analysis using software staad pro.Importance of the present study is to observe actual behaviour of tank subjected to static loading condition with special emphasis on IS:3370, PCATable and software STAAD.*Pro*. Different tanks has been considered for the analysis depending on the parameters like dimensional aspect ratio H^2/Dt (i.e. 14, 8, 4, 0.8) and end conditions at bottom having free at top (i.e. Hinged and Fixed) having similar storage capacity of 1 lac liter. Analytical calculations has been carriedout by Excel spread sheet program and finite element models have been observed in STAAD.*Pro* having similar parameters. Result output of hoop tension and bending moment shows similarity in the considered analytical approach but significant advantage of software based approach due to finite element modeling. Also, it revels that, engineers can apply software based approach more flexibly and efficiently to fulfill the practical tasks of structure modeling and analysis in engineering to achieve economy.

KEYWORDS: IS 3370, PCA, STAAD.*Pro*, Tank, Water Tank

INTRODUCTION

Water is a basic element for every life on earth. The different need of water is for drinking, irrigation, industrial manufacturing, fire suppression, etc.so it is very important to deal with the storage of water as properly as possible.Water tank is the container for storing water in large quantity. The water tanks are constructed to store water at a ground level for the daily use, treatment of water, product manufacturing, emergency storage, rainwater storage tanks etcSo,it is a very important structure for the human society.The development of the human civilization is introduced many different types of water storage tank.

For storing a large capacity of water the circular water tank is preferable. Circular water tank are mainly use for the Industrial water storage, treatment of the waste water, Storage of a large amount of water etc. Shuttering of circular tank is difficult to place at construction site compare to the rectangular water tank. Circular water tanks are not used for smaller capacities of water tank because of the costly shuttering. Circular tanks are prefer for the large capacities since they are economical and have a high stability compare to rectangular water tank. Circular water tank required less construction material than the Rectangular water tank.

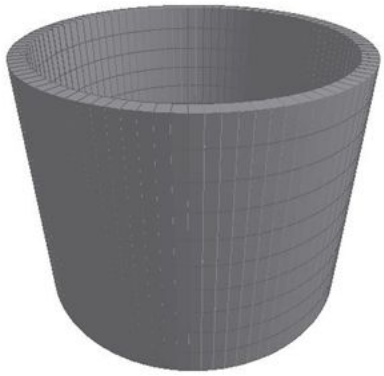


Figure 1: Software Model of Circular Water Tank

Past Study

Prof.R.V.R.K.Prasad, Akshaya B. Kamdi [3]study on the design of circular water tank using working stress method and limit state method.Dr. H. K. Sharma, V. P. Singh, Satpal Sharma[4]Comparative study for different end condition using exact analysis and standard software STAAD Pro.

An exhaustive literature review revealed that a minimum amount of research work had been done on parametric study of circular water tankusing different methodology in India. Comparison between IS 3370:2009 and PCA Table is not evaluated yet. Comparative study of IS 3370 : 2009 and STAAD.*Pro* is not accomplished.Monolithic behavior of the tank is not occupied in the code.

Different Approaches for the Analysis of Circular Water Tank

This work is focused only on tanks resting over ground (clear water reservoirs, settling tanks, aeration tanks etc. are some of the examples). The wall of these Tanks is subjected to water pressure. Water tanks are used to store water and are designed as crack free structures, to eliminate any leakage. In this work design of eight types of circular water tanks resting on ground is presented.

The Codes are prepared to fulfill the general requirements for the design and construction of concrete structures for storage of liquid, mainly water. At present, different codes are available to give the reference about the water retaining structures in the different countries. In India IS 3370:2009[5,6,7,8] practice and the PCA Tablefor a circular water tank is a foreign code for the water retaining structures, this two codes are selected for the comparative study.

Is 3370:2009[5, 6, 7, 8]

Bureau of Indian Standards Prepared the code for the Water retaining structures. The code contains four different parts (I, II, III, and IV) for the designing of the water tank.IS: 3370 (Part I) [5] deals with the basic requirement for liquid storagestructures mainly dealing with type of material, concrete mix, site condition,protection against corrosion, crack controlling, thickness of section, jointrequirements and finally construction and testing on structure.IS: 3370 (Part II) [6] Reinforced concrete structures. IS: 3370 (Part III)[7] deals with prestressed concrete structures for thestorage of liquid.IS: 3370 (Part IV)[8] recommendsthe hoop tension and moment coefficient for circular water tank at the different height level.IS 3370:2009 provide two end conditions for the circular water tank free top fixed based and free top hinged based end conditions. Code provide different H2/Dt ratios for the circular water tank. Ratios are (0.4, 0.8, 1.2, 1.6, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16)

A computer program in MS-EXCEL has been developed for solving numerical examples using the Indian standard code IS-3370-I, II, III, IV.The recommendations in this work are intended to supplement the general requirements for reinforced concrete design, materials and construction, given in IS 3370 PART I, II,III,IV for economical design of water tank.

PCA Table for Circular Water Tank [9]

PCA Table for circular water tank is preparedby the Portland Cement Association.It provide coefficients of Moment and Hoop Tension for the circular water tank.PCA provide two end conditions for the circular water tank free top fixed based and free top hinged based end conditions. PCA provide different H^2/Dt ratio (0.4, 0.8, 1.2, 1.6, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16) for the circular water tank.A computer program in MS-EXCEL has been developed for solving numerical examples using the PCA table.

Staad.*Pro*[10]

STAAD.*Pro* is a structural analysis and design computer program. The software provide both the plate element and shell element approach for the design of the circular water tank. In current studyplate element approach used for the circular water tank design. The plate element approach provides plate property and behavior of plate under different load and support conditions to the structure.STAAD.*Pro*provides different end conditionsand load condition to the structure as per the design requirement. In present study plate element used for wall with free top- fixed based and wall with free top-hinged based end conditions are consider.

Triangular load applied on the wall to represent the water load on the walls.For the Optimum conversions of plate behaviouron to achive appropreate analysis outcome under the applied load and end condition size of plates has been decided based try and error analysis.STAAD.*Pro* provide the moment and hoop tension value at the end corner of the plate and average plate value at the midpoint of plate separately for every plate used in the circular water tank.

Description of Structure

In this study, models of Circular water tank with 1 lac litters storage capacity have been investigated. Variations are made in tank's Diameter, Height and End Conditions. Adapted Ratio of Height^2/Dia*thickness (H^2/Dt) are 14, 8, 4 and 0.8 for each End Conditions are taken under consideration. All the structures are made of RCC and grade of concrete is M25. Tanks are designed with perfect accordance to the Indian Standard criteria for liquid retaining structure and PCA Tables for circular water Tank. Other structural configurations are as per Table 1. Figure 2shows the finite element models of the tanks prepared in STAAD.*Pro*.

Table 1: Circular Tank Model Details

No.	Tank Name	H^2/DT Ratio	D (M)	H (M)	T (M)	End Conditions
1	Tank 1					Free Top Hinged Bottom
2	Tank 2	**14**	5.5	4.4	0.25	Free Top Fixed Bottom
3	Tank 3					Free Top Hinged Bottom
4	Tank 4	**8**	6.05	3.5	0.25	Free Top Fixed Bottom
5	Tank 5					Free Top Hinged Bottom
6	Tank 6	**4**	6.95	2.65	0.25	Free Top Fixed Bottom
7	Tank 7					Free Top Hinged Bottom
8	Tank 8	**0.8**	9.8	1.4	0.25	Free Top Fixed Bottom

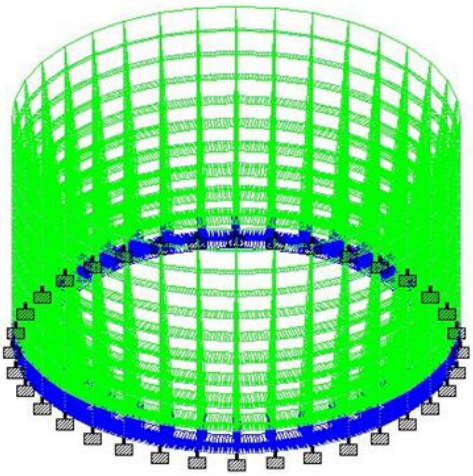


Figure 2: STAAD.*Pro* Model of Circular Tank with Fixed Base Free Top End Condition

RESULTS AND DISCUSSIONS

The behavior of circular water tank is studied in the terms of hoop tension and moment at different height levels. Fixed base Free top and Hinged base Free top end conditions are premeditated for the circular water tank. Four different H^2/Dt ratio are calculatedas per Table 1. Each particular tank is design through the IS 3370:2009, PCA Table and STAAD. *Pro*. Graphs of the results for Hoop tension and Moment are the comparative study of the one particular water tank.

Tank: 1 ($H^2/Dt = 14$)

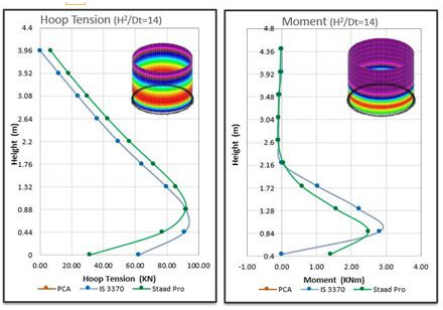


Figure 3: Fixed Base and Free Top

Tank: 2 ($H^2/Dt = 14$)

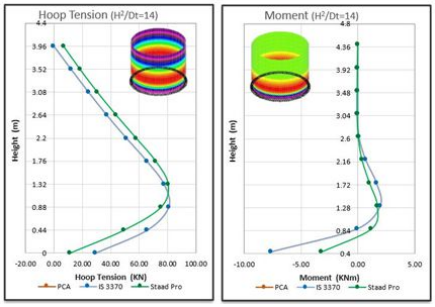


Figure 4: Hinged Base and Free Top

Tank: 3 ($H^2/Dt = 8$)

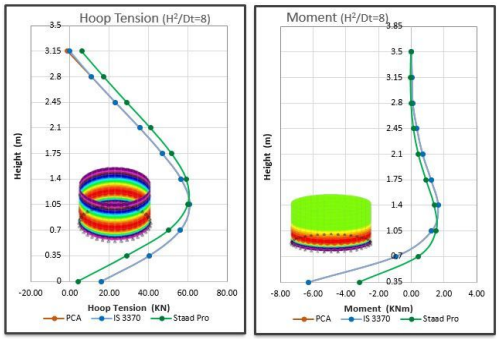


Figure 5: Fixed Base and Free Top

Tank: 4 ($H^2/Dt = 8$)

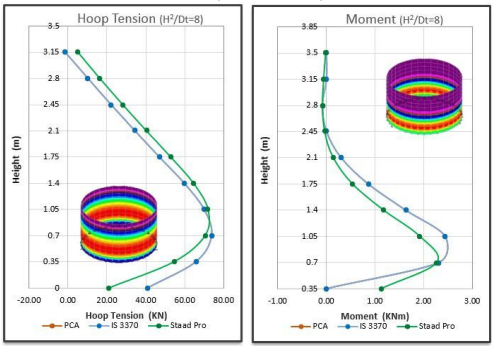
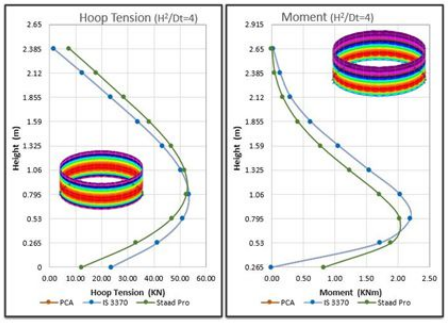


Figure 6: Hinged Base and Free Top

Tank: 5 (H^2/Dt = 4) **Tank**: 6 (H^2/Dt = 4)



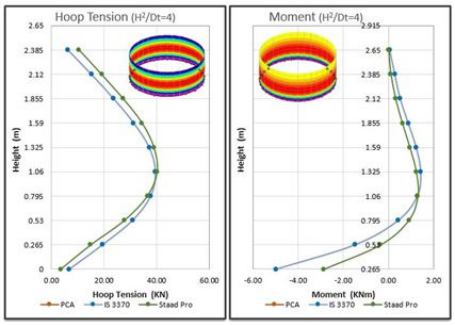
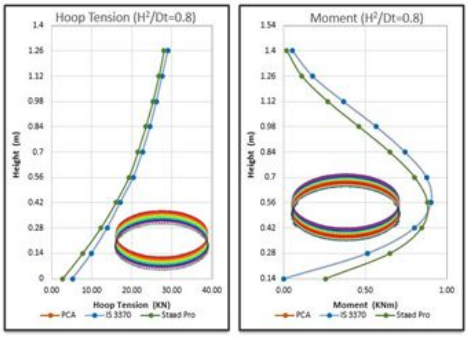


Figure 7: Fixed Base and Free Top **Figure 8: Hinged Base and Free Top**

Tank 7: (H^2/Dt = 0.8) **Tank: 8 (H^2/Dt = 0.8)**



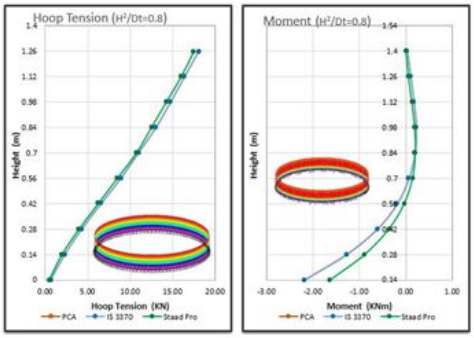


Figure 9: Fixed Base and Free Top **Figure 10: Hinged Base and Free Top**

CONCLUSIONS

- Results from the parametric study of circular water tank based on IS 3370:2009, PCA table and STAAD.*Pro* is accomplish that IS 3370:2009 and the PCA Table have exactly similar result for the circular water tank. Other hand Result from softwareSTAAD.*Pro* have some variation than the IS 3370:2009 and PCA Table.
- Value of Hoop Tension in the case of IS 3370 and PCA table in comparison ofSTAAD.*Pro* is gradually decreasing as the H^2/DT ratio is decreased from 14 to 0.8.
- Circular water tank the graphs show for all H^2/DT Ratio have a maximum hoop tension value near from the 1m height of the wall of the water tank.
- Study of the circular water tank using different ratio for same capacity gives Hoop Tension value which is higher at the ratioH^2/DT = 14 compare to the lower ratioH^2/DT = 8, 4 and 0.8.

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