Intze Tank: A Brief Survey

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Abstract - *Liquid storage tanks whether it be underground or overhead or on the surface are commonly used in industries for storing chemicals, petroleum products, many such fluids, etc. and for storing water in public water distribution systems. Importance of maintaining safety norms of such tanks against seismic loads cannot be neglected and taken lightly. Indian seismic code IS 1893:1984 showed very limited provisions on seismic design of both elevated and underground tanks. Compared to present international practice, those provisions of IS 1893:1984 are highly inadequate. Moreover, the code failed to cover ground-supported tanks. In 2002, revised Part 1 of IS 1893 was established in the market by the Bureau of Indian Standards (BIS) in order to maintain safety issues for these tanks. The present study will deal with the whole design analysis and parametric study of structural analysis of circular and rectangular water tank to avoid stresses and cracking. Modal analysis of tank will be done to define the mode shapes of tank under self-weight. After modal analysis seismic loading of tank will be done to check for deformations. The simulation of tank will be done using ANSYS work bench considering both thermal and structural analysis of tank.*

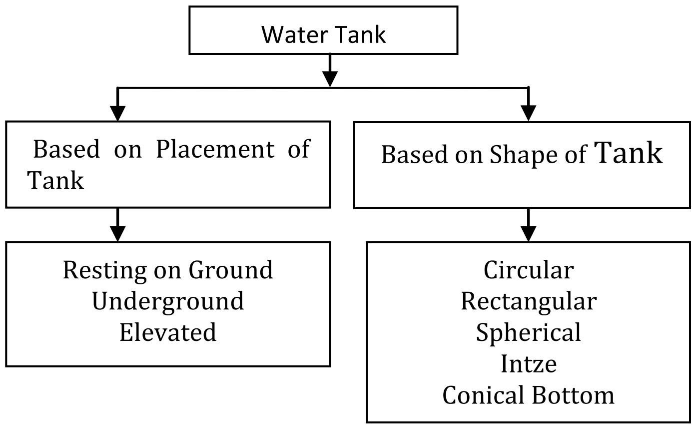
Key Words: **IS code, ANSYS, Parametric, Structural, Modal, Seismic loading**

1. INTRODUCTION

Reservoirs and Tanks are used to ensure the safety from the liquid it is storing, unwanted spillage and in majority cases to store products like liquid petroleum, water, petroleum products and different types of fluids. The structural analysis mainly the forces involved with these reservoirs or tanks is about the same importance when compared to the chemical degradation of the products. All tanks are designed in order to have a crack free structuresso as to eliminate any leakage from it. The walls and retaining slabs of these tanks and reservoirs are made up of reinforced concrete with adequate cover to the reinforcement. Whether its water or petroleum, the liquid stored in these tanks may or may not react with concrete and, therefore, for safety issues no special treatment to the surface is being preferred. So, the tank itself should be self-resistible to these types of dangers whether it be chemical or structural. Sometimes, different kind of wastes from different places like industries and household chores are collected and also processed in these tanks for recycling purpose but with very strict exception. The products of petroleum such as petrol, diesel oil, etc. are most likely to leak through the concrete walls, thus these kind of tanks need special membranes to prevent leakage of the fluid it is enclosing. Reservoir is a common term applied to liquid storage structure and it can be below or on the surface or above the ground level. Reservoirs situated under the ground are normally built to store large quantities of water whereas those of overhead nature and built are used for direct distribution by gravity flow and are usually used to store smaller capacity of water.

1.1 Classification of water Tank

The classification of a reservoir is based on the location on which it is to be built and also on the shape of the reservoir



2. SLOSHING EFFECT

The movement of liquid inside another object is known as Sloshing. The liquid sloshing may cause various engineering problems, for example instability of ships, in aerospace engineering and ocean engineering, failures on structural system of the liquid container. The motion of liquid with a free surface is of great concern in many engineering disciplines such as propellant slosh in spacecraft tanks and rockets (especially upper stages), cargo slosh in ship and trucks transporting liquid (for example oil and gasoline), oil oscillation in large storage tanks, water oscillation in a reservoir due to earthquake, sloshing of water in pressure-suppression pools of boiling water reactors and several others. Depending on the types of disturbance and container geometry, the free liquid surface can experience different types of motion including planar, non-planar, rotational, and symmetric, asymmetric, disintegration, quasiperiodic and chaotic When interacting with its elastic container or its support structures, the free liquid surface can exhibit fascinating types of motion in the form of energy exchange between interacting modes

2.1 Linear Wave Theory

Sloshing is often analyzed in a simpler form where no overturn takes place, that is to say when the free surface strays intact. Assumptions like incompressibility, irrotational flow, inviscid (viscous/drag/friction terms are negligible), no ambient velocity (no current), two dimensional and small amplitudes allow for a simplified analysis via linear wave theory

2.2 Sloshing in Moving vehicle

The problem of liquid sloshing in moving or stationary containers is of great concern to aerospace, nuclear and civil engineers, designers of road tankers, physicists, and ship tankers and mathematicians. Seismologists and civil engineers have been studying liquid sloshing effects on oil tanks, large dams, and elevated water towers underground motion. They also mounted liquid tanks on the roofs of multistory buildings as a means to control building oscillations due to earthquakes

3. LITERATURE SURVEY

Krishnakumar [1] performed a seismic analysis on a steel tank based on complex fluid interactions that leads to global overturning moments and base shear which is caused as a result of inertial forces acting in the horizontal direction. The entire reservoir along with the loads is modelled in Ansys and modal analysis and response spectrum analysis are performed. The study is related to modelling a reservoir having a base diameter of 10 m and a height of 11m and exposed to four different liquid levels of the tank (25, 50, 75 and 100 percent). The results for the reservoir was very much acceptable as it was found that the tank failed to be under acceptable limits when it was 0, 25 and fully filled to sustain seismic loading and the maximum effect was obtained in the direction perpendicular to the base of the tank as the normal stresses showed very high values. The design philosophy that was followed is based on two distinct modes of vibration of the water that is contained in the reservoir. The two modes are rigid impulsive mode and convective mode. In the figure, m_i and $m_c$denotes the impulsive as well as convective masses of the liquid in the retainer.

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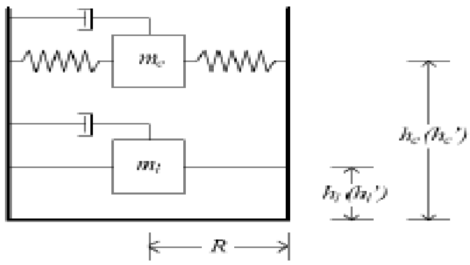

Fig- 3.1: Impulsive and Convective fluid mass

Anumod [2] performed a study on various components of earthquake so as to get an idea on the sloshing response of liquid storage tanks. The study was based on two fronts namely the basic analysis of the tank so as to have a unidirectional analysis and secondly a FEM model was made and a dynamic response of the tank behaviour was handled. The third part of this study was a parametric observation made for different geometrical aspects of the tank so as to handle various time series of earthquake excitations. The modelled tank was subjected to both unidirectional as well as bidirectional earthquake excitations. At last the observations were made so as to estimate the maximum sloshing height inside the tank and the tank was assumed to be under the influence of an earthquake prone zone in India. This study helped us to develop a simple procedural approach so as to handle directional earthquake excitations when it comes to reservoir safety.

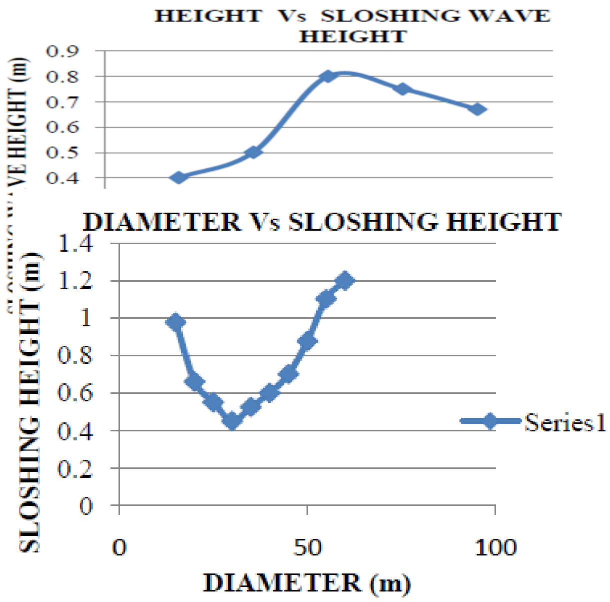

Fig- 3.2: Variation of sloshing wave height with Tank Height and Diameter

Lodhi [3] presented a paper that was based on the study of Intze type water tank which was designed under Code of Practice IS 3370. The study was performed so as to determine the differences in design parameters for two conditions, the first condition being the design analysis of Intze tank without considering the earthquake forces and the second one being the design analysis of Intze tank by considering the earthquake forces. Both the design procedureare based on ISO standard codes. The first one was based on Indian Standard Code 3370 – 1965 and the second one on 3370 – 2009 and draft code of 1893 – Part 2 (2005). From this study, it was concluded that old code IS: 3370 – 1965 was found unsafe for water tank design.

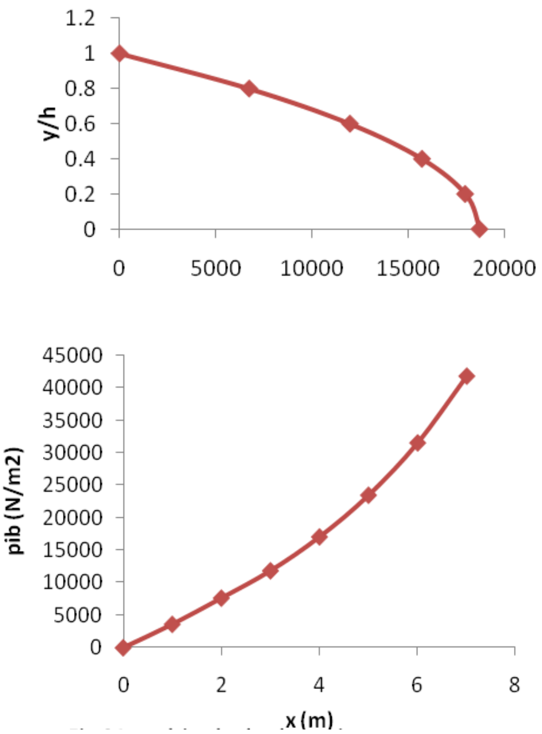

Fig-3.3: Variation of Hydrodynamic pressure for both the models.

This paper presented two empirical relations based on which the hydrodynamic pressure was calculated for side wall of the reservoir and also for the base slab of the tank.

Harsha [4] presented in their study a design analysis for water tank based on new IS code 3370-2009 and draft code of 1893-Part 2. They considered two mass models one being the impulsive one and the other being the convective model. Simulation work is performed on STAAD Pro on Intze type water tank supported on frame staging. The loading conditions were seismic and wind forces. From this study, it was clear that for elevated tanks, two degree of freedom idealization of tank showed better results when they were compared with the one degree of freedom of idealization. The figure above shows the three dimensional model of the Intze type water tank along with the beams, sections and plates of the tank. The model was loaded with earthquake loads (seismic loads) followed by Wind loads on the columns of the tank and summed up by considering the self-weight of the entire assembly. Few observations were made – the first being the variation of hydrodynamic pressures on the geometrical aspects of the tank, the second being the comparison of total base shear and moment for empty and full conditions of the tank and the last being a comparative study among time period, base shear and base moment for impulsive and convective modes of vibration.

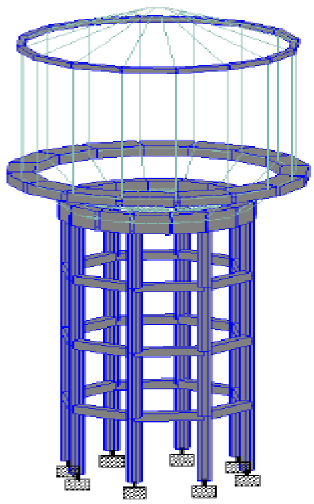

Fig-3.4: CAD model of the Intze type tank along with the foundation

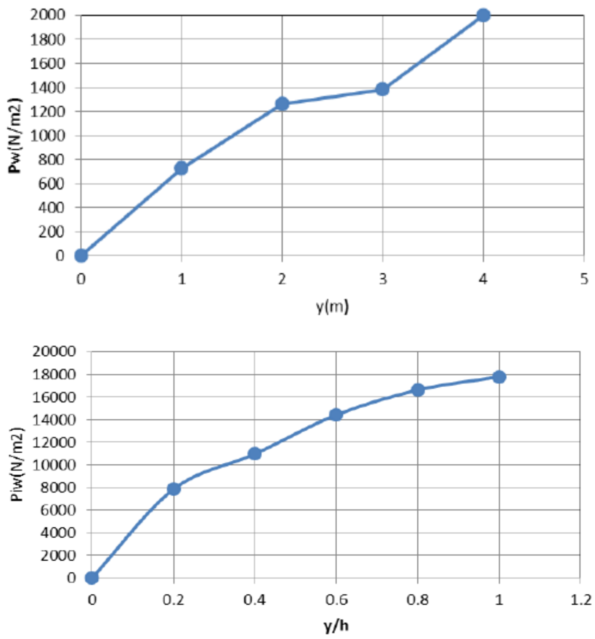

Fig -3.5 Variation of Hydrodynamic pressures for impulsive and convective modes of vibration

Eltaly[5] performed an experimental study to calculate the dynamic parameters which include frequencies and mode shapes of scaled models of liquid retaining elevated water tanks. The entire experimental work was also modelled in

Ansys and simulation was run so as to simplify the long analytical calculations and to get better and accurate results from the simulations for seismic loading. The method which was used to represent the dynamic nature of the elevated water tank is Housner and the entire loading was done at the base of the tank. The entire calculation was based for two models of tanks. The results showed that AVT (Ambient Vibration Test) showed better results to capture the modes of the water tanks basically the sloshing mode of water in the tank at very low frequencies.

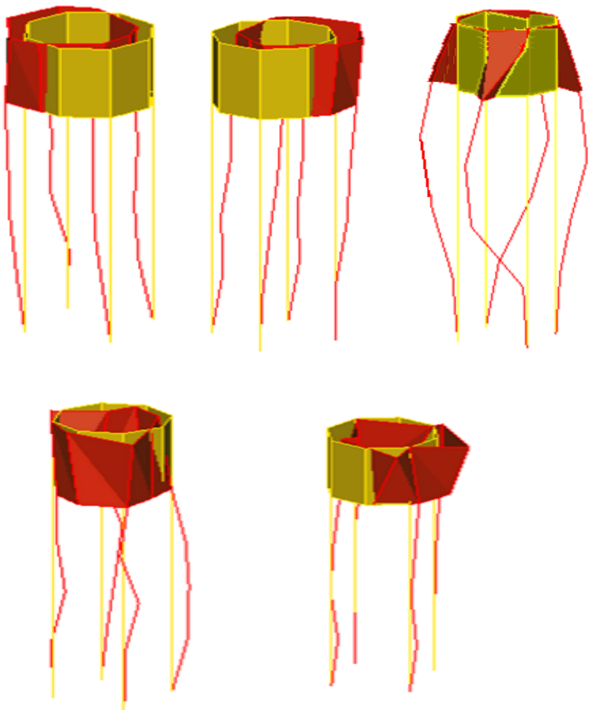

Fig -3.6: Five Experimental Mode Shapes of Prototype for Water Tank

The figures above shows the mode shapes that was experimentally determined by subjecting the small scale prototype of the water tank to variable loads having frequencies between 15 Hz to 174 Hz

3. CONCLUSIONS

In this paper we have discussed about the sloshing effects of the water contained inside the reservoir and also to understand the modal characteristics of the model that is underlined. However, very less emphasis is given on the design aspects and to calculate the entire Elevated Liquid Reservoir geometrical characteristics by taking into considerations the standard IS codes. Thus, we can revise our work based on design perspective and complete the simulation on the calculated results for the tank so as to better optimize the design instead of considering non designed tank structure.

REFERENCES

[1] Krishnakumar P and Jacob J, "Seismic Analysis of Steel Fuel Storage Tanks", IOSR Journal of Mechanical and Civil Engineering, e-ISSN: 2278-1684, p-ISSN: 2320-334X, PP – 41-47

[2] Anumod AS, Harinarayan S and Usha S, "Finite Element Analysis of Steel Storage Tank under Seismic Load", International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622M.

[3] Lodhi RS, Sharma A and Garg V, "Design of Intze Tank in Perspective of Revision of IS:3370", International Journal of Scientific Engineering and Technology (IJSET), ISSN:2277-1581, Volume No 3, Issue No 9, PP – 1193-1197

[4] Harsha K, Reddy KSK and Kala KS, "Seismic Analysis and Design of Intze Type Water Tank", International Journal of Science Technology and Engineering, ISSN: 2349-784X, Volume 2, Issue 3, September 2015

[5] Eltaly B et al, "Experimental and FE Modal Analysis for Elevated Steel Water Tanks", International Journal of Engineering Research and Technology (IJERT), ISSN: 2278-0181, Volume 3, Issue 1, January 2014