Comparision of Analysis of Overhead Intze Water Tank by Finite Element Method on Seismic Loading and Wind Loading

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Abstract - *The high-end water tank is made of reinforced concrete A building of great importance. They are considered the main lifeline elements during and after the earthquake. Inze tank behavior Something like an inverted pendulum made of a huge mass of water at the top of lean staging. this is the most important Consideration of tank failure during an earthquake. Basically, the support system, the so-called staging, A group of columns and horizontal brackets that form a column. staging is fully responsible for lateral resistance structure. This analysis is performed by the finite element method as follows. intze tank seismic stress in zone 4 acc Geographic Survey of India. Comparison of principles different packing states of stress and deflection occur. Applying Earthquakes and wind loads . The analysis is The performs for different types of water tanks. capacity. You can run the same analysis for different earthquakes zone in India. This analysis can also be performed using different storage materials instead of water. Stress increases as water level rises The tank is due to the FSI effect of liquids, which causes stress when the tank is full. Found about twice the empty tank voltage on the state. As the amount of water increases, the deflection also increases. At the level in the tank, the stress increases and deflection occurs. The water level rises very little when the wind hits it Loads, Maximum Stresses and Deflections with Different Fillings The conditions are almost the same as for wind loads.*

Key Words: **structural analysis, axial force, soil, seismic zone, deflection, Maximum Stresses.**

1.INTRODUCTION

Similar to round tanks, they are provided with a conical bottom at the bottom. More forces and vibrations act on the water tank. B. Water pressure on tank walls, wind pressure, dead weight of tank, seismic forces on base tank, and sloshing behavior of liquid in tank at different fill levels. Therefore, to fully investigate a water tank, it is necessary to investigate the effects of all forces on the tank under different filling states, either with fluid-structure interactions or without FSI. Many studies have been done in the past on the analysis of aquaria using different loading conditions and different analytical methods. For example, various studies are being conducted such as static analysis of water tanks against wind load and seismic load, free vibration analysis of water tanks, and forced vibration analysis of water tanks. In this study, ANSYS software is used to perform a static model analysis of a water tank with a capacity of 1000 m3. A finite element analysis of a tank for seismic loads at different filling states, including the effects of fluid-structure interaction, is performed in this study for the same tank with a capacity of 1000 m3. Seismicity is the sudden movement of the earth's crust caused by the rapid release of crustal energy. Earthquakes are relatively severe geological disasters that destroy homes and buildings and lead to subsequent disasters. Soil-structural interactions are a complex phenomenon involving the effects between various components such as the foundation and bearing soil, liquid and walls of the liquid layered soil system of the Intze aquaria. The typical design of the Intze water tank ignores the interaction between the soil, foundation, and tank structure to simplify the analysis. In general, the effect of subsidence of supporting soil on the tank superstructure is neglected. Previous studies have shown that interaction effects are important studies for the analysis of stresses, especially for structures placed in highly compressible soils.

Aquarium type tanks can be divided into three categories based on the location of the tank within the building. These are:

- Underground tanks
- Tank is on Terrain
- Overhead or elevated tanks

Elevated Tank

The elevated tank has many advantages. Elevated tanks do not require continuous operation of the pump. Pressure is maintained by gravity, so momentary pump stoppages do not affect water pressure in the water distribution system. The strategic placement of tanks also helps balance the water pressure in the water distribution system. However, it can be difficult to control the exact water pressure in some elevated tanks. The pressure of the water flowing out of the elevated tank depends on the depth of the water in the tank. A nearly empty tank is likely not providing enough pressure, and a completely full tank can be providing too much pressure. Optimal pressure is reached only at one depth.

Optimal water depth for pressurization purposes is more specific to standpipes than to foot-mounted tanks. The length of the standpipe causes constant and highly uneven pressure in the distribution system. It also requires a large amount of water in the standpipe to generate the required water pressure.

types of elevated water tanks by shape The types of tanks by shape are as follows:-

1. Round Tank
2. Rectangular tank
3. inzetank

Inzetank Similar to the round tank, the bottom is provided with a conical bottom. Support can be divided into two types. 1. Pillar mounted water tanks 2nd shaft waste water tank In general, a water tank attached to the column is preferred for easier SOC calculations. Many more forces and vibrations act on the water tank, such as water pressure on the tank wall, wind pressure, self-weight of the tank, seismic forces on the base tank, sloshing behavior of the liquid in the tank at different filling levels. To fully investigate the effects of all forces on the tank under different filling conditions, with fluid-structure interactions or without FSI, should be investigated. Many studies have been done in the past on the analysis of aquaria using different loading conditions and different analytical methods. For example, various studies are being conducted such as static analysis of water tanks against wind load and seismic load, free vibration analysis of water tanks, and forced vibration analysis of water tanks.

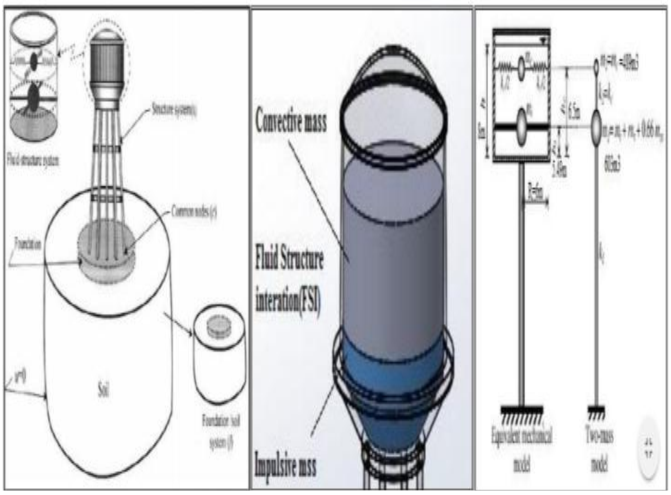
1.1 Soil Interaction

Theory of soil-structure interaction

Soil structure interaction is the interaction between structure and soil called soil structure interaction. Two mechanisms are involved in the soil structure interaction: (1) kinematic interaction and (2) inertial interaction. A "free field" is a space sufficiently distant from a support structure that ground movement (called free field ground movement) is not impeded by movement of adjacent structures. In general, if the distance traveled by the base is less than the dimensions of the base, the movement of the base will not match the movement on the ground in the field. This effect is called kinematic interaction. On the other hand, structures have a large mass and give inertial motion to the ground, causing ground displacement. This phenomenon is called inertial interaction (Wolf1985). Structural interactions with the surrounding soil are stratified, which leads to changes in dynamic wave behavior. Dynamic analysis must consider the interaction between structure and soil. The dynamic response of a geo-structural interaction system is the objective of a seismic model of the system when subjected to three components, the seismic parameters of position, motion, and stimuli, and seismic loads. Site seismic parameters include Young's modulus (E), density (D), soil Poisson's ratio, and soil damping. Attenuation can also be divided into two different types: internal attenuation and radiation attenuation. Internal attenuation is caused by kinetic waves passing through layered soil and can be considered as a source of energy loss due to debris in the soil, whereas radiation attenuation is the energy loss due to wave emission from the structure foundation to the structure. cause loss. And outside of hemispheric reason, such an algebraic distribution of elastic motion is called geometric damping. Proper seismic analysis of soil-structure interaction system response requires excitation, including determination of the various components and free-field motions of the system. Calculation of structure-free earth movement and scattering of seismic waves by the interaction system of soil and structure. Following the principle of superposition, excitations resulting from free-field and interaction analyzes are added, and the seismic model of the system includes dynamic model relationships of the underlying environment. Many models are available for considering and analyzing interactions. Soil-structure interactions generally fall into two categories, direct and substructural approaches, each of which is complex.

Theory of Fluid-Structure Interaction

Fluid-structure interaction (FSI) is a complex phenomenon between laws describing fluids and structures. This phenomenon is characterized by a stable or possibly oscillating interaction between a deformable or moving structure and the surrounding or internal fluid flow. When a fluid stream impinges on a structure, it subjects the frozen part to stress and strain patterns that can cause displacement. These displacements are determined by the pressure and momentum of the flow and the material properties of the actual structure and can be very large or small. There are two types of vibrations that occur in tank tops of tank containers. They are called convective masses and are always sloshing kinetic effects and the bottom of the part is called impact mass.



2 METHEDOLOGY

Finite element analysis with circular INTZE type water tank

Pretreatment:

Modeling a circular Intze Type Water Tank Model of the Current Problem of the Waterline.

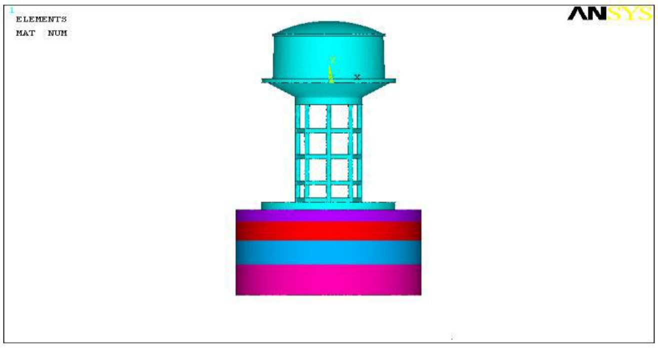


Fig -1: model of intz water tank by ANSYS

Item Type: Solids 187 elements are used for concrete structures. Also, the Fluid 30 element is used to indicate the presence of water in the tank. solid 187 element description: The SOLID187 element is a high order 3D element with 10 nodes. SOLID 187 has second order displacement behavior and is suitable for modeling irregular meshes. The element is defined by 10 nodes with 3 degrees of freedom at each node (displacements in the nodal directions x, y, z). This element has the features of plasticity, hyperelasticity, creep, stress hardening, large deflection, and large elongation.

Material model:

Table 1: Material Properties Used in Analysis

Material used	Young's modulus of elasticity	Poisson's Ratio	Density
Concrete	25.49 Gpa	0.2	25 kN/m3
Soil 1	35 Gpa	0.28	17 kN/m3
Soil 2	40 Gpa	0.29	17.4 kN/m3
Soil 3	45 Gpa	0.3	18 kN/m3
Soil 4	55 Gpa	0.32	19.2 kN/m3
Soil 5	60 Gpa	0.33	19.9 kN/m3
Water			10 kN/m3

Mashing:

Tetrahedral free mashing is used for the mashing of water tank. And the element size is taken 500 mm

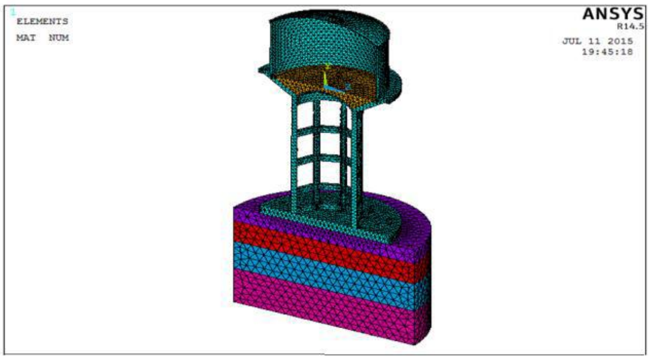


Fig -2: Mashing of tank full homogenous empty.

Analysis type: -

In present study we have to analyze the random vibration analysis of water tank due to seismic loading condition. Therefore analysis type used in this study is Static and Static and modal

Boundary condition: -

In present study the intze tank is fixed at base. For analysis of full tank only base are fixed but for analysis of same tank by half model we have to fix the base as well as symmetric boundary condition is also applied on symmetric portion.

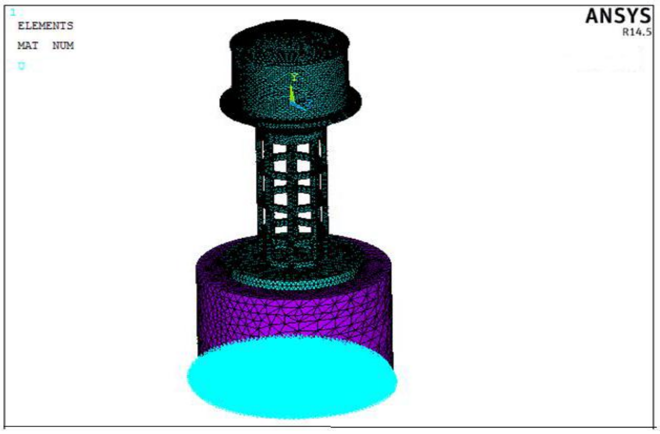


Fig -3: boundary condition for full tank (only base fixed)

3. RESULTS AND DISCUSSION

In present study we have done static analysis of Intze water tank for seismic loading including fluid structure interaction effect due to presence of water in tank for seismic loading condition as well as for wind loading condition. In present analysis we assume that wind loading and seismic loading is same in nature, both induced random effect on any structure but only difference is this the wind load is act on superstructure and seismic load is act on substructure of intze water tank.

Therefore in this chapter we discuss the performing results of different analysis in different loading condition on intze water tank. The headlines are given below:

Static analysis of intze water tank for different loading condition including FSI effect

- Static analysis of tank due to seismic loading.
- Static analysis of tank due to only wind loading condition.

Static Analysis of Overhead Intze Water Tank Including FSI Effect

In static analysis we take all three cases loading that can be applied on an elevated intze type water tank, and mutually compare the results of all three cases and then conclude the worst condition of loads. The condition of loading and their results are discussed below.

- Analysis of tank due to seismic loading.
- Analysis of tank due to only wind loading.

These all studies and their results are given below.

3.1 Static analysis of elevated intze water tank for seismic loading including FSI effect

In this analysis we applied an seismic load on different filling condition in the tank and plot the results for maximum principal stresses, minimum principal stresses, maximum deflection, minimum deflection, and overall stresses on the in all six filling condition of tank. The results of that analysis are summarized in given table.

Table -2: Stresses and deflections of the tank due to seismic loading

Filling condition of tank	1st Principal stress (N/mm²)		2nd Principal stress (N/mm²)		3rd Principal stress (N/mm²)		Max deflection
	(+ve)		(+ve)	(-ve)	(+ve)		(mm)
Empty	9.13	1.56	2.42	2.41	1.75	8.49	11.59
20%	2.29	0.48	0.69	0.67	0.43	2.58	2.98
40%	2.09	0.43	0.63	0.55	0.43	2.07	2.78
60%	2.08	0.43	0.63	0.55	0.40	2.04	2.77
80%	2.09	0.45	0.62	0.57	0.38	2.25	2.77
100%	2.18	0.37	0.58	0.58	0.42	2.03	2.77

Discussion:

maximum stress in tank due to seismic loading is generated at full tank condition and the value of stress is 12.842 N/mm2and permissible stress of concrete which is used is 25N/mm2, Stress generated in tank is approximately half of the permissible stress of tank therefore we can conclude that the tank is safe in stress due to seismic loading in all filling condition. And maximum deflection 16.3034mm occurs at top dome in tank full condition which is also acceptable.

3.2 Static analysis of elevated intze water tank for Wind loading including FSI effect

In this analysis we applied an wind load instead of seismic load as in previous study on different filling condition in the tank and plot the results for maximum principal stresses, minimum principal stresses, maximum deflection, minimum deflection, and overall stresses on the in all six filling condition of tank. The values of deflections and stresses in different filling condition in tank are mentions in table given below.

Table -2: Stresses and deflections of the tank due to Wind loading

Filling condition of tank	1st Principal stress (N/mm²)		2nd Principal stress (N/mm²)		3rd Principal stress (N/mm²)		Max deflection
	(+ve)		(+ve)	(-ve)	(+ve)		(mm)
Empty	9.13	1.56	2.42	2.41	1.75	8.49	11.59
20%	2.29	0.48	0.69	0.67	0.43	2.58	2.98
40%	2.09	0.43	0.63	0.55	0.43	2.07	2.78
60%	2.08	0.43	0.63	0.55	0.40	2.04	2.77
80%	2.09	0.45	0.62	0.57	0.38	2.25	2.77
100%	2.18	0.37	0.58	0.58	0.42	2.03	2.77

Discussion:

When the tank is fully loaded, the maximum stress of the tank due to the seismic load occurs. The stress value is 2.1845N/mm2, and the allowable stress of the concrete used is 25N/mm2. The stresses occurring in the tank are very low compared to seismic loads. Therefore, it can be concluded that the tank is safe under load due to seismic loading under all filling conditions. And the maximum deviation of 2.7732mm occurs at the top of the tank full dome, which is very small and acceptable.

3. CONCLUSIONS

1. **Conclusion from Static analysis of elevated intze water tank for seismic loading**

    1) 1st principle stress in tank due to seismic loading is generate at full tank condition and gradually decreases up to 50% with decreasing the water level in the tank.

    2) Maximum increment of stress due to increase the water level in the tank is 14% at 20% filling condition.

    3) Maximum deflection occurs at top dome in tank full condition is 16.303mm and minimum in tank empty condition is 8.6548mm

    4) Deflections are gradually decreases from 0 to 45% with decreasing the water level in tank.

2. **Static analysis of elevated intze water tank for wind loading**

    1) Very less increments or decrements occur due to decrease the water level in tank. Therefore effect of water level can be ignored.

    2) Maximum stress in tank due to seismic loading are generated at 20% filling condition due to sloshing behavior.

    3) Stresses and deflections generated in tank are very low as compare with seismic loading condition therefore tank is safe for wind loading in all filling condition.

3. **Overall Conclusions form Static Analysis**

    1) Stresses are increase with increase the water level in tank due to FSI effect of fluid, stresses at tank full condition are found approximately double of the stresses in tank empty condition.

    2) Deflection are also increase with increase the water level in tank, maximum deflection occurs at top dome of tank in tank full condition at critical condition (combined seismic & wind load condition) are found 166% of minimum deflection at top dome in same condition.

    3) Increments in stresses and deflections with increment of water level is very less in application of wind load, maximum stresses and deflection in different filling condition are almost same for wind loading.

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