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Random Vibration Analysis of Intze Water Tank with Fluid-Structure-Interaction – A Review

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Abstract

Pre-stressed (Random) vibration analysis due to wind and seismic load in different filling condition of an elevated intze water tank fluid system has been studied using finite element method. In present work the pre-stress effect of seismic load on the free vibration of intze water tank up to 10^{th} mode shape is compared with the pre-stress effect of wind load on free vibration of intze water tank fluid system in different filling condition. It is seen in the present work that the difference in pre-stress effect on frequencies of free vibration in intze water tank is very low or it can be negligible for different loading condition. The static analysis of tank due to seismic load and wind load of an intze type water tank fluid system in different filling condition are also studied using finite analysis. Stresses and deflection in static analysis due to seismic load and wind load and also compare with each other. The maximum stresses and deflections in all cases in present study are calculated. The analysis has been done for different loading condition in different filling condition of tank. The analysis is performing using ANSYS -14.5 MECHANICAL APDL software, in which Solid 187 element is used for discretizing tank & Fluid 30 elements, is used for discretizing fluid system. To validate the present work frequencies of free vibration is calculated and compare with the previous study (transient and free vibration analysis of elevated intze water tank fluid soil system). The results obtained are same calculated previously by the other author. After validation the pre-stress (random) vibration analysis is done and results obtained from this research work are presented in table form as well as in figures form and comparison of results in graphical form also. Resonance condition for vibration analysis is also discussed.

Keywords: *Intze tank, Pre-Stress (Random) vibration, Natural frequency, Mode shape, Static analysis, Resonance*

INTRODUCTION

Water Tank

The purpose of water tank is to contain water, thus the water tightness of concrete is of utmost importance. For underground tanks, contamination of stored water by ground water must be prevented. Hence high quality concrete is used for the construction of water tanks. Since shrinkage is normal behavior for fresh concrete, the construction sequence of tank should be designed to minimize the effect. Detailing of joints should be able to accommodate shrinkage, thus preventing shrinkage cracks. The high quality concrete mixes used should be designed for minimum shrinkage and strict quality control used in the field.

Many more forces and vibration are acts on an water tank such as water pressure on the wall of tank, wind pressure, self-weight of tank, earthquake forces on base tank, and sloshing behavior of liquid present in tank at different filling condition. Therefore for complete study of a water tank we have to study effect of all the forces on tank in different filling

condition with fluid-structure-interaction (FSI) or without FSI.

Earlier many studies are done for analysis of a water tank for different loading condition and using different methods for analysis. Such as static analysis of water tank for wind load and seismic load, free vibration analysis of a water tank, forced vibration analysis of water tank and much more studies are done. In free vibration analysis model analysis of water tank whose capacity is $1000m^3$ is performed by using the ANSYS software is done in that study natural frequencies of given tank is studied. In forced vibration analysis harmonic & transient analysis of water tank of same capacity is also studied by using same ANSYS. The finite element analysis of water tank for seismic loading in different filling condition including the effect of fluid-structure-interaction is done in present study for same water tank of capacity 1000 m^3.

LITRETURE REVIEW

Previous Study about the Water Tank

There are so many investigations have taken place in the area of soil-structure interaction of over-head and underground water tanks. Many more investigators have proposed different approaches for solution of interaction problems to obtain more realistic analysis.

Some studies with their conclusions and year of studies are discussed below.

Amani, *et al.* (2010) in this examination, take a RC circular compartment which is incompletely loaded up with water, they are utilizing limited component technique in his investigation and results are confirmed tentatively. They conclude for spherical tank, 3 independent mass motions are that is: first sloshing also called convective, second translation also called structural and pendulum motions.

Moslemi, M. *et al*. (2011) in this study, the finite element method is used to investigate the seismic response of liquid filled tanks. Besides, sloshing of water free surface and the impact of tank divider adaptability are represented in the FEM examination. In this investigation for the conical molded tanks complexities are related with displaying are examined.

Kianoush, *et al.* (2011) by using finite element method a 3-D soil structure liquid interaction is used for the analysis of seismic behavior for different ground motions on partially filled concrete rectangular tank. In this analysis, seismic behavior of rectangular tank partially filled with water is investigated using four different seismic motions.

Neeraj tiwari & M.S. Hora (2015) the conventional analysis of elevated water tank is analyzed in this paper. Assumption was taken that columns are rest on unyielding supports. In any case, in really, the structure is upheld by deformable soil strata which disfigures under the activity on load henceforth causes redistribution of powers in the parts of over-head water tank. Using ANSYS software find stresses in different parts of the structure. Von-mises stresses, natural frequencies and acceleration BT transient analysis are also found for different filling conditions.

METHDOLOGY

FINITE ELEMENT METHOD

The FEM is mostly suited for problems involving complicated loadings, geometry and boundary conditions for which analytical solution are not possible.

Initially this method is originated for analysis of stresses in aircrafts. But now a days this method is used for analysis of all type of structural problems also for the fluid flow problems, electric and magnetic field problems, etc. in civil engineering this method is used in various analysis such as analysis of frames, beams, foundation, plates, shells, seepage etc. the solution for a structural engineering problem by the Finite Element Method

refers to calculate the displacement and stresses at each node of element which is within the structure to be analyzed for given loading systems. Advantage of FEM is it is able to use the element of different size, shape, and type of any structural model on the basis of type of accuracy to be achieved in the problem. It is also able to prepare the model of composite structure with different properties.

Two features of finite element method are worth to be mentioned:

- Piece wise approximation of physical filed on FEM gives good precision even with simple approximating.
- Locality of approximation leads to spares equation systems for a discretized problem. This helps to solve problem with very large number of nodal unknowns.

In finite element method the structure or region of interested is divide into a number of sub-structure or smaller sub-regions these sub-regions or sub-structures are called as finite elements and these sub-regions are connected at different number of point that points are termed as nodes. It means in this method we analysis different-different element which is connected to each other by nodes for applied boundary condition or at different loading condition there for the original problem which have infinite degree of freedom is now converted into a finite degree of freedom problem.

Once the domain or region of interest is divided into smaller sub-regions or elements and the interconnected nodes are identified it becomes necessary to evaluate the characteristics of the element. As the entire element would be similar, it is necessary determine these characteristics for one typical element. The unknown functional within the elements depends upon the type of problem, that's displacement & stresses in structural engineering problem, temperature in heat conduction problem, velocity & pressure for fluid flow etc.

The matrix equation governing the behavior of the whole region can now be obtained by combining the matrix equation of each element. These assembled equations are usefully symmetric and banded. These can be solved after application of boundary condition and the unknown functional at the nodes can be obtained.

CONCLUSION

The vibrations in water tank are very important topic in the field of engineering because of its uses in almost every cities and residential township. Many researchers have done different work, analysis and research in past decades. Simple cases were analyzed by the researchers in the earlier periods by analytical method. Now a day different types of analysis of water tank are done with the help of modern computer technology or with the use of different analytical software. In this chapter we discussed a brief description about different theories and mathematical formulas available for analyzing intze type water storage tank. In present research work we have analyze an intze water tank of 1 million liters capacity, supported on 16 m above ground level. Depth of foundation is at 1 m below ground level. Bearing capacity of soil is 250kN/m^2. The tank is to be designed for Delhi region which is in IV^{th} zone of seismic zone of India.

REFERENCES

1. Moslemi M., Kianoush M. R. & Pogorzelski W. Seismic response of liquid-filled elevated tanks. Engineering Structures. 2011; 33: pp. 2074–2084.
2. Neeraj tiwari M. S. Hora. Transient analysis of elevated intze water-tank-fluid-soil system. *ARPN Journal of Engineering and Applied Sciences*. 2015; 10(2).
3. Pedro A. et al. Failure analysis and remedial measures applied to a RC

water tank. *Engineering Failure Analysis*. 2008; 16(2009): pp. 1674–1685.
4. Livaoglu R. et al. Simplified seismic analysis procedures for elevated tanks considering fluid–structure–soil interaction. *Journal of Fluids and Structures*. 2006; 22(2006): pp. 421–439.
5. Livaoglu R. et al. Effect of foundation embedment on seismic behavior of elevated tanks considering fluid–structure-soil interaction. Soil Dynamics and Earthquake Engineering. 2007; 27(2007): pp. 855–863.
6. Resheidat R.M. & Sunna H. Behavior of elevated storage tanks during earthquakes. *In: Proceedings of the 3rd US National Conference on Earthquake Engineering*. 1986: pp. 2143–54.
7. Shekari M.R. et al. a coupled BE–FE study for evaluation of seismically isolated cylindrical liquid storage tanks considering fluid–structure interaction. *Journal of Fluids and Structures*. 2008; 25(2009): pp. 567–585.
8. Stewart P.J., Seed R.B. & Fenves G.L. Seismic soil structure interaction in buildings. II: empirical findings. *J Geo-techn Geoenviron Eng*. 1999; 125(1): pp. 38–48.
9. Xiong Jiangao et. al. A modified lumped parametric model for nonlinear soil-structure interaction analysis. Soil dynamics and earthquake engineering. 1992; 12(1993): pp. 273–282.