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Design and Seismic Analysis of Overhead Water Tank

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ABSTRACT. Water tank is a water storage structured built for long term use. These tanks were utilized for various uses like distribution of water, firefighting, agriculture, food industry, paper mills etc. It comes in handy when there is an intermittent supply of water or scarcity of water. Materials like concrete, pvc Galvanized Iron, Fiber is used to manufacture tanks. Water is pumped through pipe by using pumps from a source. For distribution purpose water can be distributed either gravity or pump to reach individual with desired pressure and velocity. Volume is calculated based upon population and their usage and demand. Water demand varies hour to hour. For a continues supply water tanks are best suited. To meet water demand by public water tanks are to be constructed. Design and analysis are similar for any liquid present in water tank but is should be crack free to avoid leakage.

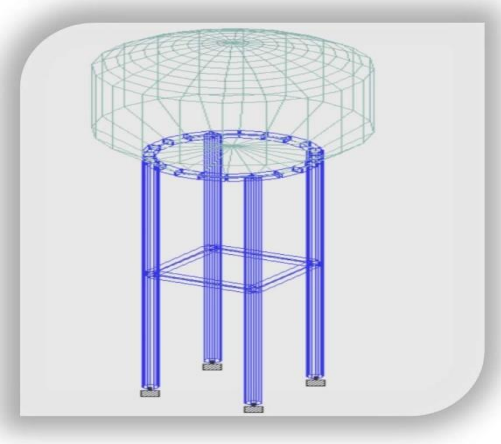
KEY WORDS: INTZ Water Tank Seismic Analysis, Base Shear, Base Moment, STAAD PRO, Hydrodynamic Pressure.

1. INTRODUCTION

Overhead tanks and reservoirs are liquid storage containers. These containers are generally used for storing water for irrigation works, human consumption, fire, manufacturing units, rainwater harvesting, and for many purposes. The main purpose of design of tanks are economical, strength, service life, to provide safe portable drinking water after storing for a long time and it also resist special conditions like wind and earthquakes. Water tanks are generally constructed with reinforced concrete or steel and design is based on IS code. Design of tanks depends on the position of tank i.e., above or below, at the ground level. The overhead tanks are generally constructed at certain height from the ground level using columns and braces, for direct distribution of water by gravity. In any case, the underground tanks are rest underneath the ground level.

2. OBJECTIVE

- To determine the hydrodynamic effect on Elevated Circular type water tank with different staging system.
- To determine Base Shear on water tank.
- To determine Max. Nodal displacement at the top of water tank.
- Comparison of Base Shear and



A Tank on Staad Pro

Displacement of water tank for different staging system with different tank conditions.

- To study the effect of soil stiffness, base isolation, and sloshing.

3. LITERATURE REVIEW

I) Design and Analysis of Elevated Water Tank **Tejaswini, Mamatha**

Base shear and base moment for empty tank condition is more compared to full tank condition. Because of water tank is empty hence no water pressure from inside, only earthquake forces are acting from outer side only. Hence baser shear and base moment in empty tank condition. The area of steel required in limit state method increase when compared to that of working stress method as the allowable stresses in steel were lower.

II)Seismic Analysis of Elevated Water Tank with Different Staging Configuration **"Prashant A Bansode, V.P. Datye"**

Seismic Analysis of elevated water tank with an objective to understand behaviour of different staging system using STADD Pro.

III) Seismic Analysis and Design of Elevated water Tank for Variation of H/D Ratio and Patterns by **"Manali Ugemuge, Prof. H. Rangari**

Investigation for the effect of varying the height to diameter(H/D) ratio and different bracing pattern on the seismic performance of tank using Finite Element Analysis (FEA) Software.

4. METHODOLOGY

It must be ensured that the design of water tank is capable for resistance of certainty like earthquake and wind loading, which varies with an increase in seismic zones.

3.1 Methods of seismic analysis Mainly two different types of design analysis are as follows.

3.1.1 **Equivalent static analysis**: Statistical approach can be efficiently appeal to elevated water tank. It is dependent on representation of seismic load in the form of identical static loads. Approximate in context to tank is vital and without any degradation, in accuracy estimate, a single degree of freedom is sufficient. $K = P / \Delta$ Where K= Lateral Stiffness of staging P= Applied lateral force Δ = Deflection in mm

3.1.2 **Dynamic analysis**: It is very hard to analyse the dynamic nature of elevated water tank. Due to static behaviour of tank, predictions can hardly be done. An elevated water tank having liquid with free surfaces related to motion of natural calamity like earthquake and the direction of motion result in acceleration of the tank wall and liquid. The liquid in the tank at lower region acts such a man that is stacked to wall. This is called impulsive mass of liquid (mi). Whereas liquid in tank at upper region is termed as convective mass of liquid (mc) due to sloshing motion. For analysis of elevated tanks, whole structure is to be considered as two degree of freedom system includes of two uncoupled single degree of freedom systems that is impulsive and mass of structure act as an inverted pendulum having, lateral stiffness equal to that of the staging, Ks and the other is the convective phase with a spring of stiffness, Kc.

Study Parameters

5. SCOPE OF WORK

S No	Constants	Value
1	Volume of liquid	250 m3
2	Materials	M-30& Fe415
3	Unit weight (RCC)	25.01 kN/m3
4	Ec	2.73x107 kN/m2
5	Seismic Zone (Z)	iv
6	(I)	1.5
7	Soil Type	Alluvial Soil

The scope of the present work includes the study of the Seismic load analysis on Over Head water tank.

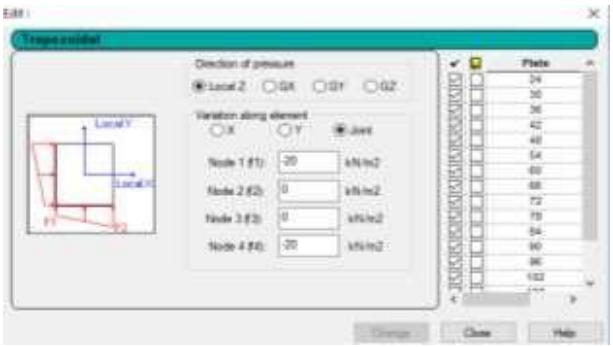
1. To determine the hydrodynamic effect on staging system.
2. To determine Base Shear on water tank.
3. To determine Max. Nodal displacement at the top of water tank.
4. Comparison of Base Shear and Displacement of water tank for different staging system with different tank conditions.
5. To study the effect of soil stiffness, base isolation and sloshing.
6. The entire process of modelling, analysis and design of all the primary elements for all the models are carried by using STAAD PRO software.

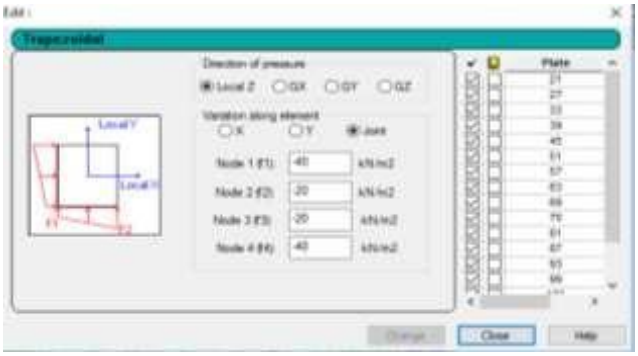
6. ANALYSIS

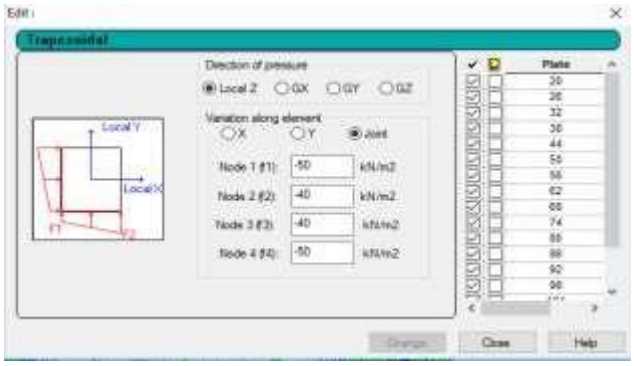
- **Rate Analysis**

We have analysed the cost including Rates of concrete and steel as per CPWD, Manpower, GST 18%, Management cost 15%, Wastage 7%, Contractor Profit 10%
Our Estimated Cost for the complete construction of the Intze water tank is 20,10,208.99 Rupees.

- **Staad Pro Analysis**







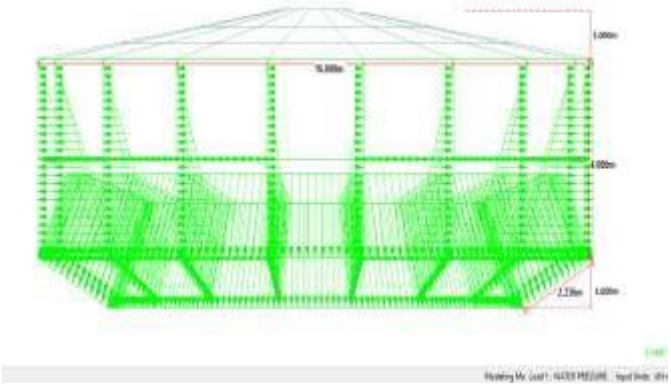
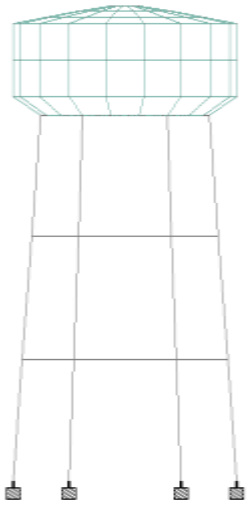
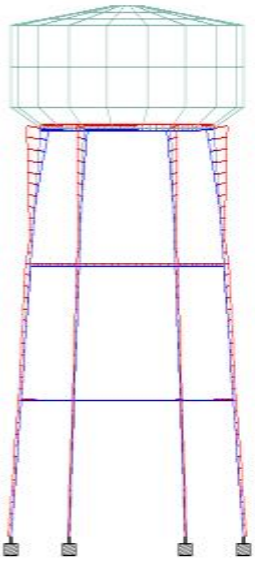


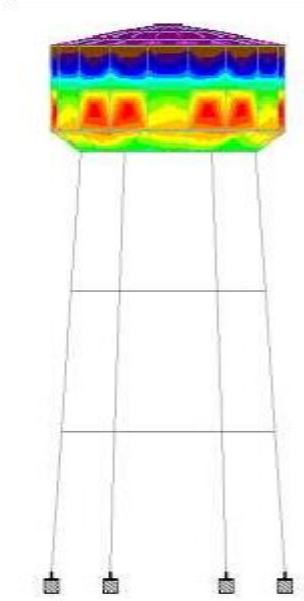
Figure-2: Hydrostatic load acted on Water Tank



Beam Stresses



Shers, Bending due to Hydrostatic pressure



Pressure on Plates

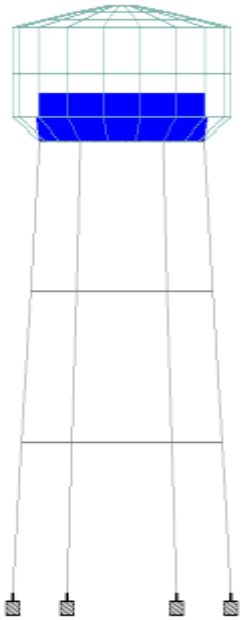
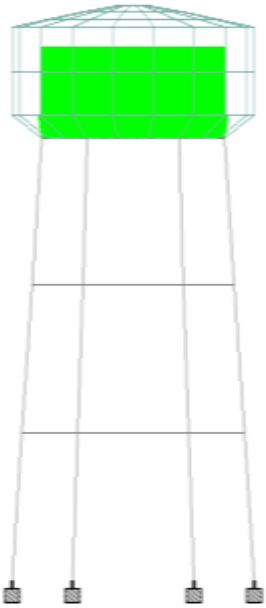
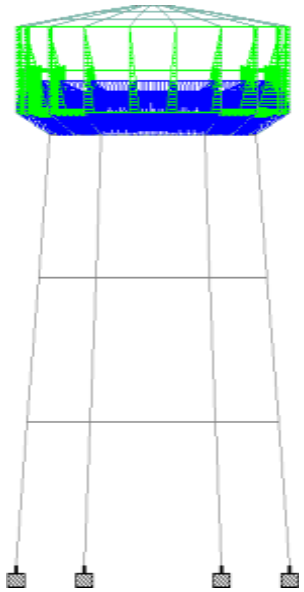


Plate Load



Hydrostatic Pressure



Shear, Membrane and Bending | Sun

			Principal	
	Plate	L/C	Top psi	Bottom psi
Max Pri	163	3 LOAD CAS	**231.410**	-214.533
Min Prin	146	3 LOAD CAS	**-261.384**	4.920
Max Pri	21	1 WATER PR	226.522	**270.126**
Min Prin	163	3 LOAD CAS	229.101	**-215.354**
Max Vo	122	1 WATER PR	207.109	122.358
Min Vo	107	2 LOAD CAS	-0.030	0.021
Max Vo	92	1 WATER PR	155.346	168.255
Min Vo	101	2 LOAD CAS	-0.033	0.025
Max Tr	122	1 WATER PR	207.109	122.358
Min Tre	107	2 LOAD CAS	-0.030	0.021
Max Tr	92	1 WATER PR	155.346	168.255
Min Tre	101	2 LOAD CAS	-0.033	0.025

All | Max Stresses | Profile Stress Points

			Max Compressive		
Beam	L/C	Length m	Stress psi	Dist m	Corner
	2 LOAD CAS	6.700	30.363	6.700	3
	3 LOAD CAS	6.700	42.508	6.700	3
217	1 WATER PR	6.700	214.065	6.700	3
	2 LOAD CAS	6.700	51.258	6.700	1
	3 LOAD CAS	6.700	71.762	6.700	1
218	1 WATER PR	6.700	279.857	6.700	2
	2 LOAD CAS	6.700	134.370	6.700	3
	3 LOAD CAS	6.700	188.118	6.700	3
219	1 WATER PR	6.000	87.600	6.000	3

7. RESULT AND DISCUSSION

- Soft soil condition is more severe than medium and hard soil condition. Base shear and base moment increase by 36% and 67% for medium and soft soil 2019, pp. 2354-236. As compared to hard soil as per IS 1893 (PartI) 2002 /IS 1893 (Part-II) 2014 for all seismic zones for both tank condition.
- An Intze water is designed with 300000 litres capacity with 19.5m staging has designed with M30 grade of concrete.
- We design the tank by both manually and using STAAD Pro, the program results shown that design is safe.
- After completion of Intze water tank design in STAAD Pro and from manual calculations we conclude that design is safe.

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