Lateral Load Analysis of Elevated Intze Water Tank By STAAD.PRO

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Abstract –*Water is one of the important elements in our life. As water is used in many different fields like distribution of drinking water, agriculture, industry, fire fighting etc. All these purpose needs various types of flow throughout the year according to the use. We need to store the water to maintain the flow of water. For this purpose we have to construct an elevated water tanks. INTZE water tank is one of the large structures to store the water and these types of structure are build for long term use. These types of structures need to resist the strong wind load and earthquake loads. In this project total of three models were prepared one model with empty water condition, second model with full water condition and third model with half water condition with presence of wind in different terrain category. In this project the parameters displacement, bending moment and shear force is checked. The maximum values obtained in the full tank condition. With regard to terrain categorization, various models have been used in the comparison.*

Key Words: Elevated Intze tank, Wind Analysis, Staad Pro, Terrain Category

1. INTRODUCTION

Water is essential for the survival of every type of animal in the planet. Intze type are frequently utilized as water reservoirs. The basic components of an Intze tank are a Top Dome (roof), a cylindrical wall, and a floor slab made up of a conical dome and a bottom spherical dome. Both the movement of the tank with regard to the water inside it and the movement of the tank with respect to the ground must be considered when analyzing the dynamic behavior of these tanks. The current design of high water tank support structures is extremely vulnerable to lateral stresses as it is constructed for wind forces.

1.1 Water Tanks in General and Water Tank Types:

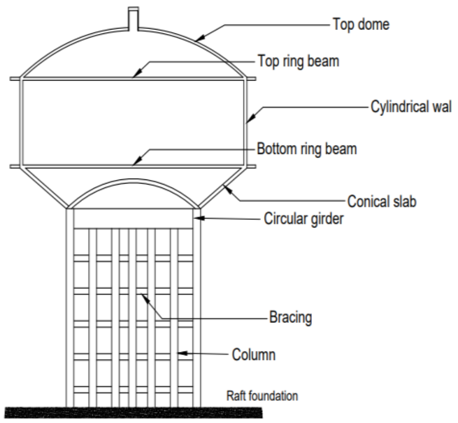
Water supply projects are crucial for the nation's social and industrial growth and have attracted a lot of interest in recent years across the globe. Depending on how much water is used, water tanks come in a variety of capacities. Based on where they are located, water tanks are divided into three types.:

1. Water tanks buried underneath
2. The tank is sitting on the ground.
3. Water tanks that are elevated.

According to their shape, water tanks are also categorized:

1. Circular tanks
2. Rectangular tanks
3. Intze tanks
4. Circular tank with conical bottom
5. Spherical tanks

1.2 Intze Tank Elements



Top dome: In general, we supply a 110 to 150 mm thick top dome with reinforcement throughout the latitudes and longitudes. The dome's rise is typically one-fifth of its length.

Top ring beam: There is a meridional thrust applied to the top ring beam. The beam is made to accommodate hoop stress brought on by water load.

Cylindrical walls: The principal force acting on the wall is hoop tension, which is brought on by water pressure. So, the wall is built to accommodate hoop tension.

Ring beam at the bottom: This ring beam was installed between the cylinder wall and the conical slab. The ring beam is employed to offset the horizontal component of the cylindrical wall's reaction to the conical wall. The bottom ring beam's purpose is to support the tension created by the hoop.

Conical slab: The slab is subjected to both meridional thrust and hoop tension. Fluid pressure is what causes the hoop tension, and vertical pressure is what causes meridional. Consequently, the slab should be built safely.

Bottom dome: The bottom slab could be dome-shaped or spherical. A circular girder serves as the support for this slab.

Circular girder: The girder should be built to support stresses from the conical slab (inclined thrust) and the bottom dome (outward thrust). It should be built to endure the torsion and bending moments since it will be put on the columns.

Columns: The columns are built to handle the overall transmission from the tank. As for wind and earthquake loads, columns are also intended for those. Bracings are positioned periodically in columns to fend off the effects of wind and earthquakes.

Foundations: In general, to support the all columns combined footing is adopted. To support a circular girder and circular slab are design.

Wind Load: The IS code IS 875 (part 3) is used to determine wind pressure acting at any height. The basic Wind Speed Vb is obtained from the wind map as shown in the IS 875 (Part 3) 2015. The following are some factors that affect the design wind speed Vz:

1. Risk component (k_1)

2. Height and Terrain Factor (k_2)

3. Topography (k_3)

4. Importance Factor for Cyclonic Region (k_4)

According to the normal wind speed, there are 6 zones, zone I to zone VI. The typical wind speed should be adjusted to account for the following parameters in order to determine the wind speed in height for the chosen construction. Based on the code for wind obstruction, there are four different types of terrain. Based on the depicted map of the Indian Wind region. India has been found to be separated into six wind zones, such as Zone I and Zone VI, fully based on the fundamental wind rhythm.

Following are the steps for calculating design wind speed at any height:

$$V_z = V_b\, k_1\, k_2\, k_3\, k_4$$

To determine the design wind pressure at any height above mean ground level, the relationship between wind pressure and wind velocity must be used.

$$P_z = 0.6\, V_z^2$$

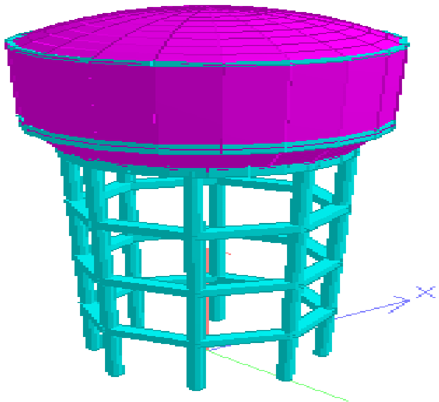
Where, Pz=Design wind pressure in N/m² at height z

Vz=Design wind velocity in m/sec at height z

2. Structural Details:

Followings are the parameters of Intze water tank

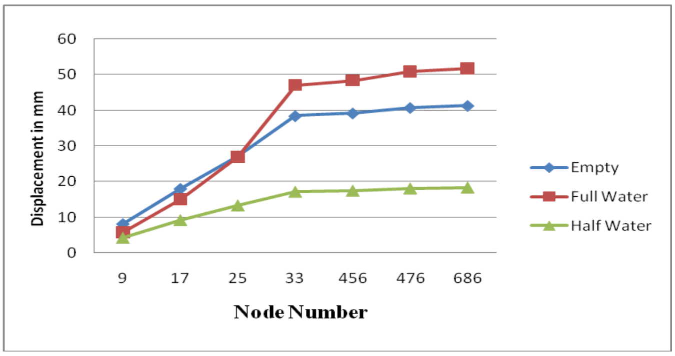
SL .No.	Parameters	Value
1	Storage Capacity	300000
2	Height of Staging	15m
3	SBC of soil	200kN/m²
4	Grade of concrete	M30
5	Diameter of Tank	8m
6	Thickness of top dome	100mm
7	Rise of top dome	1.5m
8	Top ring beam	230mmX200mm
9	Diameter cylindrical wall	8m
10	Height of cylindrical wall	4m
11	Thickness of cylindrical wall	230mm
12	Size of middle ring beam	250mmX500mm
13	Height of conical dome	1.5m
14	Thickness of conical dome	200mm
15	Average diameter of conical dome	7.2m
16	Rise of bottom dome	1.2m
17	Radius of bottom dome	3.2m
18	Thickness of bottom dome	200mm
19	Size of bottom ring girder	400mmX600mm
20	Number of columns	8
21	Diameter of column	450mm
22	Height of water tank	22m



3. WIND ANALYSIS RESULTS:

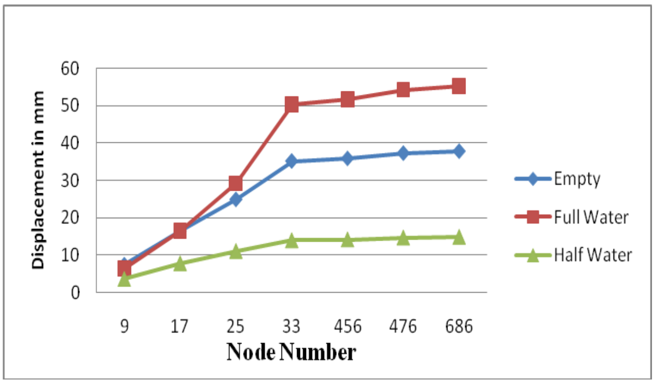
3.1 Comparison of displacement among all three cases

Table 1: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 in **terrain category-I**



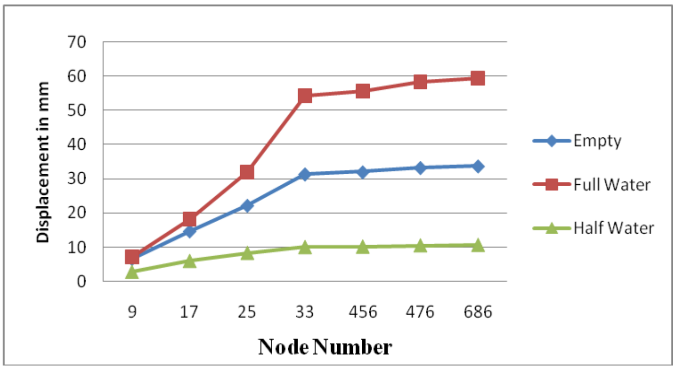
Graph 1: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 In terrain category-I

Table 2: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 in **terrain category-II**



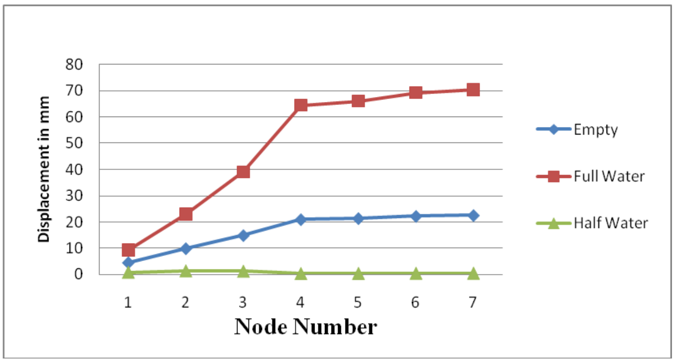
Graph 2: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 in terrain category-II

Table 3: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 in **terrain category-III**



Graph 3: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 in terrain **category-III**

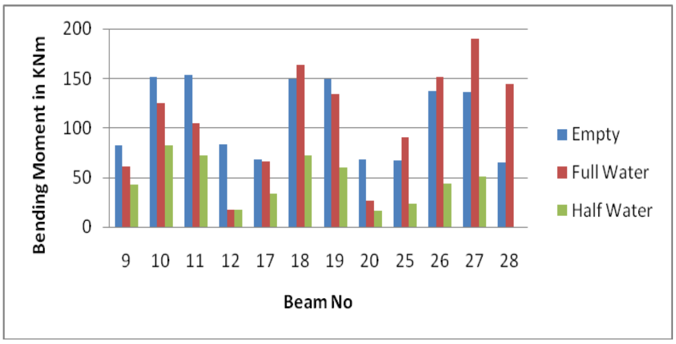
Table 4: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 in terrain category-IV



Graph 4: Displacement in mm in X-direction for Model-1, Model-2 and Model-3 in terrain **category-IV**

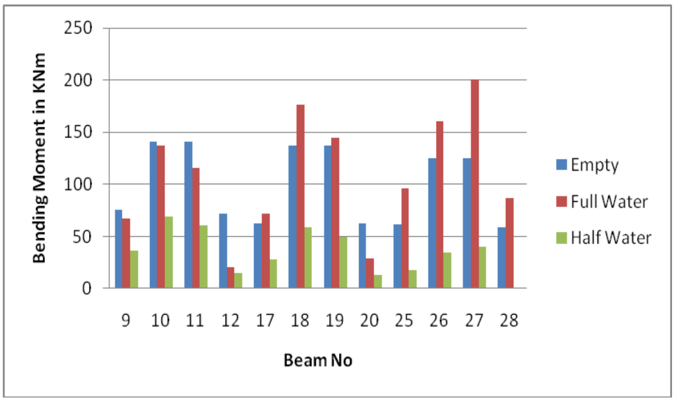
3.2 Comparison of bending moment among all three cases:

Table 5: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in **terrain category-I**



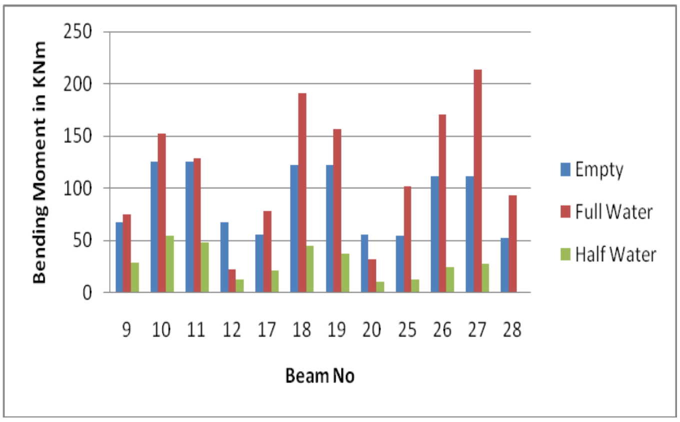
Graph 5: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in terrain category-I

Table 6: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in **terrain category-II**



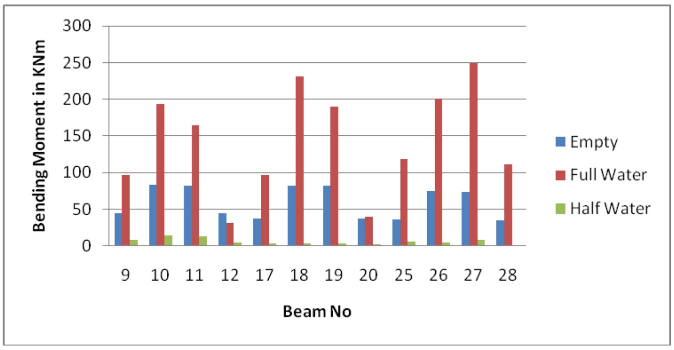
Graph 6: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in terrain category-II

Table 7: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in **terrain category-III**



Graph 7: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in terrain category-III

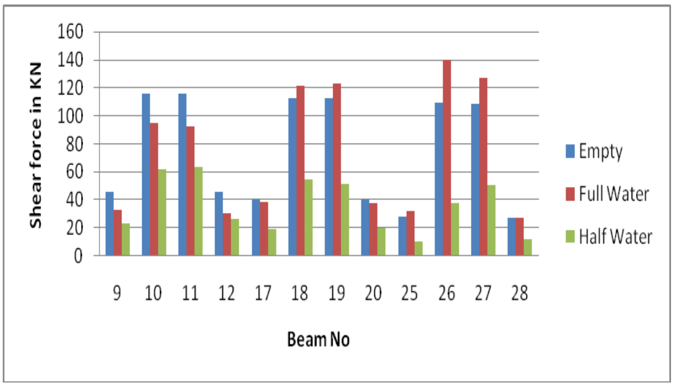
Table 8: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in **terrain category-IV**



Graph 8: Bending Moment in KNm in X-direction for Model-1, Model-2 and Model-3 in terrain category-IV

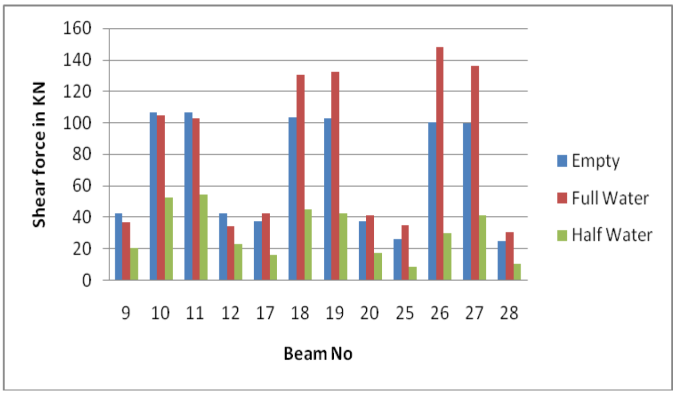
3.3 Comparison of shear force among all three cases:

Table 9: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in **terrain category-I**



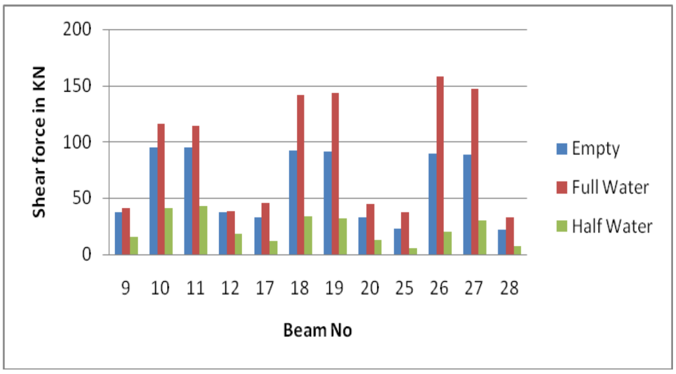
Graph 9: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in terrain category-I

Table 10: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in **terrain category-II**



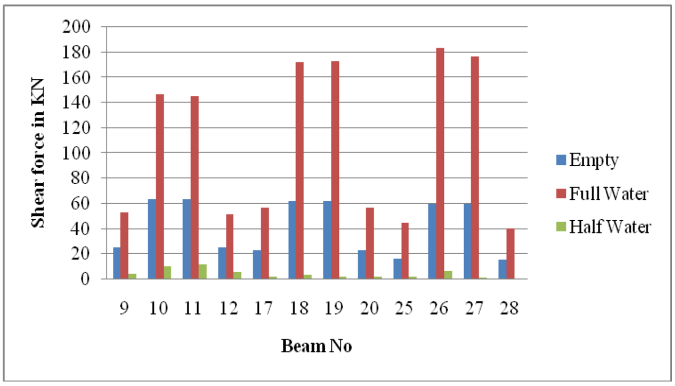
Graph 10: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in terrain category-II

Table 11: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in **terrain category-III**



Graph 11: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in terrain category-III

Table 12: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in **terrain category-IV**



Graph 12: Shear force in KN in X-direction for Model-1, Model-2 and Model-3 in terrain category-IV

4. Observation:

1. For each of the three models in this project's various terrain categories, wind analysis was performed.

2. Wind forces applied in x and z direction. All the loads are assigned to the models.

3. In model-1 the displacement is maximum for the terrain category-1 and values goes on decreasing for other three terrain category.

4. Comparing the displacement in full tank condition to the other terrain categories, we can observe that it is greater.

5. The displacement is maximum in model-2 i.e. water tank full condition

6. It is observed that the Bending Moment is more when there is water pressure from inside the tank.

7. It is also noticed that Bending Moment is reduced when there is half water pressure from inside the tank.

8. It is observed that the shear force is maximum when the tank is empty for the beams at lower level(i.e. 9,10,11,12,17,18,19,20) and the Shear force is maximum when water pressure from inside for beams at upper level(25,26,27,28) for terrain category-I

10. It was noticed that the shear force is minimum for all beams when there is half water pressure from inside for terrain category-I.

11. It is seen that the shear force is maximum for beam 9,10,11,12 and for remaining beam the shear force is minimum for terrain category-II.

12. It was noticed that in case of terrain category-III, the Shear force is maximum when there is tank with full of water, and shear force is minimum for the case with no water pressure and half water pressure from inside.

13. In case of terrain category-IV, the shear force is maximum for the tank with full of water, and minimum for the case with no water pressure from inside, and half water pressure from inside.

5. Conclusion:

1. In this project we have seen that Intze tank with full tank condition is critical.

2. It is conclude that as the displacement decreases from category I to IV due the terrain roughness factor with terrain category.

3. The parameters like displacement, bending moment and shear forces are calculated with respect to different terrain category.

4. Comparison of three different tank fill condition with the different terrain category has been done.

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