An Analytical study of overhead water tank subjected to seismic load

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Abstract:-

In this research paper, the effect of seismic load for overhead water tank, the water is the most essential element to a life on the earth. There is two different types of tank, of same capacity but having different height and different diameter of the overhead water tank in seismic zone (zone IV and V), this study on displacement of tank, time period, base shear and base moment cofficient of different height and diameter of overhead water tank, seismic plays an important in design of tank structure because of dynamic nature. Effect of seismic is predominant on tank structure, height of the struture in this paper the compression of the tank their height and its different diameter on tank for analysis of seismic loads on tanks

Keyword:- Seismic analysis, seismic zone iv and v, water tank, stagging, water tank seismic code IS 1893 Part II

1.0 INTRODUCTION:-

There are a large number of storage tanks around the world, most of which are used as storage of water and oil facilities, There are several different ways of storing water such as underground, on ground and above ground tank An elevated water tanks consists of a container at the top supported on a staging to transfer the load of container to the foundation .These tank are particularly at risk of damage due to vibrations caused by earthquake because the tanks consist of a huge mass of water acting in the top of the staging, A large number of elevated water tanks damaged during the past earthquake histories, majority of them were shaft type while some were in the frame type stagin Water tank are used for agriculture , firefighting, drinking. Failure of water tank has a negative impact on a performance of water network. Earthquake is the major cause of failure of water tank so. Structure should be design in such a way that it have the ability to withstand against the seismic force. In this review paper we will study intz tank for different type of staging i.e. Frame staging & shaft staging. The aim of design of this tank to have seismic resistance propose . Comparative study of frame staging &shaft staging will be done . In this paper we will study the behaviors of different staging under different loading condition, this can be done using Staad-Pro software

1.1 TOTAL SEISMIC RESPONSE:-

The total seismic response of a tank structure should be analysed in terms of natural periods of vibrations, base shear force and overturning moments. As already mentioned, these quantities will be determined in accordance with the provisions of Eurocode 8. The modal properties of a tank structure should be determined at the beginning of the analysis. The natural periods of the impulsive and the convective modes are calculated by the Eqns. 1 and 2, respectively

$$Ti = \square\square \frac{H\sqrt{P}}{\sqrt{\frac{S}{R}}\sqrt{R}} \quad (1)$$

$$Tc = Cc\sqrt{\square} \quad (2)$$

here s represents equivalent uniform thickness of the tank wall (in the case of a wall with constant thickness, s is equal to the wall thickness), E is the modulus of elasticity of tank material and ρ is mass density of the liquid. The total base shear force is calculated by the

$$\square = (\square\square + \square\square + \square\square)\square\square(\square\square) + \square\square\square\square(\square\square) \quad (3)$$

Where m_w, represent the mass of the tank wall, m_r, represent the mass of the tank roof Se(Ti) is the impulse spectral acceleratio

1.2 SEISMIC WAVES:-

Seismic waves are waves of energy that travel through Earth's layers, and area result of earthquakes, volcanic eruptions, magma movement, large landslides and large manmade explosions that give out low-frequency acoustic energy. Many other natural andanthropogenic sources create low-amplitude waves commonly referred to as ambient vibrations.Seismic waves are studied by geophysicists called seismologists. Seismic wave fields arerecorded by a seismometer, hydrophone (in water), or accelerometer.

2.0 SCOPE OF THE STUDY:-

To know design philosophy for safe and economical design of circular water tank.To study seismic response of circular water tank for various zone of earthquake (Zone IV,V) the performance was studied in terms of mode period, base shear, story displacement. The modelling, analysis, and design were carried out by STAAD PRO Vi8 software

3.0 OBJECTIVE OF THE STUDY:-

1. To study the seismic performance of overhead tank with different filled up condition of tank and different height of tank which located on seismic zone IV and V on medium soil under seismic loads.

2. To evaluate and comparison of same capacity but having different height and diameter of the overhead water tank in seismic zone (zone IV and V) by their dynamic response result like time period ,deflection ,displacement and base shear.

4.0 Methodology :-

4.1 Model formulation:-

The study in focused on the seismic load effect on a overhead water tank of same capacity of different height i.e 9.5m, 13.5m and different diameter i.e 12m, 10 m with the help of STAAD Pro Vi8 Software. The seismic effect analysis carried out seismic zone iv and v

1. Model 1-
   - Capacity of tank = 1000 kl
   - Height of tank with free board = 9.5 m
   - Diameter of tank = 12 m

2. Model 2-
   - Capacity of tank = 1000 kl
   - Height oh tank with free board = 13.5 m
   - Diameter of tank = 10 m

4.2 Description of tank-

S. No.	Parameter	Values
1	Capacity	1000 kl
2	Diameter of tank	12m
3	Height of tank with free board	9.5m
4	Rise of dome	1.5m
5	Diameter of bottom ring beam	12m
6	Thickness of bottom slab	300 mm
7	Wall thickness	0.3m
8	Density of concrete	25 N/mm2
9	No of columns	12

10	Column size	600 mm
11	Column height	14 m
12	Bracing interval size	4
13	Beam Bracing Size	0.23 x3.0
14	Zone	IV . V
15	Soil Type	Medium soil
16	Damping Ratio	5%

5.0 Modelling of tank –

The Modeling of tank is based on the different height and different diameter of tank using Staad pro vi8 software. The structure material is considered to be isotrophic and homogenous. The modeling of structure of tank having 2 model of tank is shown in bellow with height of tank 9.5m, 13.5 m

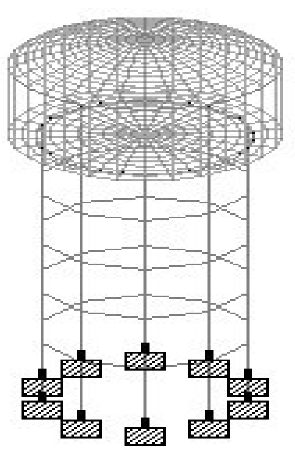

Fig.1. circular staad pro model

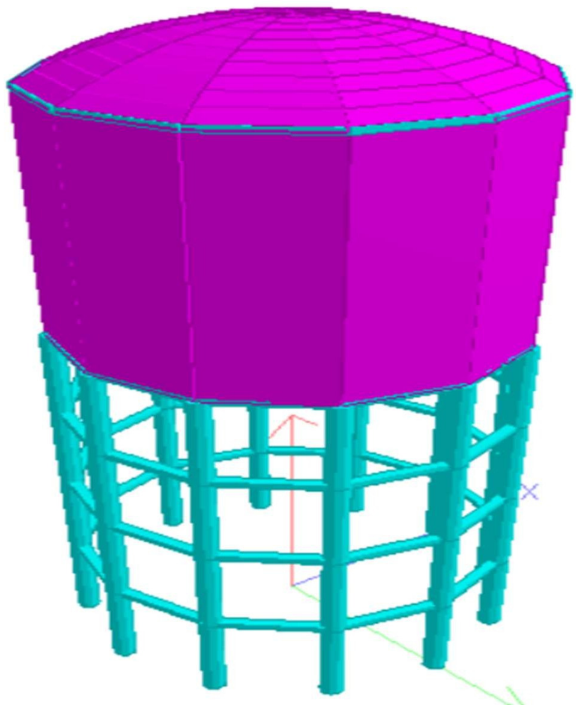

Fig.2. 3D staad pro model

6.0 loading pattern:-

As the test models are generated inSTAAD Pro Vi8 . In order to model and analyze them, various methods can be used. But I have used a certain method in order to maintain simplicity in calculation. The following points will elaborate

- As the test models will undergo seismic analysis for comparative study in term of time period, Base Shear, Storey Displacement, similar loading patterns are used throughout the model, the following points will elaborate.

    1. The live loads and dead loads will be similar in all the models as well at various levels in the structure.

7.0 RESULT AND DISCUSSION:-

7.1.1 Time Period –

Natural Period 'T' of a water tank is the time taken by it to undergo one complete cycle of oscillation

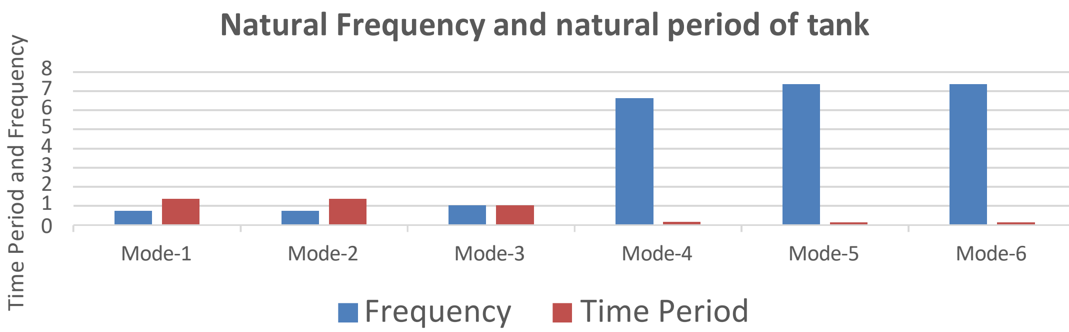

Table.1. Natural Frequency and natural period of tank

Mode	Natural frequency	Natural period
6	7.366	0.135

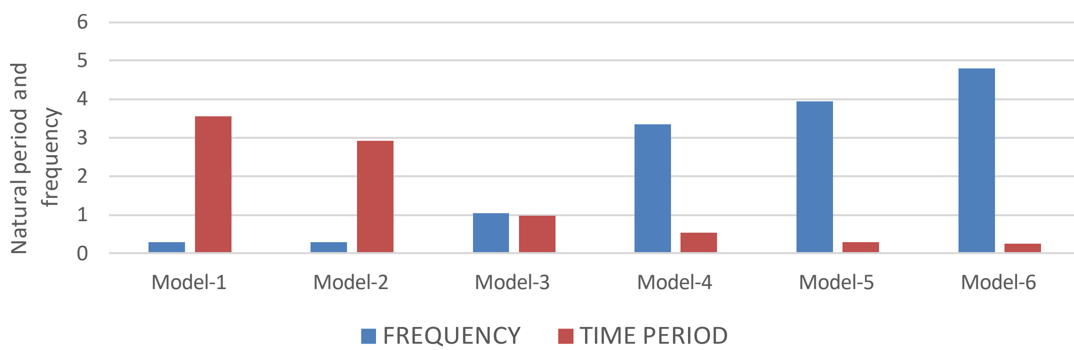

Table.2. Natural Frequency and natural period of tank

Mode	Natural frequency	Natural period
6	4.791	0.2542

7.1.2. BASE SHEAR :-

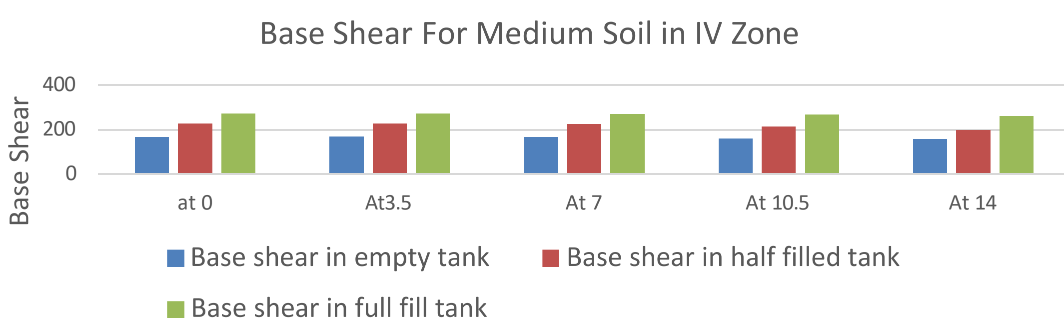

Table.3. Base shear in zone IV for medium soil

Empty tank	Half filled tank	Full filled tank
165.58	228.27	273.12

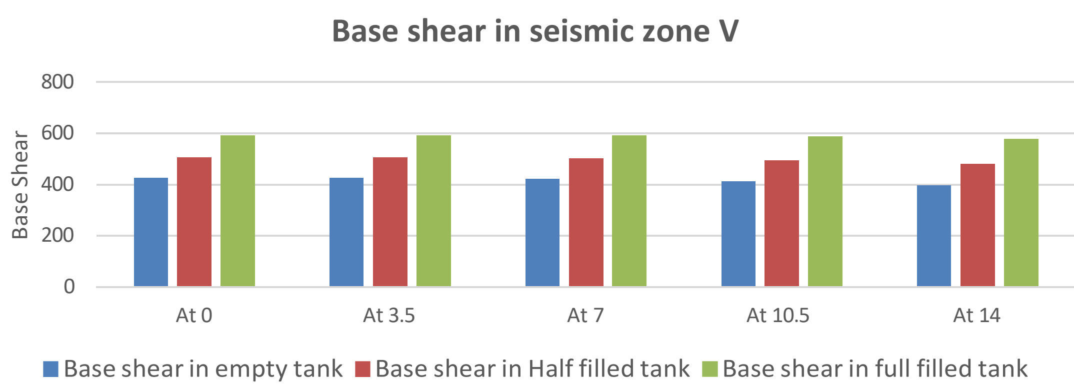

Table.4. Base shear in zone V for medium soil

Empty tank	Half filled tank	Full filled tank
425.8	505.41	593.11

7.1.3. MODEL .2:-

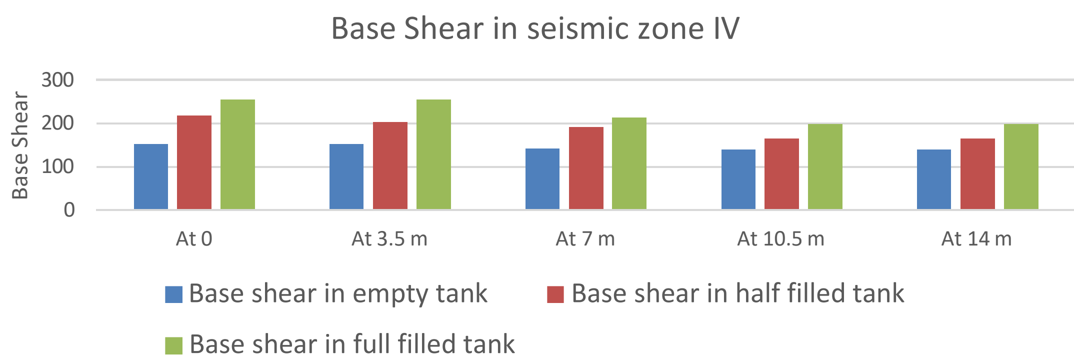

Table.5. Base shear in zone IV for medium soil

Empty tank	Half filled tank	Full filled tank
153.21	217.17	254.63

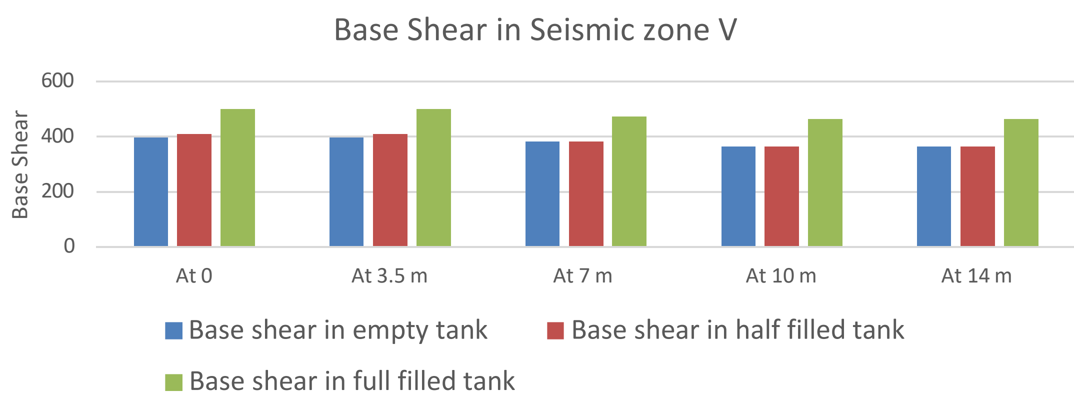

Table.6. Base shear in zone IV for medium soil

Empty tank	Half filled tank	Full filled tank
396.81	409.42	498.52

7.1.4. STORY DISPLACEMENT:-

7.1.5. model 1 –

The displacement of all models has been analysis. all displacement of all models is tabulated in the form of graph for different level for transverse direction

Displacement in seismic zone IV

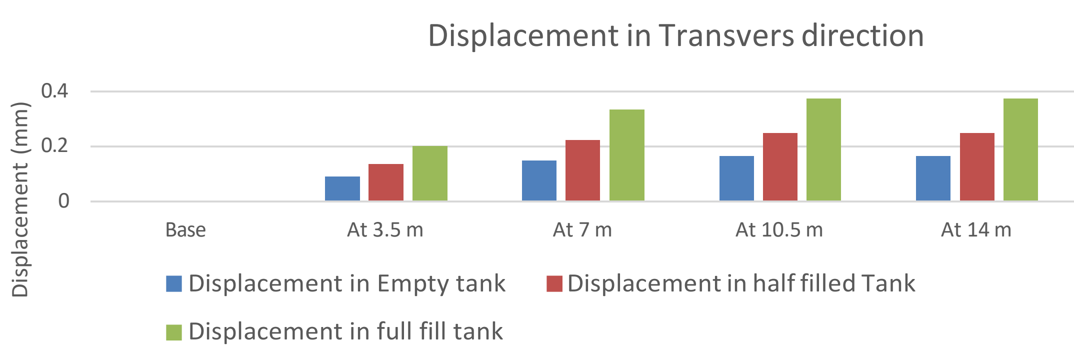

Table.7.Displacement in zone IV for medium soil

Different level of tank	Empty tank	Half filled tank	Full filled tank
At 14 m	0.165	0.248	0.372

Displacement in seismic zone V

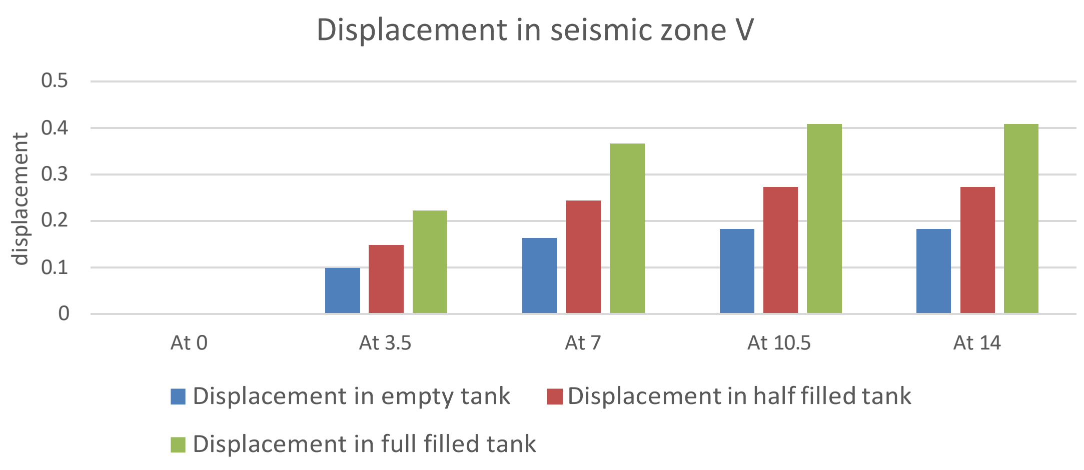

Table.8.Displacement in zone V for medium soil

Different level of tank	Empty tank	Half filled tank	Full filled tank
At 14 m	0.182	0.273	0.409

7.1.6. model.2.

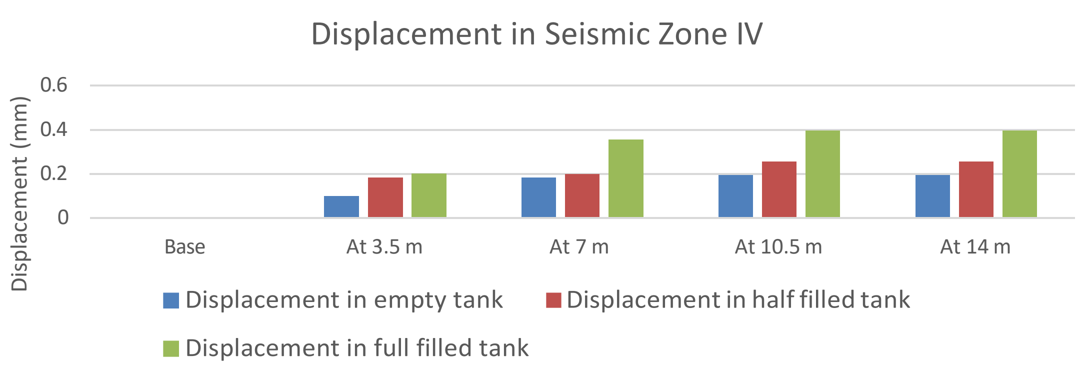

Table.9.Displacement in zone IV for medium soil

Different level of tank	Empty tank	Half filled tank	Full filled tank
At 14 m	0.196	0.256	0.396

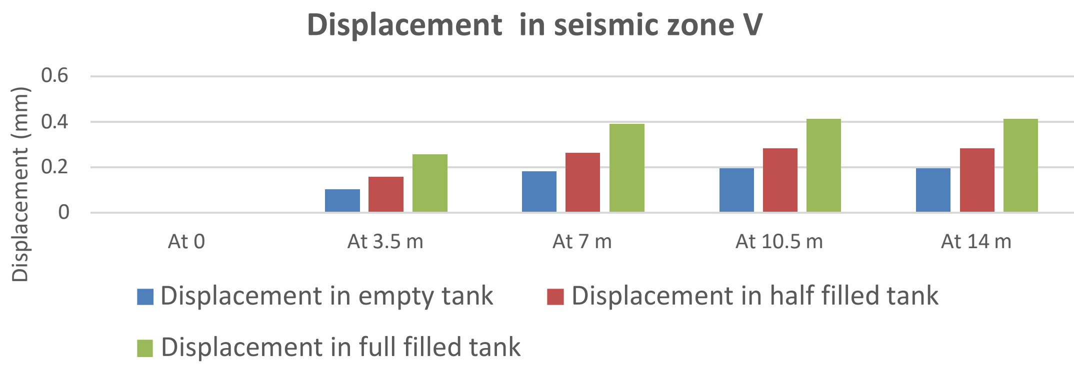

Table.10.Displacement in zone V for medium soil

Different level of tank	Empty tank	Half filled tank	Full filled tank
At 14 m	0.196	0.0.283	0.412

8.0 CONCLUSION:-

A seismic analysis of overhead circular tank on same capacity and varying height of tank is presented in seismic zone IV and V for the medium soil. Further conclusions are listed below:

a) As the mode shape tank is increase then time period is decrease and in Model-1 having the less time period as 61.46% from Model-2.

b) Maximum displacement and base shear is found in full fill tank but minimum displacement and base shear is found in empty tank.

c) When the height of the overhead tank is increase then the displacement is increase and base shear is decrease but in the case of seismic zone V having the maximum displacement and base shear than seismic zone IV.

d) The displacement of Model-2 is more than 6.06% in seismic zone IV and 0.73% in seismic zone V from Model-1 in the case of the full fill tank.

e) The base shear of Model-2 is less than 6.77% in seismic zone IV and 15.95% in seismic zone V from Model-1 in the case of full fill tank.

f) The displacement of Model-2 is more than 15.82% in seismic zone IV and 7.14% in seismic zone V from Model-1 in the case of the half filled tank.

g) The base shear of Model-2 is less than 7.46% in seismic zone IV and 6.81% in seismic zone V from Model-1 in the case of half filled tank.

h) The displacement of Model-2 is more than 3.125% in seismic zone IV and 3.53% in seismic zone V from Model-1 in the case of the empty tank.

The base shear of Model-2 is less than 4.862% in seismic zone IV and 18.99% in seismic zone V from Model-1 in the case of empty tank

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