STUDY OF SEISMIC BEHAVIOUR OF INTZE TANK IN VARIOUS SEISMIC ZONES UNDER DIFFERENT SOIL CONDITION

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ABSTRACT

In case of elevated tanks having larger diameter, thicker floor slabs are required which resulting in uneconomical designs. In such cases intze type tank with conical and bottom spherical domes provides an economical solution. Ratio of the conical and spherical dome are selected so that the outward thrust from the bottom dome balances the inward thrust due to the conical domed part of the tank floor. Most of the designers consider the wind effect and neglect the seismic effect on the structure which might be disastrous sometimes.

Proper seismic analysis of intze tank in different soil condition makes the structure more safe and durable. This paper present literature review on Study of seismic behaviour of Intze tank in different seismic zones and different soil condition which includes current and future trends of research.

Keywords: Dynamic Analysis, Intze Tank, STAAD PRO, displacement, Base Shear

INTRODUCTION

Tanks are the storage structures which are used to store the important liquids like water and other important things like grains etc, here in this study we will take water as important liquid. For its economical design and when tank of large diameter required Intze tanks are preferred. Earthquakes are one of the major natural calamities which have a potential to destroy human life by causing disturbance to infrastructure and lifeline facilities Water tanks are considered to be a part of crucial life services in most of the cities. Their safety and behaviour is critical during strong earthquakes as they contribute for essential requirements viz. drinking water, fire fighting's in case of fire accidents, etc. Hence, these tanks should not be collapse even after an major earthquake. Intze tanks are somewhat critical & strategic structures, damage happening of these structures during earthquakes, can cause interruption in drinking water supply, cause to fail in preventing large fires and may cause substantial economic loss.

Intze tank behaves differently in different seismic zones and different soil condition and they need to be study in . For modelling and study of Intze tank STADD Pro V8i 2007 is used.

Types of water tank

Based on the location of the tank ,tanks can be classified into three categories.

Those are:

1. Underground tanks
2. Tank resting on grounds
3. Overhead tanks or Elevated tanks

Types of elevated water tanks based on shape

Water tanks based on shape are as follows

1. Circular tank
2. Rectangular tank
3. Intze tank

Intze tank

It is quite similar to Circular tank, the conical bottom is provided at the bottom. It can be divided into two types based on support.

1. Column rested water tank
2. Shaft rested water tank

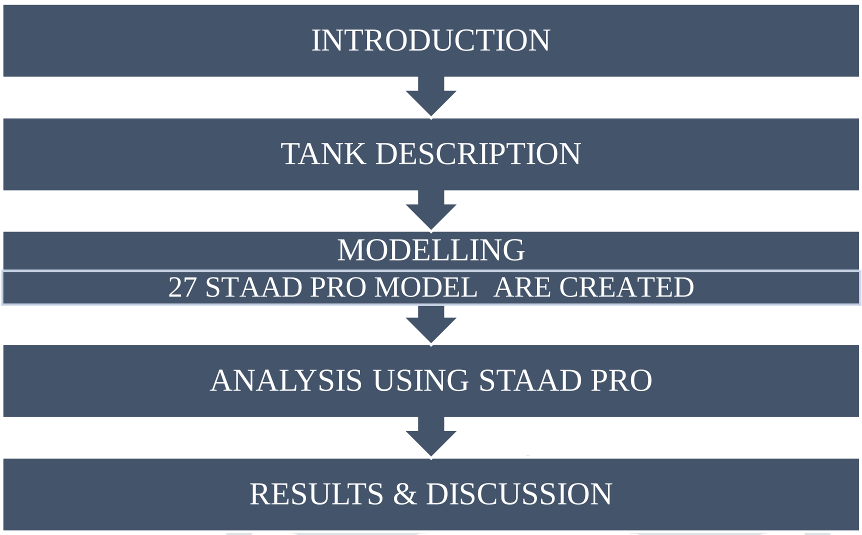
Generally water tank rested on column are preferred for easy calculation of loading condition.

OBJECTIVES

The main objectives of the proposed research study are summarized as follows:

1. To analyze the behavior of the of intze tank in different seismic zones under different soil condition
2. Comparison of Displacement for various seismic zones under all soil types in different filling condition.
3. Comparison of Base Shear for various seismic zones under all soil types in different filling condition.

METHODOLOGY



Description of Intze Tank

Height of the tank	18m
Staging height (linear)	14m
Base diameter of tank	14 m
Diameter of Sphere	49 m
Number of columns	16
Grade of Concrete	M30
Grade of Steel	Fe500
Diameter of column	450mm
Size of Beam -	300 X 250 mm
Plate Thickness -	200 mm

Modelling

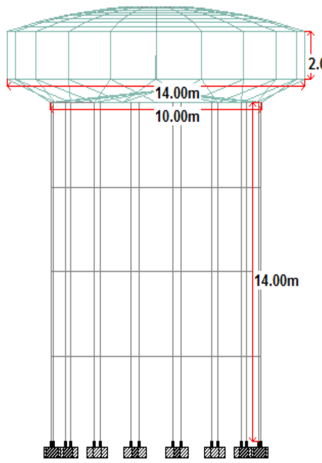


Fig : Side View of Tank

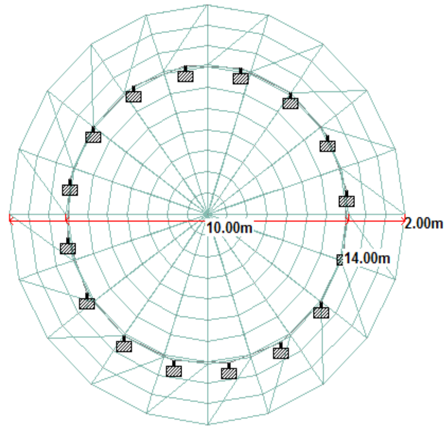


Fig : Top view of Tank

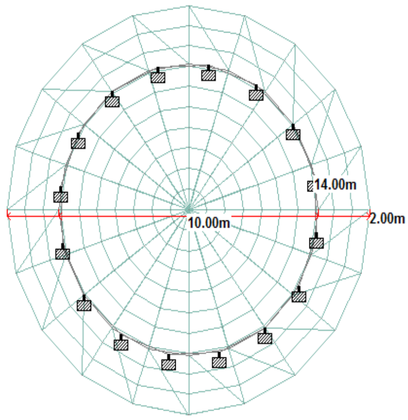
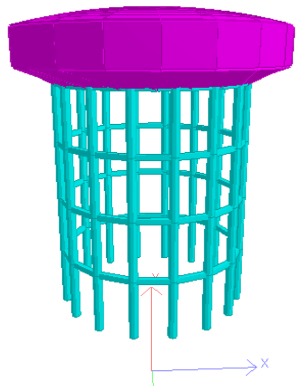


Fig : Bottom View of Tank

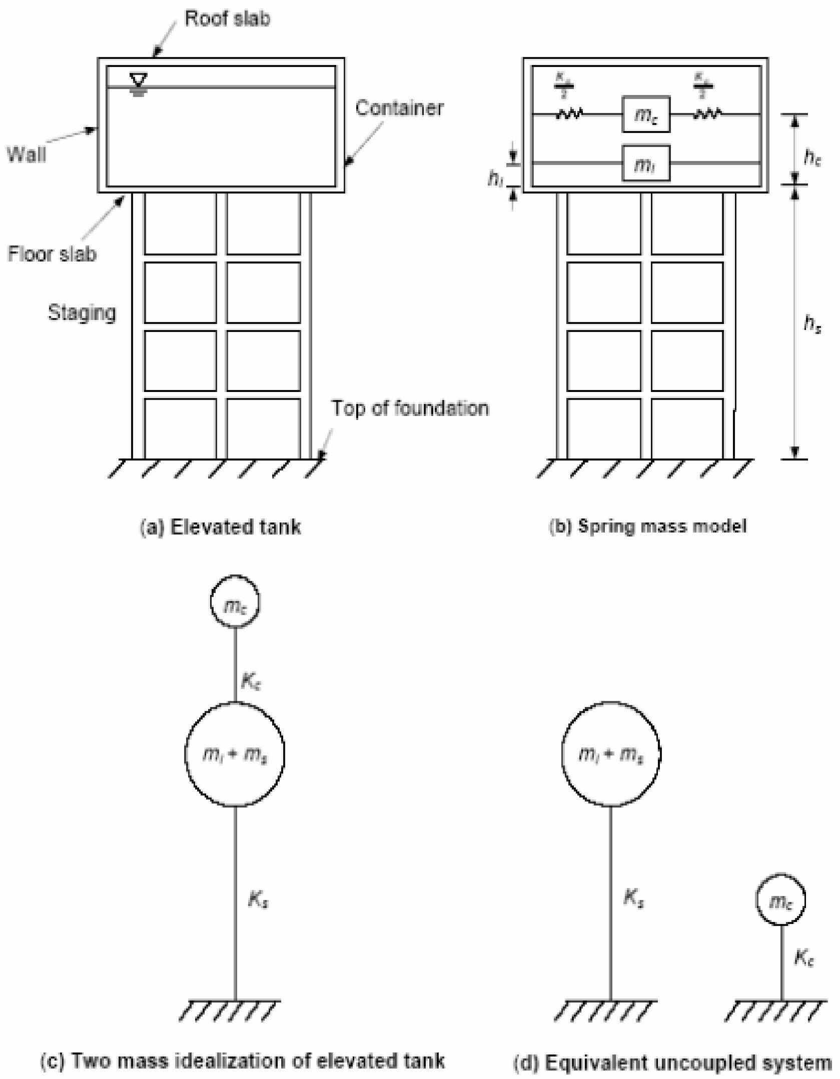


3D STAAD Pro Model of Intze Tank

for Analysis of Intze tank Principle of Two mass Idealization are considered

Principle of Two Mass Idealizations

Analyzing elevated water tanks as a single degree of freedom system is not satisfactory because these are never completely filled and there comes the effect of sloshing effect. The respective lateral stiffness of the different type of tanks can be calculated by any FEM based Software. (STAAD PRO-V8i used for this paper) where as the stiffness for rested on column type can be calculated by applying an arbitrary force at the centre of Gravity of the elevated tank.



(Refer Clause 4.2.2.4)

Figure 4 – Two mass idealization for elevated tank

Design Seismic Base Shear

Base shear in impulsive mode, just above the staging (i.e. at the top of footing of staging) is given by

$$\mathbf{Vi = (A_h)_i\,(m_i+m_s)\,g}$$

and base shear in convective mode can be calculated by

$$\mathbf{V_c = (A_h)_c\,m_c\,g}$$

where ms = Mass of container and 1/3rd mass of staging. Total base shear V, can be obtained by combining the base shear in convective mode and impulsive through Square root of Sum of Squares (SRSS) rule and is given as follows

$$\mathbf{V_c = \sqrt{V_i^{\,2} + V_C^{\,2}}}$$

where A_h is

Design Horizontal Seismic Coefficient

(Ah) can be obtained by the following expression, subject to Clauses 4.5.1 to 4.5.4

$$\mathbf{Ah = \frac{Z}{2}\frac{I}{R}\frac{Sa}{g}}$$

where

Z = Zone factor in Table 2 of IS 1893 (Part 1): 2002

I = Importance factor given in Table 1 of IS 1893 (Part2):2014,

R = Response reduction factor given in Table 2 of IS 1893 (Part2):2014, and

$\frac{Sa}{g}$= Average response acceleration coeff. as given by Fig. 2 and Table 3 of IS 1893(Part 1): 2002 and subject to Clauses 4.5.1 to 4.5.4 of this standard.

And Sa / g can be determined by

For rocky, or hard soil sites

$$\frac{S_a}{g} = \begin{cases} 1 + 15\,T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.40 \\ 1.00/T & 0.40 \le T \le 4.00 \end{cases}$$

For medium soil sites

$$\frac{S_a}{g} = \begin{cases} 1 + 15\,T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.55 \\ 1.36/T & 0.55 \le T \le 4.00 \end{cases}$$

For soft soil sites

$$\frac{S_a}{g} = \begin{cases} 1 + 15\,T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.67 \\ 1.67/T & 0.67 \le T \le 4.00 \end{cases}$$

Where T is

Fundamental Natural Period

Elevated Tank

Impulsive mode

Time period for impulsive mode in second is given by :

$$T_i = 2\pi \sqrt{\frac{m_i + m_s}{K_s}}$$

where

m_i = Impulsive mass of tank

m_s = mass of container 1/3rd mass of staging, and

K_s = lateral stiffness of staging

In this study dynamic analysis was performed on Intze tank for analyzing seismic behaviour of intze tank.

Dynamic Analysis

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the tank.

Time History Method

This method of analysis shall be based on an appropriate ground motion and shall be performed using accepted principles of dynamics.

Response Spectrum

This approach permits the multiple modes of response of a tank to be taken into account. This is required in many tank codes for all except for very simple or very complex structures. The structural response can be defined as a combination of many modes. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the model frequency and the model mass, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all directions is calculated and then effect on the tank is observed. Following are the types of combination methods:

i) Absolute - peak values are added together

ii) Square root of the sum of the squares (SRSS)

ii) Complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes.

The result of a RSM analysis from the response spectrum of a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, because information of the phase is lost in the process of generating the response spectrum .In cases of structures with large irregularity, too tall or of significance to a community in disaster response, spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static or dynamic analysis.

RESULTS AND DISCUSSION

Natural Frequency and Natural Period

The natural frequency of a system is the frequency at which a system naturally vibrates once it has been set into motion. The natural frequency depends on two things: the stiffness and mass of the system.

Table: Natural Frequency and Natural Period of tank

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	0.391	2.55960
2	0.393	2.54751
3	1.027	0.97405
4	3.232	0.30943

5	3.501	0.28562
6	3.794	0.26359

Displacement

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 transverse direction under Seismic zone iii, iv, v for Hard soil

Table : Displacement in (mm) in transverse direction under Seismic zone iii, iv, v for Hard soil

Different levels of tank	Displacement in (mm) in transverse direction		
	Seismic Zone III	Seismic Zone IV	Seismic Zone V
Base	0	0	0
At 3.5 m	0.090	0.134	0.201
At 7 m	0.148	0.222	0.333
At 10.5 m	0.165	0.248	0.372
At 14 m	0.165	0.248	0.372

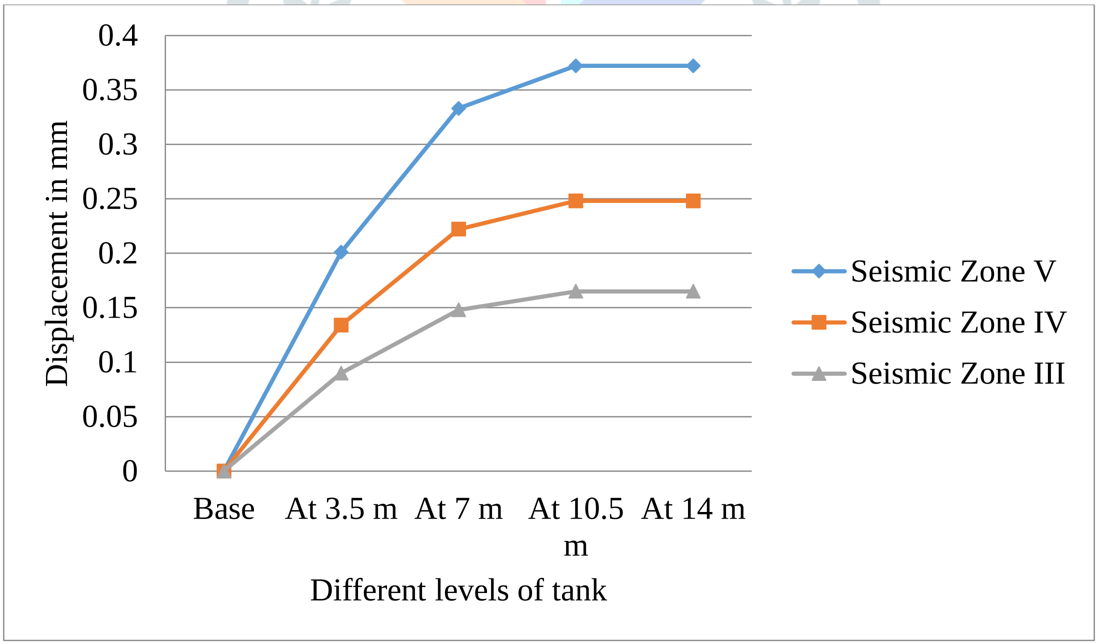


Fig : Plot for displacement in (mm) in Transverse Direction under Seismic zone iii, iv, v for Hard soil

Displacement in transverse direction under Seismic zone iii, iv, v for Medium soil

Table : Displacement in (mm) in transverse direction under Seismic zone iii, iv, v for Medium soil

Different levels of tank	Displacement in (mm) in transverse direction		
	Seismic Zone III	Seismic Zone IV	Seismic Zone V
Base	0	0	0
At 3.5 m	0.099	0.148	0.222
At 7 m	0.163	0.244	0.366
At 10.5 m	0.182	0.273	0.409
At 14 m	0.182	0.273	0.409

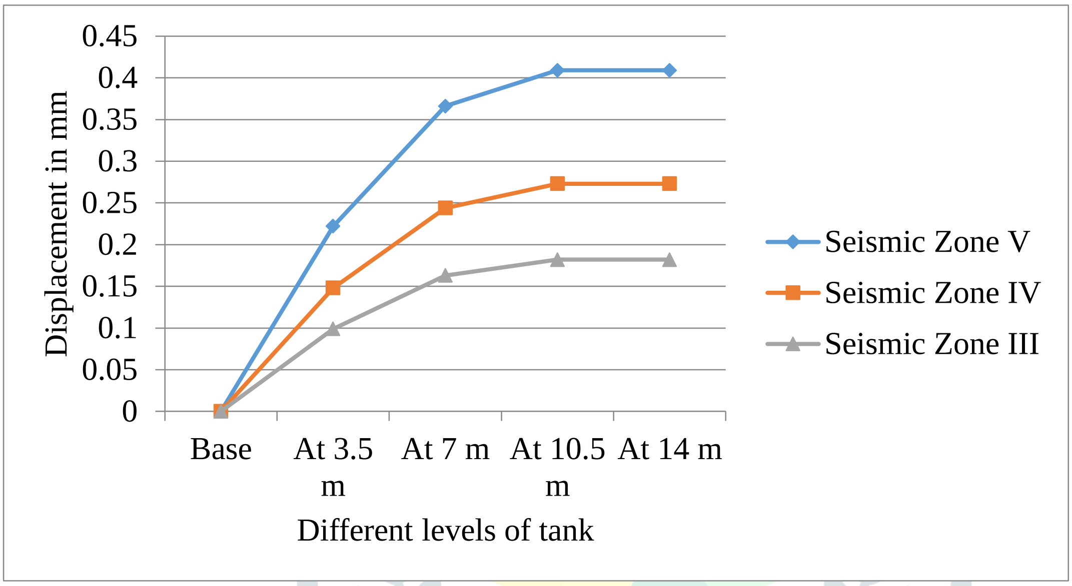


Fig : Plot for displacement in (mm) in Transverse Direction under Seismic zone iii, iv, v for Medium soil

Displacement in transverse direction under Seismic zone iii, iv, v for Soft soil

Table 5.4 Displacement in (mm) in transverse direction under Seismic zone iii, iv, v for Soft soil

Different levels of tank	Displacement in (mm) in transverse direction		
	Seismic Zone III	Seismic Zone IV	Seismic Zone V
Base	0	0	0
At 3.5 m	0.136	0.204	0.302
At 7 m	0.224	0.337	0.500
At 10.5 m	0.250	0.376	0.558
At 14 m	0.250	0.376	0.558

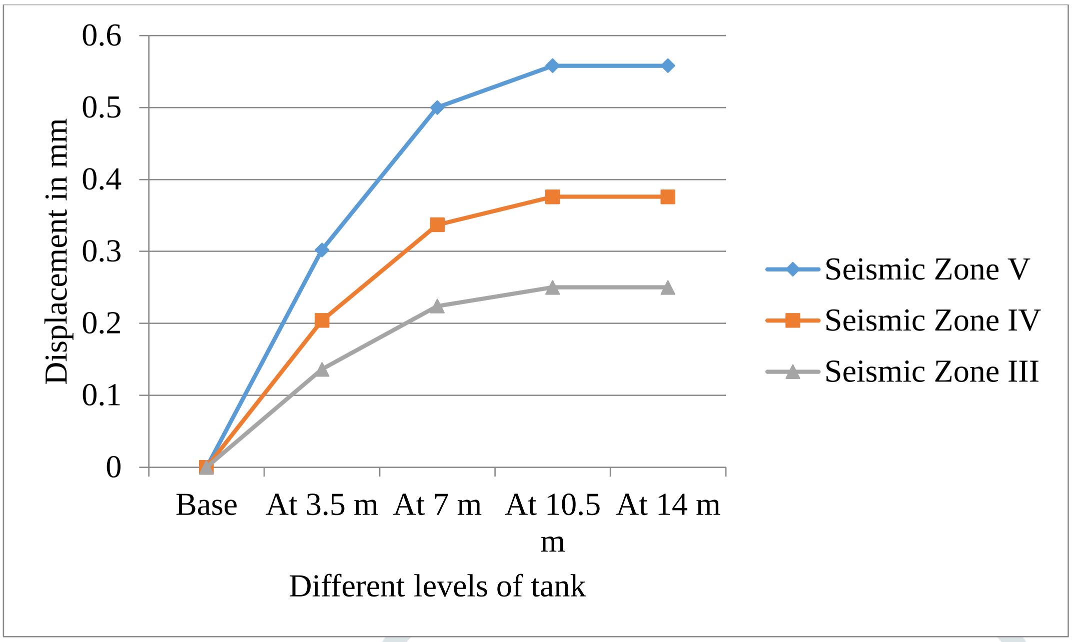


Fig : Plot for displacement in (mm) in Transverse Direction under Seismic zone iii, iv, v for Soft soil

As we know from above analysis the maximum displacement occurs in zone 5 under soft soil condition hence we can compare these displacement with displacement occurs in empty tank condition considering the same zone 5 and soft soil for better understanding of displacement.

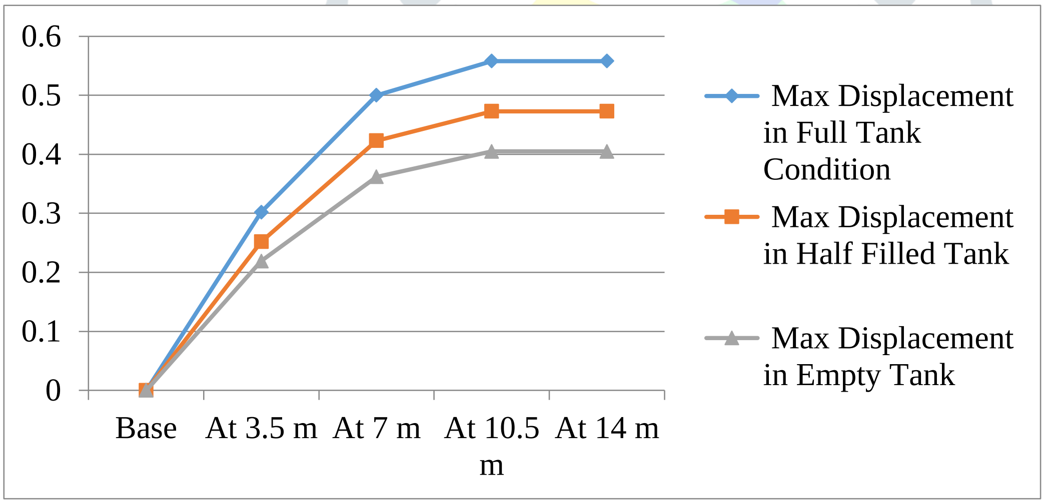


Fig : Plot for Max displacement in (mm) in Transverse Direction under Seismic zone V for Soft soil for Full Tank and Empty Tank Condition

Base Shear

Base shear is the maximum expected lateral force that will occur due to seismic ground motion at the base of the structure. Below figures compare the base shear values of the model's directions respectively using static method.

Base Shear For Hard Soil

In Seismic Zone III

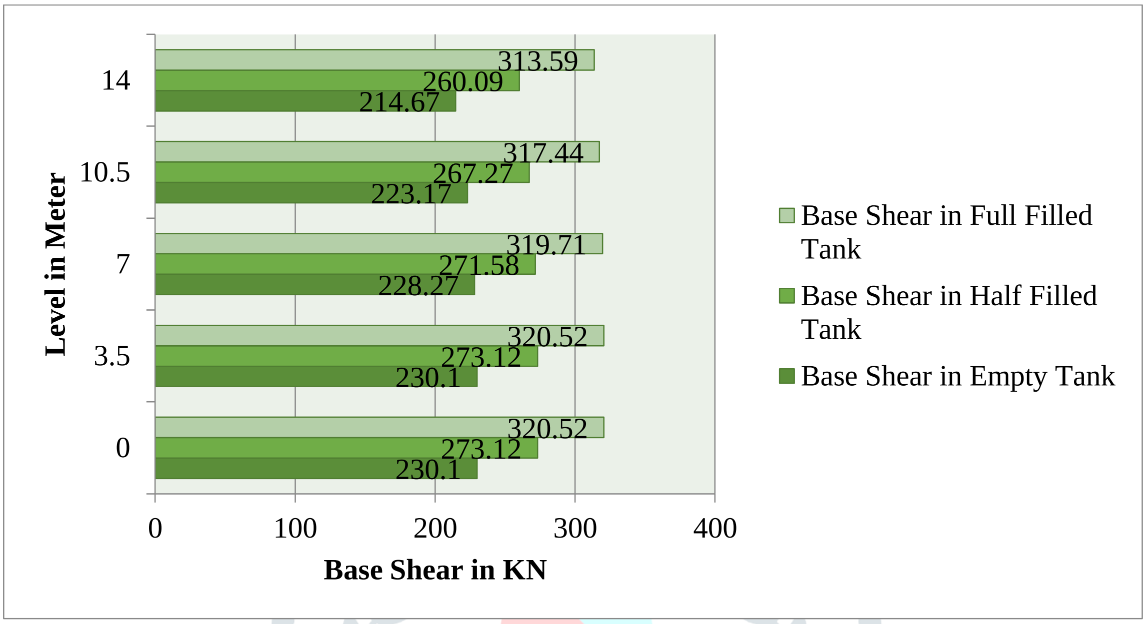


Fig : Base Shear in Zone III for Hard Soil

In Seismic Zone IV

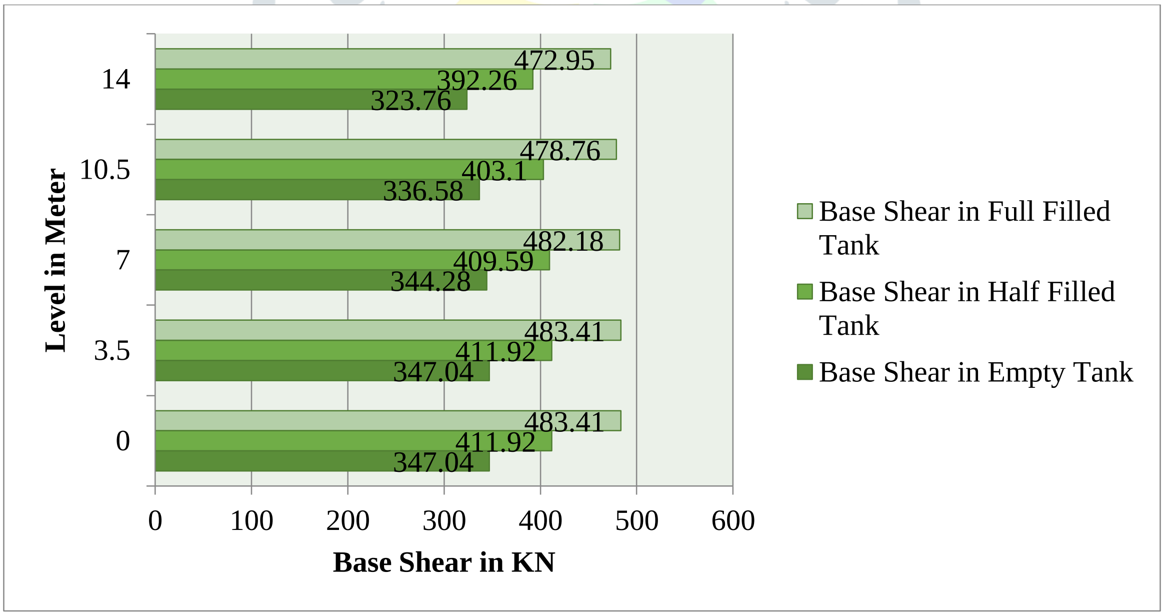


Fig : Base Shear in Zone IV for Hard Soil

In Seismic Zone V

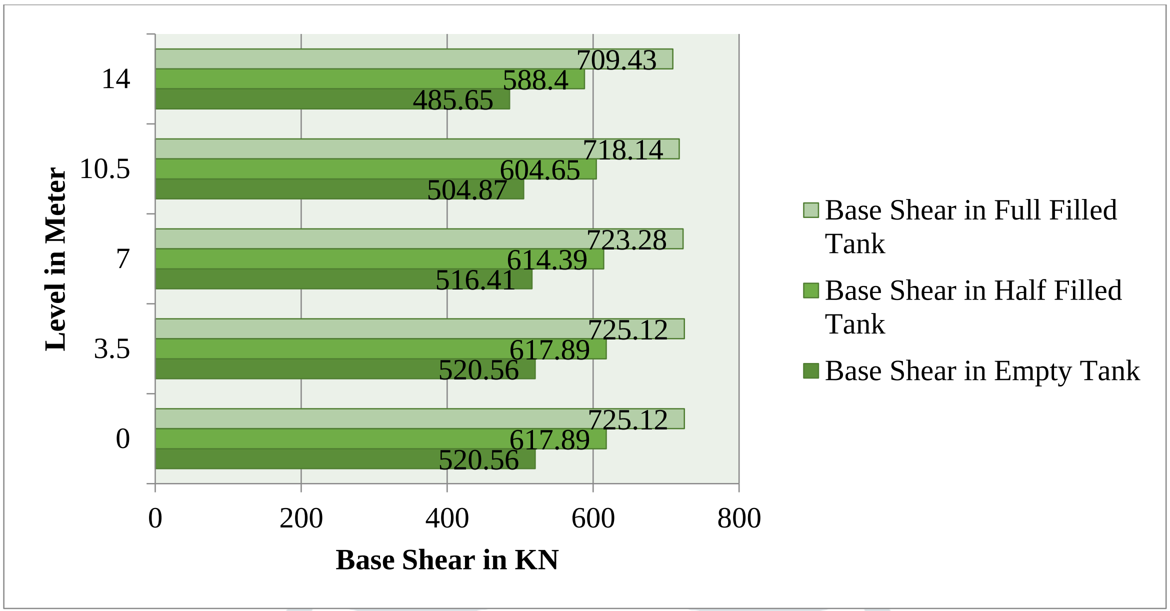


Fig : Base Shear in Zone V for Hard Soil

Base Shear For Medium Soil

In Seismic Zone III

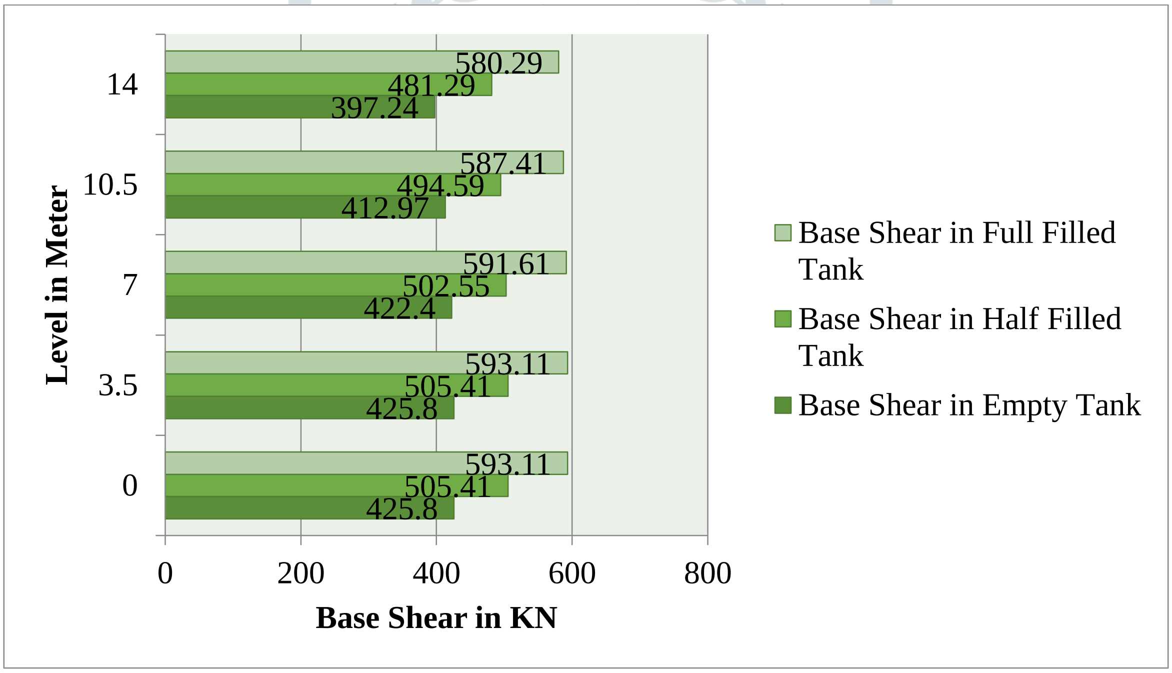


Fig : Base Shear in Zone III for Medium Soil

In Seismic Zone IV

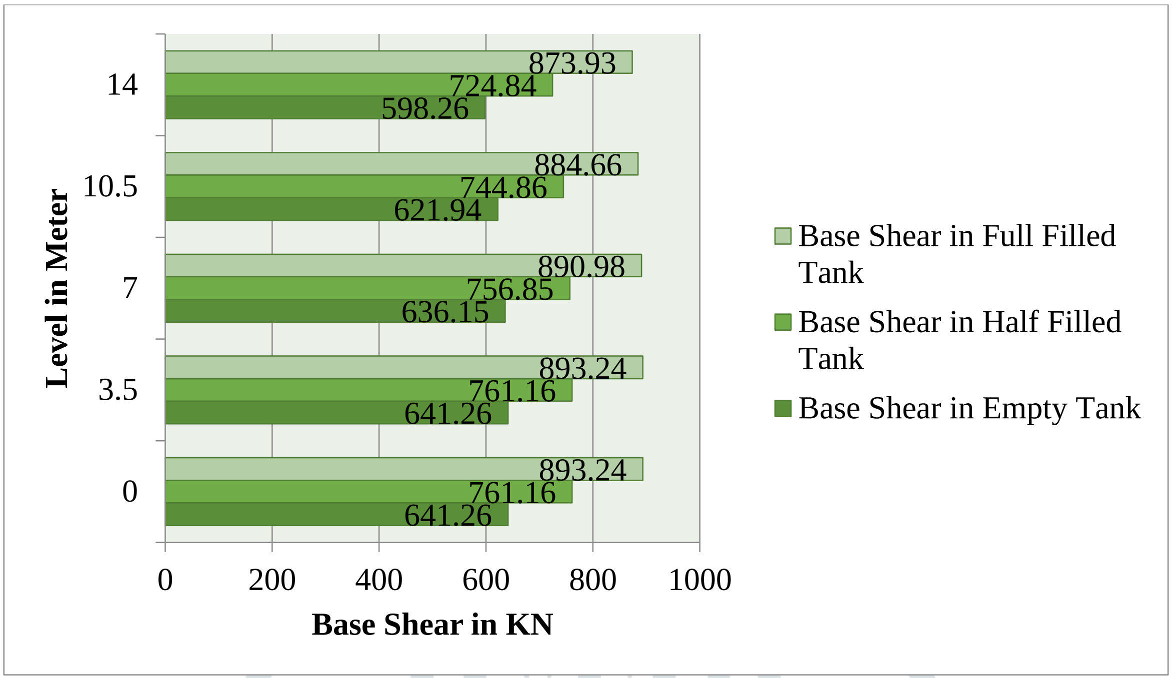


Fig : Base Shear in Zone IV for Medium Soil

In Seismic Zone V

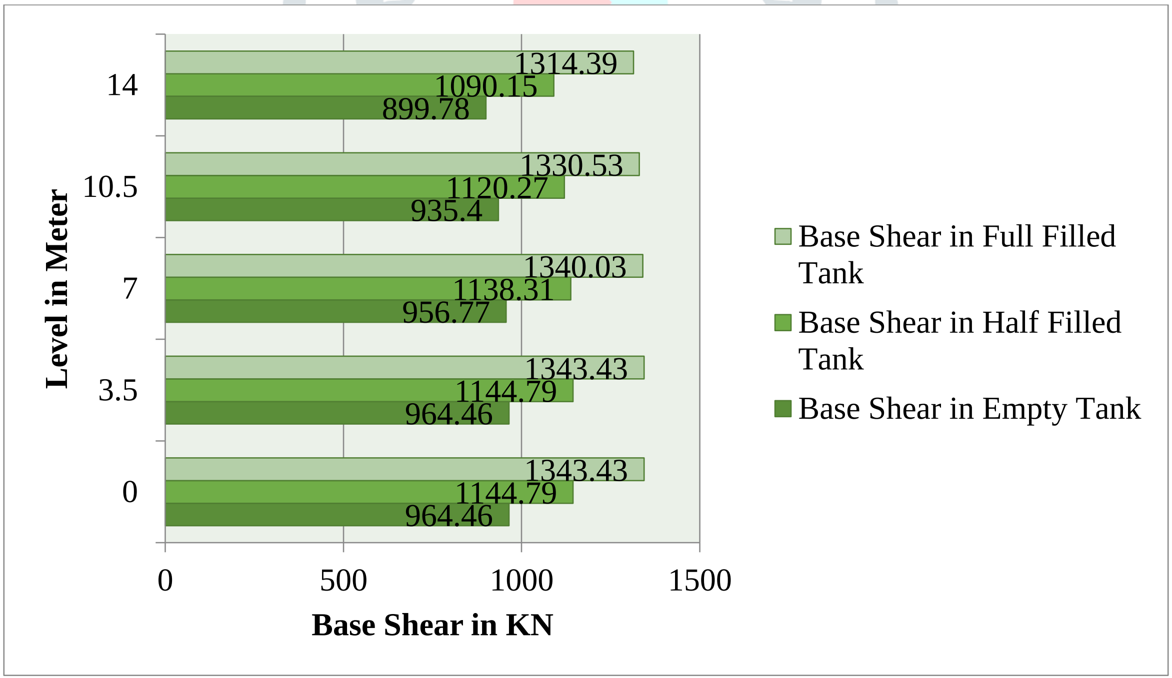


Fig : Base Shear in Zone V for Medium Soil

Base Shear For Soft Soil

In Seismic Zone III

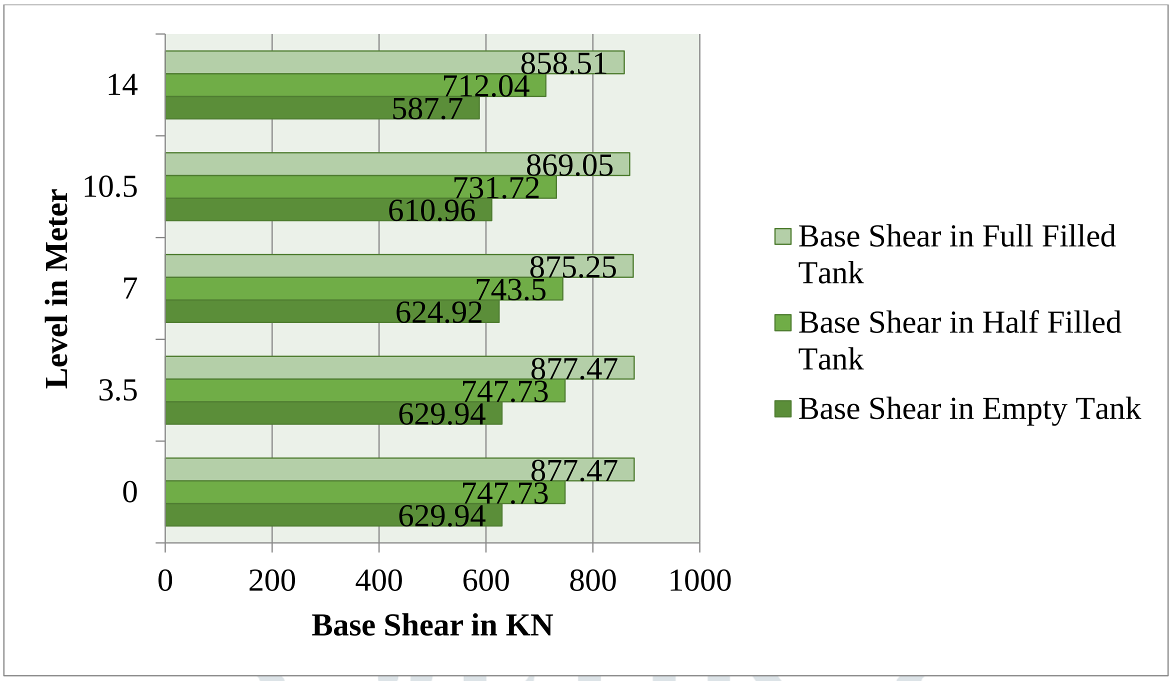


Fig : Base Shear in Zone III for Soft Soil

In Seismic Zone IV

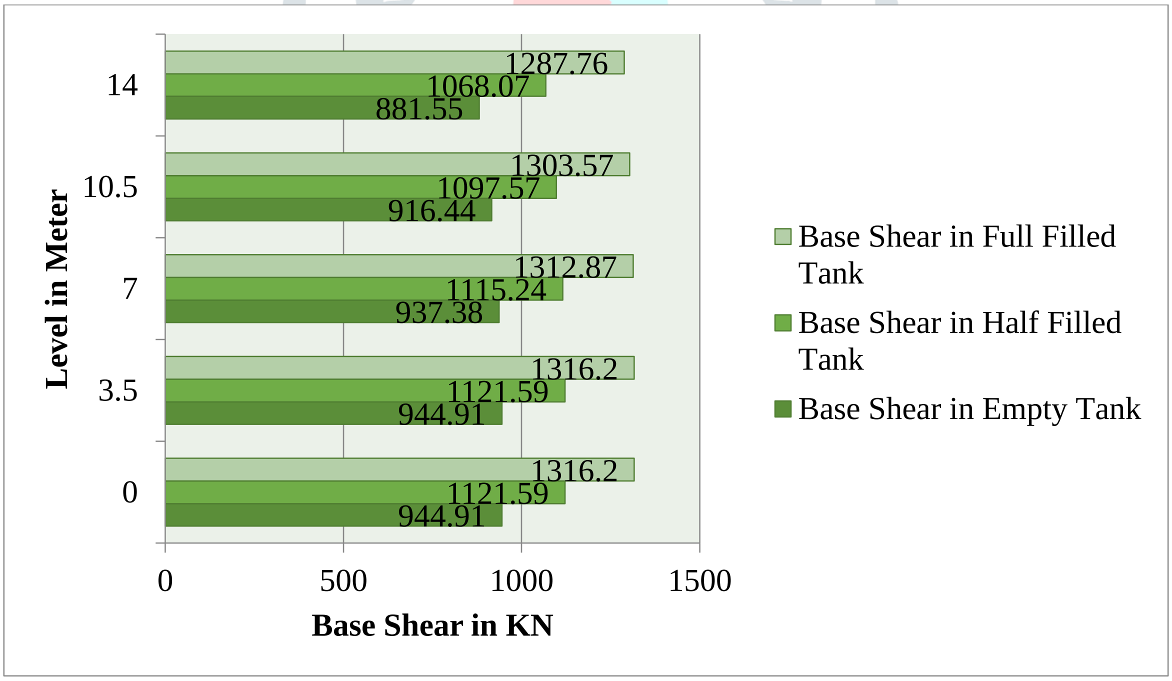


Fig : Base Shear in Zone IV for Soft Soil

In Seismic Zone V

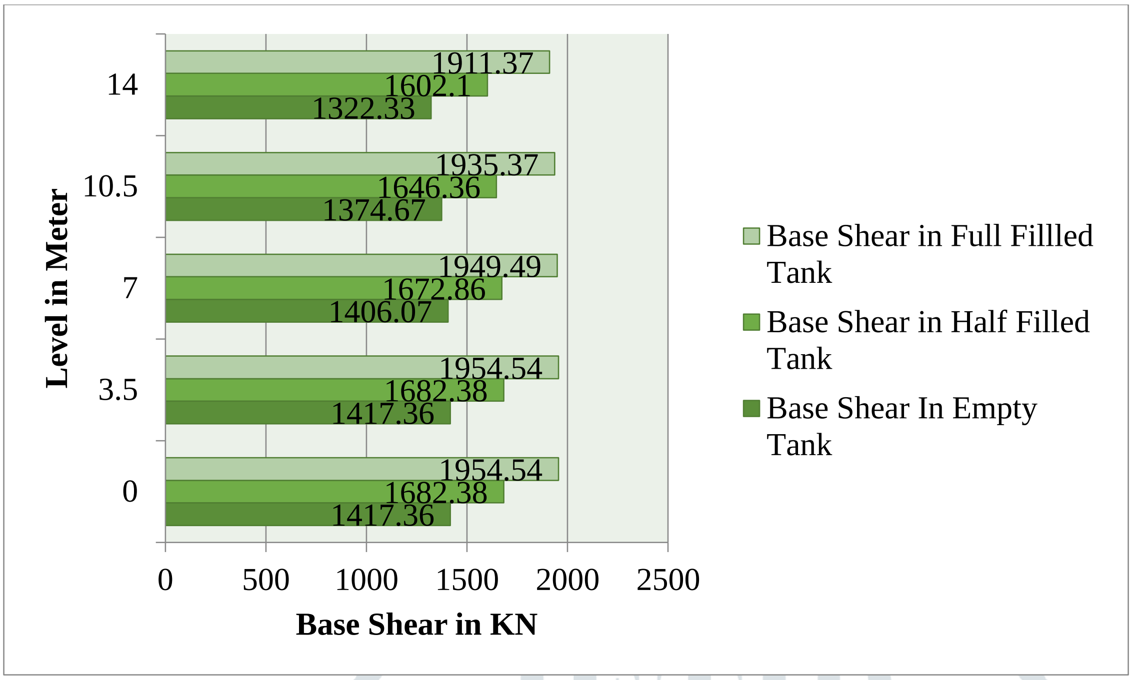


Fig : Base Shear in Zone V for Soft Soil

CHAPTER 6
CONCLUSION

- The hydrodynamic pressure is acting due to separation of water into convective and impulsive masses respectively. The mass at top of the container is convective whereas at bottom is impulsive. The sloshing occurs due to convective mass only.

- According to result the base shear was found to be maximum at base and it decreased to minimum at top in all cases.

- Large displacement was observed in Seismic zone V under Soft soil condition for full tank, Half filled and empty tank condition.

- While comparing to different filling condition Full tank shows higher value of base shear and displacement.

- It is observed that the seismic forces are maximum for the soft soil condition for every seismic zone. Minimum displacement was observed for Hard soil in seismic zone III, followed by Zone IV and V, It indicates tank is more safe in Hard soil in compare with other two.

- In the study the different parameter such as soil structure interaction, Soil types, Zone types, Natural frequency, Natural Period, Base reaction and Lateral displacement are considered and these parameters are important in the analysis of Intze type water tank for different seismic zones under different soil condition.

- At various height of tank increases the lateral displacement, natural frequency and are also increases.

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