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Dynamic Analysis of Elevated Water Tanks

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ABSTRACT: Water tanks are very important components of lifeline. They are vital component in municipal water system, firefighting systems and in many industrial facilities for storage of water. The water tanks get heavily damaged or collapsed during earthquake due to the fluid-structure interactions; hence the seismic behavior of tanks has the characteristics of complex phenomena. Water storage tanks ought to stay practical within the post-earthquake amount to confirm potable water system to earthquake affected regions. The parametric study suggests that the elevated circular tanks performs better than elevated rectangular tanks. In the present study, a dynamic analysis of elevated RCC water tanks design for the zone III and zone V as per Indian Standard: 1893-2002 (Part-2) and analyzed manually as well as using the software considering all the earthquake forces. Objective of this paper is to understand the dynamic behavior of elevated water tanks under earthquake loading.

KEYWORDS: Elevated Circular Tanks, Dynamic Analysis, and STAAD-PRO.

1 INTRODUCTION

Earthquakes are major calamities which have a potential to causing disturbance to infrastructure and lifeline facility. Water is basic needs for daily life. An elevated water tank is a large container built for the purpose of water supply it consists large water mass at the top of slender staging which is considering critical during an earthquake. For certain proportion of tank and structure, the sloshing of water during an earthquake is also a dominant factor.

The presence of a free fluid surface which allows motions related to container called liquid sloshing. Seismic ground motion cause hydrostatic and hydrodynamic pressure on the tank which depend on the dimension of tank, the percentage of liquid, properties of liquid, fluid tank interaction etc. Most of the people developed a mathematical model, theoretical solution for calculating or studying sloshing effects. Therefore an understanding of earthquake damage for elevated service reservoir requires information about dynamic forces, staging height associated with sloshing liquid is important Main objective of seismic design of structure is to ensure that the structure even though does not fully recent percent resist the earthquake force it at least has an acceptable performance when subjected to various intensity earthquakes and the probability of such occurrences during its lifetime.

1.1 *Classification of tanks*

1.1.1. Based on Location

a. Ground level tanks
b. Elevated tanks
c. Underground tanks

1.1.2. Based on Shape

d. Rectangular Tanks
e. Circular Tanks
f. Intze Tanks
g. Spherical Bottom Tanks
h. Domed Bottom Tanks
i. Conical Bottom Tanks

1.2 *Seismic zoning*

Different locations have different geology. The possibility of occurrence of earthquakes and its damaging effects is different at different locations. Hence analyzing the earthquakes in our country taking India as one whole region will not be precise. Thus, India was divided into five regions known as Zones and a map representing these zones called Seismic Zone Map is prepared to recognize these earthquake prone areas. India was divided into five zones – I, II, III, IV and V by the 1970 version of the zone map based on the levels of intensities sustained during past earthquakes. These maps need to be revised time to time as there will be changes and better understanding is obtained on the geologic condition and the seismic activity in the country.

The first seismic zone map was provided in 1962 by the Indian Standards, which was further revised in 1967 and once again in 1970. The map has been last revised in 2002, and it now has seismic zones – II, III, IV and V. The seismic zone I areas were merged with those of seismic zone II in 1970. Seismic Zone Map presents an outsized scale read of the unstable zones. Hence soil variations and variations in the geology cannot be represented at that scale. Therefore, for major projects, such as large scale dams or a power plant, the seismic danger is investigated specifically in detail for that particular site. For the purposes of urban planning, the area to be urbanized is again zoned further as smaller unit which is known as micro-zoning. By doing so, the local of earthquake forces are:

Seismic variations in soil profile, geology etc. can also be considered. The necessary factors that have an effect on the magnitude,

1.2.1. Zone Factor, Z

As mentioned earlier, India has been divided into four seismic zones as per IS 1893 (Part 1): 2002. There are different zone factors for different zones.

1.2.2. Important Factor, I

It relies upon useful utilization of the structures, characterized by hazardous results of its collapse or failure and post-earthquake practical requirements or financial significance. Elevated water tanks are utilized for putting away consumable water and used during crisis for example, putting out fires and are of post-earthquake significance. Importance factor is taken as 1.5for elevated water tank.

1.2.3. Response reduction factor, R

It relies on the apparent earthquake hazard and harm caused on the building, described by brittle or ductile displacements. R values of tanks are not as much as buildings since tanks are less ductile and have low redundancy when compared with other building. For Special Moment Resisting Frame (SMRF), R value is 2.5.

1.2.4. Structural Response Factor,(Sa/g)

It is a component meaning which denotes acceleration response spectrum of the building subjected to soil disturbance due to earthquake and depends on the damping of the structure and natural period of vibration.

1.3 *Loads Considered*

1.3.1 *Dead load*

The dead load in a tank includes the self-weight of the structure and all other superimposed dead loads (viz, all permanent constructions and installations including weight of all side slabs).

1.3.2 *Live Load*

The magnitude of live load to be taken generally depends upon the type of occupancy of the tank. IS 3375 part 4 gives certain minimum values of live loads for specific purpose.

1.3.3 *Water Pressure*

The water pressure is triangular or uniformly varying load which is zero at the top and maximum at the bottom of the water tank.

1.4 *Aim of the study*

The aim of design is the performance of an adequate probability that structures being designed will carry out.

Satisfactorily during their intended life. Structural design of the water tank should be economical.

1.5 *Objectives of the study*

- The main objective of this project is Dynamic Analysis of the Elevated water tanks.
- To study the Examine base shear of Elevated Circular water tanks Supported on Frame Staging considering different height and zone and plotting the graphs as base shear Vs height and base shear Vs zone.

- To know about the manual design of structure for the safe and economical structure of the tanks.

2 METHODOLOGY

2.1 *Design 1: Analysing structure manually in Microsoft Excel.*

The first step for the analysis has been the elevated water tank designed manually in Microsoft excel It will be design for earthquake acting. Proper loading conditions, earthquake zone etc. are to be considered in this design. All wall loads and slab loads has calculated in excel and directly applied in modeling of the elevated water tank structure in staad-pro.

2.2 *Design 2: Elevated water tank structure in STAAD-PRO.*

After clear analysis of water tank, the next step has the effect on tank at different height of structure with the help of STAAD-PRO software. For this attempt, we have tried to consider same loading conditions, and earthquake zones coming on the structure so that it will be easy for comparison.

The tank selected for study will be circular type. Tank is analyzed by using STAAD-PRO analysis package and performance with respect to displacement, base shear and maximum forces are presented.

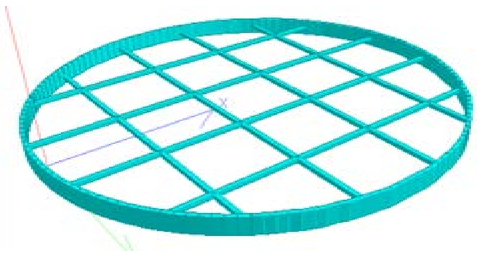

Figure 1: 3-D View of Roof

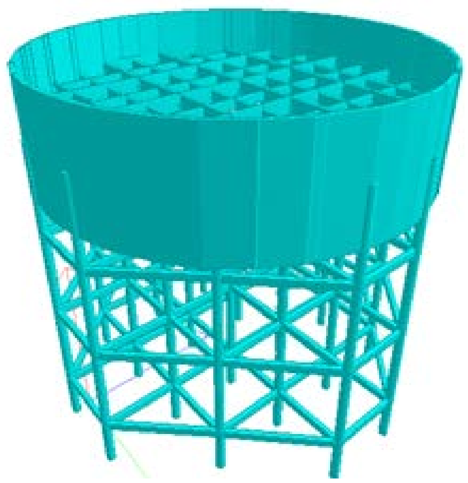

Figure 2: 3-D model of Staging

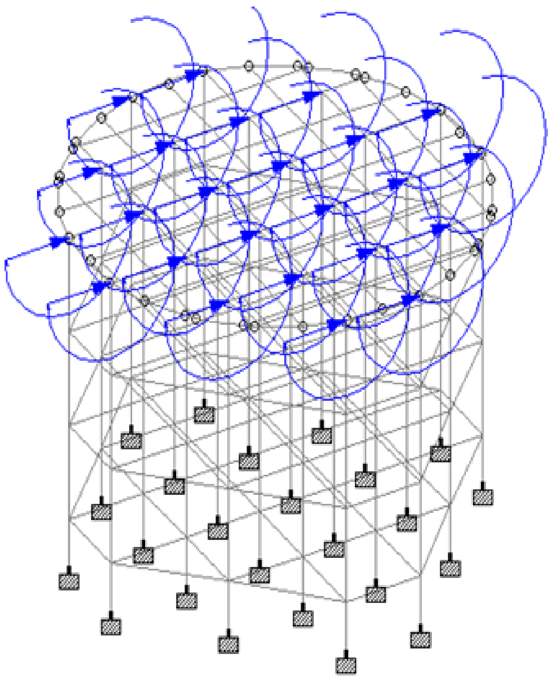

Figure 3: Wind load on staging

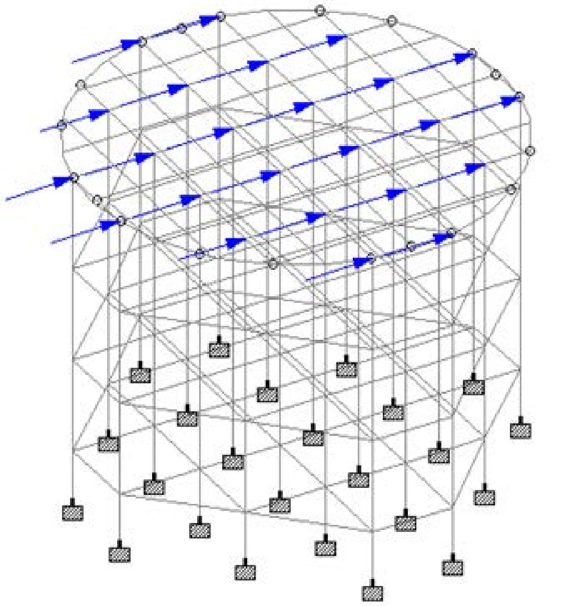

Figure 4: Seismic load

Table 1:design data of the tank

Type of tank	- Circular type
Capacity of tank	- 20 Lakh Liters
Staging Height	- 12 m
	- 15 m
	- 18 m
Water Height	- 5 m
SBC of Soil	- 200 kN/m^2
Number of columns	- 24 no.
C/C span of the Roof Slab	- 4.5(Div.in 2Prts)
C/c Span of the Floor Slab	- 2.25 m
Thickness of tank wall	- 2.25 m
Thickness of Roof Slab	- 0.12 m
Thickness of Floor Slab	- 0.20 m
Size of Roof beam	- 0.23 X 0.23 m
Column inside Container	- 0.30 dia.
Main Staging Column	- 0.50 dia.
Free Board of Roof Beam	- 0.50 m
Grade of Concrete	- M30
Grade of Steel	- Fe500
Seismic Zones	- III, V
Density of Concrete	- 25 kN/m^3
Density of Water	- 10 kN/m^3
Young's modulus of Steel E_s	- 200000 N/mm^2

3 RESULTS

The behavior of structure due to seismic loads and wind loads are observed by performing dynamic analysis considering seismic zone III, zone V and wind zone VI. Parameter considered for comparison are displacement, height variation, time period, base Shear.

Table 2: Height of the tank Vs Displacement

Height of the tanks	12m	15 m	18 m
Maximum Displacement	21.338	38.08	59.955
Minimum Displacement	1.351	5.796	8.048

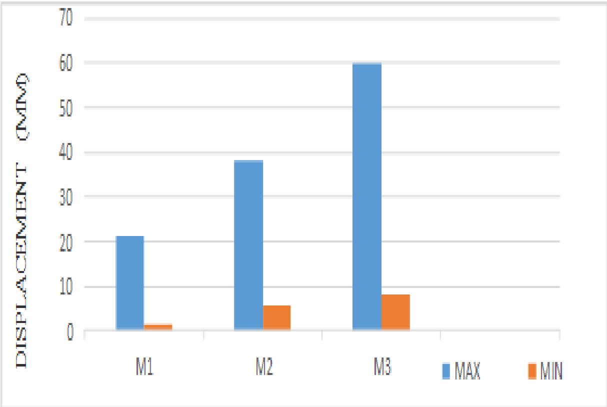

Figure 5: Height of the tank Vs Displacement

Table 3: Base Shear in zone III Vs Zone V

Base Shear(kN)	12m	15 m	18 m
Zone III	191.96	223.23	242.92
Zone V	431.91	502.26	546.58

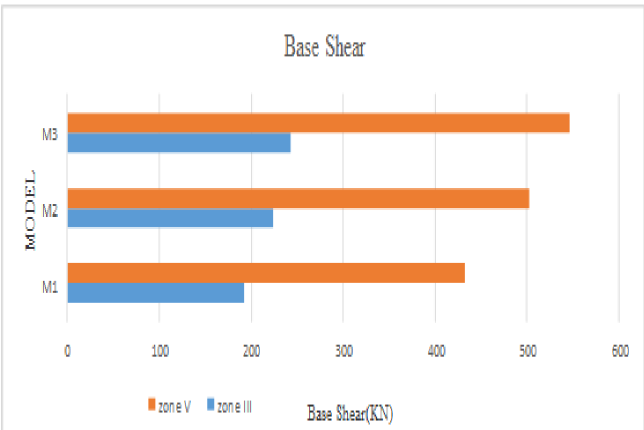

Figure 6: Base Shear in zone III Vs Zone V

Table 4: Base moment in zone III Vs zone V

Base Moment(kN.m)	12m	15 m	18 m
Zone III	1713.33	2906.12	2974.88
Zone V	3854.99	6538.77	6693.48

Figure 7: Base moment in zone III Vs zone V

Table 5: Disp. in zone III Vs zone V

Disp.	12m	15 m	18 m
Fixed	21.338	38.080	52.195
pinned	29.164	45.651	59.955

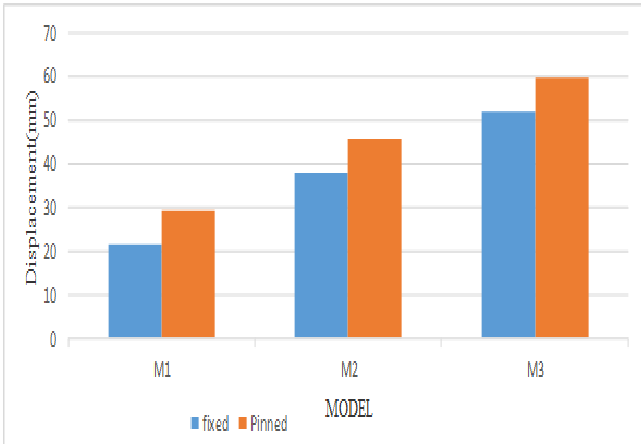

Figure 8: Disp. in zone III Vs zone V

4 CONCLUSIONS

The objective of research was to study Elevated water tanks (Circular type) variation of height and base shear analysis in different zones is to suggest the height of tank increases displacement are increases. The behavior of Tank due to seismic loads and wind loads are observed by performing dynamic analysis considering seismic zone V and zone III.

5 SCOPE FOR THE FUTURE WOR

Dynamic analysis of elevated RCC circular water tanks has been carry out as per IITK-GSDMA guidelines and behaviour of the elevated water tanks for different parameters viz., Zone factor, Base shear different staging heights have been analysed. The modal characteristics of the structure were ascertained using STAAD-PRO. The Supporting structures i.e. the stagings were found vulnerable for seismic forces. Hence, an attempt has been made to study the effect of variations in staging height on the seismic behaviour of elevated water tank. The following observations were found in the analysis as listed below.

- The height of the staging has effect on base shear characteristics. The base shear will increases until a detracting staging height. Care should be taken in avoiding the high altitude.
- The base shear varies linearly with the change in zone

The results showed that there is a good implementation of numerical studies with field studies.

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