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SEISMIC ANALYSIS OF ELEVATED CIRCULAR WATER TANK DESIGNED BY INDIAN STANDARD CODE

Siddhnath Verma[1], Ganesh Jaiswal[2]

[1]PG Student, Department of civil engineering, Institute of Engineering and Technology, Lucknow, Uttar Pradesh, India

[2]Assistant Professor, Department of civil engineering, Institute of Engineering and Technology, Lucknow, Uttar Pradesh, India

Abstract- This study analyses the findings of a seismic analysis of an above circular water tank conducted in seismic zones III and IV in accordance with IS 1893:2016. The analysis is carried out for a 35 cubic meter elevated water tank that is positioned in three different seismic zones and three different soil types (Hard rock, Medium soil, soft soil). ETABS software was also used to do the analysis. The comparative parameters in varied soil conditions are storey drift, storey displacement, base shear, and base moment. By changing soil types, the research revealed an increase in storey drift, storey displacement, base shear, and base moment.

Keyword- Storey drift, Storey displacement, base shear, base moment and ETABS.

INTRODUCTION

Water is the lifeblood of all living things on this planet. A water tank is a life-saving facility that should continue to function even after an earthquake. Earthquakes are vibrations that affect the earth's surface as a result of waves generated within the earth. These water tank structures are vulnerable to horizontal stresses such as earthquake shaking because of the huge general mass concentrated at the summit of a slender aiding structure. As a result, the design of a R.C. liquid storage tank for earthquake effects is critical, given the unquestionably terrible consequences of liquid storage tank failures.

Expanded water tanks have been significantly damaged or collapsed in the past during earthquakes, which is likely owing to a lack of competence in determining the suitable behavior of the tank's aiding system against dynamic effects, as well as an incorrect geometrical choice of staging style. Although it is believed that earthquakes do not kill people, systems that are not designed to withstand earthquakes do.

India is a subcontinent with more than 60% of its land mass located in an earthquake-prone area. In India, the bulk of architectural structures are constructed largely with permanent, semi-permanent, and moveable masses in mind. However, earthquakes are a rare occurrence that not only results in human deaths but also disrupts India's societal status. The current designs of supporting structures for elevated water tanks are particularly vulnerable to lateral stresses caused by earthquakes, as the Bhuj (Gujarat) earthquake demonstrated, with an incredible diversity of water tanks with frame staging being damaged and some was collapsing.

Because of the possible negative financial and environmental consequences of a tank breakdown and liquid spills on the surrounding areas, the safety of elevated tanks used for storage of water or other liquids is a key priority. As a result, a significant amount of effort has gone into better understanding the seismic behavior of liquid-storage elevated tanks and reservoirs, as well as improving related design codes.

Earthquake-induced motions are three-dimensional, and recent examinations of recorded earth motions have shown that the vertical component of ground acceleration can exceed the horizontal component of ground acceleration, particularly near the epi centre. Vertical excitation has an impact on fluid surface elevations and hydrodynamic pressures. Tanks with flexible sides also have a lot of horizontal force.

METHODOLOGY

The methodology includes designing of circular elevated water tank as per Indian standard code. The modeling of the circular elevated tank is done at ETABS software. All the analysis of the tank is being done at full water condition. The dynamic analysis is done on software and equivalent static method as per codal provisions is also done. The analysis is carried out in seismic zone III and IV and on hard, medium and soft soil conditions.

Step-1 The first step involves in analysis by equivalent static method is fixing of the size of the tank.

Component name	Size (in mm)
Capacity of tank	35 cubic meter
Top dome	150mm
Top ring beam	230mm ×300mm
Side wall thickness	230 mm
Column size	300mm ×300mm
Bottom ring beam	300mm×600mm
Bracing	300mm×600mm
Number of columns	6

Step 2 Determination of parameters m_i, M_i^*, M_c^*, m_c, h_i, h_c, and k_c based upon h/D ratio as per IS 1893(part 2):2014.

Step 3 Determination of lateral stiffness of staging as per IS 1893(part 2):2014 clause 4.3.1.3

Step 4 Time periods for impulsive and convective modes are determined according to clauses 4.3.1 and 4.3.2, respectively.

Step 5 calculation of design horizontal seismic coefficient (A_h)

$$A_h=\frac{Z}{2}\times\frac{I}{R}\times\frac{Sa}{g}$$

Where z=zone factor, I= importance factor, R= response reduction factor given in table 2 and table 3 in code, S_a/g= average response acceleration coefficient

Step-6 For both impulsive and convective modes, base shear is estimated. The impulsive mode base shear-

$$V_i= (A_h)_I\,(m_i+m_s)g$$

Base shear in convective mode

$$V_c=(A_h)_c\; m_c\; g$$

Total base shear

$$V=\sqrt{Vi^2 + Vc^2}$$

Step-7 The impulsive base moment is calculated by following given formula-

$$M_i^*= (A_h)_I[m_i(h_i^*+h_s)+m_s h_{cg}]g$$

Base moment in convective mode

$$M_c^*= (A_h)_c\; m_c\; (hcg+hs)g$$

Total moment shall be obtained as

$$M^*=\sqrt{Mi *^2 + Mc *^2}$$

Seismic parameters

I=importance factor=1.0

R=response reduction factor=2.5

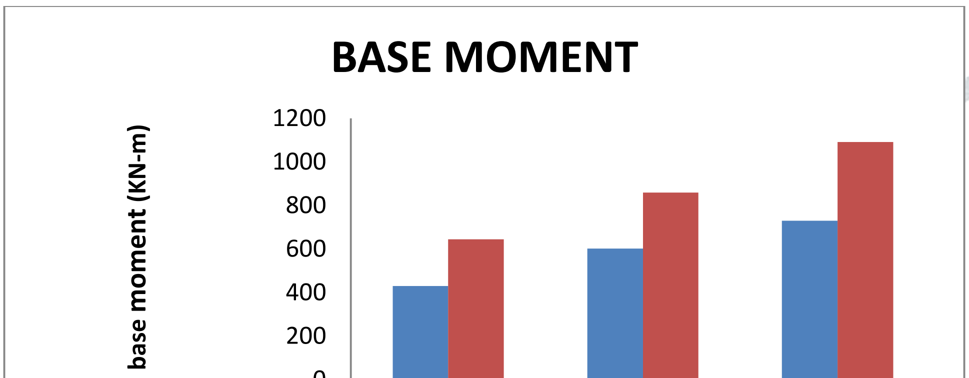
Z=zone factor= 0.16 for zone III

= 0.24 for zone IV

RESULT AND CONCLUSIONS

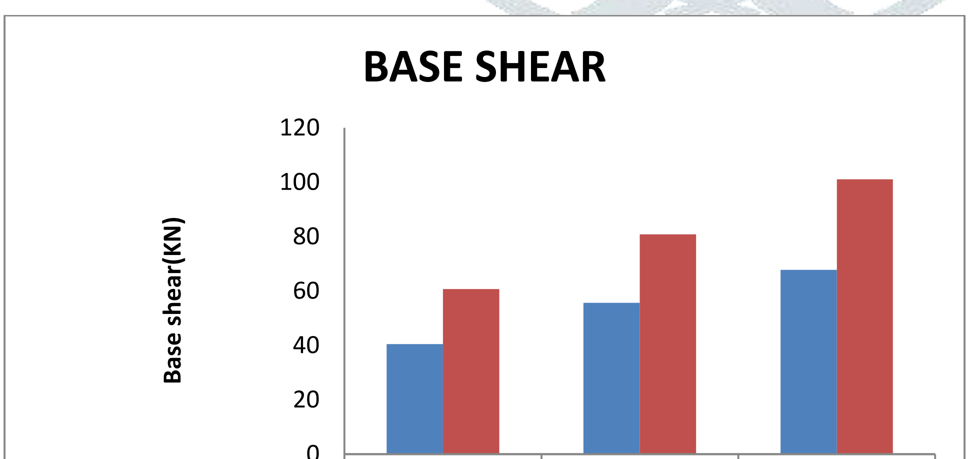
Here an elevated water tank is designed base on IS3370 and IS 1893(part-2) and dynamic analysis is being carried out on ETABS software. Above mentioned method is applied for static analysis as per IS 1893(part 2):2014. The result of base moment, base shear, storey displacement, storey drift is calculated which values and variations in seismic zone III and IV for hard, medium and soft soils are as follows-

(1)BASE MOMENT



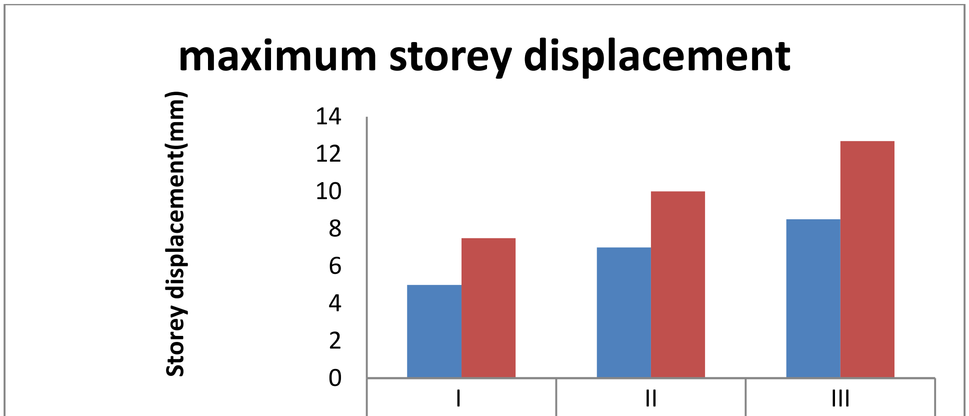
	I	II	III
BASE MOMENT IN ZONE III(KN-m)	429.5847	601.4009	730.2631
BASE MOMENT IN ZONE IV(KN-m)	644.355	859.0811	1091.1859

2 BASE SHEAR



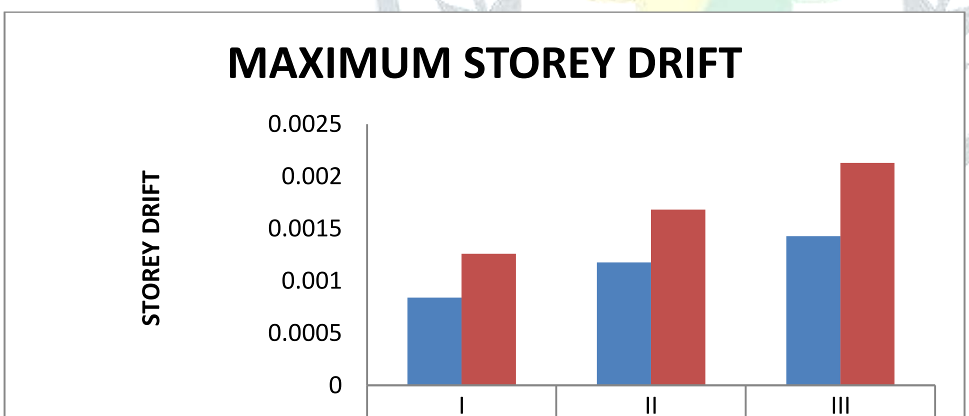
	I	II	III
BASE SHEAR IN ZONE III	40.4094	55.5732	67.696
BASE SHEAR IN ZONE IV	60.6141	80.8188	101.057

3 MAXIMUM STOREY DISPLACEMENTS



	I	II	III
Max. storey displacement (in mm) in zone III	5.003	7.004	8.505
Max. storey displacement (in mm) in zone IV	7.504	10.005	12.688

4-STOREY DRIFT



	I	II	III
maximum storey drift in zone III	0.000841	0.001177	0.001429
MAXIMUM STOREY DRIFT IN ZONE IV	0.001261	0.001681	0.00213

CONCLUSIONS

Followings are the conclusions observed from above column charts-

1. From base moment chart it is to be concluded that the value of base moment increases from zone III to zone IV. Also the value increases as soil condition changes from hard soil to medium soil to soft soil giving the maximum value in soft soil of zone IV.
2. From base shear chart it is understandable that base shear is minimum in hard soil and maximum in soft soil of both seismic zones III and IV.
3. Maximum value of storey displacement comes out at the top storey of water tank and it increases from zone III to zone IV. Also the value of displacement increases by changing soil type from hard to medium to soft soils.
4. Storey drift value comes out to be maximum in soft soil in both seismic zone III and IV. The drift value increases by changing soil conditions in both zones.

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