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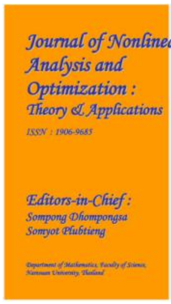

EARTHQUAKE ANALYSIS OF ELEVATED WATER TANK WITH VARIOUSARRANGEMENTS TO FIND BEST POSSIBLE SOLUTION

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Abstract.:
A Water tank means a container to store water in a huge amount of capacity. As known from experience, liquid storage tanks collapsed or are heavily damaged during earthquakes all over the world. The economic lifetime of ESR is generally around 40 to 65 years. Damage or collapse of the tanks causes some unwanted events such as shortage of drinking and utilizing water, uncontrolled fires, etc. Therefore, to avoid all those disadvantages numerous or various studies are been carried out regarding tanks. In this study, I have compared reinforced cement concrete Elevated Service Reservoir (E.S.R) of Square & Circular shape of 1 lakh capacity and a total height of 12.6m with 3m staging in Earthquake Zone II, III, IV, and V by Equivalent static analysis using ETABS software for base shear and deflection guidelines for the design of the tank and IS 1893 - 2016 code. It can be seen that a Circular water tank is more economical and preferable.
Keywords: ESR – elevated service reservoir, max displacement, base shear, ETABS.

Introduction

An elevated water tank is viewed as a global water storage container that is built to supply water at a specific height for the water distribution system. Municipalities and industries employ a variety of liquid storage methods, including underground, ground-supported, and raised storage. As a result, water tanks are critical for both public utility and industrial structures. Elevated water tanks have a large water mass at the top of a slender staging, and are the most important factor in the tank's failure during earthquakes. These are the most important and unique structures, and their destruction during earthquakes could affect the supply of drinking water, fail to prevent big fires, and result in significant financial damage. Water is one of the most basic human requirements. The design of a water tank determines how much water is distributed in different areas. In our country, water storage is provided by overhead water tanks since the required pressure in the water delivery process is achieved by gravity in elevated tanks rather than the use of large pumping systems. The Indian subcontinent is extremely vulnerable to natural calamities such as earthquakes, droughts, floods, and cyclones. More than 60% of India is vulnerable to earthquakes, according to the seismic code IS 1893 (Part 2)-2002. The fact that a large water mass is at the top of a slender stage during an earthquake is the most critical aspect of the failure of elevated water tanks. Elevated tanks are commonly employed in seismically active areas; thus, their seismic behavior must be thoroughly examined.

1) Square Water Tanks
 a) Rectangular tanks are mostly in the square plan for economic purposes.
 b) It is also notable that the longer side not be greater than twice the smaller side.
 c) Moments are caused in both the way/direction of the wall i.e. vertical and horizontal.

d) For small capacities, a circular tank is undesirable because of curved shuttering’s. therefore rectangular tank is preferable

2) Circular Water Tanks

a) Mainly circular water tank possesses or shows the properties of the cylinder.

b) The base of the circular water tank has a flexible joint.

c) On account of its circular shape, it can be made watertight easily as there are no sharp corners.

Literature Survey

Lodhi et al. [1] designed and seismic loading of an intze type water tank was examined. These Intze type water tanks were created in accordance with IS: 3370, or the Code of Practice for Concrete Structures for Liquid Storage. The Intze water tank has been developed and examined under two different circumstances—without taking seismic impacts into account, and considering seismic effects. The reinforcing needs were increased when the Intze water tank was designed using the New IS Code: 3370-2009 and taking into account the influence of seismic forces, which were computed using the Draft IS Code: 1893-2005.**Singh et al. [2]** based on Indian codes, examined the water tank and came to a decision regarding the appropriate type of water tank for various wind and earthquake zones. Study was done on the seismic and wind forces affecting the water tank. The raised structure was built to withstand a range of wind speeds, and the same was double-checked with various earthquake zones. The conclusion reached was that for a given bearing capacity, concrete volume and steel quality both rose as wind speed and seismic zone increased. Each time, there is a 4-5% difference between the wind moment computed manually and the analysis performed using Staad Pro software as the wind speed changes or increases.**Aware and Mathada [3]** finite modelling techniques are used to analyse. This essay examines the seismic performance of elevated water tanks in India at various heights and seismic zones. This research used analysis of 20 models with the same parameters to show the impact of water tank height and seismic zones on nodal displacement. STAAD-PRO, a finite element programme, is used to conduct the analysis. The conclusion reached was that maximum nodal displacement increases as water tank height increases.**Madahvi et al. [4]** RCC elevated liquid storage tank seismic analysis and earthquake characteristics with various bracing and staging systems are shown. With STAAD Pro V8i software, the behaviour of the supporting system was improved under various earthquake characteristics or earthquake zones. Here, a basic supporting system and two different staging patterns, such as radial bracing and cross bracing, were examined for varied fluid filling circumstances. Zone-III and Zone-V seismic zones as well as the associated earthquake characteristics were obtained from IS 1893 (PART 1)-2002 and draught code IS 1893. (Part 2). The outcome demonstrates that the features of the earthquake and the presence of water had a significant impact on the structure reactions. The study also highlights the significance of having a staging arrangement that can withstand the failure of an elevated water tank during seismic events.**Gandhi et al. [5]** conducted on circular raised water tanks with various bracing and staging for earthquake resistance. The primary goal of this study is to better understand how various staging patterns behave when bracing in order to reinforce the traditional kind of staging and provide better performance during an earthquake. STAAD Pro is used to perform equivalent static analysis for staging with various bracing systems applied to the staging of the elevated circular water tank in zone V. The circular water tank's base shear and maximum displacement in X, Y, and Z directions were compared.Various bracing designs were used in the staging of an elevated water tank for the parametric investigation. It was evident from the base shear for the various bracing patterns that the base shear value decreases for alternative bracing patterns in staging. This study concluded that cross bracing in staging is the most efficient way to reduce displacement caused by lateral loading. Cross bracing efficiently reduced displacement by 81.09% in the X direction and 92.98% in the Z direction compared to a structure without bracings.

Scope of the Project

This work aimed to investigate the impact of earthquakeon a tank under different water tank conditions. Utilizing the software ETABS, the tank's finite element model was created, and seismic analysis was performed. Peak displacements and base shear were compared based on the study.

Methodology

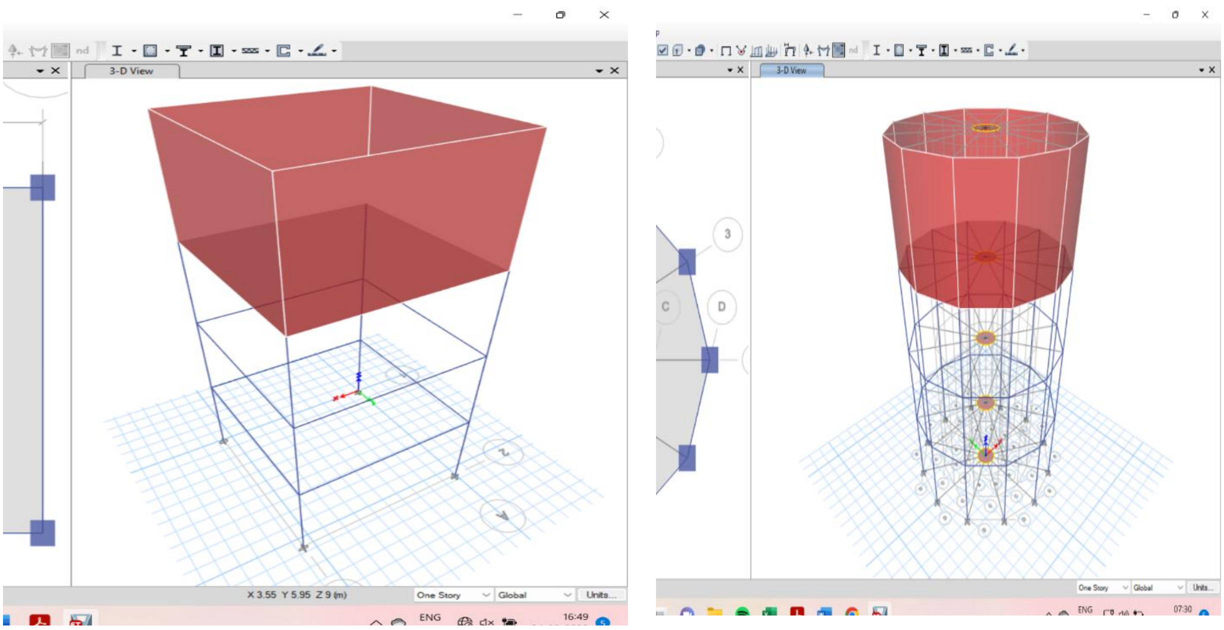
The methodology includes fixing the dimension of a selected type of water tank and performing linear dynamic analysis using IS 1893-2002 (part2). In thisstudy, 1 lakh liter water tankswithcircular and square shapes are considered for analysis. It is analyzed for the base shear and the deflection using ETABS software. Peakdisplacement and base shear obtained from the analysis are compared.

FEM Analysis using ETABS software

The details of the 100m3 circular overhead water tank considered for seismicanalysis are listedbelow:
Internaldiameter- 5m
Height -3.6m (Including FB-0.4m)
Tank bottomslabthickness 150 mm
Tank top slabthickness 150 mm
Column size – 0.3x0.4 m
Beam size – 0.3x0.3 m
Steel Grades – Fe415, Fe500
Type of soil – Hard, medium and Soft
Seismic zones considered – II, III, IV, V

Modeling

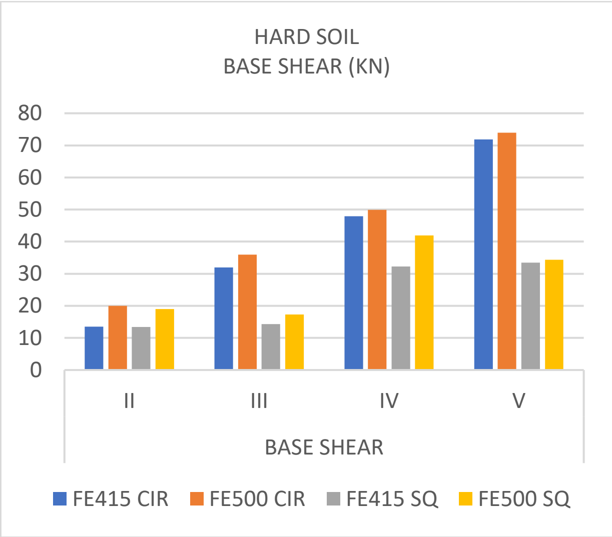
Figure. 1 Typical 3D View of circular and square water tank modeled on ETABS

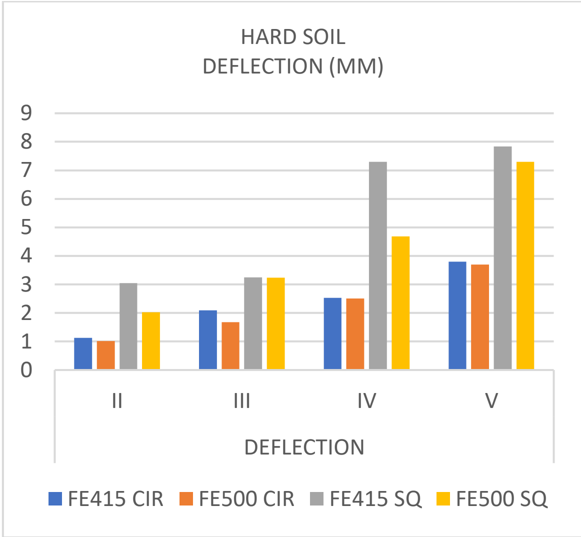


Observations

For Hard Soil Condition:

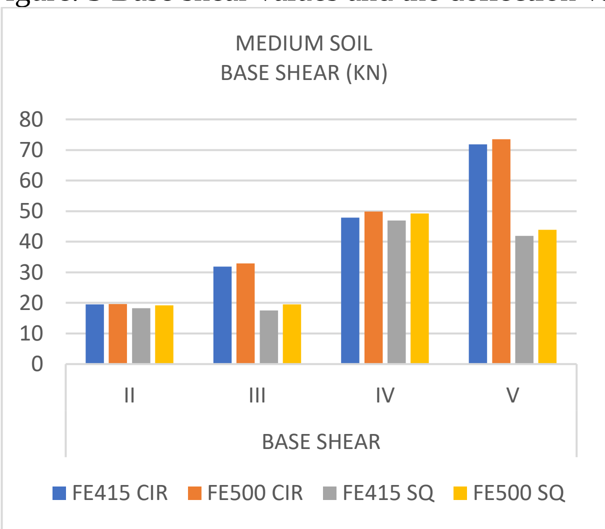
Figure. 2 Base shear values and the deflection values for the hard soil condition

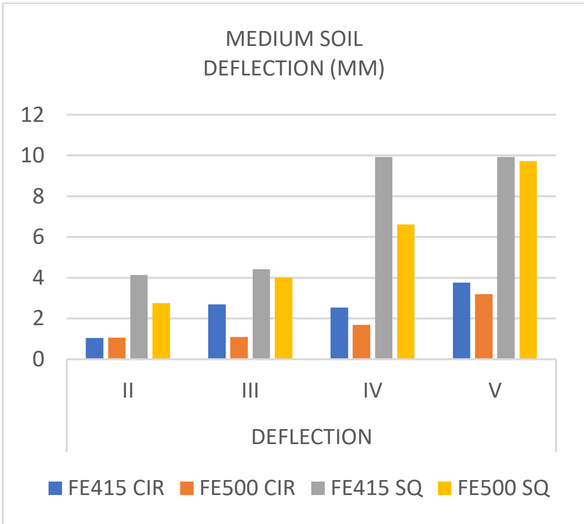




1. In the graph variation of the base shear in hard soil condition with seismic zones it can be observed that its increasing from low seismic zone to high seismic zone.
2. Base shear variation for the for Fe415 and Fe500 steel are increasing linearly in each seismic zone as shown in fig 2
3. The deflection given by the Fe500 steel are comparatively less than the Fe415 steel as shown in Fig. 2

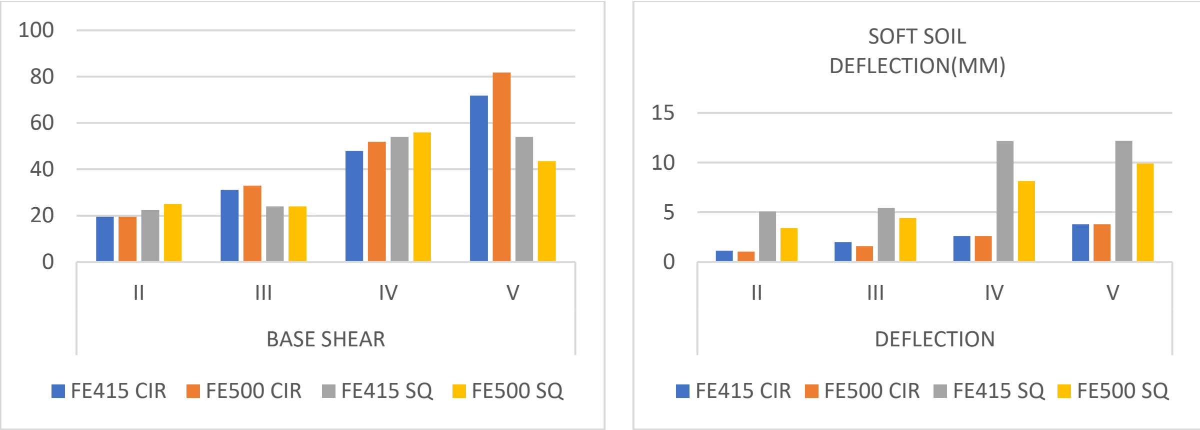
For Medium Soil Condition:
Figure. 3 Base shear values and the deflection values for the medium soil condition





1. In the graph variation of the base shear in medium soil condition with seismic zones it can be observed that its increasing from low seismic zone to high seismic zone.
2. Base shear variation for the for Fe415 and Fe500 steel are increasing linearly in each seismic zone as shown in fig 3
3. The deflection given by the Fe500 steel are comparatively less than the Fe415 steel as shown in Fig. 3

ForSoft Soil Condition:
Figure. 4 Base shear values and the deflection values for the soft soil condition



1. In the graph variation of the base shear in soft soil condition with seismic zones it can be observed that its increasing from low seismic zone to high seismic zone.
2. Base shear variation for the for Fe415 and Fe500 steel are increasing linearly in each seismic zone as shown in fig 4
3. The deflection given by the Fe500 steel are comparatively less than the Fe415 steel as shown in Fig. 4

Results

In this study, the analysis of water tanks with different grades of steel in each seismic zone was investigated by using ETAB Software. The circular and square shapes of the water tank with Fe415 and Fe500 in each seismic zone were modeled in soft, medium, and hard soil conditions, and the base shear and deflection of the water tank were obtained.

1.According to the obtained result, the variation of base shear increases from seismic zone II to seismic zone V in each soil condition, so it is concluded that corresponding base shear would increase if the water tank is located in a higher seismic zone.

2.Based on the observed base shear values in the various soil conditions, it can be concluded that in each seismic zone, steel grade Fe500 produces more base shear values than steel grade Fe415 gives.

3. It is concluded that the deflections produced by the water tank with the Fe500 grade are significantly lower than those produced by the steel of the Fe415 grade.

4.In each seismic zone and soil condition, the base shear for a circular reservoir is greater than that of a square water tank when the same tank's capacity is taken into consideration in the parametric study of the tank.

5. It is concluded that the optimal solution for all other models looked at is to suggest a water tank with a circular shape made of Fe500 steel.

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