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Seismic Analysis of Circular and Hexagonal Elevated Water Tank with Different Seismic Zones using Staad.Pro

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ABSTRACT

Water tank is used for storage of water. Direct source of water in water tank is from the rainfall. Taking water from tank for irrigation purpose is economical in that place where construction of well is costly. Water obtained from elevated water tank is useful for domestic purpose. Such as drinking, cooking, washing purpose. Elevated water tanks are integrated part of lifeline facilities elevated water tank is storage container construction for the purpose of holding water supply. A large number of water tank is damage during past earthquake. So, there is need to focus on seismic safety. The present work objective is to propose a seismic response of intze water tank for two different type of container shape i.e., circular and hexagonal water tank and achieved one which have best earthquake resistance behavior. Also, in the present work, a dynamic analysisof elevated RCC water tanks design for the zone III – V as per Indian Standard: 1893-2002 (Part-2) and analyzed using the software considering all the earthquake forces. To study dynamic and static analysis of water tank by using Staad.Pro software.

Keywords:RCCWater Tank, Stagging System, Staad Pro, Earthquake, Seismic Zone

1. Introduction

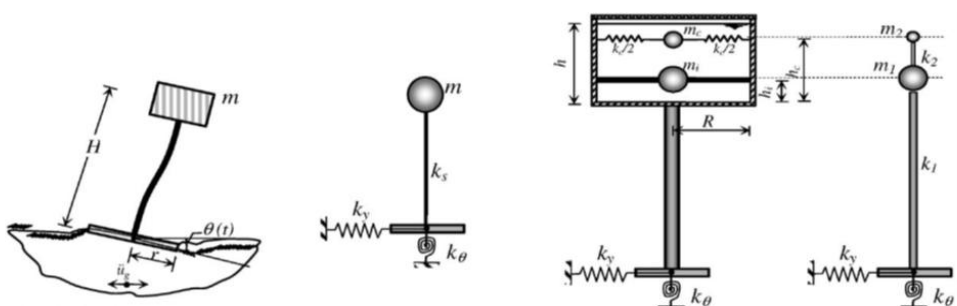
Water is life line for every kind of creature in this world. All around the world liquid storage tanks are used extensively by municipalities and industries for water supply, firefighting systems, inflammable liquids and other chemicals. Thus Water tanks plays a vital role for public utility as well as industrial structure having basic purpose to secure constant water supply from longer distance with sufficient static head to the desired location under the effect of gravitational force. Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. Water or raw petroleum retaining slab and walls can be of reinforced concrete with adequate cover to the reinforcement. Water and petroleum and react with concrete and, therefore, no special treatment to the surface is required. Industrial wastes can also be collected and processed in concrete tanks with few exceptions. The petroleum product such as petrol, diesel oil, etc. are likely to leak through the concrete walls, therefore such tanks need special membranes to prevent leakage. Reservoir is a common term applied to liquid storage structure and it can be below or above the ground level. Reservoirs below the ground level are normally built to store large quantities of water whereas those of overhead type are built for direct distribution by gravity flow and are usually of smaller capacity. Elevated tanks should remain functional in the post-earthquake period to ensure water supply is available in earthquake-affected regions. Never the less, several elevated tanks were damaged or collapsed during past earthquakes Due to the fluid–structure–soil/foundation interactions, the seismic behavior of elevated tanks has the characteristics of complex phenomena. Therefore, the seismic behavior of elevated tanks should be known and understood, and they should be designed to be earthquake-resistant. Some general programs have been carried out, which cover large amounts of data; these programs include STAAD PRO etc. However, a general-purpose structural analysis program generally exists in every engineering office. So, the evaluation of the applicability of these structural analysis programs in the design of elevated tanks is important from an engineering point of view and it will be helpful to present the application and results to designers. There is a second important reason that should be considered. That is, simplified models are used for a straightforward estimate of the seismic hazard of existing elevated tanks. Only if the estimated risk is high, it is convenient to measure all the data (e.g. geometry of the tank, material properties) that are required by the general finite element codes and to spend time and money to prepare a reliable general model.

2. SEISMIC ANALYSIS OF ELEVATED WATER TANK

Seismic analysis of elevated water tank involved two types of analysis,

1. Equivalent Static analysis of elevated water tanks.
2. Dynamic analysis of elevated water tanks

Equivalent static analysis of elevated water tanks is the conventional analysis based on the conversion of seismic load in equivalent static load. IS: 1893- 2002 has provided the method of analysis of elevated water tank for seismic loading. Historically, seismic loads were taken as equivalent static accelerations which were modified by various factors, depending on the location's seismicity, its soil properties, the natural frequency of the structure, and its intended use. Elevated water tank can be analyzed for both the condition i.e. tank full condition and tank empty condition. For both the condition, the tank can be idealized by one- mass structure. For equivalent static analysis, water-structure interaction shows, both water and structure achieve a pick at the same time due to the assumption that water is stuck to the container and acts as a structure itself and both water and structure has same stiffness. The response of elevated water tanks obtained from static analysis shows the high scale value. That's why for large capacities of tanks, static response are not precise. If we analyzed the elevated water tank by static method and design by the same, we get over stabilized or say over reinforced section but it will be uneconomical. That's why static systems of designing of elevated water tanks is not useful in seismic zones. And hence, IS code provision for static analysis is restricted for small capacities of tanks only.



(a) A simple structure supports on deformable soil (b) Simple idealized model for soil-structure interaction (c) Springs-masses model for considering the effects of the fluid-structure-soil interaction model for the soil-structure interaction

Fig. 1. Mechanical model for the fluid–structure–soil interaction of the elevated tank

3. METHODOLOGY

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4. FINITE ELEMENT MODELLING AND ANALYSIS

The methodology includes the selection of type of water tank, fixing the dimensions of components for the selected water tank and performing linear dynamic analysis (Response Spectrum Method of Analysis) by IS: 1893-1984 and IS: 1893-2002 (Part 2) draft code. In this study, various capacity circular and rectangular overhead water tank is considered for analysis. It is analyzed for four different zones (zone-II to V), and for two tank-fill conditions, i.e., tank full and tank empty conditions. Lastly, the results of the analysis of tanks performed on the basis of IS: 1893-1984 and IS: 1893-2002 (Part 2) draft code have been compared by using the software STAAD PRO software.

5. RESULTS AND DISCUSSION

Such an analysis can be compared with the different structure type, Zone and column height and serve to troubleshoot the model. Staad.Pro software has been used to conduct the dynamic analysis of the FE model. In present work, the various elevated water tank has been analyzed by varying its parametric data viz. tank type (tank on full condition, tank on empty condition), seismic zones and column height.

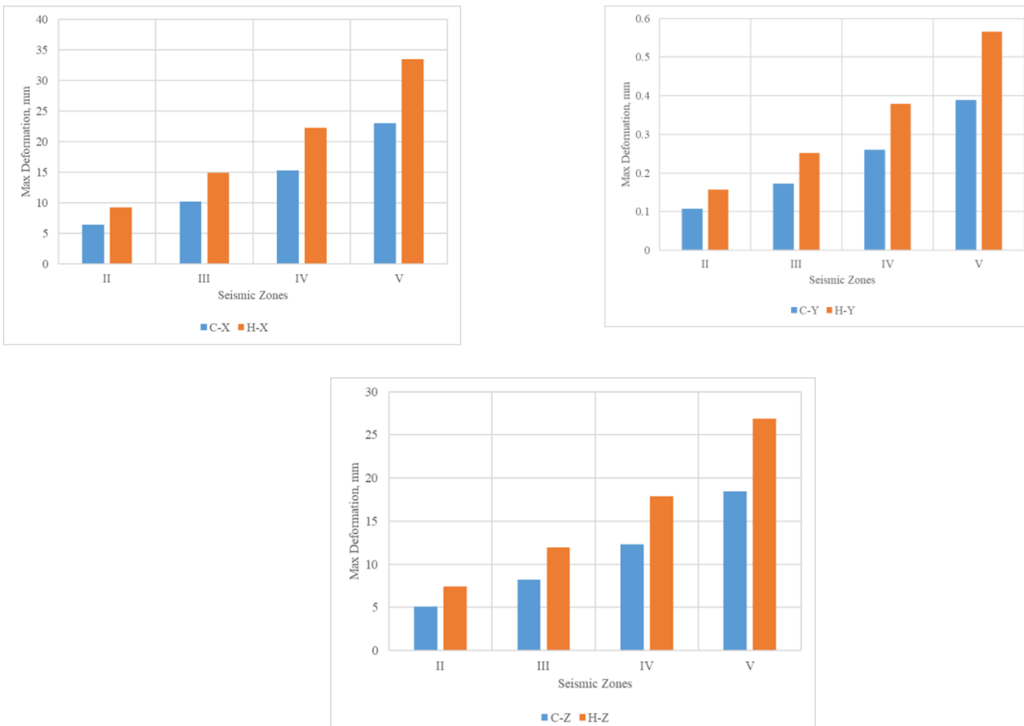

Figure 2. Maximum deformation X, Y and Z direction on RC circular and hexagonal elevated water tank in full tank condition with different seismic zones

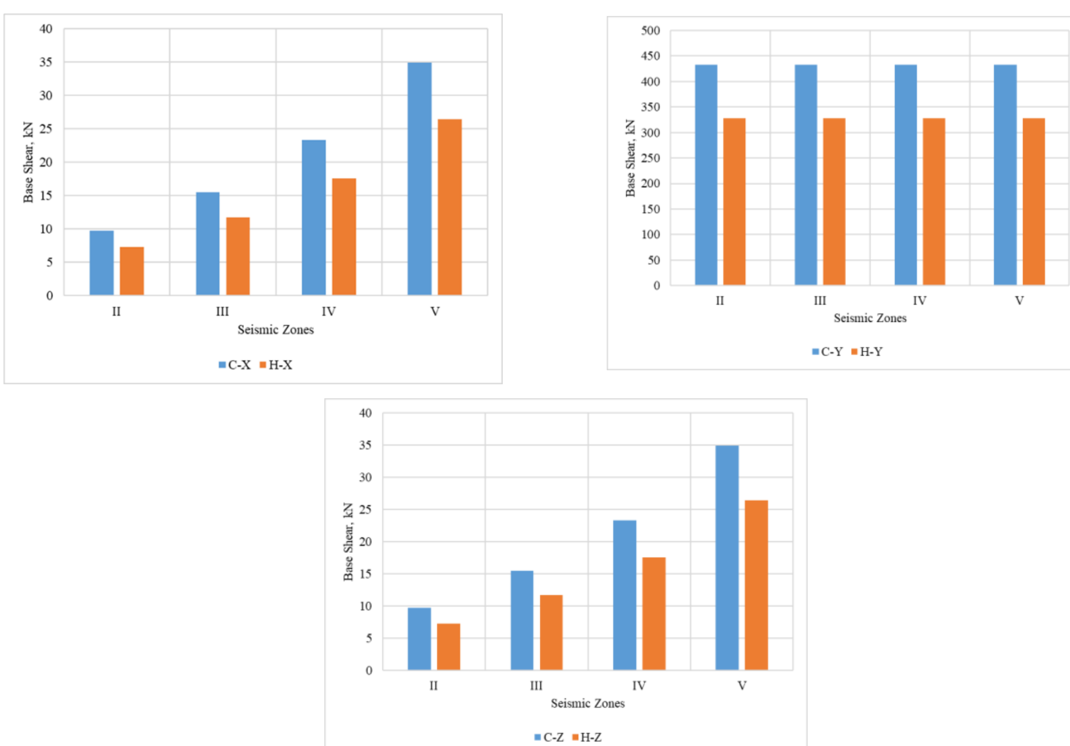

Figure 3. Base shear X, Y and Z direction on RC circular and hexagonal elevated water tank in full tank condition with different seismic zones

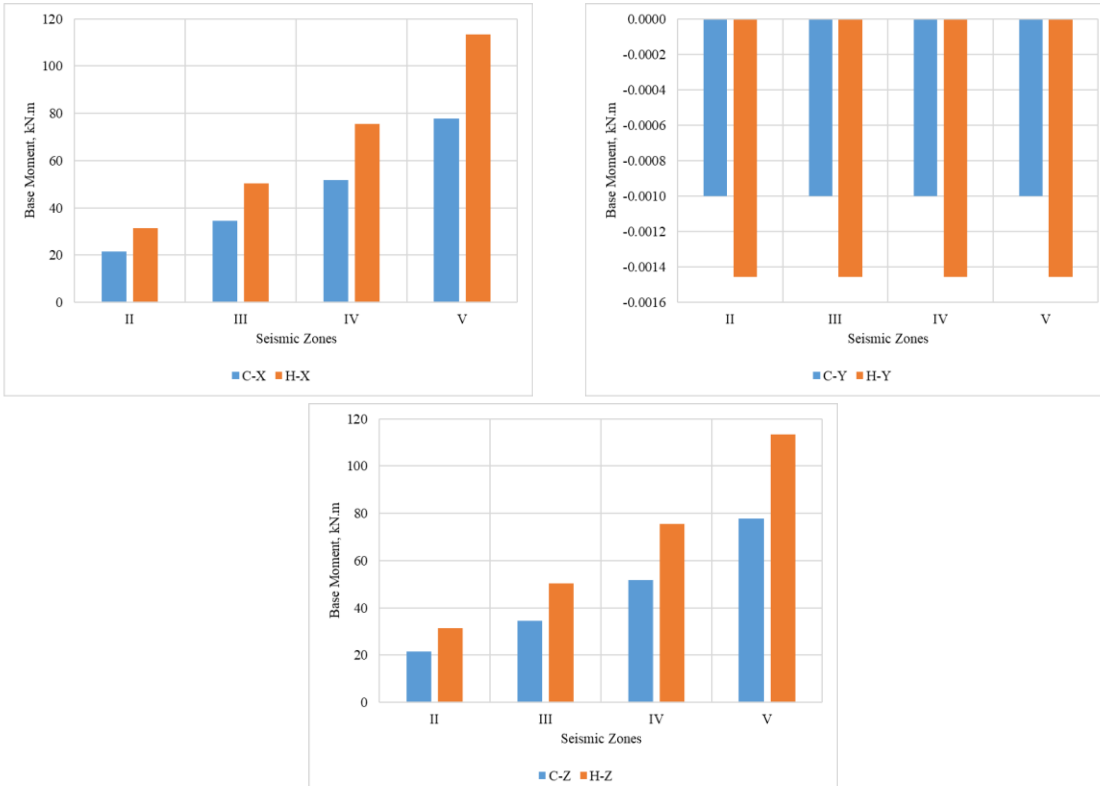

Figure 4. Base moment X, Y and Z direction on RC circular and hexagonal elevated water tank in full tank condition with different seismic zones

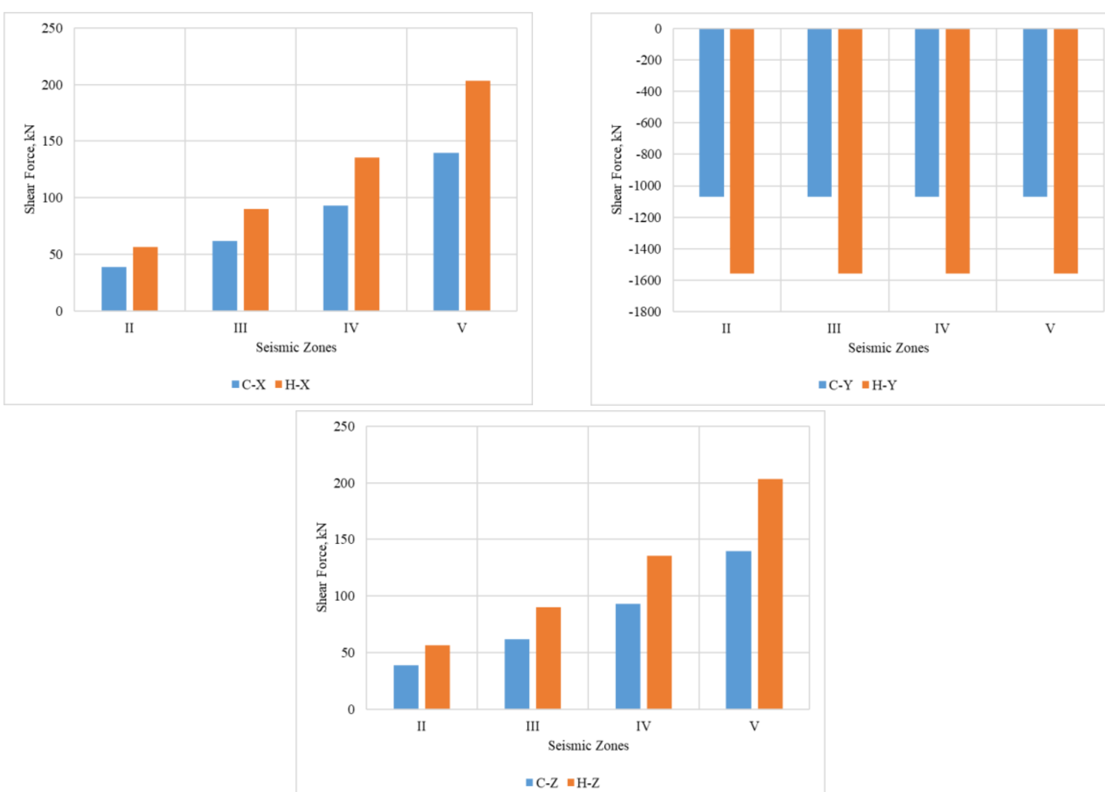

Figure 5. Shear force X, Y and Z direction on RC circular and hexagonal elevated water tank in full tank condition with different seismic zones

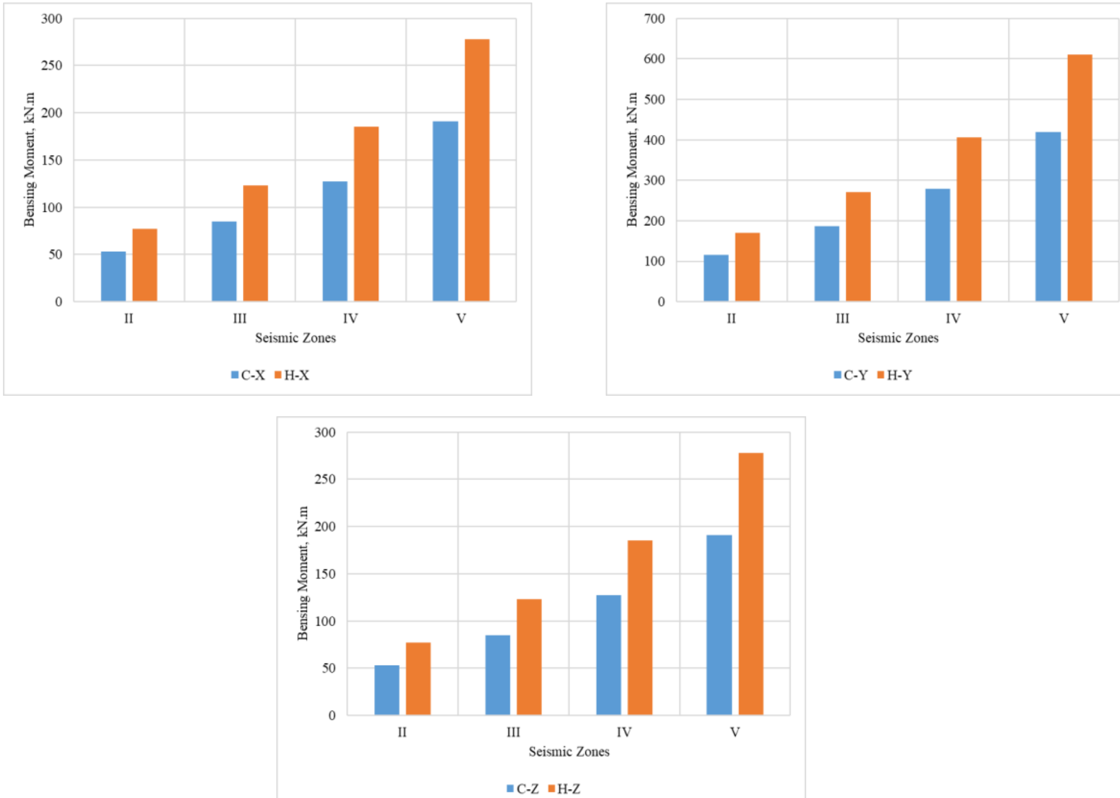

Figure 6. Bending Moment X, Y and Z direction on RC circular and hexagonal elevated water tank in full tank condition with different seismic zones

6. CONCLUSION

The high-water tanks are clearly visible to the public and are visible from close distances over long distances. The Intze type tank is commonly used as a water reservoir in India. Currently, a large number of water tanks are used at the top to distribute water for public use. They often become landmarks in the landscape. Therefore, it is important that the shape and shape of the container and the support structure receive due attention from an aesthetic point of view. The water storage tanks must remain operational in the post-earthquake period to ensure the supply of drinking water to the regions affected by the earthquake and to meet the demand for firefighting. Following are the conclusions based on the Seismic Analysis of Elevated Water Tank are as follows:

- Base shear of full water tank and empty water tank are increased with seismic zone II-V because of zone factor, response reduction factor etc. while considering seismic analysis.
- base shear in full condition tank is slightly higher than empty tank due to absence of water or hydro static pressure.
- Displacement of full water tank and empty water tank are increased with seismic zone II-V because of zone factor, response reduction factor etc. while considering seismic analysis.
- Maximum nodal displacement and minimum nodal displacement found at the wall of water tank when tank is full condition.
- Shear force and bending moment of full water tank and empty water tank are increased with seismic zone II-V because of zone factor, response reduction factor etc. while considering seismic analysis.
- Shear force and bending moment in full condition tank is slightly higher than empty tank due to absence of water or hydro static pressure.
- From analysis it has been found that the RC Circular water tank gives more stiffness as compared to the hexagonal type water tank.

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