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A Review-Seismic Analysis of Rectangular Water Tank with Different Length by Width Ratio

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Abstract:

As known from very upsetting experiences, liquid storage tanks were collapsed or heavily damaged during the earthquakes all over the word. The economic lifetime of concrete or steel tanks is usually in the range of 40 to 75 years (ALA 2001).Damage or collapse of the tanks causes some unwanted events such as shortage of drinking and utilizing water, uncontrolled fires and spillage of dangerous fluids. In this study, Seismic forces acting on an Elevated water tank e.g. rectangular tank are studied with constant stagging height. IS: 1893-2002 for seismic design and then checked the Design of Tanks by using the software STAAD PRO.

Keywords: - water tank, stagging system, staad pro, earthquake.

1. INTRODUCTION

A huge water storage container is said to be an elevated water tank which is constructed for supplying the water at certain height for the water distribution system. There are different ways for the storage of liquid such as underground, ground supported and elevated used extensively by municipalities and industries. Hence water tanks are most important for public usefulness and for industrial structures. Elevated water tanks consist of huge water mass at the top of a slender staging which is most critical consideration for the failure of the tank during earthquakes. These are the most important and special structures; and during earthquakes damaging of these structures may cause danger to drinking water supply, fail in preventing large fires and may cause substantial economic loss.

It is known that, some of the fluid containers are damaged in many earthquakes. Some unwanted events are caused such as shortage of drinking and utilizing water, uncontrolled fires and spillage of dangerous fluids which are due to damage or collapse of these structures. Even uncontrolled fires and spillage of dangerous fluids subsequent to a major earthquake may cause substantially more damage than the earthquake itself. Due to these reasons this type of structures which are special in construction and in function from engineering point of view must be constructed well to be resistant against earthquakes.

2. REVIEW OF LITERATURE

Syed Saif Uddin (2013), studied the behavior of liquid storage tanks under earthquake loads as per Draft code Part II of IS 1893:2002. Software SAP 2000 is used for seismic analysis of tanks which gives the earthquake induced forces on tank systems. Indian standard earthquake code IS 1893:1984 have some limitations on seismic design of elevated tanks. This code did not cover ground-supported tanks. Dynamic analysis of liquid containing tank is a complex problem involving fluid-structure interaction. Under earthquake loads, a complicated pattern of stresses is generated in the tanks. Due to earthquake inadequately designed tanks have leaked, buckled or even collapsed. General failures due to earthquake are wall buckling, sloshing damage to roof, inlet/outlet pipe breaks and implosion due to rapid loss of contents.

S. K. Jangave, (2014), aimed to understand the seismic behaviour of the elevated water tank with consideration and modeling of impulsive and convective water masses inside the container as one mass model and two mass model as per IS:1893-2002 under different time history records using finite element software SAP 2000.The present work aims at checking the adequacy of water tank for the seismic excitations. It is determined from the results that response of structure is extremely influenced by completely different capacities of water storage tank and their one mass and two mass models and earthquake characteristics.

Jay Lakhanakiya (2015) "focused on hydrodynamic analysis of Intze water tank and comparison of the cost of water tank for different staging conditions like shaft and frame type. To achieve the work they designed container of the water tank by using excel worksheet. And in this excel worksheet hydrodynamic analysis is carried out. The staging part is analyze in software STAAD Pro. V8i and the design has been done in excel worksheet. Tanks considered for analysis were same in dimensions and capacities for all the different staging.

Pradnya V. Sambary, (2015), carried out manual seismic analysis of elevated circular water tank in accordance with IS: 1893-1984 (i.e. lumped massmodel) and IS: 1893-2002 (Part-2) draft code (i.e. two mass model).The tank is located in zones III and V and on two different soil typesi.e. hard rock and soft soil. Hence there are total four cases. Further comparison between the framed type and shaft type staging is done as per manually calculated responses such as base shear and base moment. The water tanks are been analyzed for tank full and tank empty conditions for which response spectrum method is used. Seismic responses such as base shear, base moment and hydrodynamic pressure are evaluated and compared.

Rupachandra J. Aware (2015), studied the behavior of Cylindrical liquid storage tanks under earthquake loads as per Draft code Part II of IS 1893:2002. A FEM based computer software (STAAD -PRO) used for seismic analysis of tanks which gives the earthquake induced forces on tank systems. Under earthquake loads, a complicated pattern of stresses is generated in the tanks. Poorly designed tanks have leaked, buckled or even collapsed during earthquakes. For this they analyzed a circular cylindrical elevated water tank, with 500 cubic meters capacity and is analyzed by using finite modeling techniques. And they had done the study of seismic performance of the elevated water tanks for various heights and various seismic zones of India. The effect of height of water tank, earthquake zones on earthquake forces have been presented in this study with the help of analysis of 20 models for same parameters. Analysis is carried out by using finite element software STAAD-PRO.

Ankush N. Asati, (2016), studied the seismic behavioral effect of circular elevated water tank for specific capacity of tank for various staging arrangements in plan, variation in number of periphery columns and variation in number of stages in elevation. Two mass idealizations suggested by Gujarat State Disaster Management Authority are considered here. Under earthquake loads; a complicated pattern of stresses is generated in the tanks. For the purpose they have considered tank with capacity of 500m3 and staging height of 16m. The type of staging considered is normal staging, radial staging and cross staging. All the models are analyzed for 6, 8, 10 and 12 columns having diameters 520mm, 450mm, 350mm and 300mm respectively. Total 36 combinations were analyzed with SAP2000 using Response Spectrum Method (RSM) and results are presented. It is observed that increase in number of columns, does not assure the increase in the improvement of structural responses. Radial arrangement with six staging levels is found to be best for the number of columns used. Radial staging arrangement with 6 staging levels are provided to suggest number of columns with suitable diameter cost optimization. It is found that eight numbers of columns gives less cost as compared to six, ten and twelve with optimized diameter of 300mm. It can be said that sometimes instead of increasing number of columns for the stiffened of structure or safety, it is better to optimize after assuring proper structural responses.

SIVY Martin, (2016), dealt with the procedure for seismic resistance of liquid storage tanks which are in accordance with the principles of Eurocode8 standard. They performed seismic analysis on flexible (steel) circular vertical ground-supported model of tank containing liquid (water). The objective is to observe the basic seismic characteristics, dynamic properties, distributions of hydrodynamic pressure, and response of investigated tank-liquid system subjected toearthquake excitation (El Centro). Seismic analysis and results comparison are carried out on mechanical spring mass model (Eurocode 8) and finite element model (ANSYS). Finite element model was used for comparison of dynamic properties of investigated system and for computation of the response to seismic loading using appropriate method. The results between each solution represented good conformity. Seismic analysis is one of the analyses which should be carried out to provide satisfactory performance of tanks, especially in earthquake prone regions.

A. C. Chougule, (2017), considered a parametric study on spring mass model, Time period in impulsive and convective mode, Design seismic horizontal element, hydrodynamic pressure and base shear due to impulsive and convective mass of water. The effect of earthquake on the ground supported water tank resting on soft soil consisting of mass of roof, mass of tank wall, mass of water and mass of base slab is carried out. It has been found that under influence of seismic forces with increasing ratio of maximum depth of water to the diameter of tank (h/D) the more mass of water will excite in impulsive mode while decreasing ratio of (h/D) more the mass of water will excite in convective mode. The Time period of Impulsive mode increase with increase in (h/D) ratio and Time period in convective mode decrease with increase in (h/D) ratio. Location of tank is considered in seismic zone IV. For circular water tank with same storage capacity and different height; the Base shear, Bending Moment & Max. Hydrodynamic pressure gradually increases with increase in h/D ratio. In case of rectangular water tank with same storage capacity and different height of tank wall if the h/L ratio is up to 0.6 the base shear, Bending Moment& Max. Hydrodynamic pressure increases gradually and if the h/L ratio is in between 0.6 to 0.8; it suddenly increases & after that it decreases gradually. Hence it is feasible for water tank at ground level the h/L ratio up to 0.6. It is observed from the results that for both the circular & rectangular water tank having same storage capacity but different wall height of tank, sloshing wave height increases up to certain limit & after that it decreases gradually. In case of circular water tank for h/D ratio 0.4, the mass participation factor for impulsive & convective are nearly equal.In rectangular water tankthe mass participation factors are almost equal for h/L ratio 0.5.

Mayank Gopal Manwani1, (2017), studied the seismic forces acting on an elevated circular and rectangular water tank with constant staging height. Also they determined the seismic forces acting on the tank changing the Seismic Response Reduction Factor(R). IS: 1893-1984/2002 for seismic design and then checked the design of tanks by using the software STAAD PRO.

Nimmy Sen Sebastian, (2017), studied the performance of elevated water tanks in framed building subjected to dynamic loading, considering the effect of sloshing. They also provided certain design recommendations for elevated water tank in framed building to avoid negative damping and resonance. Linear static and non-linear dynamic analysis (Time history analysis) was conducted to estimate the earthquake response of the system. The seismic response of the building models with varying tank geometries are also discussed. Using this method, the study of liquid sloshing effects in tanks with rectangular and circular tank geometries is made possible. The design of the tank are not performed since it is an analytical comparison of the seismic performance in a framed building with varying number of storey. Elevated water tank is analysed in framed building with the use of SAP 2000 software and the results are compared to obtain an economic design strategy. In fact, the study helps in making an Engineer aware on what all aspects he/she should consider while deciding on the tank shape, whether circular or rectangular whether placed at corner or near to centre position in a framed building. However one general comment could be made that-rectangular water tank placed near corner position in framed building performed better than another one. The results of this study help to predict the response of elevated tank in framed building with reasonable accuracy. Building model without water tank with varying number of storey (3, 6, 9, and 12) are developed for the study. Also developed the building models with rectangular and circular water tanks placed at position near to the centre and at corner with number of storey3, 6, 9 and 12.

Rasha F. Hassan (2021) The objective of this paper is to study the response of reinforced concrete rectangular tank on grade in the presence of cleanout hole under the effect of an earthquake. This numerical analysis was conducted using nonlinear finite element three-dimensional models using ABAQUS. The water in the tank was modeled according to the hydrodynamic effects by including both the impulsive and the convective parts combined with hydrostatic pressure. The sloshing action was simulated based on a threedimension added-mass approach. Additionally, eleven numerical models were investigated to determine the critical position of the cleanout opening relative to the base of the tank and as a function of earthquake direction and peak ground acceleration.

3. CONCLUSIONS

1. For all the zones considered displacement values follow around the similar gradually increasing straight path along the staging height and the base shear follows somewhat zigzag path having maximum value in tank of L/B ratio 4.0.
2. For all the models displacement values and base shear are less for lower zones and it goes on increases for higher zones.
3. With increase in L/B ratio the value of displacement slightly decreases in models upto L/B ratio 2.5 in all the zones.
4. In all the zones tanks having L/B ratio 3.0 and 4.0 experiences maximum displacement values.
5. In all the zones base shear is minimum in L/B ratio 3.0 and maximum in L/B ratio 4.0.

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