Seismic Analysis of Elevated Rectangular RCC Water Tanks

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Abstract - *During many earthquakes, some of the fluid containers are damaged badly. Damage or collapse of these containers causes some unwanted events such as shortage of drinking and utilizing water, uncontrolled fires and spillage of dangerous fluids. Also unrestrained fires and spillage of dangerous fluids due to a major earthquake may cause significantly 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. The object of the present work is to compare the seismic behavior of elevated rectangular RCC water tanks having different length to width ratios with constant depth and height of staging. For this purpose L/B ratios considered are 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.5, 3.0 and 4.0. The depth of tank for all the ratios is 2.5m and capacity of tank is considered as 1 lakh litres. Height of staging for all the ratios is considered as 18m. All the models are analysed for zone III, zone IV and zone V using Staad.Pro v8i software. To study the seismic behavior of all the models the response parameters selected are lateral displacement and base shear.*

Observation shows that with large increase in L/B ratio, displacement also increases largely. From the analysis, result parameters displacement and base shear of the water tanks increases from lower to higher zones because the magnitude of intensity will be more for higher zones.

Present work provides good information on the result parameters displacement and base shear in the water tanks having different L/B ratios with constant depth, staging height and capacity.

Key Words: Water tank, seismic, displacement, base shear, length to width ratio.

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. For the storage of liquid so many ways are there 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.

In many earthquakes it is observed that, some of the fluid containers are damaged. 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. Also the uncontrolled fires and spillage of dangerous fluids subsequent to a major earthquake may cause substantially more damage than the earthquake itself. This type of structures which are special in construction and in function from engineering point of view, due to these reasons must be constructed well to be resistant against earthquakes.

1.1 Water Tank

Water is human basic needs for daily life. Mostly the sufficient water distribution depends on the design of a water tank. In our country the supply of water depends on overhead water tanks for storage as the required pressure in water supply process is obtained by gravity in elevated tanks rather than the need of heavy pumping facilities. Due to natural disasters like earthquakes, draughts, floods, cyclones etc Indian sub-continent is highly vulnerable. According to seismic code IS: 1893 (Part 1)-2002, more than 60% of India is prone to earthquakes. During earthquake for the failure of elevated water tanks it is most critical consideration that huge water mass is at top of a slender staging. Since, the elevated tanks are frequently used in seismic active regions also hence their seismic behavior has to be investigated in detail. There are three categories of tanks which are based on the location of tank in a building:

1. Tanks resting on ground
2. Underground tanks
3. Overhead tanks

2. OBJECTIVES

The objectives of the present research works are:

1. To study the performance of elevated rectangular RCC water tanks under seismic forces.
2. To compare the seismic behaviour of elevated rectangular RCC water tanks having different length to width ratios with constant depth and height of staging.
3. To compare the result parameters of different rectangular RCC water tanks having different length to width ratios with a constant depth and capacity.

3. Problem Formulation

The object of the present work is to compare the seismic behavior of elevated rectangular RCC water tanks having different length to width ratios with constant depth and height of staging. For this purpose L/B ratios considered are 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.5, 3.0 and 4.0. The depth of tank for all the ratios is 2.5m and capacity of tank is considered as 1 lakh litres. Height of staging for all the ratios is considered as 18m. All the models considered are analysed for seismic zones, zone III, zone IV and zone V using Staad.Pro v8i software. To study the seismic behavior of all the models the response parameters selected are lateral displacement, stresses and base shear.

For all the models considered structural details are as follows:

Size of tank having L/B = 1.0 is 6.4m x 6.4m x 2.5m.
Size of tank having L/B = 1.2 is 5.8m x 7.0m x 2.5m.
Size of tank having L/B = 1.4 is 5.4m x 7.6m x 2.5m.
Size of tank having L/B = 1.6 is 5.1m x 8.2m x 2.5m.
Size of tank having L/B = 1.8 is 4.75m x 8.55m x 2.5m.
Size of tank having L/B = 2.0 is 4.5m x 9.0m x 2.5m.
Size of tank having L/B = 2.5 is 4.0m x 10.0m x 2.5m.
Size of tank having L/B = 3.0 is 3.7m x 11.1m x 2.5m.
Size of tank having L/B = 4.0 is 3.2m x 12.8m x 2.5m.
Thickness of wall is 200mm.
Size of columns is 400mm x 400mm.
Size of beams is 300mm x 400mm.
Grade of concrete is M-30.
Grade of steel is Fe-500.

4. RESULT AND DISCUSSIONS

This analysis observes the performance of rectangular RCC water tank having different length to width ratios with constant depth, staging height and storage capacity for seismic forces in zone III, zone IV and zone V. From the analysis performed, results are organized and discussed in details.

4.1 Seismic Effect on Displacement

The result shows the effect of earthquake zones on displacement by considering different length to width ratios for particular zone. From the results it is observed that by varying zone, the value of deflection successively increases from zone III to zone V.

1. It is observed from results that for all the L/B ratios considered displacement values follow around the similar gradually increasing straight path along the staging height.
2. It is observed here that in all the models displacement values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.
3. From the results it is observed that the tank having L/B ratio 3.0 and 4.0 experiences maximum displacement values in all the zones.
4. From figure no. 5.10 to 5.12 it is observed that with increase in L/B ratio of tank from 1.0 to 2.5 the value of displacement slightly decreases but suddenly increases largely for ratio 3.0 and 4.0.
5. In zone III, the value of displacement decreases from 23.09mm to 21.88mm in L/B ratio 1.0 to 2.0 then in L/B ration 2.5 it slightly increases to 22.28mm. But in L/B ratios 3.0 and 4.0 suddenly increases to 40.47mm and 47.72mm respectively.
6. In zone IV, the value of displacement decreases from 34.63mm to 32.82mm in L/B ratio 1.0 to 2.0 then in L/B ration 2.5 it slightly increases to 33.43mm. But in L/B ratios 3.0 and 4.0 suddenly increases to 60.71mm and 71.58mm respectively.
7. In zone V, the value of displacement decreases from 51.95mm to 49.23mm in L/B ratio 1.0 to 2.0 then in L/B ration 2.5 it slightly increases to 50.14mm. But in L/B ratios 3.0 and 4.0 suddenly increases to 91.07mm and 107.36mm respectively.

4.2 Seismic Effect on Base Shear

The result shows the effect of earthquake zones on base shear by considering different length to width ratios for particular zone. From the results it is observed that by varying zone, the value of base shear successively increases from zone III to zone V.

1. It is observed from results that for all the L/B ratios considered base shear follows somewhat zigzag path having maximum value in tank of L/B ratio 4.0.
2. It is observed here that in all the models the values of base shear are less for lower zones and it goes on increases for higher zones because in higher zones the magnitude of intensity will be the more.
3. From the results it is observed that the tank having L/B ratio 3.0 experiences minimum base shear but in L/B ratio 4.0 experiences maximum base shear in all the zones.
4. In zone III, the value of base shear varies from 141 KN to 145 KN in L/B ratio 1.0 to 2.5 then in L/B ration 3.0 it minimum value 125 KN. But in L/B ratios 4.0 the value of base shear is 163 KN which is maximum in all the values.
5. In zone IV, the value of base shear varies from 210 KN to 218 KN in L/B ratio 1.0 to 2.5 then in L/B ration 3.0 it minimum value 188 KN. But in L/B ratios 4.0 the value of base shear is 245 KN which is maximum in all the values.
6. In zone V, the value of base shear varies from 315 KN to 326 KN in L/B ratio 1.0 to 2.5 then in L/B ration 3.0 it minimum value 281 KN. But in L/B ratios 4.0 the value of base shear is 367 KN which is maximum in all the values.

4.3 Seismic Effect on Stresses

The result shows the effect of earthquake forces on stresses by considering different length to width ratios for particular zone in X and Y both directions. From the results it is observed that by varying zone, the value of stresses successively increases from zone III to zone V.

1. It is observed from results that for all the L/B ratios considered base shear follows somewhat zigzag path having maximum value in tank of L/B ratio 4.0 in X direction and L/B ratio 1.6 in Y direction.
2. From the results it is observed that the tank having L/B ratio 1.0 experiences minimum stresses in X direction and L/B ratio 4.0 experiences minimum stresses in Y direction, whereas in L/B ratio 4.0 experiences maximum stresses in X direction and L/B ratio 1.6 experiences maximum stresses in Y direction.
3. In X direction, the value of stresses varies from 2.01 KNm/m to 7.31 KNm/m. It suddenly increases to 7.24 KNm/m at L/B ratio 2.0.
4. In Y direction, the value of stresses varies from 2.27 KNm/m to 10.3 KNm/m. The value increases to L/B ratio 1.6 and later gradually decreases upto L/B ratio 4.0.

5. CONCLUSIONS

The following conclusions are drawn within the scope of present work:

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, stresses 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.
6. In X direction stresses are minimum in L/B ratio 1.0 and maximum in L/B ratio 4.0.
7. In Y direction stresses are minimum in L/B ratio 4.0 and maximum in L/B ratio 1.6.

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