Seismic Analysis of RCC Elevated Circular Water Tank with Varying Staging Height

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Abstract— An elevated water tank is used for storage of water at certain height to provide sufficient pressure in the water distribution system. Water storage tanks are used in municipality and industries. Elevated circular water tank is a critical structure. When in the case of earthquakes, it effect drinking water supply. And also cause to fail in preventing large fires, substantial economic loss. In this study seismic behavior of circular elevated tank was carried out by performing response spectrum analysis using FEM base software (ETABS) as per IS 1893: 2016. The elevated circular water tank analyzed at different H/D ratio and varying staging height at empty condition in seismic zone III and zone V in medium soil condition. Analysis is carried out to find the base shear.

Keywords— Base shear, Elevated water tank, E-TABS, H/D ratio, Seismic zone, Staging height, Soil condition

1 INTRODUCTION

An elevated water tank is container used for storage of water at different height by providing sufficient pressure for supply water. Water is basic need of all living organism. It is used for drinking, irrigation, industrial and domestic purposes [1].

An elevated water tank can be constructed in different staging height. During the earthquake water tank will be damaged. Which badly affect all living organism and all around the world. Hence the water tank must function properly during and after the earthquake and should properly supply water in earthquake affected area. It should not damage after earthquake. Hence it is important to analyze the water tank at seismic force. The parameter like base shear helps to understand the seismic performance of tank. The staging system is an important supporting system for elevated water tank. The staging height provides an important role to resist the earthquake. When staging height also affect the pressure of water supply. The height of staging increases may affect the base shear. H/D ratio is another parameter for to deciding the effect of earthquake in water tank. When H/D ratio increases the base shear decreased. Base shear will be reduced when H/D ratio and staging height increased[5].

Here response spectra analysis were conducted to find out variation of base shear of different H/D ratio RCC water tanks of 1034m^3 capacity for medium soil condition and also comparing the result at varying staging height of circular elevated water tank.

Analysis performed using the well-known software ETABS 2018.

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2 LITERATURE REVIEW

In Shubham M. Khomane et al. paper, the seismic behavior of cylindrical elevated storage tanks was studied using dynamic response spectrum analysis. Design is perform for expanded round tank for unique H/D ratio in special zones. This paper includes percentage of metal required and fee of water tanks for circular extended storage reservoir in special seismic zones comparison and most low in cost segment is found out in design. The round expanded garage reservoir represents right settlement in phrases of H/D ratio when in comparison with unique zones. The cost of creation will increase with increasing H/D ratio for one of a kind quarter. It's far determined that lowest cost can be carried out for decrease price of H/D ratio. Cost of water tank increases as H/D ratio will increase, because as top of tank will increase because of heavy loads coming from the superstructure of the water tank if we take the H/D ratio beneath 0.4 then there's greater deflection of base slab of tank takes place [3].

Latha M. S, the evaluation and layout is done for round overhead water tank and square overhead water tank for the region 2. The round overhead tank and square over head tank are as compared for parameters like storey drift, storey shear, storey displacement, storey stiffness, hoop anxiety, region of metal, base shear and deflection. The consequences received after the analysis and design for the parameters are inside the restriction and the storey glide of the circular water tank is most because of its height, the storey shear of rectangular water tank is mostly due to its shape. The deflection and storey displacement of round water tank is most and the storey stiffness is maximum for the rectangular water tank. The ring anxiety and place of steel is more in circular water tank because of similarly distribution of strain. By way of this we say that round overhead water tank is used for the larger capacities and rectangular overhead water tank is used for the smaller capacities and for large potential the rectangular tank is not low cost [2].

Mr.Santosh T Basaragi.et al, in this task, the modeling of each square and round water tank is considered for information the behavior throughout the earthquake. The staging peak additionally various for exceptional height for a constant ability of tank of one Lakh Liters. Both static and dynamic analysis are done and outcomes and tabulated and in comparison. The displacement values of increased tank show that, the displacement values rely on the peak of the shape for the same capability. The growth in height increases the displacement. For round Tank, the boom in staging increases the displacement through 72% and 250% for model kind C2 and C3 when as compared with model kind C1 while evaluating the displacement of circular tank for seismic and wind analysis, Wind analysis suggests maximum displacement in comparison with seismic analysis. The boom in percent is round 19%, 31% and 41% for version kind C1, C2 and C3 respectively. While the rectangular tank is in comparison with circular Tank, the displacement values reduce for rectangular tank in seismic and displacement values will increase for square tank in wind analysis. The decreased values vary from 15% to 25% for seismic analysis. The base shear additionally relies upon on the weight of the shape. The maximum bending moment is found in the beams in case of circular water tank. However, the bending moment in columns increases with increase in tank height. The shear pressure is equal line with bending moment [10].

Asst. Prof A.V. Karvekar et.al, in this challenge all structural elements of round water tank are analyzed and design by using the use of manually and ETAB software. The theory at the back of the design of liquid keeping systems (elevated round water tank) the use of restriction kingdom method with reference to IS: 3370 (2009) and IS 456:2000 The behavior of shape for the parameters like tale glide, displacement stiffness, deflection, storey shear, base shear, region of metal, for circular water tank are studied on ETAB software and then comparison of the outcomes is made between manually design via this examine we are saying that the round water tank evaluation and layout on ETAB software program is more economical and secure than manually layout of water tank. Design of circular water tank is a totally tedious approach the whole shape is designed manually thinking about M20 grade concrete and Fe415 metal. After manual layout and evaluation in ETAB our shape is safe for each structural design and seismic evaluation with admire to load carried out software evaluation and layout is always useful over the conventional technique of evaluation and layout of water tank. Manual evaluation and design requires lengthy complex process while software program calls for much less time, smooth layout and analysis [9].

Ankush N et.al, Radial arrangement with six staging levels is fine suited for six, eight, ten and twelve quantities of columns observed via move and every day. Complete tank circumstance shows important responses than empty tank condition. But we cannot forget the structural responses of empty tank condition. 8 columns with 300mm optimized diameter are giving less cost (quantity of steel and urban) than six, ten and twelve columns optimized diameter for radial association, six staging tiers and full tank situation handiest. It is able to be stated that occasionally in place of increasing variety of columns for the stiffened of structure or protection, it is far better to optimize after assuring right structural responses [4].

3 Methodology and Objectives

3.1 Objectives

The salient objectives chosen for the present study are: (a) To perform response spectra analysis of different H/D ratio RCC water tanks with varying staging height. (b) To compare the base shear of each water tanks in zone III and zone V.

3.1 Methodology

The steps undertaken in the present study to achieve the objectives are as follows: (a) Models of 0.5, 0.6, 0.7, 0.8 H/D ratio of RCC elevated circular water tank with capacity 1034m^3 water tanks were modeled in ETABS 2016. (b) Response spectra analysis were performed in each water tank at different staging height (c) The obtained base shear compare for each staging and H/D ratio in zone III and zone V.

4 Structural Geometry and Modeling

The elevated water tank consists of roof slab, walls and base slab. RCC framed staging were also provided to support the tank. For elevated circular water tank were provided with RCC framed staging circular in plan here columns are circular in shape. For different H/D ratio, water tank have different height and diameter. Each water tank has capacity 1034m^3, located at medium soil condition in zone III and zone V. The size of roof slab, side wall, floor slab, bottom, ring beam, RCC bracing size are same for all models, only changes the diameter and height of tank for different H/D ratio. The specifications of water tanks are given in table 1.

TABLE 1

DIMENSIONS OF WATER TANKS

Specifications	H/D Ratio 0.5	H/D Ratio 0.6	H/D Ratio 0.7	H/D Ratio 0.8
Capacity,*m*^{3}	1034	1034	1034	1034
Tank dia, *m*	13.81	13	12.347	11.81
Tank height, *m*	6.9	7.8	8.642	9.447
Roof thickness,*mm*	250	250	250	250
Side wall thickness,*mm*	200	200	200	200
Floor slab tk,*mm*	100	100	100	100
Zone	III,V	III,V	III,V	III,V
Soil type	Medium	Medium	Medium	Medium
Bottom ring beam, *mm*	250x500	250x500	250x500	250x500
Column dia, *mm*	300	300	300	300
RCC Bracing, *mm*	300x500	300x500	300x500	300x500

In software modeling walls and slabs of tanks were modeled as shell elements, columns, beams and bracings were modeled as frame element. The diameter and height is varying for different H/D ratio while there is change in the staging height for different zone. The models of water tanks are shown in Fig. 1.

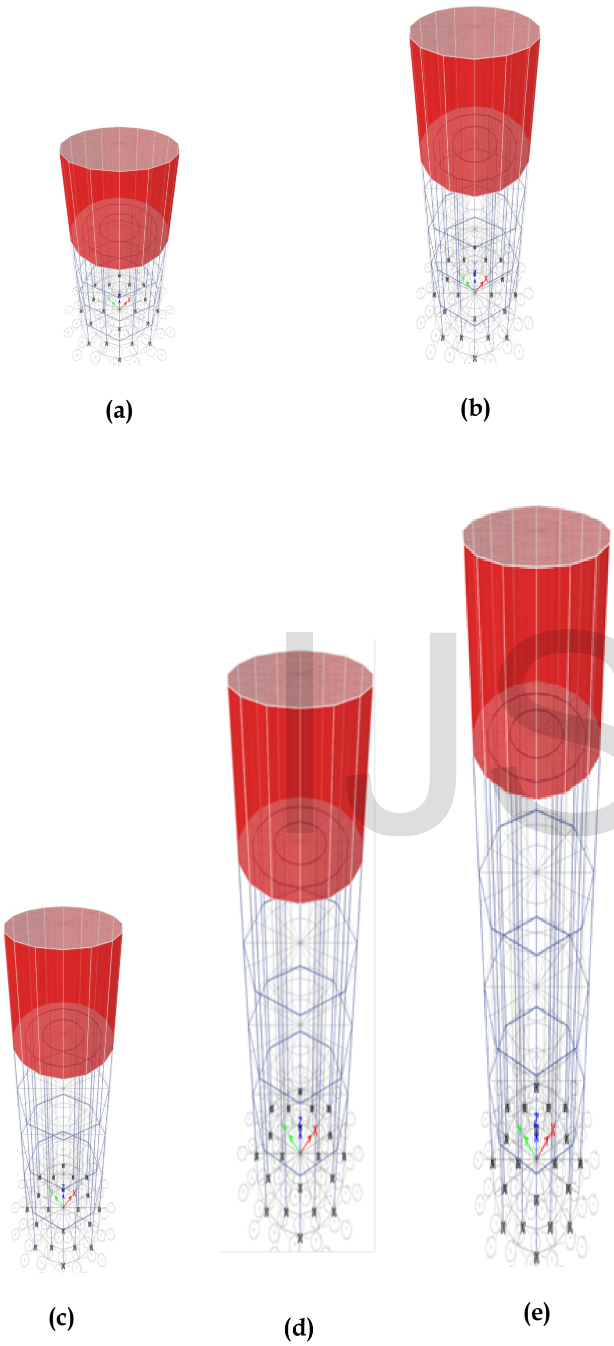

Fig. 1 Models with different staging height **(a)** Staging height 12*m* **(b)** Staging height 16*m* **(c)** Staging height 20*m* **(d)** Staging height 24*m* **(e)** Staging height 28*m*

5 Results and Discussions

Response spectra analysis of four types of water tanks were carried out. Base shear of each tank for each cases are calculated. The variation of base shear in 0.5, 0.6, 0.7, 0.8 H/D ratio in staging height 12*m* in zone III and zone V shown in figure 2.

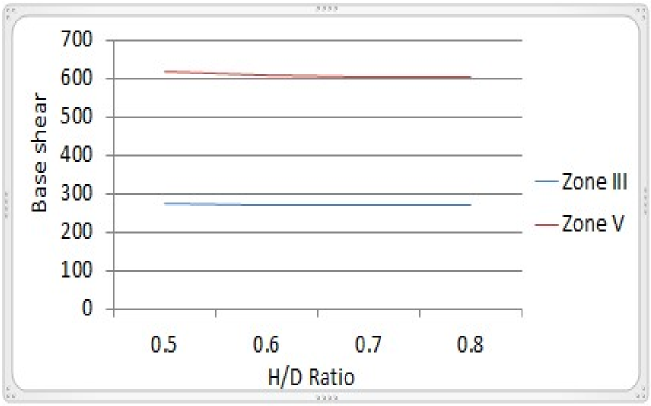

Fig. 2 Variation of base shear in 0.5, 0.6, 0.7, 0.8 H/D ratio in staging height 12*m* in zone III and zone V

Similarly base shear in 16*m* staging height in Fig. 3, 20*m* staging height in Fig. 4, 24*m* staging height Fig. 5, and 28*m* staging height in Fig. 6 respectively. Base shear for H/D ratio 0.5, 0.6, 0.7, and 0.8 in zone III & V was determined Staging height of 12, 16, 20, 24, 28*m* was used in analysis.

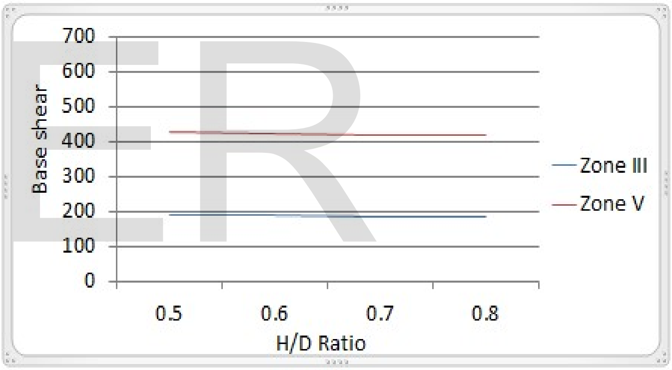

Fig. 3 Variation of base shear in 0.5, 0.6, 0.7, 0.8 H/D ratio in staging height 16*m* in zone III and zone V

For 12m staging height in zone III base shear decreased from 275.22*kN* to 267.95*kN* and zone V base shear decreased from 619.25*kN* to 602.89*kN* from H/D ratio 0.5 to 0.8

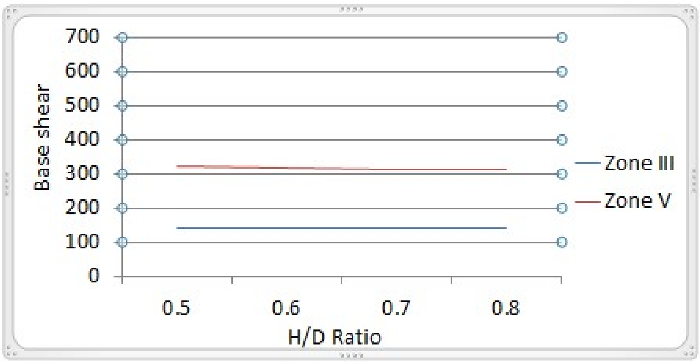

Fig. 4 Variation of base shear in 0.5, 0.6, 0.7, 0.8 H/D ratio in staging height 20*m* in zone III and zone V

For 16m staging height in zone III base shear decreased from 189.83*kN* to 185.09*kN* and zone V base shear decreased from 427.12*kN* to 416.46*kN* from H/D ratio 0.5 to 0.8

For 20m staging height in zone III base shear decreased from 142.46*kN* to 139.06*kN* and zone V base shear decreased from 320.54*kN* to 312.89*kN* from H/D ratio 0.5 to 0.8

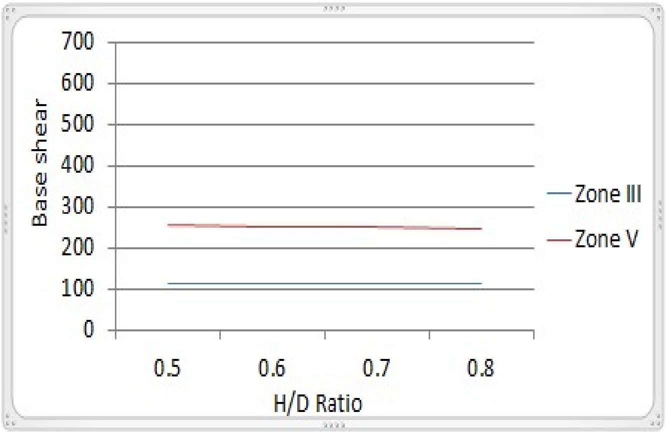

Fig. 5 Variation of base shear in 0.5, 0.6, 0.7, 0.8 H/D ratio in staging height 24*m* in zone III and zone V

For 24m stahing height in zone III base shear decreased from 112.84*kN* to 110.26*kN* and zone V base shear decreased from 253.89*kN* to 248.08*kN* from H/D ratio 0.5 to 0.8

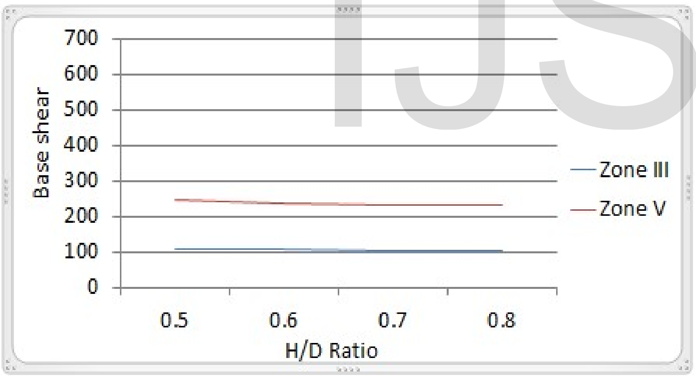

Fig. 6 Variation of base shear in 0.5, 0.6, 0.7, 0.8 H/D ratio in staging height 28*m* in zone III and zone V

For 28m stahing height in zone III base shear decreased from 109.45*kN* to 102.76*kN* and zone V base shear decreased from 246.47*kN* to 231.21*kN* from H/D ratio 0.5 to 0.8

In case of circular elevated water tanks the base shear reduced when H/D ratio increases. So the geometry of tank has importance in analysis. In the case of elevated water tank 12 m staging is provided which is much more than staging height of 28m. So when the staging height increases the base shear get reduced. The elevated water tanks have less base shear, which is due to height and diameter of tank. The H/D ratio increases the diameter of tank also decreases and height increases. The base shear decreases when diameter decreases. And also base shear decreases with height increases. While comparing staging height with height of tank wall, height of tank wall is too smaller than height of staging. The base shear of tank mainly depends on the height tank. When around height increases the base shear decreases.

6 Conclusion

Based on the work presented in this study, the conclusions can be summarized as,Base shear decreases with increasing H/D ratio.Elevated water tank shows lower base shear increase in staging height.When H/D ratio increases the diameter decreases and height of tank increases. When base shear decreases with diameter decreases and height increases. So geometry of water tank can influence base shear. Base shear for H/D ratio 0.5, 0.6, 0.7, and 0.8 in zone III & V for different staging height was determined in empty condition. For Empty condition base shear decreases with decreasing zone factor.Comparing the result of base shear for zone 3 and 5 , zone 3 shows better result than zone 5.For Empty condition base shear decreases with increasing staging height. By increasing staging height structure show better result than other height for both zone conditions.When H/D increases the base shear also increased.

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