Analysis of Water Tanks Considering Different Bracing Systems: A Review

Aditya Singh Chouhan[1], Hitesh Kodwani[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Sam Global University, Raisen-464551, Madhya Pradesh, India

Abstract- *Elevated water tanks made of reinforced concrete are very significant constructions. They are regarded as the primary components of lifelines both during and after earthquakes. An elevated water tank, which has a large water mass at the top of a thin stage, has the behaviour of an inverted pendulum. The most important factor in the tank failing during earthquakes is this. In order to shorten the effective length of the columns, horizontal braces are placed at intermediate levels and form the basic framework of the supporting system, or staging. The entire structure's lateral resistance is a result of staging.*

In this paper we have reviewed articles related to water tanks analysis considering different bracing systems and softwares.

Keywords- Earthquake, Elevated water tank stand, Non-linear Time history analysis, Seismic analysis, Seismic demand, Tekla.

I. INTRODUCTION

An elevated water tank is a sizable water storage container built with the intention of keeping water supply at a specific height to ensure adequate pressure in the water distribution system. Municipalities and businesses frequently employ liquid storage tanks to store chemicals, flammable liquids, and water. Industrial liquid tanks might hold highly flammable and hazardous liquids, and these tanks shouldn't leak during an earthquake. RC braced frame, steel frame, RC shaft, and even masonry pedestal are just a few of the different support systems that these tanks have. The staging that is utilised in practice the most frequently is the frame kind. Columns and braces are the primary staging elements of the frame style. For the transfer of loads operating on the tank, the staging functions as a bridge between the container and the foundation. Water tanks are therefore crucial for industrial structures and public utilities.

II. TYPES OF WATER TANK

In present year, there has been much accentuation on water supply extends everywhere throughout the world, which are exceptionally fundamental for the social and modern improvement of the nation. Depending on the need for use, water tanks come in a variety of capacities. Depending on their shape, water tanks are categorized:

a. Rectangular tanks
b. Circular tanks
c. Intze tanks
d. Spherical tanks
e. Circular tank with conical bottom.

Also, there are three ways water tanks are classified based on the location:

a. Tank resting on grounds
b. Underground water tanks
c. Elevated or overhead water tanks.

III. LITERATURE REVIEW

Vaishnavi Bahale and S.P. Tak (2022) A Steel elevated service reservoir with a 743 m3 capacity had its seismic reaction analysed by the author. The steel water tank was created in accordance with Indian Standard IS: 805-1968. (Reaffirmed 2006). Whole water mass was separated into two masses: convective mass and impulsive mass after careful analysis of internal fluid sloshing events. ETABS software was used to do a non-linear time history study on a tank model with or without base isolation under the Bhuj earthquake.

Results stated that the performance of the elevated steel water tank with Laminated rubber bearing isolator was found to be effective in reducing the Base shear by 55 - 75 % as compared to non-isolated tanks. Elevated slender tanks are seismically more vulnerable than broad tanks so it is recommended to provide base isolation at top of the staging for slender tank as the Tank deformation while providing isolation between superstructure and substructure is around 80 % more as compare to the isolation between tank shell and supporting structure. Bracing Structures gives more resistance

to lateral deflection and it is also suitable in earthquake prone areas. Comparison with staging pattern shows that performance of X Braced frame shows better seismic response as compared to the Inverted V braces frame.

Yogendra Borkar et.al (2022) objective of the research paper was to investigate effect of soil condition on seismic loading for underground, above the ground and elevated water tank to carry out Response Spectrum Analysis of water tanks for full water level conditions by using ETABS Software so as to obtain story Drift in X and Y direction with different soil types for all water tanks and determine and compare the Base Shear and Base Moment for all water tanks model with hard, medium and soft soil.

Results stated that base shear increases by 26 % from hard soil to medium soil. Base shear increases by 18% from medium soil to soft soil. Base Moment increases by 26.5% from hard soil to medium soil. Base Moment increases by 19% from medium soil to soft soil. Drift is decreases with increases in stiffness of soil for all water tanks

Jayesh Malaviya and P. H. Andharia (2021) Using STAAD Pro version 8i (SS6), the research paper conducted a parametric study of a circular elevated water tank with a 500m3 capacity. The seismic behavioural effect was seen when different staging layouts (bracing), variations in the h/d ratio, and variations in the quantity and size of perimeter columns were taken into account. Several parameters were taken into account in a comparative analysis, and the best outcomes in terms of base shear and displacement were considered. Using the Response Spectrum Technique, a total of 12 combinations were examined for the full tank and empty tank circumstances.

The best results are produced by an elevated circular water tank with diagonal bracing, a height-to-depth ratio of 0.7, and six columns since these factors result in the lowest base shear and displacement values. In comparison to an empty tank, base shear was higher for filled tanks. Because load due to water is subtracted when a tank is empty. When a tank is full, displacement is greater than when it is empty. For a h/d ratio of 0.7 and 6 columns, which has the least base shear and displacement values, diagonal bracing works well under these conditions. There is no set pattern of Base Shear and displacement rise or reduction when the number of columns and their respective diameters vary.

Venkata Raju Badanapuri (2021) The elevated Intez water tanks' seismic performance for high seismicity zones in India was reported in a research paper for several sections. Avoiding the use of thick wooden shuttering, which hinders the easy escape of heat from the concrete mass during hydration, will help prevent cracks. A container at the top of the elevated Intez tank is supported by a staging that transfers the weight of the container to the foundation. The dome roof, cylindrical vertical wall, conical dome, and bottom dome make up the container. A framework made of columns and bracing or a narrow, round shaft makes up the staging. For raised Intez tanks, a column-brace arrangement is typically preferred. STAAD PRO software has been used to illustrate the impact of the height of a water tank in an earthquake zone and the section of the tank on seismic forces.

According to the findings, the moments were greater for the tank with full water in seismic zone IV than for the tank with full water in seismic zone III. The elevated Intez water structure's reinforcing can be lowered due of the high moments found during analysis. The fundamental requirement of every construction is to be designed as economically as possible. The elevated Intez water tank is one such building, and it should not be overly reinforced.

Nikita S. Gholap and M.N. Shirsath (2020) research paper analyzed elevated water tank with various bracing systems for staging height 20m. Firstly, the water tank model is designed for 150 m3 capacity and for time history analysis BHUJ earthquake was considered. Various models of bracing systems.

The maximum velocity for a rectangular water tank without bracing is 45 mm/s. The percentage difference between a rectangular water tank without bracing and one bracing is 5%. Maximum velocity for a spherical water tank without bracing is 39 mm/s. Circular water tanks without bracing differ by 8% from rectangular water tanks with a single brace. The maximum distortion for a rectangular water tank without bracing is 6.8 mm. A rectangular water tank without bracing differs 30% from a rectangle water tank with a single brace. The maximum distortion for a circular water tank without bracing is 4.4 mm. The difference between circular water tanks with a single bracing and those without one is up to 15-20%.

Chetan Agari et.al (2019) in the research paper, four different types of horizontal braces with Intze type water tank's staging were analyzed using STAAD.ProV8i for dynamic response spectrum analysis primarily focused on investigating the stability of elevated water tanks during seismic motion. The tank's response i.e. displacement, maximum bending moment, maximum shear force and base shear under these seismic zone II, III and IV were calculated.

Results stated that tanks have less base shear in empty condition as compared to filled condition. The base

shear increases due to increase in seismic zone intensity. Base shear is less for the lower seismic zones and goes on increase for the higher seismic zones. Rectangular type brace staging have less displacement then simple type brace staging but the shear and bending values higher. Therefore, it is avoided for the field jobs in seismic zone II, III and IV. The radial type brace staging have minor effect due to seismic loads and the responses of staging with radial type brace give strong stability as compare to other brace staging. Therefore, it can minimize the chances of collapse of the elevated water tank.

L.Raghava Naidu et.al (2019) research paper analyzed the tank under seismic forces with the variations of different seismic zones and shape of containers e.g. rectangular tank and circular tank with constant staging height according with IS 1893-1984 (i.e. single lumped mass method) and IS 1893-2002 (i.e. two mass model method), by changing seismic zone and soil type i.e. hard rock and soft soil. Analysis was carried out for two different tank fill conditions i.e. full and empty tank conditions. Seismic forces acting on the tank were evaluated by the response spectrum method by changing response spectrum value (R), by using the software STADD PRO. Seismic response such as nodal displacement, base shear, base moment, shear force and bending moment was evaluated and compared.

Results stated that base shear, nodal displacements, shear force& bending moment are increased in full water tank and empty water tank with the changing of seismic zone from II-V because of change in zone factor& response reduction factors. Base shear in empty water tank isslightly less than full water tank due to the absence of hydro-static pressure. The analysis of tank as lumped mass model is applicable to closed tanks with the full of water. Hence tanks with free board are analyzed by using two mass model of tank. Base shear and base moments obtained from lumped mass method are far less than two mass model methods. Hence lumped mass model method should not used for dynamic analysis of water tanks

IV. CONCLUSION

Past researches suggested the use of different types of water tanks and bracing systems depending upon the suitability of the condition. Implementation of softwares is found beneficial in order to develop a relation between software and practical condition.

REFERENCES

[1] Jayesh Malaviya and P. H. Andharia, [Parametric Seismic Analysis of Elevated Circular Water Tank for Various Staging Patterns], International Advanced Research Journal in Science, Engineering and Technology Vol. 8, Issue 4, April 2021.

[2] Sonali M. Maidankar, G.D. Dhawale and S.G. Makarande, [Seismic Analysis of Elevated Circular Water Tank using various Bracing Systems], International Journal of Advanced Engineering Research and Science (IJAERS), Vol-2, Issue-1, Jan.- 2015, ISSN: 2349-6495.

[3] Yogendra Borkar, Sandeep Gaikwad and Priyanka Kamble, [Seismic Analysis of Underground above the Ground and Elevated Water Tank with Different Soil Conditions by using ETABS 18], International Journal for Research Trends and Innovation, 2022 IJRTI | Volume 7, Issue 5 | ISSN: 2456-3315.

[4] Tiruveedhula Chandana and S.V. Surendhar, [Comparative Seismic and Cost Analysis of RCC Circular, Rectangular and Intze Elevated Water Tank], International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-8, June, 2019.

[5] Chetan Agari, V. K. Verma and Aman Gupta, [Seismic Analysis of Intze Water Tank with Different Bracing Configurations], International Journal of Research in Engineering, Science and Management Volume-2, Issue-8, August-2019.

[6] Ravi S. Gupta, Dr. Vikram. A. Patil and Somangoud Takkalki, [Analysis Of Dynamic Behaviour Of Rc Elevated Water Tank], International Journal of Engineering Development and Research, 2019 | Volume 7, Issue 4 | ISSN: 2321-9939.

[7] Nikita S. Gholap and M.N. Shirsath, [NonLinear Time History Analysis of an Elevated Water Tank], International Journal of Advanced Research in Science & Technology (IJARST) Volume 7, Issue 2, July 2020.

[8] Vaishnavi Bahale and S.P. Tak, [SEISMIC ANALYSIS OF ELEVATED STEEL WATER TANK WITH OR WITHOUT BASE ISOLATION], International Journal of Creative Research Thoughts (IJCRT), Volume 10, Issue 10 October 2022 | ISSN: 2320-2882.

[9] Venkata Raju Badanapuri, [Analysis and Design of Elevated Intez Water Tank based on Normal Frame Staging Subjected to Seismic Loading by Using Staad Pro Software], International Journal of Science and Research (IJSR), Volume 10 Issue 3, March 2021.

[10] L.Raghava Naidu, Dr.H.Sudarsana Rao and Dr.Vaishali G Ghorpade, [SEISMIC ANALYSIS OF RC ELEVATED WATER TANK IN DIFFERENT SEISMIC ZONES], International Journal of Civil Engineering and Technology (IJCIET) Volume 10, Issue 02, February 2019, pp. 2354-2364.