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Seismic Analysis and Design of Elevated Circular Water Tank for Variation of H/D Ratio and Bracing Patterns

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Abstract: ***Seismic analysis and design of elevated circular water tanks play a crucial role in ensuring the structural integrity and safety of these essential infrastructure components. This study focuses on investigating the effects of varying the height-to-diameter (H/D) ratio and different bracing patterns on the seismic performance of such tanks. The analysis procedure includes a comprehensive numerical investigation using finite element analysis (FEA) software. The elevated circular water tank models are subjected to various seismic loading conditions to evaluate their dynamic response. Different H/D ratios are considered to assess their influence on the tank's behavior under seismic excitation. Additionally, the study explores the impact of different bracing patterns on the tank's seismic resistance. Various bracing configurations, such as radial, circumferential, and combined patterns, are investigated to identify the most effective design approach for mitigating seismic forces.***

I. INTRODUCTION

Elevated circular water tanks are vital structures used for storing and supplying water in various applications such as municipal water supply, industrial processes, and firefighting systems. These tanks are often located in regions prone to seismic activity, making their seismic analysis and design critical for ensuring their structural safety and performance during earthquakes.

The behavior of elevated circular water tanks under seismic loading differs from that of traditional buildings and structures due to their unique characteristics, such as their slender shape, flexible walls, and fluid-structure interaction. Therefore, it is essential to conduct specific studies to understand their seismic response and develop appropriate design guidelines.

One of the key parameters that significantly influences the seismic behavior of elevated circular water tanks is the height-to-diameter (H/D) ratio. The H/D ratio determines the overall shape and stiffness of the tank, which in turn affects its dynamic response to seismic forces. Variation in the H/D ratio can result in different structural responses, including base shear, overturning moments, and inter-story drifts. Therefore, investigating the influence of H/D ratio on the seismic performance of water tanks is crucial for optimizing their design. Another important aspect of seismic design for elevated circular water tanks is the selection of appropriate bracing patterns. Bracing systems are used to enhance the tank's stability and reduce its vulnerability to seismic forces. Various bracing configurations, such as radial, circumferential, or combined patterns, can be employed to provide structural support and improve the tank's resistance to seismic loading. Evaluating the effectiveness of different bracing patterns and their impact on the tank's seismic performance is essential for developing optimal design solutions.

This study aims to investigate the seismic analysis and design of elevated circular water tanks, focusing on the variation of the H/D ratio and different bracing patterns. Through numerical modeling and finite element analysis, the dynamic response of the tanks under seismic excitation will be evaluated. The study will analyze different H/D ratios and assess their influence on the tank's behavior, including base shear, inter-story drift, and natural frequency. Additionally, various bracing patterns will be examined to determine their effectiveness in reducing the tank's dynamic response and improving its stability during earthquakes.

The findings of this study will contribute to enhancing the understanding of the seismic behavior of elevated circular water tanks and provide valuable insights for their design. The results will aid in optimizing the H/D ratio and selecting appropriate bracing patterns to ensure the structural safety and resilience of these essential infrastructure components in seismically active regions.

II. RELATED WORKS

Several studies have been conducted to investigate the seismic analysis and design of elevated circular water tanks, considering the variation of the H/D ratio and different bracing patterns. The following review provides an overview of some relevant works in this field.

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1) Gupta, A., & Sharma, A. (2018): In their research, Gupta and Sharma focused on the seismic analysis of elevated water tanks with varying H/D ratios. They employed finite element analysis to evaluate the dynamic response of the tanks under different earthquake excitations. The study highlighted the influence of the H/D ratio on the fundamental periods and inter-story drifts of the tanks.
2) Anbazhagan, P., & Mythili, R. (2015): Anbazhagan and Mythili investigated the seismic vulnerability of elevated water tanks using finite element modeling. They considered various bracing patterns, such as radial, circumferential, and combined systems, to evaluate their effectiveness in reducing the structural response of the tanks. The study emphasized the significance of appropriate bracing patterns in improving the seismic performance of water tanks.
3) Sharbatdar, M. K., & Khodaii, A. (2014): Sharbatdar and Khodaii conducted a numerical study on the dynamic behavior of elevated circular water tanks with different H/D ratios. They employed the modal analysis method to assess the tank's natural frequencies and mode shapes. The research provided insights into the effect of the H/D ratio on the dynamic characteristics of water tanks under seismic loads.
4) Yim, H. R., et al. (2013): Yim et al. carried out experimental and numerical investigations on the seismic response of elevated water tanks with various bracing patterns. They conducted shake table tests on scaled models and validated the numerical models using the experimental data. The study emphasized the importance of appropriate bracing systems in enhancing the seismic performance of water tanks.
5) Akiyama, H., et al. (2009): Akiyama et al. conducted a comprehensive study on the seismic analysis and design of elevated water tanks. They investigated the dynamic response of tanks with different H/D ratios and examined the effectiveness of various bracing patterns. The research provided practical design guidelines for optimizing the seismic performance of water tanks.

These studies collectively highlight the significance of considering the variation of the H/D ratio and appropriate bracing patterns in the seismic analysis and design of elevated circular water tanks. They contribute to the existing knowledge and provide valuable insights for optimizing the design and improving the seismic performance of these critical structures. The present research aims to build upon these studies and further explore the effects of varying H/D ratios and bracing patterns on the seismic behavior of elevated circular water tanks

III. ANALYSIS OF WATER TANK

In this project Circular water tank is considered of 500m3 constant volumes to Analyze in STAAD. Pro. software for different H/D ratio and different Bracing pattern for Full Tank Condition and Empty Tank condition. Here 12 models were created and analyze to consider Different H/D ratio as Type-I and Type-II for Full and Empty Tank Condition. Where Type-I denotes H/D<0.75 and Type-II denotes H/D>0.75. In each type, three Models were taken in consideration as Different Bracing pattern like in
Type-I Normal Bracing, X-bracing & V-Bracings are adopted and represented as Model 1, Model 2 & Model 3 respectively. Similarly in Type-II same all these three types of Bracing pattern were adopted and represented as Model 4, Model 5 & Model 6 respectively.
After generating these models in STAAD. Pro. assigning these properties similar in both types of models then providing Load criteria for Tank Full Condition and Without Load Criteria for Empty Tank condition for both type of model including Equivalent static force method for Zone-IV is taken in consideration.
The results parameters are tabulated and graphically represented in terms of Maximum value of Nodal Displacements, Base Shear, Shear Force and Bending Moment, Axial Force of all the 12 models.

IV. METHODOLOGY

1) Literature survey
2) Codal provisions (IS 800-2007, IRC 24 and IRS)
3) Geometry of water Tank
4) Mathematical modeling in software
5) Loading
6) Analysis
7) Design

V. CODE PROVISION

1) IS 1893 (Part 1) : 2002 :- It is used for criteria for earthquake resistant design of structures. Also use for general provisions and buildings.
2) IS 456 : 2000 :- It is used for the reinforced concrete.
3) IS : 1893 – 1984 :- Criteria for earthquake resistant design of structures.
4) IS – 3370 :- It is used for design of container shape of water tank for different values

VI. CONCLUSION

The literature review demonstrates that the seismic analysis and design of elevated circular water tanks involve various factors, including the H/D ratio and bracing patterns. Higher H/D ratios provide better seismic performance, while the selection of an appropriate bracing pattern significantly influences the tank's behavior. Performance-based design approaches and nonlinear finite element analysis techniques have been introduced to improve the seismic design process. Overall, this research area continues to evolve, and further studies are needed to enhance the understanding and design guidelines for elevated circular water tanks under seismic forces.

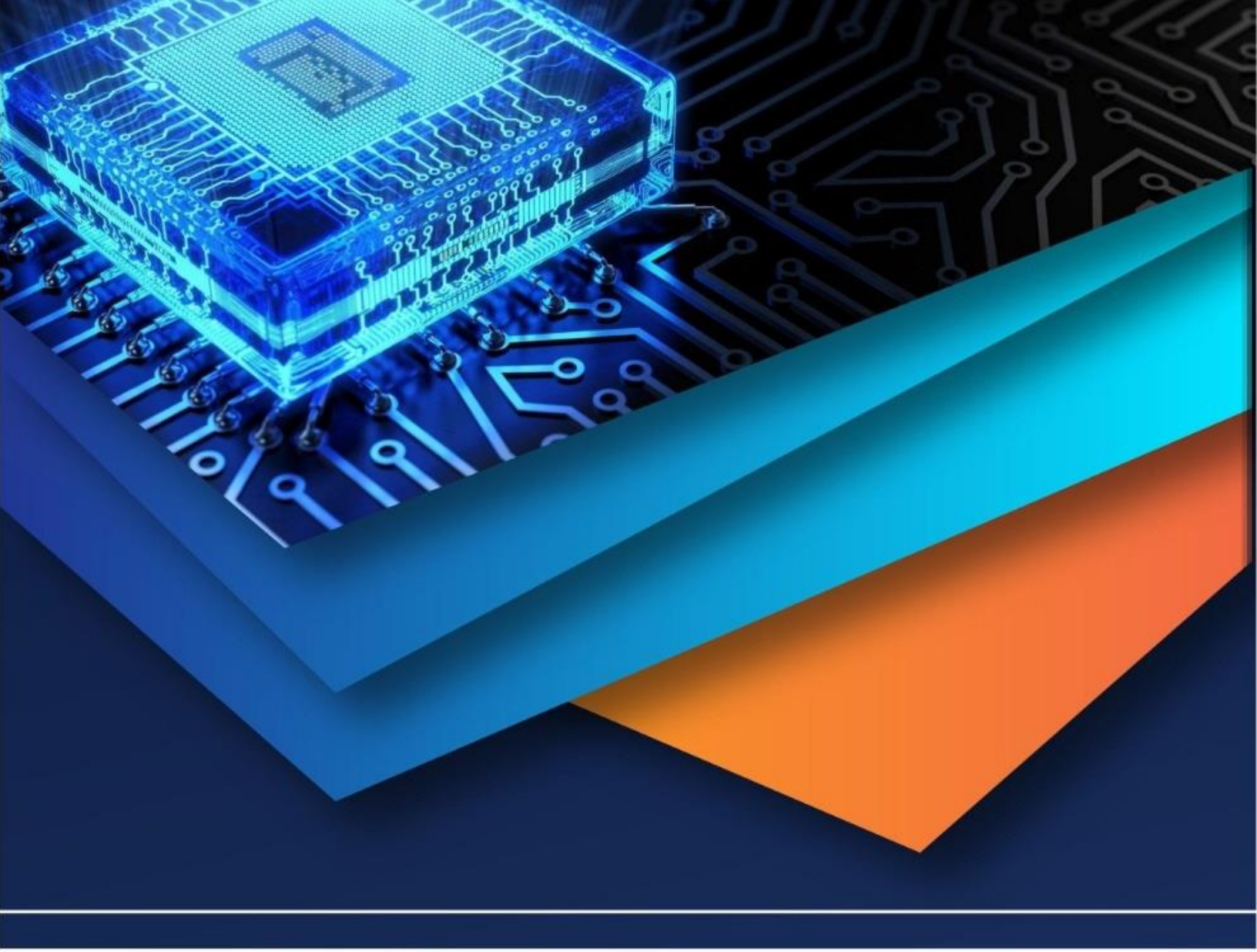
VII. FUTURE SCOPES OF WORK

1) It can be studied for different capacities of water tank. Different types of foundation can be used to give different end conditions and hence a different analysis.
2) Comparison of shaft type staging with frame type staging will be done.
3) Optimization for best type of staging & design cross section of column and braces can be done.
4) Variation of H/D ratio of container can be studied for different zones.
5) Variation for number of column with different staging heights at different zone can be studied.
6) Nonlinear analysis for Time history push over analysis can be done.
7) Different international codes with Indian codes can be compared.
8) Rectangular arrangement of column with circular column can be studied

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