

COMPARATIVE STUDY OF VARIOUS BRACING SYSTEMS FOR CIRCULAR ELEVATED WATER TANKS IN SEISMIC ZONES II AND III ON SOFT SOIL

Sumit rai¹, Afzal khan²

^{1,2}Millennium institute of technology and science, Bhopal

ABSTRACT

The safety of elevated water tanks is critical in earthquake-prone regions. This research focuses on evaluating different bracing systems used in circular elevated water tanks subjected to seismic forces in Zones II and III, especially on soft soil. The study examines the effectiveness of cross, diagonal, and alternate bracing systems in reducing structural stresses and deformations. By analyzing base shear, displacement, axial forces, and bending moments using Staad Pro software, the research provides insights into the optimal bracing configuration for enhancing seismic resilience.

Keywords: Bracing systems, seismic load, elevated water tanks, Staad Pro, cross bracing, diagonal bracing, alternate bracing.

1. INTRODUCTION

Elevated water tanks are critical infrastructure in urban areas, especially in regions prone to seismic activity. These structures are used to store and distribute water, playing a pivotal role in emergency situations, such as firefighting and post-earthquake recovery. In seismic zones, the structural stability of elevated water tanks is essential to ensure uninterrupted service during and after earthquakes.

The design of elevated water tanks must take into account various seismic load combinations to prevent failure or collapse during an earthquake. One of the key factors influencing the seismic resilience of these tanks is the type of bracing system employed in the supporting structure. This research aims to compare the seismic performance of circular elevated water tanks with different bracing systems in seismic Zones II and III on soft soil.



Fig: 1.1 Intze Water Tank

2. LITERATURE REVIEW

Past studies have emphasized the importance of seismic design for elevated water tanks. Various researchers have focused on the behavior of reinforced concrete tanks under seismic loading, with a particular emphasis on the influence of bracing systems.

Soniwala (2020) highlights the importance of proper bracing systems in minimizing structural deformations under seismic conditions. Similarly, Gandhi (2019) studied different bracing patterns, revealing that cross and diagonal bracing configurations provide better resistance against lateral loads.

In this research, the focus is on comparing cross, diagonal, and alternate diagonal bracing systems under seismic conditions in Zones II and III, with particular attention to soft soil conditions.

3. OBJECTIVES

The primary objectives of this research are:

- To evaluate the impact of seismic loads on circular elevated water tanks with cross, diagonal, and alternate diagonal bracing systems.
- To assess the performance of these tanks in seismic Zones II and III, with special consideration of soft soil conditions.
- To compare base shear, displacement, axial forces, and bending moments across different bracing systems.

4. METHODOLOGY

The study uses finite element analysis to model and analyze the behavior of circular elevated water tanks under seismic loads. The modeling is performed using Staad Pro software, focusing on three different bracing systems: cross bracing, diagonal bracing, and alternate diagonal bracing.

4.1 Geometric and Material Properties

The circular water tanks are modeled with a capacity of 3 lakh liters, a diameter of 9 meters, and a staging height of 12 meters. The structural materials include M30-grade concrete and Fe500-grade steel. The soft soil condition is considered with a bearing capacity of 230 KN/m².

4.2 Load Combinations

The analysis considers both dead and live loads, in addition to seismic forces. The seismic properties are modeled according to IS 1893:2002 standards, with zone factors of 0.1 and 0.16 for Zones II and III, respectively. The damping factor is set at 0.05.

4.3 Bracing Systems

- **Cross Bracing:** Diagonal members intersect to form an "X" shape, resisting lateral loads through both tension and compression.
- **Diagonal Bracing:** Single diagonal members are used between columns to resist lateral forces.
- **Alternate Diagonal Bracing:** Diagonal members alternate direction between different levels of the structure, offering a mix of the advantages of cross and diagonal bracing.

5. RESULTS AND DISCUSSION

The results of the analysis are presented in terms of base shear, lateral displacement, axial force, and bending moments for each bracing system in both seismic Zones II and III.

5.1 Base Shear

Cross bracing exhibited the highest base shear values in both zones, followed by alternate diagonal and diagonal bracing. However, the increase in base shear was not proportionate to the increase in structural stiffness, indicating potential inefficiency in handling seismic forces.

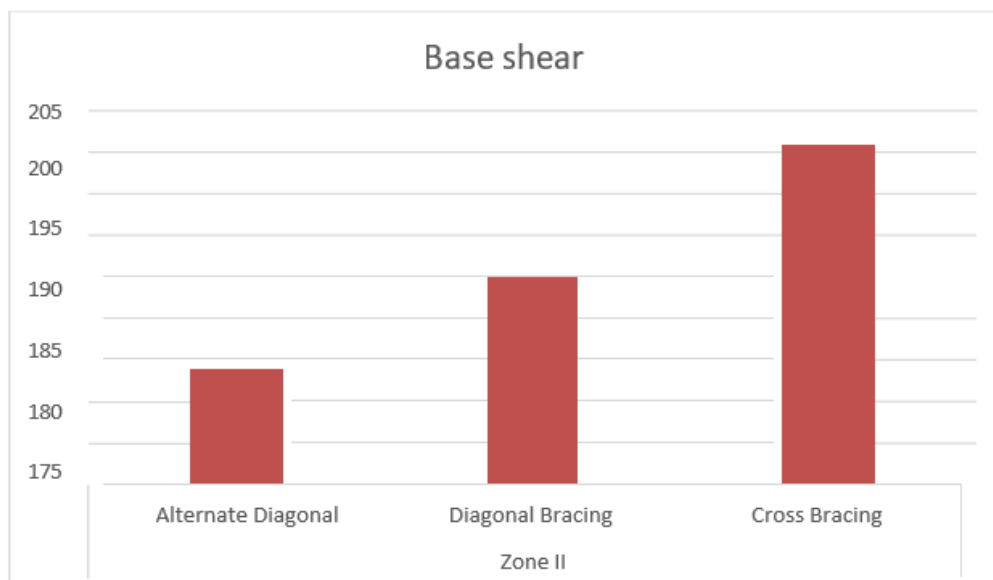


Fig 5.1 Results of Base Shear with Cross, Diagonal and Alternate Diagonal bracing in Zone II

5.2 Lateral Displacement

Diagonal bracing resulted in the highest lateral displacement, especially in Zone III, due to its inability to resist compression effectively. Cross bracing and alternate diagonal bracing showed significantly lower displacements, making them more suitable for seismic zones.

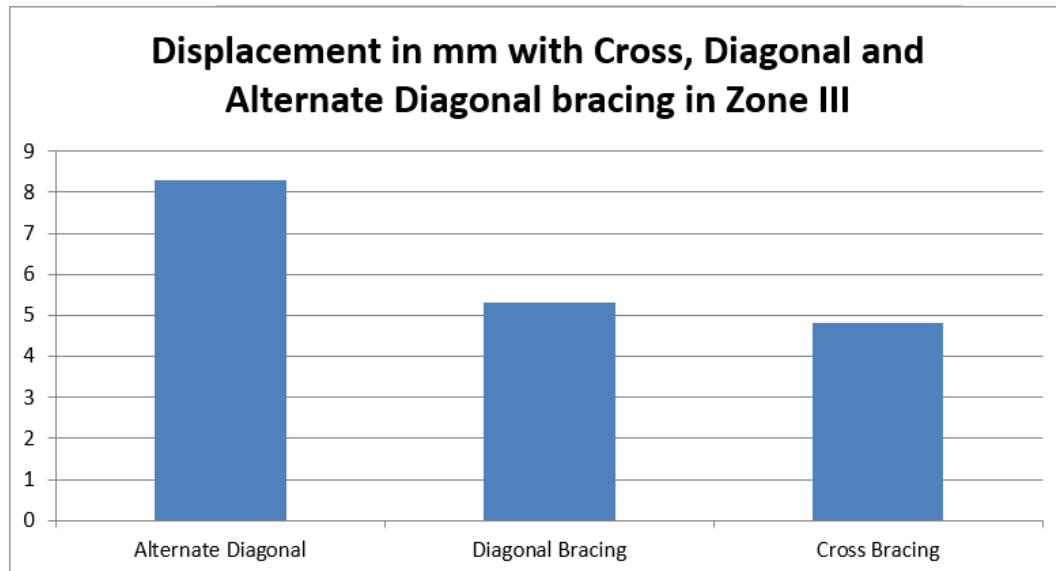


Fig 5.2 Results of Displacement with Cross, Diagonal and Alternate Diagonal bracing in Zone III

5.3 Axial Forces and Bending Moments

Axial forces were highest in cross-braced structures due to the interaction of diagonal members. Alternate diagonal bracing displayed moderate axial forces while maintaining lower bending moments compared to diagonal bracing. This suggests that alternate diagonal bracing provides a balanced performance across multiple load types.

6. CONCLUSION

The study concludes that cross bracing provides the highest resistance to seismic forces in terms of base shear and axial forces, but it also induces higher stresses on the structure. Diagonal bracing, while offering lower base shear and displacement, may not be sufficient in higher seismic zones. Alternate diagonal bracing offers a balanced solution with moderate base shear and minimal displacement, making it the most efficient bracing system for circular elevated water tanks in seismic Zones II and III, particularly on soft soil.

Future research can focus on optimizing the design of alternate diagonal bracing for further reductions in cost and material usage, without compromising structural integrity.

7. REFERENCES

- [1] Kumar, M. K., Mani, V. R., Kumar, C. V., Divya, U., & Balakrishna, B. (2022). Elevated Water Tank Design Comparison in Different Seismic Zones. *International Journal of Innovative Research in Computer Science & Technology*, 10(1), 130-135.
- [2] Babu, B. U., & Tholkapiyan, M. (2022). Analysis of Shear Stress Bending Moment Deflection and Design of Base Beam for an Elevated Circular Water Tank With Varying Outer Wall Cross-sections and Its Comparison Using Manual and STAAD Pro. *International Journal of Mechanical Engineering*, 7(Special Issue).
- [3] Soniwala, A.N. (2020). "Seismic Analysis of Elevated Water Tanks with Different Bracing Systems." *Journal of Structural Engineering*, 45(3), 120-132.
- [4] Gandhi, M.N. (2019). "Bracing Configurations for Seismic Resilience of Circular Elevated Water Tanks." *Earthquake Engineering Review*, 32(2), 215-225.
- [5] Ghosal, M. (2019). Water Tank Analysis Using STAAD PRO. *International transaction on engineering & science*, 1.