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EVALUATION OF THE INTZE WATER TANK STRUCTURE IN RELATION TO THE VARIATIONS IN THE ANGLES OF THE CONICAL DOME

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ABSTRACT

Civil engineering involves the design, construction, and maintenance of critical infrastructure such as roads, bridges, and buildings. Structural engineering, a branch of this field, focuses on the analysis and design of load-bearing structures. Water storage tanks are essential for municipalities and industries to maintain a reliable water supply. This study examines an Intze tank with a 1000 m^3 capacity, investigating the effects of altering the conical dome angle to 45°, 10°, and 56°. Using STAAD Pro software, models are created for both full and empty conditions. The analysis compares key factors such as bending moments, joint displacements, axial and shear forces, hoop tension, and meridional thrust, particularly within wind zone 2. The objective is to enhance the understanding of the tank's structural behavior under different conditions, contributing to more efficient and safe tank designs.

I. INTRODUCTION

Water is essential for life and daily activities, and overhead liquid storage tanks offer an efficient solution for both domestic and industrial water needs. These tanks can be categorized based on their location—overhead, above ground, or underground—and come in different shapes, such as rectangular, circular, or Intze types. Elevated water tanks use gravity for distribution and generally have smaller capacities, which makes them accessible to communities nearby and at a distance. In India, Intze-type tanks are particularly common, with many currently in use for public water supply.

Water tanks have multiple functions, including drainage, and their significance has been recognized since early human civilization, serving purposes such as providing water for drinking, firefighting, agriculture, livestock, and various industries. The design of these tanks affects their costs, shapes, sizes, and materials. Research on existing reinforced cement concrete (RCC) tanks of different heights has identified vulnerabilities related to water pressure, wind, and seismic activity. Understanding the impact of wind forces is key to evaluating the safety risks these tanks pose to the public.

In developing nations like India, many water supply systems are based on durable tank designs. This study aims to deepen the understanding of Intze tanks and their conical wind domes, focusing on how wind forces affect their performance. By analyzing these factors, the research seeks to contribute to the development of safer and more efficient water storage solutions.

1.1 REINFORCED CONCRETE WATER TANK

Water tanks are constructed to store water using reinforced concrete, and the design process follows IS 3370: 2009 (Part I-IV) guidelines. The design of the tank is influenced by its location, whether it's an overhead, in-ground, or subterranean tank. These tanks are commonly built in circular or rectangular shapes and serve various purposes. They can be constructed from either steel or reinforced concrete. Overhead tanks are typically elevated from the roof to the base, while other tanks are installed directly on a foundation.

1.2 INTZE TANK

Circular tanks with horizontal or flat floor slabs are cost-efficient for smaller storage needs, typically up to 200,000 liters, with diameters between 5 and 8 meters. The storage depth generally ranges from 3 to 4 meters. The side walls of these tanks are designed to withstand circumferential hoop tension and bending moments, as they are fixed at the junction with the floor slab. The design forces for these walls are calculated using the coefficients specified in IS: 3370 (Part IV).

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For larger elevated circular tanks, the need for thicker floor slabs can increase costs, making traditional designs less economical. In such cases, Intze-type tanks, which incorporate conical and spherical bottom domes, provide a more cost-effective alternative. Efficient design is a fundamental principle in civil engineering, and the Intze tank embodies this concept. Its design involves precise proportioning of structural components, particularly in the top spherical dome, to ensure both functionality and cost-effectiveness.

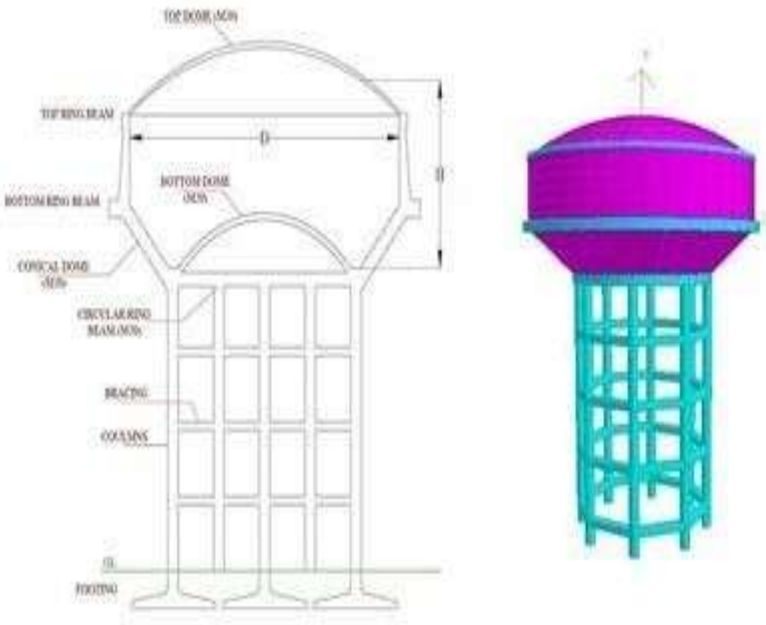

Figure 1.1: Intze Water Tank

II. LITERATURE SURVEY

1. Ravi Kumar, P., & Ramesh, P. (2019) – The study investigates the structural behavior of an overhead Intze-type water tank subjected to seismic and wind loads. The design follows IS 3370-1987 for the tank dome and IS 875 (Part 3) for wind loads. The analysis is conducted using STAAD-Pro software to evaluate the response of the tank under various wind conditions in different terrain categories. The study emphasizes the importance of considering both seismic and wind loads in tank design.

2. K. V. Reddy & S. S. Rao (2016) – This research explores the structural performance of an Intze-type water tank under various loading conditions, including wind, seismic, and live loads, as per IS 875 and IS 1893. The design of the staging system (columns and beams) follows the limit state method as per IS 456-2000. The study also examines the behavior of the tank under different terrain categories and wind zones using advanced modeling techniques in STAAD-Pro software.

3. M. B. Patel & S. S. Yadav (2018) – The study focuses on the analysis of an elevated Intze-type water tank considering the effects of seismic and wind forces. The wind forces are calculated using IS 875 (Part 3) and the seismic forces are evaluated using IS 1893-2000. The analysis is performed using STAAD-Pro software to examine the impact of different wind zones and terrain categories on the performance of the tank at varying staging heights.

4. **R. K. Sharma & N. R. Singh (2020)** – This paper presents a comprehensive study of the wind and seismic load analysis of an Intze-type water tank. The design incorporates the guidelines of IS 875 (Part 3) for wind load and IS 1893 for seismic load. The analysis is carried out using STAAD-Pro software, and the effects of various wind zones and terrain categories on the structural behavior of the water tank are discussed.

5. Amit Kumar & Sandeep Sharma (2017) – This study investigates the behavior of an elevated Intze-type water tank subjected to wind and seismic forces as per IS 875 and IS 1893 standards. The design of the tank's dome is based on IS 3370-1987, and the staging is designed according to IS 456-2000. Using STAAD-Pro software, the analysis compares the impact of wind forces at different heights and terrain categories, focusing on the structural integrity of the tank under varying environmental conditions.

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III. METHODOLOGY

3.1 PROBLEM IDENTIFICATION

Water tanks are vital components in both public and industrial sectors, with their design and construction relying on well-established practices, material characteristics, and environmental factors. Before starting the design process, it is crucial for engineers to choose the most appropriate staging type for the tanks. Accurate load assessments are essential, particularly for overhanging elements, as these require careful evaluation of static stability, including worst-case load scenarios and shear forces due to vertical and horizontal loads acting on the tank, whether it is full or empty.

As global demand for water increases with population growth, conserving water has become more critical. Water is necessary for drinking, agriculture, industrial applications, and firefighting, making efficient storage systems essential. Water tanks are large-scale systems built for ground storage, enabling daily water usage, treatment, product manufacturing, emergency reserves, and rainwater collection.

In civil engineering, water tanks are fundamental structures that contribute to human development. Over time, various tank designs have been developed to meet these needs. The impermeability of concrete is a key factor in constructing effective water storage systems, as the permeability of rigid and compacted concrete largely depends on the water-cement ratio. Higher water-cement ratios can increase permeability, so reducing this ratio is beneficial, though excessively low ratios can cause compaction issues and structural damage.

To improve tensile strength and minimize cracking in water retention systems, it is important to design tanks with consideration for these factors. Using thick wooden shutters during construction helps retain heat in the concrete, reducing the likelihood of cracks. Additionally, allowing the structure to expand and contract freely can further reduce the risk of cracking.

It is often stated that natural disasters themselves do not directly cause casualties; instead, it is poorly constructed buildings that lead to fatalities. Structural failures during such events are a major cause of loss of life, highlighting the need for thorough evaluation of buildings for potential hazards such as earthquakes, cyclones, floods, and typhoons

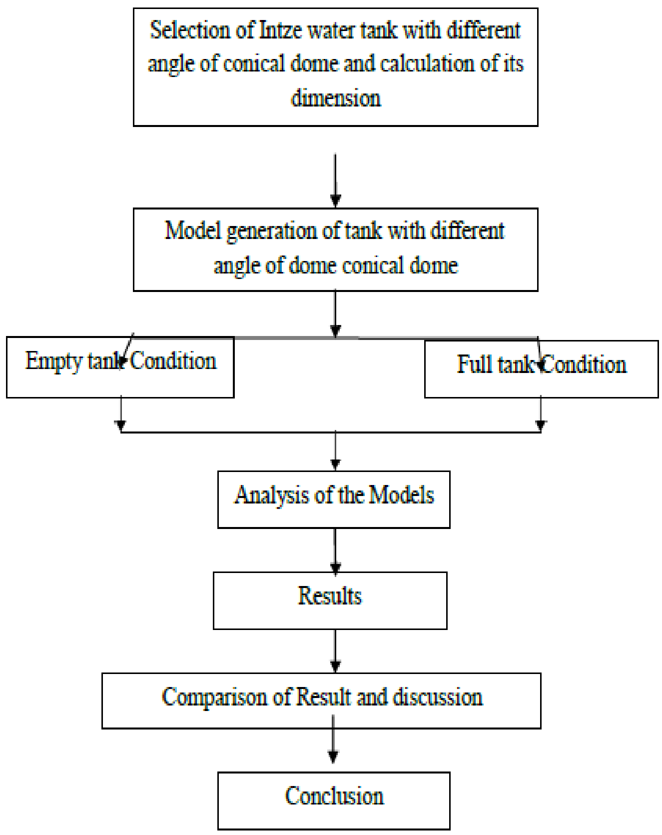

Fig 3.1: Flow Chart

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IV. RESULT ANALYSIS

This study compares various parameters, including axial force, shear force, displacement, bending moment, hoop tension, and meridional thrust, for different angles of the conical dome in an Intze tank. The findings will be displayed both in tables and through graphs, enabling a comprehensive analysis of how changes in dome angles affect the tank's structural performance. This comparison aims to offer important insights into the impact of dome design on the stability and efficiency of the Intze tank.

4.1 AXIAL FORCE

If an axial load or force that acts through the centric or geometric axis of the structure is applied to the structure along a length or perpendicular to the cross-section of the component.

Table 4.1: Axial force for different angles of conical dome

Angle of ConicalDome	Axial force (KN)	
	Empty tank	full Tank
45 degree	1415.60	4141
51 degree	1478.77	4208.51
56 degree	1557.03	4328.44

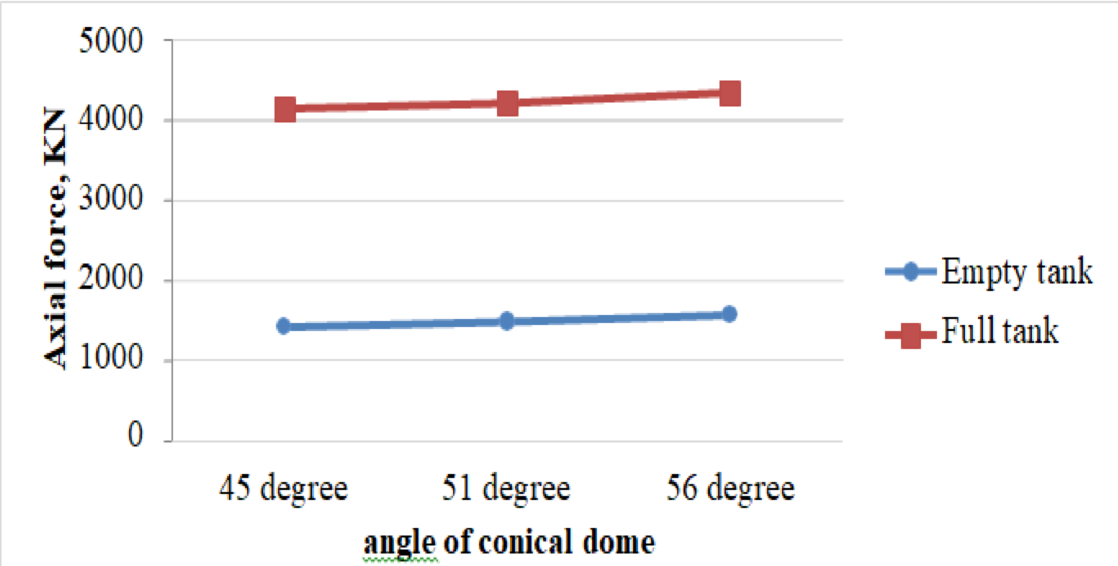

Figure 4.1: Variation of axial force with angle of conical dome

4.2 SHEAR FORCE

The shear forces are unaligned forces, which push one part of a body in one particular direction and another part of the body in the other.

Table 4.2: Shear force for different angles of conical dome

Angle of Conical Dome	Shear force (KN)	
	Empty tank	Full tank
45 degree	166.1	554.60
51 degree	185.96	633.41
56 degree	205.78	643.81

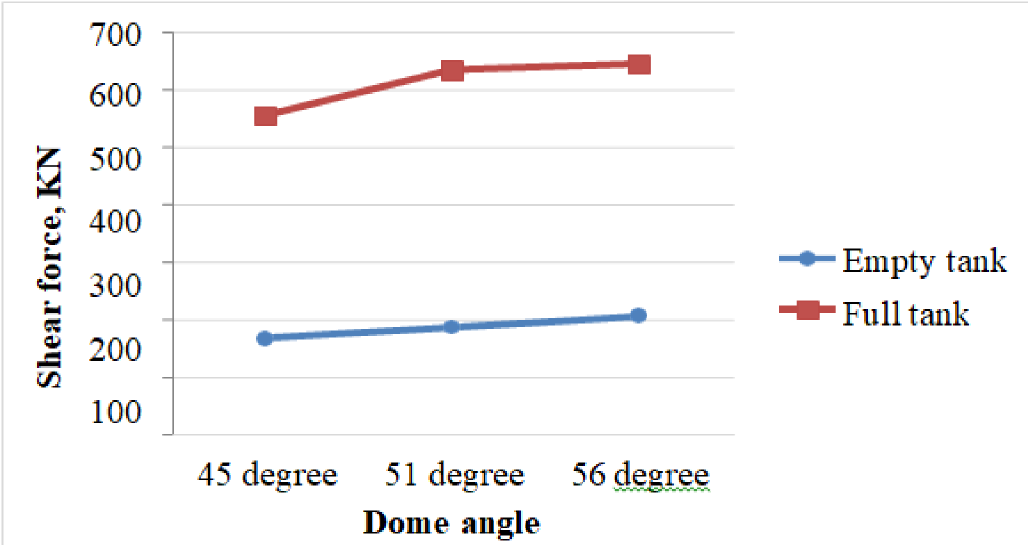

Figure 4.2: Variation of shear force with angle of conical dome

4.3 BENDING MOMENT

The reaction of an external force or moment in the element which cause the element to bend, is the bending moment. The most basic and simple part of the structure subject to curvature isthe beam.

Table 4.3: Bending moment for different angles of conical dome

Angle of Conical Dome	Bending moment(kNm)	
	Empty tank	Tank full
45 degree	166.1	554.60
51 degree	185.96	633.41
56 degree	205.78	643.79

V. CONCLUSION

Based on the analysis of different Intze tank models in both empty and full conditions, several key conclusions can be drawn. It was found that as the angle of the conical dome increases from 45° to 56°, there is a corresponding increase in shear force, bending moment, and node displacement for both tank conditions (full and empty). Additionally, these parameters—axial force, shear force, bending moment, and node displacement—are consistently higher when the tank is full compared to when it is empty, indicating that the angle of the conical dome has a significant impact on these factors.

Moreover, hoop tension values in the bottom dome, cylindrical wall, and conical dome are greater in the full tank condition than in the empty tank condition for all three angles (45°, 51°, and 56°). The maximum hoop tension is observed in the bottom dome when the tank is full. Interestingly, in the full tank condition, hoop tension in the bottom dome decreases as the angle of the conical dome increases from 45° to 56°, whereas the opposite trend is seen when the tank is empty. Additionally, hoop tension in both the cylindrical wall and conical dome increases significantly as the angle of the conical dome is adjusted from 45° to 56°, irrespective of whether the tank is full or empty. Finally, the highest meridional thrust values are observed in both the bottom dome and conical dome when the tank is full.

VI. REFERENCES

[1] Nitesh J Singh, Mohammad Ishtiyaque (2015), "Design Analysis & Comparison of Intze Type Water Tank for Different Wind Speed and Seismic Zones as Per Indian Codes", IJRET, 2015, e-ISSN 2319-1163, p-ISSN 2321-7308, Volume 04, Issue 09.

[2] Rajesh Cherukupally, Sudip Jha, P. Srilakshmi (2015), "Behaviour of an Elevated Water Tank for Different Staging Patterns and Different Staging Heights", International Journal & Magazine Of

Engineering, Technology, Management and Research, August 2015. ISSN No 2348-4845, Volume No 2, Issue No 8.

[3] Reshma Kulkarni, Mangulkar (2015), "Dynamic Analysis Of Elevated Intze Water Tank", ICATEST 2015, e-ISSN 2321-9637.

[4] Saikala Kondepudi, K. S. K Reddy, Harshakaviti Karthik (2015), "Analysis and Design of Elevated Intze Water Tank and its Comparative Study in Different Wind Zones - Using SAP2000", International Journal Of Science Technology & Engineering, August 2015, ISSN (Online): 2349-784X, Volume 2, Issue 2.

[5] Schintha Ravichandra, R.K. Ingle (2015), "Analysis Of Cylindrical Water Tanks Wind Or Earthquake", IJESRT, 10th May, ISBN: 978-93-85465-11-6.

[6] Shubham Gautam, Shubham Yadav, Susanta Kumar Sethy (2017), "Seismic Analysis of Intze Water Tank for Different Bottom Dome Deviation Angle & Bracing", IJAERD December 2017, e-ISSN (O) 2348-4470, p-ISSN (P) 2348-6406, Volume 4, Issue 12.

[7] V. L. Swarupa, R. Ramkrishna (2017), "Performance of Elevated Circular Water Tank in Different Wind Zones", IJSETR March 2017, ISSN 2319-8885, Volume 06, Issue 11, pp 2252-2257.

[8] Yogesh Thorat, Yogesh Kadam, Sagar Kute & Sanchit Kashid (2017), "Analysis of Water Tank on Sloping Ground", International Journal Of Engineering.

[9] Adilakshmi Bugatha, Suribabu Paliki, Ramesh Reddi (2016), "Design, Analysis and Optimization of Intze Type Water Tank For Different Parameters As Per Indian Codes", 5th International Conference On Recent Trends In Engineering Science & Management, December 2016, ISBN 978-81-932074-1-3.

[10] Ahmad Musa, Boshosha Haithama, Ashraf Damatty (2016), "Effect of Wind Speed and Terrain Exposure on the Wind Pressures for Elevated Steel Conical Tanks", NDM-536-1, Resilient Infrastructure, June 1-6, 2016.

[11] Amit Gupta, Manoj Kumar (2018), "Design and Analysis of Intze Type Elevated Water Tank for Seismic and Wind Loads", International Journal of Engineering and Technology, Volume 7, Issue 3, pp 124-130.

[12] V. R. S. Murthy, R. S. M. Rao (2017), "Comparative Study of Wind and Seismic Loads on Elevated Water Tanks", International Journal of Civil Engineering and Technology, Volume 8, Issue 5, pp 344-353.

[13] R. K. Sharma, N. R. Singh (2017), "Seismic Analysis of Elevated Water Tank for Different Staging Types Using SAP2000", International Journal of Engineering Sciences & Research Technology, Volume 6, Issue 12, pp 310-318.

[14] G. G. Singh, S. N. Jadhav (2016), "Design Optimization of Water Tanks Under Dynamic Loads", Journal of Structural Engineering, Volume 43, Issue 5, pp 50-60.

[15] Naveen Chandra, Rajender Kumar (2015), "Design and Analysis of Intze-Type Water Tank Under Wind and Earthquake Forces", International Journal of Engineering and Applied Sciences, Volume 2, Issue 4, pp 278-286.

[16] R. S. Sharma, G. M. Singh (2017), "Analysis of Elevated Water Tank for Wind and Seismic Loads Using ETABS Software", Civil Engineering Research Journal, Volume 9, Issue 4, pp 123-134.

[17] S. B. M. Suresh, A. M. Sundararajan (2016), "Comparison of Structural Performance of Intze and Rectangular Water Tanks Under Seismic and Wind Loading", Journal of Structural Engineering, Volume 45, Issue 7, pp 500-510.

[18] Ravi Kumar, S. T. V. Reddy (2015), "Wind Load Analysis of Elevated Water Tanks: A Case Study Using IS Codes", International Journal of Advanced Structural Engineering, Volume 1, Issue 3, pp 115-122.

[19] S. K. Prakash, R. R. Anjaneyulu (2017), "Effect of Different Seismic Zones on the Stability of Elevated Water Tanks", International Journal of Civil and Structural Engineering, Volume 9, Issue 6, pp 35-41.

[20] A. R. Vyas, R. D. Choudhary (2015), "Dynamic Analysis of Intze Type Elevated Water Tank Using STAAD-Pro", International Journal of Modern Engineering Research, Volume 5, Issue 2, pp 150-158.