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# A Review - Modal and Response Spectrum Analysis of Elevated Intze Tanks

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**ABSTRACT**

Elevated reinforced concrete (RCC) Intze water tanks are important components of water-supply infrastructure and are required to withstand various static and dynamic loading conditions. Due to the elevated location of the storage mass and the flexibility of the supporting staging system, these structures exhibit significant dynamic behaviour during earthquake excitation. Modal Analysis and Response Spectrum Analysis are therefore important methods for evaluating their seismic performance. This review focuses on the application of modal and response spectrum analysis to elevated Intze water tanks, with particular emphasis on the influence of water level, structural mass, stiffness, staging configuration and support conditions on seismic response. Modal analysis provides information regarding natural frequencies, fundamental time period and mode shapes, while response spectrum analysis facilitates the evaluation of seismic parameters such as base shear, lateral displacement, support reactions and member forces. The reviewed studies indicate that variations in water level and staging configuration can significantly modify the dynamic characteristics and seismic response of elevated water tanks. Studies also demonstrate the relevance of foundation and soil conditions in assessing the overall structural response. The review highlights the importance of considering different operating water levels and staging configurations for a comprehensive seismic assessment of elevated Intze tanks. The findings provide a basis for further parametric investigation and improved understanding of the dynamic behaviour of elevated RCC Intze water tanks.

**Keywords:** Elevated RCC Water Tank; Intze Tank; Modal Analysis; Response Spectrum Analysis; Seismic Behaviour; Water Level; Staging Configuration; Dynamic Analysis; Base Shear; Lateral Displacement.

## Introduction

Elevated reinforced concrete (RCC) water tanks are important components of water-supply infrastructure and are generally designed to remain functional under different environmental and seismic loading conditions. Due to their elevated configuration, a considerable portion of the structural mass is located at a significant height above the ground, resulting in dynamic characteristics that differ from those of conventional low-rise structures. Among the different elevated water-tank configurations, the Intze tank is widely considered an efficient form for water storage because its geometric arrangement of cylindrical walls, conical shells, domes and supporting members facilitates the transfer of storage and gravity loads to the staging system. However, the combination of elevated mass, flexible staging and stored water makes the seismic behaviour of Intze tanks an important area of structural investigation.

Modal analysis is one of the fundamental approaches used to evaluate the dynamic characteristics of an elevated Intze tank. It provides information regarding the natural frequencies, fundamental time period and mode shapes of the structural system. These parameters are essential for understanding the manner in which the tank responds to dynamic excitation. The natural period of an elevated tank is influenced by factors such as staging height, stiffness of supporting members, mass distribution, tank geometry, material properties and water level. Consequently, changes in the structural configuration or operating condition of the tank can modify its modal characteristics and subsequently affect its seismic response.

Response Spectrum Analysis (RSA) is an important dynamic analysis procedure used for estimating the maximum response of structures subjected to earthquake excitation. In this method, the modal properties of the structure are combined with the design response spectrum corresponding to the specified seismic and soil conditions. For elevated Intze tanks, response spectrum analysis can be used to evaluate important seismic response parameters such as base shear, lateral displacement, overturning effects, support reactions and member forces. The method is particularly useful for comparing the seismic response of the same tank under different water levels and staging configurations.

The presence of stored water introduces additional mass and influences the dynamic behaviour of the tank. Therefore, an elevated Intze tank may exhibit different modal characteristics and seismic responses under empty, partially filled and full conditions. The water level can affect the effective mass participating in vibration and consequently influence parameters such as natural time period, base shear and lateral displacement. Similarly, modifications in staging configuration, including changes in staging height, column arrangement and bracing, can alter the stiffness and mass distribution of the complete tank system.

Previous studies included in the present literature review have investigated the dynamic behaviour of elevated water tanks under different water-level conditions. For example, studies have considered full, half-full and empty tank conditions using modal and response-spectrum-based approaches, with parameters such as base shear, displacement, reactions and member forces being compared. Other investigations have examined seismic response under different foundation and soil conditions, highlighting the influence of structural and support conditions on the dynamic behaviour of elevated tanks.

Thus, modal analysis and response spectrum analysis provide a systematic basis for understanding and evaluating the seismic behaviour of elevated Intze water tanks. A review of these analytical approaches is particularly relevant for parametric investigations in which water level and staging configuration are varied. Such an assessment helps establish the relationship between structural configuration, dynamic characteristics and seismic response, providing useful information for the safe and efficient design of elevated RCC Intze water tanks.

## Literature

Elevated reinforced concrete water tanks are important lifeline structures because they provide water for domestic consumption, firefighting and emergency services. However, their structural configuration makes them particularly sensitive to earthquake loading because a large portion of the total mass is concentrated at an elevated level and is supported by relatively slender staging. The seismic response of such structures is governed not only by the structural properties of the tank and staging but also by the dynamic interaction between the stored liquid and the tank container.

## Literature Survey

Prakash Baral et al (2026) elevated reinforced concrete (RC) Intze tanks are an important component of water-supply infrastructure, particularly in areas where reliable storage and distribution of water are essential. Because these tanks are generally constructed at considerable heights above ground level, they are required not only to safely resist gravity loads but also to maintain structural stability and serviceability during seismic events. Observations from previous earthquakes have shown that elevated water tanks can be particularly vulnerable to earthquake-induced damage because of the flexibility of their staging systems, the considerable mass of the stored water, the dynamic interaction between the water and the supporting structure, and the irregular distribution of mass and stiffness throughout the tank–staging system. During an earthquake, the movement of the stored water generates hydrodynamic forces, including impulsive and convective components, which interact with the structural response and can significantly influence the overall seismic behaviour of the tank. The flexible staging system may further amplify lateral displacements and internal forces, while the elevated position of the large water mass increases the overturning effects and demands on the supporting columns, braces, and foundation system. Therefore, a reliable assessment of the nonlinear seismic behaviour of elevated Intze tanks is essential for understanding their performance under severe ground motions and for developing safe and economical design provisions. In this thesis, the seismic response of an elevated RC Intze water tank is investigated using Nonlinear Time History Analysis (NLTHA), which provides a detailed representation of the structural response by applying actual or appropriately selected earthquake ground-motion records as a function of time. A detailed three-dimensional finite element model of the tank is developed using SAP2000, incorporating the tank container, dome, conical shell, cylindrical wall, ring beams, staging columns, bracing members, and supporting structural components. Appropriate material properties, geometric characteristics, boundary conditions, mass distribution, gravity loads, hydrodynamic effects, and nonlinear material behaviour are considered in the analytical model. The nonlinear analysis is performed to evaluate important seismic response parameters such as lateral displacement, inter-storey drift, base shear, overturning moment, member forces, stresses, and plastic deformation demands in critical structural components. The influence of the flexible staging and stored-water mass on the dynamic response is also examined to identify critical locations and governing response mechanisms. The results obtained from the NLTHA are used to assess the overall seismic performance of the elevated Intze tank and to identify potential structural vulnerabilities, thereby providing a basis for improving the seismic design, detailing, safety, durability, and post-earthquake functionality of elevated reinforced concrete water tanks.

Navnath V. Kadam et al (2025) water tanks are essential components of municipal water-supply infrastructure because they provide storage capacity and maintain a reliable supply of water during variations in demand; however, when these tanks are constructed in elevated form, their considerable height, concentrated mass, and flexible supporting systems make them particularly sensitive to dynamic and seismic actions. This study investigates the dynamic behaviour of an elevated water tank using STAAD.Pro under three different operating conditions, namely full tank, half-full tank, and empty tank, in order to understand how the quantity of stored water influences the structural response. The water stored inside the tank contributes significantly to the total seismic mass of the structure, and therefore changes in the water level can alter the natural frequencies, mode shapes, base shear, lateral displacement, and overall seismic demand. When the tank is full, the increased mass generally leads to greater seismic inertia forces and can modify the vibration characteristics of the tank–staging system, whereas the half-full and empty conditions provide different mass distributions and consequently different dynamic responses. A comparative study is also carried out between circular and rectangular tank configurations to examine the influence of tank geometry on structural stiffness, load distribution, vibration characteristics, and seismic response. The circular tank generally provides a more continuous and uniform distribution of forces around its perimeter, while the rectangular configuration develops different stiffness characteristics and load paths because of its straight walls and corners. In addition to tank shape, the effects of varying the wall thickness and shaft or staging thickness are investigated

to determine how changes in structural stiffness and self-weight influence the dynamic behaviour of the system. Increasing member thickness generally increases stiffness and mass simultaneously, and the resulting change in natural frequency depends on the relative increase in stiffness and mass. Modal analysis is performed in STAAD.Pro to determine the natural frequencies and corresponding mode shapes of the tank for each considered configuration and water-storage condition. The natural frequencies provide an indication of the dynamic characteristics of the structure, while the mode shapes illustrate the manner in which the tank and its supporting system deform and participate in vibration during an earthquake. Particular attention is given to the fundamental modes because they generally represent significant portions of the structural response under seismic excitation. Subsequently, response spectrum analysis is carried out to evaluate the seismic response of the different tank configurations using the appropriate design response spectrum and structural parameters. The resulting seismic parameters, including base shear, lateral displacement, support reactions, member forces, and modal participation, are compared for the full, half-full, and empty tank conditions as well as for circular and rectangular tank geometries. The study therefore establishes the relationship between water level, tank geometry, structural thickness, natural frequency, mode shape, and seismic demand. The comparison of results helps identify how changes in mass and stiffness affect the dynamic characteristics and seismic performance of elevated water tanks and provides useful information for selecting appropriate structural configurations and member dimensions for safe and efficient seismic design. The results obtained from the modal and response spectrum analyses can further be used to identify critical structural components, understand governing vibration modes, and develop suitable design and detailing provisions for elevated water tanks subjected to earthquake loading.

Sangeetha et al (2024) elevated water tanks have an irregular mass distribution, making them vulnerable to amplified seismic forces during earthquakes, which can lead to structural damage or failure. To mitigate these risks and ensure reliable water distribution, proper reinforcement and seismic design are essential. The seismic performance of elevated water tanks is critical for public safety and water supply resilience, especially in earthquake-prone regions. Due to their height and mass distribution, elevated tanks are subjected to significant lateral loads. Neglecting Soil-Structure Interaction (SSI) in seismic analysis can result in inaccurate assessments of structural behavior. This study examines the seismic response of elevated water tanks on both level and sloping ground, considering fixed and flexible bases using the Response Spectrum Method (RSM) in accordance with IS 1893 (Part 1): 2016 for seismic zones II and III. Finite Element Analysis (FEA) software SAP2000 v22 is used to evaluate SSI effects. Three soil types—soft, medium, and hard—are analyzed, considering both full and empty tank conditions.

The numerical analysis reveals variations in structural response under seismic loading, with different slope angles highlighting vulnerabilities associated with sloping ground. Results emphasize the importance of incorporating SSI effects in seismic analysis to achieve realistic assessments of water tank performance. Including SSI captures the dynamic interaction between the tank and the underlying soil, offering a more comprehensive understanding of structural behavior during seismic events. This study underscores the necessity of considering SSI in the design and evaluation of elevated water tanks, particularly in earthquake-prone regions. By accounting for SSI, engineers can enhance the seismic resilience of water supply infrastructure and better mitigate risks.

Md.Sohel Ahmed et al (2024) was examine Elevated reinforced cement concrete (RCC) water tanks are crucial structures for water storage and distribution in residential, commercial, and industrial sectors. The design of these tanks requires careful consideration of structural stability, durability, and serviceability under varying loads, including self-weight, water load, wind, and seismic forces. This study focuses on the analysis and design of an elevated RCC rectangular water tank using ETABS, a leading software tool for structural analysis and design. The research incorporates a detailed review of design parameters, such as material properties, geometric configurations, and relevant codes of practice, including IS 3370 for liquid retaining structures and IS 1893 for seismic analysis. The structural model of the elevated tank, including its staging system, is developed in ETABS, which provides a comprehensive simulation of the tank's behavior under static and dynamic loading conditions. Key aspects such as bending moments, shear forces, and displacement patterns are analyzed to ensure safety and stability. The study demonstrates the effectiveness of ETABS in optimizing the design, reducing material consumption, and enhancing structural performance. The outcomes include recommendations for the efficient design of RCC water tanks with improved resistance to seismic and wind-induced stresses. The methodology and results are particularly valuable for structural engineers and designers involved in the planning and execution of water supply infrastructure projects.

Aayush Mehta et al (2023) was study elevated water tanks play a critical role in water distribution systems, ensuring a reliable water supply to communities. However, their structural integrity during seismic events is crucial for public safety. To address this concern, various design codes and guidelines have been developed worldwide, aiming to provide seismic design considerations for elevated water tanks. This paper presents a comprehensive review that compares and evaluates the seismic analysis methods employed in the design of these tanks, as prescribed by different codes such as IS, ACI, EN, and NZS. The primary objective of this review is to analyze and compare the seismic analysis approaches outlined in various design codes. By examining these approaches, the strengths and limitations of each methodology can be identified. This evaluation is essential for understanding the effectiveness and applicability of different design codes in ensuring the seismic resilience of elevated water tanks. The review also highlights potential areas for improvement in seismic analysis methodologies. By identifying limitations and areas that require further research, the study contributes to the continuous refinement and development of seismic design guidelines for elevated water tanks. Engineers and researchers can utilize these findings to enhance the design optimization and seismic behavior understanding of these critical structures.

Mr. Meet Dama et al (2023) working on the structural analysis of a circular water tank on sloping ground, considering wind and seismic loads as per IS 1893:2016 and IS 875:2015 (Part 3) using STAAD. Pro V8i. This is an important study for ensuring the safety and stability of elevated storage tanks under extreme loading conditions. How the sloping is ground affecting the base support of the tank. Are you considering soil-structure interaction. Are you considering dynamic wind response or only static wind pressure for different wind speeds (39 m/s and 44 m/s). Since you're analyzing for Zone V, are you including hydrodynamic effects (sloshing forces) in your seismic calculations storage tanks play a crucial role in various industries, and their design must consider multiple factors, including structural integrity, seismic resilience, wind loads, and blast resistance, especially for large storage tanks.

Some key points related to the design of storage tanks include. Tall storage tanks need to resist wind-induced overturning moments and lateral forces.

Abhinav Kumar Anand et al (2023) the design and analysis of elevated water tanks are crucial for ensuring their structural integrity and performance. This study presents an investigation into the design and analysis of an elevated water tank using STAAD Pro, a widely-used structural analysis and design software. The objective is to assess the structural behavior and performance of the water tank under various loading conditions and optimize its design for safety and efficiency. The analysis starts with the selection of suitable materials and dimensions for the water tank, considering factors such as capacity, site conditions, and design standards. The structural model of the tank is then developed in STAAD Pro, incorporating appropriate boundary conditions and loading scenarios, including dead loads, live loads, wind loads, and seismic loads. The software allows for accurate modeling of the tank's components, such as the tank shell, columns, base slab, and support structure. The study evaluates the structural response of the water tank through various analyses, including static analysis, dynamic analysis, and stability analysis. STAAD Pro provides advanced analysis capabilities to assess the effects of different load combinations, determine the critical locations, and identify potential failure modes. The analysis results guide the design modifications and reinforcements required to enhance the tank's overall stability, strength, and durability. The study also considers important design considerations, such as water pressure, temperature variations, and corrosion protection measures. By incorporating these factors, the final design aims to ensure the safety and functionality of the elevated water tank while minimizing maintenance requirements and lifecycle costs. Through this research, the design and analysis process using STAAD Pro for elevated water tanks can be further understood and improved. The findings contribute to the development of optimized design guidelines and construction practices for elevated water tanks, which are essential for reliable water storage and distribution systems.

Anand Khune et al (2023) water is a basic human necessity, and an efficient water distribution system is essential to ensure a continuous and reliable supply. The design of water storage tanks plays a critical role in meeting the water demands of a specific area. Water storage tanks are essential structures used to store water for domestic, industrial, and firefighting purposes. They ensure that water is available when needed, helping to regulate the supply during peak and off-peak demand periods. During periods of low demand, water is pumped into the storage tank to be stored for later use. Conversely, during periods of high demand, water is pushed out of the storage tank into the distribution system, ensuring a consistent supply. These storage tanks help to maintain pressure stability, reduce energy costs, and ensure availability in case of emergencies. Water storage tanks are designed in various forms based on their application, location, and required storage capacity. Water storage tanks must be designed to withstand hydrostatic pressure, seismic forces, wind loads, and soil pressure (for underground tanks). Various materials such as reinforced concrete, steel, and fiber-reinforced plastics are used depending on the project requirements. STAAD. Pro (Structural Analysis and Design Program) is a widely used software for analyzing and designing various structural systems, including water storage tanks. It helps structural engineers perform 3D structural analysis and design for steel and concrete structures efficiently.

Katari Yogeshwar et al (2022) every structural design originates from a specific problem that needs to be addressed, and the primary purpose of engineering design is to develop a safe, economical, and efficient solution to an existing need. In many regions where water availability and distribution are inadequate, people face serious difficulties in obtaining sufficient water, particularly in multi-storied buildings where the pressure, flow rate, and discharge may not be adequate to supply the upper floors. This inadequate water supply can affect essential daily activities and create considerable inconvenience for the occupants. One effective solution to overcome this problem is to provide a properly designed water storage system capable of collecting and storing water and supplying it when required. An Overhead Water Reservoir (OHR) is one such system, in which water is stored at an elevated level so that gravitational head can provide the required pressure and facilitate distribution to different parts of a building or surrounding area. The present study focuses on the analysis and structural design of an elevated circular water tank using STAAD.Pro V8i, a widely used structural analysis and design software. The study includes the preliminary determination of the tank dimensions, estimation of water storage capacity, calculation of various loads, and manual evaluation of the structural components before developing the structural model in STAAD.Pro V8i. The elevated water tank consists of the container, supporting staging, columns, beams, bracing members, and foundation system, all of which must be designed to safely resist the applied loads and transfer them effectively to the ground. The major loads considered in the analysis include the self-weight of the structural members, dead load of the tank and associated components, hydrostatic pressure exerted by the stored water, and wind load acting on the elevated structure and tank. Hydrostatic pressure is particularly important because it increases with the depth of water and produces forces on the tank walls and base, while wind loads can create significant lateral forces and overturning effects due to the considerable height of the structure. After calculating the relevant loads manually, the complete structural system is modeled and analyzed using STAAD.Pro V8i to determine critical structural responses such as bending moments, shear forces, axial forces, reactions, and displacements. The design is carried out using the Limit State Design method, in accordance with the relevant structural design provisions and safety requirements, so that the structure remains safe and serviceable under the expected loading conditions. The analysis results obtained from STAAD.Pro are then used to design and verify the individual structural members, ensuring that the elevated circular water tank has adequate strength, stability, durability, and serviceability. Thus, the study demonstrates how the principles of structural engineering, manual load calculations, and computer-aided analysis can be combined to develop a reliable Overhead Water Reservoir capable of addressing inadequate water supply and meeting the daily water requirements of users in areas where sufficient water pressure and distribution are otherwise difficult to achieve..

Deepshikha Gadekar et al (2022) water tanks and reservoirs are essential structures used for storing water, petroleum, and chemicals for domestic, commercial, and industrial purposes. An underground water tank is designed to store water while maintaining a stable temperature and providing an efficient system for pumping water to an overhead tank. In this project, a rectangular underground water tank with a capacity of 2 lakh liters (200 cubic meters) is designed following IS code norms. The design incorporates structural stability against lateral earth pressure and hydrostatic water pressure. The analysis and design are performed using STAAD. Pro, and the Limit State Method (LSM) is applied for structural safety. The design of an underground water tank involves the analysis of various forces, materials, and load conditions as per IS 3370:2009 and IS 456:2000.

M. Ravikanth et al. (2019) highlights the importance of seismic considerations in the design of hydraulic water tanks using STAAD-Pro. Their approach focused on optimizing the tank's structural design while ensuring economic feasibility. The key findings include. The influence of seismic loads in different seismic zones (II, III, IV, and V) on the design parameters of circular water tanks. The variation in steel and concrete requirements across seismic zones. The conclusion that designing a water tank in Zone V (the highest seismic risk zone) is significantly more expensive due to increased reinforcement and structural requirements. This research provides valuable insights for engineers involved in the structural design of water tanks, particularly in seismic-prone regions. Would you like a more detailed breakdown of the methodology or any specific insights.

Issar Kapadia et al. (2018) introduced an innovative concept by designing and analyzing a combined rectangular water tank, where an overhead rectangular water tank is integrated with a rectangular surface water tank into a single structure. The study was carried out using STAAD-Pro software, a widely used structural analysis and design tool. Instead of constructing two separate water tanks (one overhead and one ground-level), they designed a single combined structure that consists of the research used Finite Element Analysis (FEA) within STAAD-Pro to assess structural behavior under different load conditions. Successfully demonstrated that combining an overhead rectangular water tank with a surface rectangular tank into a single structural system results in lower hydrostatic pressures, reduced deflections, and improved performance compared to conventional separate tank designs. The use of STAAD-Pro for analysis validated the feasibility and efficiency of the combined design.This research provides valuable insights for engineers and designers looking for innovative and efficient water storage solutions in urban and rural infrastructure projects.

Mareddy Arunkumar et al (2018) in this study focuses on the structural design, analysis, and safety assessment of a 15-lakh-litre (1.5 million litres) overhead circular water tank supported at an elevation of approximately 15 m, with particular emphasis on achieving adequate strength, serviceability, durability, and resistance to cracking. The primary objective of designing such a large-capacity elevated water tank is to provide reliable water storage and sufficient hydraulic head so that water can be distributed effectively to consumers, including buildings and areas where inadequate pressure or insufficient flow may otherwise occur. Since the tank is elevated, its structural system must safely transfer the considerable weight of the stored water, tank components, and supporting structure to the foundation while also resisting environmental forces such as wind and earthquake effects. STAAD.Pro can be used to develop a three-dimensional structural model of the supporting system and to perform analysis under different load combinations, including self-weight, water load, imposed or maintenance loads, wind load, and seismic load as applicable to the site. The tank itself generally consists of major components such as the roof slab, cylindrical wall or shell, bottom slab, ring beams, supporting columns or staging, braces, and foundation, and each component must be designed according to the forces and stresses obtained from structural analysis. In a circular tank, the stored water produces hydrostatic pressure that increases with depth, generating significant circumferential or hoop tension in the cylindrical wall; therefore, adequate horizontal reinforcement is essential to control tensile stresses and prevent leakage and cracking, while vertical reinforcement is provided to resist vertical bending, temperature effects, shrinkage, and other structural actions. The bottom slab must safely resist the upward and downward forces associated with water pressure, self-weight, and support reactions, while the roof must withstand its own weight, maintenance loads, environmental loads, and any applicable lateral effects. For the elevated staging, the columns and bracing system must be designed to resist both gravity loads and lateral forces, particularly because the 15 m elevation increases the overturning effects produced by wind and seismic actions. A major concern in reinforced-concrete water tanks is crack control, because even relatively small cracks can permit water leakage, accelerate reinforcement corrosion, and reduce the durability of the structure; therefore, the design should consider appropriate concrete strength and quality, adequate reinforcement detailing, limiting tensile stresses and crack widths, proper bar spacing and cover, suitable construction joints and water-retaining detailing, and proper placing, compaction, and curing of concrete. STAAD.Pro assists in determining critical member forces, reactions, displacements, and stress conditions, which can then be used for the detailed design and reinforcement calculation of individual structural elements. However, software analysis alone does not guarantee a crack-free or safe tank; the final design must also consider the applicable IS codes and water-retaining-structure requirements, site-specific soil conditions, groundwater conditions, seismic zone, wind parameters, material properties, construction methodology, and appropriate serviceability checks. Thus, the overall approach presented in the paper can be understood as an integrated process in which the 15-lakh-litre storage requirement and 15 m elevation establish the basic geometry and loading requirements, STAAD.Pro provides the structural analysis framework, reinforced-concrete design provides the required strength, and careful crack-control and durability provisions ensure that the completed overhead circular water tank remains safe, watertight, stable, and functional throughout its intended service life.

Mr. Suraj P. Shinde et al (2018) was study Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential. The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio. Where space is limited, underground tanks can be placed under driveways or lawns. Underground tanks are protected from fires and other natural disasters such as hurricanes. In an agricultural or wildlife situation, underground tanks are protected from animal that may rub against or otherwise damage above ground tanks. Manual Analysis and design of Underground Water tank by using IS code method is compare with STAAD-PRO and SAP software design result, comparison of reinforcement is done and optimize results are determined. This report gives in brief, the theory behind the design of liquid retaining structure (Rectangular water tank) using working stress method. This water tank of 1,00,000-10,00,000 liters capacity is designed in computer added analysis.

Shreya Salunke et al. (2017) conducted a study titled "Analysis of Solid and Hollow Wall of Circular Steel Petroleum Tank for Stress in STAAD-Pro." This research aimed to analyze a storage tank with a capacity of 1.5 lakh liters of hazardous petroleum liquid. The study adhered to relevant standards and design codes, selecting materials in compliance with the latest IS codes and adopting an appropriate design methodology. The storage tank's design specifications were outlined, considering two types of tanks—hollow and solid—with identical thicknesses. The tank design followed IS codes, with a nominal diameter of 12m and a height of 14.1m, without any space constraints. The number of courses was specified, with the bottom plate thickness set

at 8mm, and carbon steel (IS 2062:1969) chosen as the material. The study found that the maximum absolute stress in the solid tank was lower than in the hollow section. As theory suggests, with an increase in deformation, the hollow tank exhibited greater deformation compared to the solid tank.

## Conclusion

Modal and Response Spectrum Analysis are important analytical approaches for evaluating the dynamic and seismic behaviour of elevated RCC Intze water tanks. Modal analysis provides essential information regarding the natural time period, frequencies and mode shapes of the tank–staging system, which are strongly influenced by the mass and stiffness distribution of the structure. Response Spectrum Analysis subsequently enables the estimation of important seismic response parameters such as base shear, lateral displacement, support reactions, overturning effects and member forces.

The reviewed studies indicate that the seismic response of elevated water tanks is significantly affected by the operating water level. Empty, partially filled and fully filled conditions can produce different dynamic characteristics because the stored water contributes to the effective mass of the system. Similarly, changes in staging height, column arrangement and bracing configuration can modify the stiffness and dynamic response of the tank. Studies considering different soil and foundation conditions also demonstrate that the support conditions can influence the seismic response of elevated water-tank systems.

Therefore, evaluation of an elevated Intze tank under a single structural and water condition may not fully represent its range of possible seismic responses. A parametric investigation considering different water levels and staging configurations can provide a systematic understanding of the variation in modal properties and seismic response parameters. Such an approach can assist in identifying the influence of structural configuration and operating condition on the overall behaviour of a 150 KL elevated RCC Intze water tank and can provide a useful basis for seismic assessment and structural design.

**References**

1. Prakash Baral “Seismic Performance Evaluation of Reinforced Concrete Elevated Intze Tank Using Non Linear Time History Analysis” Madhesh Journal of Interdisciplinary Research Volume 01 Issue 01, 2026. pp. 45–63 Research Article

2. Navnath V. Kadam “Dynamic Analysis and Seismic Behaviour of Elevated Water Tank Structures” International Journal on Science and Technology (IJSAT) E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org IJSAT25024558 Volume 16, Issue 2, April-June 2025

3. Sangeetha1, Jayadeep K S2, L. Govindaraju “seismic analysis and design of elevated water tank with comprehensive soil-structure interaction assessment” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 11 Issue: 03 | Mar 2024 www.irjet.net p-ISSN: 2395-0072

4. Md.Sohel Ahmeda , Bhukya Joshib , Bharath Kumar Mudavathc , Akhil.B “Design and Simulation of Elevated RCC Water Tanks with ETABS” |www.ijirset.com |A Monthly, Peer Reviewed & Referred Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710| Volume 13, Issue 11, November 2024 |DOI: 10.15680/IJIRSET.2024.1311158|

5. Aayush Mehta [1], Vimlesh V. Agrawal [2], Vishal A. Arekar “Codal Comparison of Seismic Analysis for Elevated Water Tank Using Different Codes: A Comprehensive Review” International Advanced Research Journal in Science, Engineering and Technology ISO 3297:2007 Certified | Impact Factor 8.066 | Peer-reviewed / Refereed journal | Vol. 10, Issue 4, April 2023 DOI: 10.17148/IARJSET.2023.10464

6. Mr. Meet Dama, Prof. Ayyazoddin Shaikh “Effects of Sloping Ground on Analysis of Cicular Water Tank” International Journal of Research in Engineering and Science (IJRES) ISSN (Online): 2320-9364, ISSN (Print): 2320-9356 www.ijres.org Volume 11 Issue 10 ǁ October 2023 ǁ PP. 156-162

7. Abhinav Kumar Anand*1, Abhinav Sharma*2, Divya Gupta*3, Shakir Hasan*4, Shariq Shameem*5, Mr. Ankit Soni* “appendix 2 design and analysis of rcc water tank by using stadd pro” International Research Journal of Modernization in Engineering Technology and Science ( Peer-Reviewed, Open Access, Fully Refereed International Journal ) Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

8. Anand Khune1 , Krishna Natikar2 , Mohit Bhujbal3 , Satish Wabale4 , Prof. Swapnil Bijwe “Design of RCC Well Using StaadPro Software” International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 11 Issue II Feb 2023- Available at www.ijraset.com

9. Deepshikha Gadekar1 , Rakesh Patel “Design and Analysis of Under Ground Water Tank Considering Different Fill Conditions Using STAAD.PRO” International Journal of Scientific Research in Civil Engineering © 2022 | IJSRCE | Volume 6 | Issue 1 | ISSN : 2456-6667

10. Katari yogeshwar1 , Tsurendra “Analysis and design the circular water tank using staad pro” International Journal of Advance Research in Civil Engineering Volume 12, Issue 09, Sept 2022 ISSN 2581 – 4575 Page 51