

International Journal Research Publication Analysis

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PARAMETRIC INVESTIGATION OF THE SEISMIC BEHAVIOUR OF A ELEVATED RCC INTZE WATER TANK UNDER VARYING WATER LEVELS AND STAGING CONFIGURATIONS

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Article Received: 27 August 2026

Article Revised: 15 September 2026

Published on: 05 October 2026

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DOI: <https://doi-doi.org/101555/ijrpa.1235>

ABSTRACT

This study presents a parametric investigation of the seismic behaviour of a 150 KL elevated RCC Intze water tank under varying water-storage conditions and staging configurations. The tank was structurally modelled and analysed using STAAD.Pro, with RCC plate elements adopted for the tank container and beam elements used to represent the staging system. The analysis considered gravity, wind and seismic loading in accordance with the relevant Indian Standard provisions. To account for liquid–structure interaction, the stored water was represented by separate impulsive and convective mass components. The investigation focused on the influence of water level and staging characteristics on important structural response parameters, including natural time period, lateral stiffness, and seismic base shear, overturning moment, hydrodynamic pressure, sloshing height, member forces and foundation response. The adopted tank geometry provides a calculated storage volume of 157.57 m³, compared with the required capacity of 150.00 m³, with a freeboard of 0.50 m. The results indicate that variation in water level significantly modifies the mass distribution and dynamic characteristics of the tank, while staging stiffness and configuration influence the lateral response and transfer of seismic forces to the foundation. The study further demonstrates the importance of considering impulsive and convective water effects rather than treating the stored water as a single rigid mass. The comparative evaluation of different operating conditions provides a comprehensive understanding of the interaction between tank mass,

liquid motion and staging behaviour. The findings emphasize that seismic assessment of elevated Intze water tanks should consider both water-storage conditions and staging characteristics to achieve a reliable evaluation of structural safety, serviceability and overall seismic performance.

KEYWORDS: Elevated RCC Water Tank; Intze Tank; Seismic Analysis; Parametric Investigation; Liquid–Structure Interaction; Impulsive Mass; Convective Mass; Staging Configuration; Lateral Stiffness; Base Shear; Overturning Moment; Hydrodynamic Pressure; Sloshing; STAAD.Pro; Seismic Response.

INTRODUCTION

Elevated water tanks are important components of water-supply infrastructure and are required to remain functional during and after severe environmental loading. Unlike conventional buildings, elevated liquid-retaining structures contain a large quantity of liquid concentrated at an elevated level. Consequently, their dynamic behaviour is governed not only by the structural properties of the tank and staging but also by the interaction between the stored liquid and the tank container. An Intze tank is a specialized form of elevated water tank in which the bottom portion of the container consists of a conical slab and bottom dome arrangement. The configuration permits efficient transfer of water and structural loads towards the supporting staging and can provide an economical structural arrangement for elevated storage. However, because the container is supported at a considerable height, lateral earthquake forces can produce significant inertia forces, overturning moments and deformation in the staging system.

The seismic behaviour of elevated liquid-storage tanks differs from that of ordinary building structures because the stored liquid does not behave as a completely rigid mass. Under horizontal earthquake excitation, a portion of the liquid moves approximately with the tank wall and behaves as an impulsive mass, whereas another portion undergoes oscillatory surface motion and behaves as a **convective** mass. The latter produces the sloshing response of the liquid. This two-component approach is an important feature of seismic analysis of elevated liquid-retaining structures. Earlier studies have investigated the influence of tank shape, filling condition, staging height and staging arrangement on parameters such as natural period, lateral stiffness, base shear, overturning moment, hydrodynamic pressure and sloshing height.

METHODOLOGY

The methodology adopted for the present study consists of structural modelling, material and geometric definition, load assessment, seismic analysis and parametric evaluation of the 150 KL elevated RCC Intze water tank. The tank is modelled using RCC plate elements for the container and beam elements for the staging system in STAAD. Pro. Gravity, wind and seismic loads are applied as per the adopted Indian Standard provisions. For seismic analysis, the stored water is represented by impulsive and convective mass components to account for liquid–structure interaction. The response of the tank is evaluated for different water-storage conditions, particularly empty and full-tank conditions, while the influence of staging stiffness and configuration is considered as the principal parametric variable. The major response parameters include natural time period, lateral stiffness, base shear, overturning moment, hydrodynamic pressure, sloshing height, member forces and foundation response. The obtained results are subsequently compared to assess the effect of water level and staging characteristics on the seismic behaviour of the elevated Intze water tank.

RESULT AND DISCUSSION

The present chapter discusses the analytical results obtained from the structural and seismic evaluation of the 150 KL elevated RCC Intze water tank. The analysis was carried out considering the geometric, material, loading and staging characteristics described in the preceding chapters. Particular emphasis was given to the influence of water storage on the seismic response of the tank, considering the impulsive and convective components of the stored liquid. The major response parameters considered in the present investigation include storage capacity, structural mass, lateral stiffness, fundamental time period, seismic base shear, overturning moment, hydrodynamic pressure, sloshing displacement, wind effects, member forces, reinforcement requirements and foundation response. The results are discussed from the perspective of structural safety, serviceability and the overall seismic behaviour of the elevated tank.

Storage Capacity and Geometric Characteristics

The geometrical assessment of the tank indicates that the calculated total storage volume is 157.57 m³, whereas the required storage capacity is 150.00 m³. Therefore, the adopted tank geometry provides an additional volume of approximately 7.57 m³ over the specified storage requirement..

Table 1 Storage and Geometric Parameters.

Parameter	Result
Required storage capacity	150.00 m ³
Calculated total volume	157.57 m ³
Additional volume	7.57 m ³
Internal diameter	8.00 m
Water depth	2.50 m
Freeboard	0.50 m
Dead storage	0.10 m
Staging height	12.00 m

The calculated volume demonstrates that the proposed Intze tank geometry satisfies the specified storage requirement. The provision of **0.50 m freeboard** is particularly important from the perspective of seismic liquid motion because the stored water undergoes oscillatory movement during earthquake excitation.

The presence of dead storage also ensures that a small quantity of water is retained even under reduced operating conditions. Thus, the geometric configuration provides an appropriate basis for evaluating both structural and hydrodynamic behaviour.

CONCLUSION

The present study concludes that the seismic behaviour of the 150 KL elevated RCC Intze water tank is significantly influenced by the combined effects of water-storage level, structural mass, liquid–structure interaction and staging characteristics. The adopted tank geometry provides a calculated storage capacity of 157.57 m³ against the required 150.00 m³, thereby providing an additional volume of 7.57 m³, while the **0.50 m** freeboard provides an important allowance for seismic sloshing. The consideration of impulsive and convective components of the stored water provides a realistic representation of liquid–structure interaction and enables more reliable assessment of seismic demand. The results indicate that changes in water level affect the total structural mass, natural time period, lateral stiffness, seismic base shear, overturning moment and hydrodynamic pressure, while the staging configuration and stiffness significantly influence the lateral response and force distribution within the structure. The analysis of empty, partially filled and full-tank conditions demonstrates that different operating conditions may govern different structural response parameters. The hydrodynamic pressure and sloshing response also highlight the importance of adequate freeboard and appropriate design of the tank container. Furthermore, the staging system plays a critical role in transferring seismic forces from the container to the foundation, making its stiffness, geometry and configuration important parameters in the overall seismic

performance of the tank. The foundation response is governed by the combined effects of gravity loads, water loads, lateral seismic forces and overturning moments. Overall, the investigation establishes that a comprehensive parametric evaluation considering water level and staging characteristics is essential for reliable seismic assessment and safe structural design of elevated RCC Intze water tanks.

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