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Design and Performance Evaluation of an RCC Overhead Water Tank at G+10 Levels

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ABSTRACT

Reinforced Cement Concrete (RCC) overhead water tanks are critical components of urban water supply systems, requiring safe and economical structural designs to withstand operational and environmental loads. This study presents the design and performance evaluation of a circular RCC overhead water tank located at the G+10 level using ETABS software. The structural analysis considers two operating conditions: a fully filled tank and an empty tank, to evaluate the variation in bending moment, shear force, and overall structural behavior under static loading. The design is carried out in accordance with standard RCC design principles, emphasizing structural strength, serviceability, and crack resistance to ensure water tightness and durability. Concrete of grade M20 or higher and appropriate reinforcement detailing are adopted to satisfy design requirements and minimize the risk of leakage. The results indicate that the full-tank condition generates higher structural forces than the empty-tank condition, making it the governing load case for design. The study demonstrates that proper structural analysis, reinforcement detailing, and compliance with design standards significantly enhance the safety, stability, and long-term performance of elevated RCC water tanks, providing a reliable framework for practical water storage infrastructure.

Keywords — RCC, Concrete, Water Tank, G+10, Structural, ETABS.

1. INTRODUCTION

Water is one of the most essential natural resources for human life, agriculture, industry, and sustainable urban development. The rapid growth of population, urbanization, and industrialization has significantly increased the demand for reliable water supply systems. An efficient water distribution network requires adequate storage facilities to ensure continuous water availability during peak demand, emergencies, and maintenance periods. Among various storage structures, Reinforced Cement Concrete (RCC) overhead water tanks are widely used because of their durability, structural strength, cost-effectiveness, and long service life. These tanks provide the necessary hydraulic head for gravity-based water distribution, thereby reducing pumping costs and ensuring uninterrupted water supply.

The structural design of RCC overhead water tanks is a complex engineering task because the structure must safely resist multiple loading conditions, including self-weight, hydrostatic pressure, wind load, seismic forces, and service loads. Unlike ordinary buildings, elevated water tanks are subjected to continuously varying internal water pressure depending on the water level, making their structural behavior more critical. Improper design or inadequate reinforcement may result in excessive deflection, cracking, leakage, and structural failure, affecting both safety and serviceability. Therefore, careful structural analysis and design are essential to ensure the reliability and durability of these critical infrastructures.

Advancements in structural analysis software have considerably improved the design process of RCC water tanks. Modern software packages such as ETABS enable engineers to develop accurate three-dimensional structural models, evaluate internal forces, and optimize reinforcement requirements under different loading conditions. The software provides efficient analysis of bending moments, shear forces, axial forces, and displacement while complying with national and international design standards. These computational tools reduce manual calculations, improve design accuracy, and facilitate economical structural solutions.

The structural performance of an elevated water tank varies significantly under different operating conditions. When the tank is completely filled, hydrostatic pressure produces maximum bending moments and shear forces on the container and supporting structure. Conversely, the empty-tank condition primarily represents the dead load of the structure and may govern stability under lateral loads such as wind and earthquakes. Therefore, evaluating both full and empty tank conditions is necessary for identifying the critical design case and ensuring structural safety throughout the service life of the tank.

Several researchers have investigated the analysis and design of RCC overhead water tanks using conventional analytical methods, finite element analysis, and commercial structural software. Previous studies have focused on optimizing reinforcement, evaluating seismic behavior, improving crack resistance, and comparing different tank geometries. However, the structural response of elevated circular water tanks at high-rise levels requires further investigation to achieve economical and safe designs while satisfying serviceability requirements.

This research presents the design and performance evaluation of a circular RCC overhead water tank at the G+10 level using ETABS software. The study investigates the structural behavior of the tank under full and empty loading conditions through static structural analysis. The performance is evaluated by comparing bending moments and shear forces developed in the supporting structure and tank components. The design emphasizes adequate structural strength, crack resistance, and water tightness in accordance with standard RCC design provisions. The findings provide useful insights for the safe, economical, and efficient design of elevated RCC water tanks used in modern water supply systems.

2. MODEL GEOMETRY

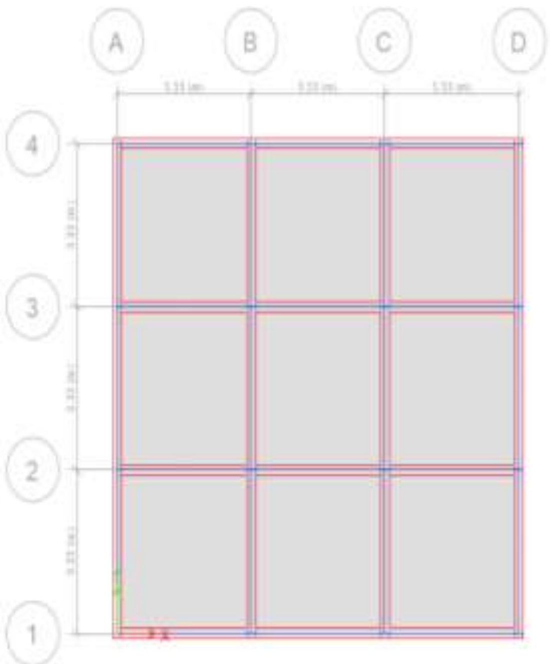

Fig. 1: Plan View of Filled Elevated Composited Water tank

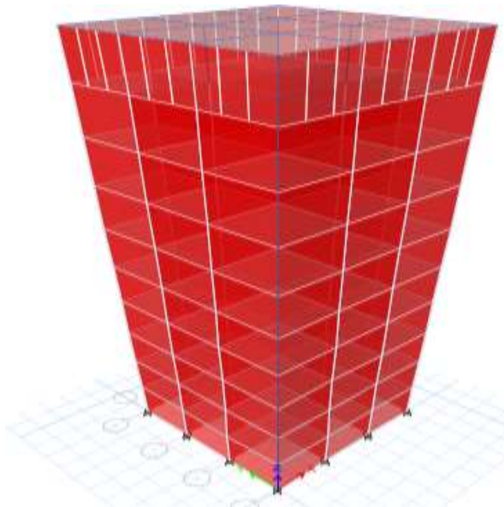

Fig. 2: 3D View ofDeformed Shape of Filled Elevated Composited Water tank

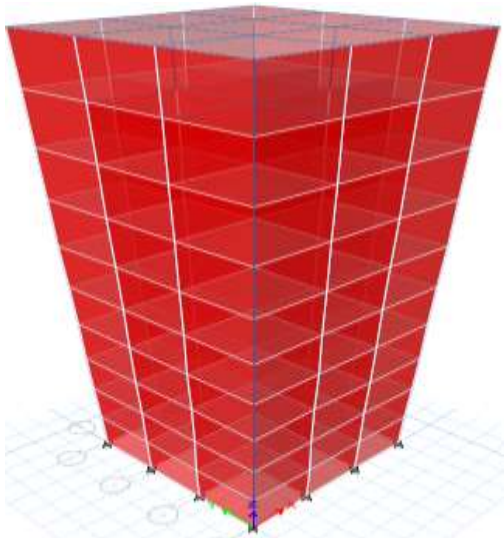

Fig. 3: 3D View of Empty Elevated Composited Water tank

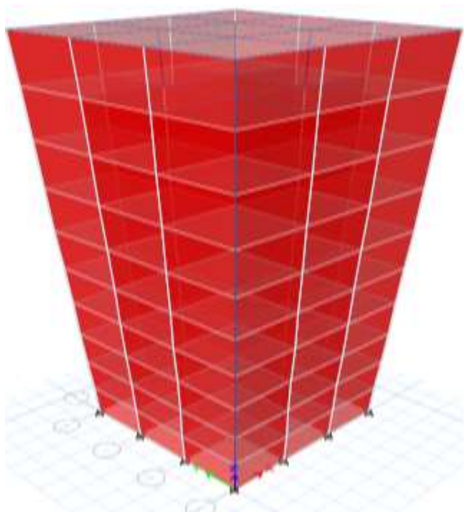

Fig. 4: 3D View of Empty Elevated Water tank

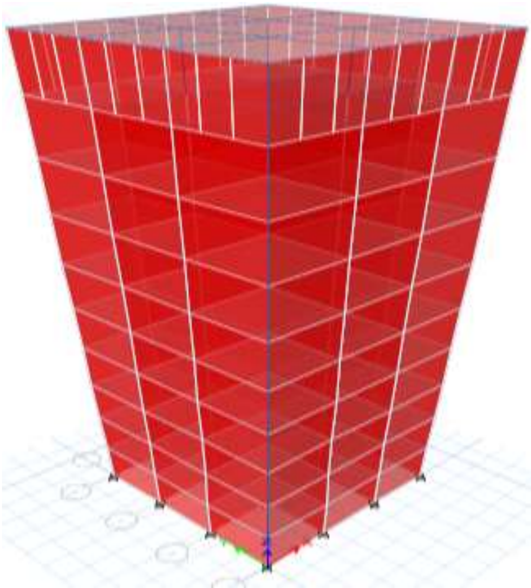

Fig. 5: 3D View of Filled Elevated Water Tank

3. MATERIAL PROPERTIES

Table 1: Material Properties– Basic Mechanical Properties

Material	Unit Weight	Unit Mass	E1
	KN/m^3	KG/m^3	KN/m^2
M-25	24.992	2548.538	25000
HYSD415	76.972	7849.047	200000
Masnory	19.2	1957.85	1500
Fe250	76.972	7849.047	210000

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4. RESULTS AND DISCUSSION

On behalf of comparison of both tanks joint displacement in filled elevated water tank is more.Maximum Joint Displacements of Empty –EWT and Filled EWT occurs at top floor Due to Load Combination of 1.2 (DL+EQL+WP).On behalf of comparison of both tanks joint displacement in filled elevated water tank is more.On behalf of comparison of both tanks joint displacement in filled elevated composite water tank is more.

Fig. 6: Joint Displacement Due to Load Combination 1.2 (DL+EQL+WP)

On behalf of comparison of both tanks Storey drift in filled elevated water tank is more.Maximum Storey drifts of Empty –EWT and Filled EWT occurs at top floor Due to Load Combination of 1.2 (DL+EQL+WP).On behalf of comparison of both tanks Storey drift in filled elevated water tank is more.On behalf of comparison of both tanks Storey drift in filled elevated composite water tank is more.

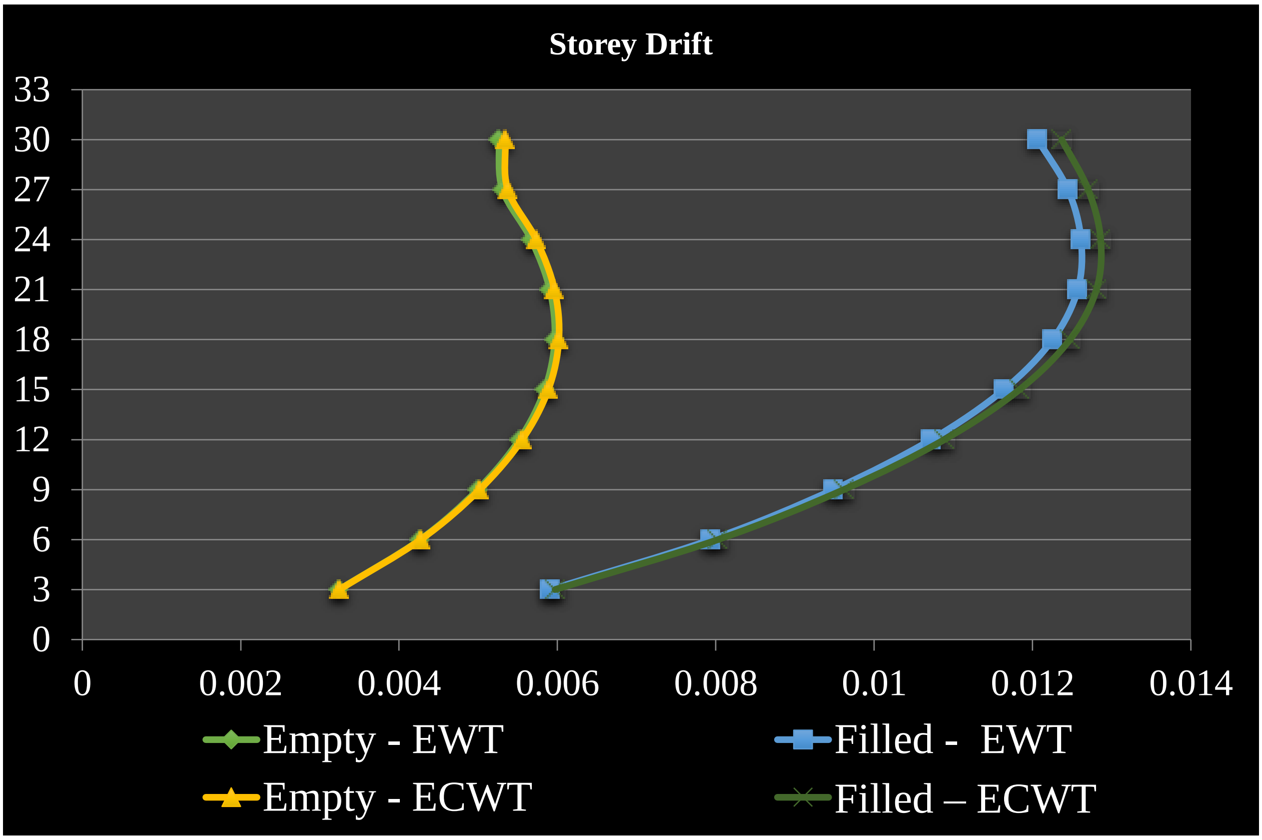

Fig. 7: Storey drift (MM) Due Load Combination of 1.2 (DL+EQL+WP)

Maximum Base Shear occurs in Empty – ECWT is 23699.276KN and minimum base shear occurs in Filled - EWT is 9389.1936KN.

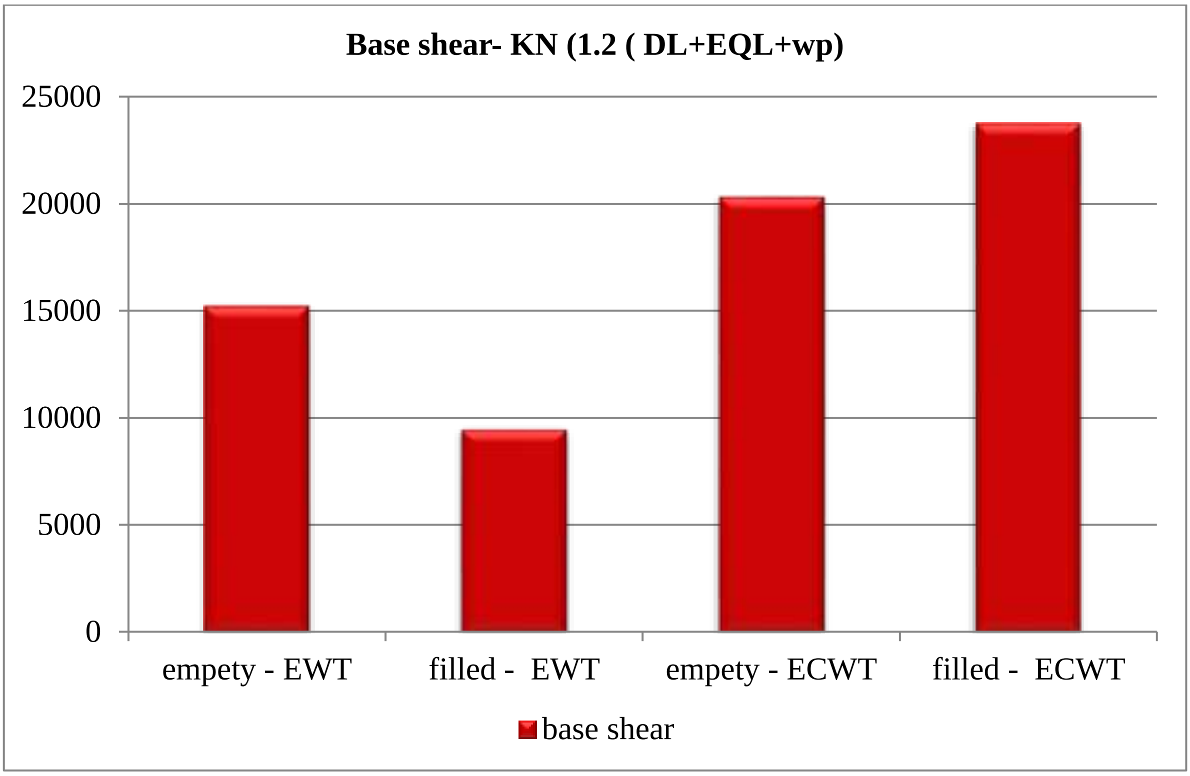

Fig. 8: Base Shear

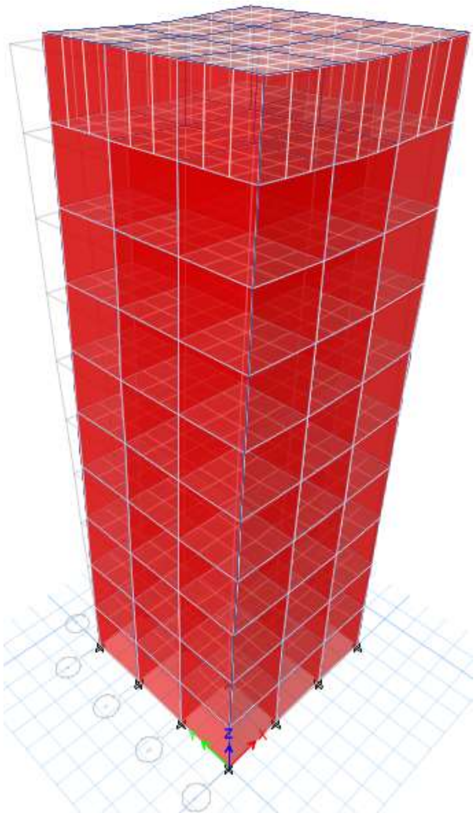

Fig. 9: Deformed Shape of Filled Elevated Water tank due Earth Quake Load

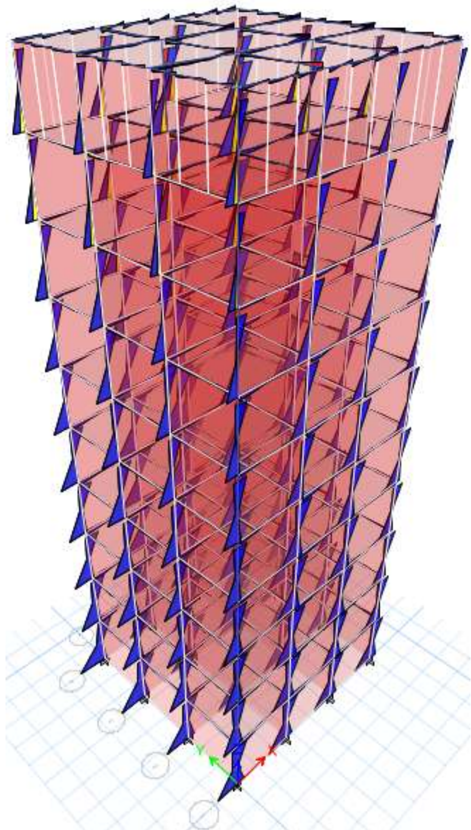

Fig. 11: Bending Moment in Filled Elevated Water tank due Load Combination of 1.2 (DL+EQL+WP)

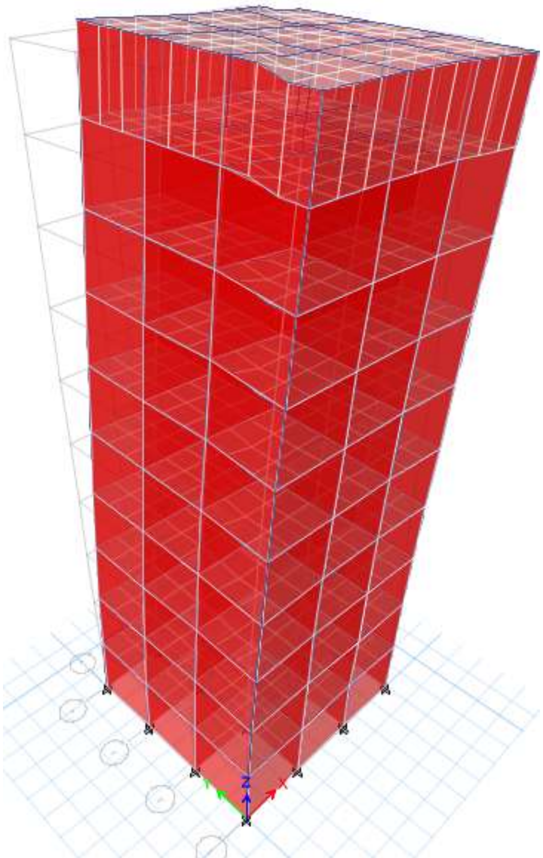

Fig. 10: Deformed Shape of Filled Elevated Water tank due Load Combination of 1.2 (DL+EQL+WP)

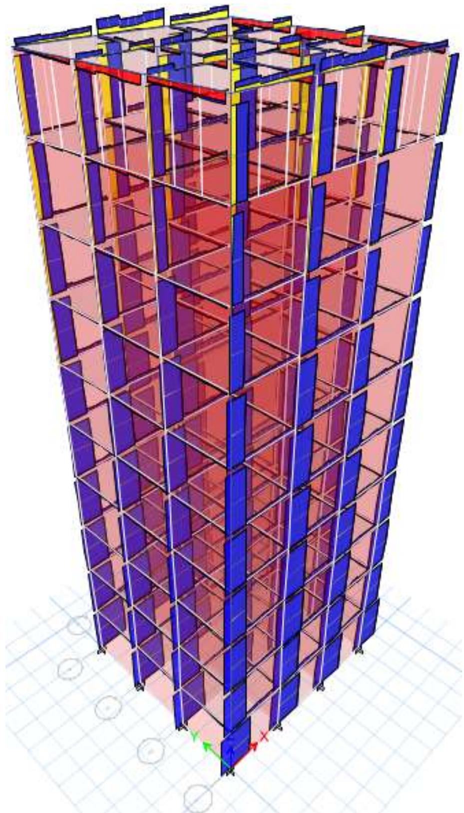

Fig. 12: Shear Force in Filled Elevated Water tank due Load Combination of 1.2 (DL+EQL+WP)

5. CONCLUSION

This study presented the design and performance evaluation of a circular RCC overhead water tank at the G+10 level using ETABS software. The structural behavior of the tank was analyzed under both full and empty operating conditions to evaluate critical parameters such as joint displacement, storey drift, base shear, bending moment, and shear force. The results indicate that the filled water tank experiences higher joint displacement and storey drift due to the additional hydrostatic load, while the empty tank develops comparatively higher base shear under seismic loading conditions. These findings demonstrate that different loading conditions govern different structural responses and must be considered during the design process. The study confirms that ETABS provides an efficient and reliable platform for the analysis and design of RCC overhead water tanks, enabling accurate assessment of structural performance under various load combinations. Proper selection of material properties, adequate reinforcement detailing, and compliance with standard RCC design provisions ensure sufficient strength, serviceability, durability, and water tightness of the structure. Overall, the proposed design methodology offers a safe, economical, and practical solution for elevated water storage systems and can serve as a useful reference for the design and evaluation of RCC overhead water tanks in modern urban infrastructure.

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