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# Design and Simulation of Elevated RCC Water Tanks with ETABS

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**ABSTRACT:** 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 behaviour under static and dynamic loading conditions. Key aspects such as bending moments, shear forces, and displacement patterns are analysed 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.

**KEYWORDS:** Elevated rectangular water tank, linear static analysis, linear dynamic analysis, ETABS, earthquake,

## I. INTRODUCTION

Water is a fundamental resource, and efficient storage and distribution systems are essential for ensuring its availability in urban and rural settings. Elevated reinforced cement concrete (RCC) water tanks play a critical role in storing and distributing water at adequate pressure levels. Among various configurations, rectangular water tanks are often preferred for their space efficiency and structural adaptability. However, their design and analysis require a thorough understanding of structural mechanics to ensure safety, durability, and cost-effectiveness. The design of elevated water tanks involves addressing multiple structural challenges, including self-weight, water load, wind forces, and seismic impacts. Additionally, the supporting staging system must be designed to withstand these loads while maintaining stability and minimizing deflections. This complexity necessitates the use of advanced computational tools for precise analysis and design.

ETABS, a state-of-the-art structural analysis and design software, offers a powerful platform for simulating and optimizing the performance of RCC water tanks. Its ability to model intricate geometries, incorporate material properties, and analyse various load conditions makes it an invaluable tool for engineers. With its user-friendly interface and comprehensive analysis capabilities, ETABS facilitates efficient design iterations, ensuring compliance with relevant standards such as IS 3370 for liquid-retaining structures and IS 1893 for seismic design.

This study focuses on the design and analysis of an elevated RCC rectangular water tank using ETABS. It explores the structural behaviour of the tank and its supporting framework under diverse loading scenarios. By leveraging ETABS, the research aims to provide a systematic approach to creating robust and cost-effective designs, contributing to the advancement of water storage infrastructure.

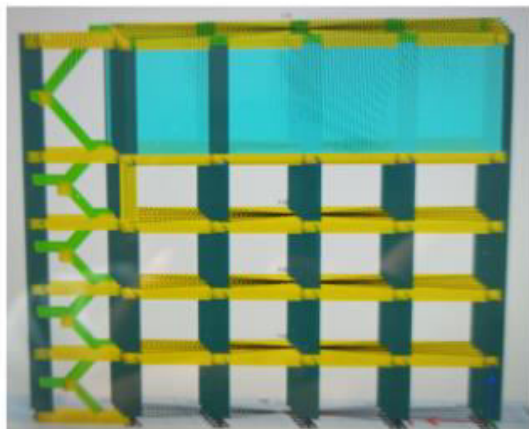
**II. DESCRIPTION OF MODEL**

The model considered here is rectangular elevated water tank of 1008m cube capacity supported on RCC frame, staging of height 16m and 16 number of columns. The elevated tank is analysed for various soil condition they are hard, medium and soft soil and various zones were considered they are zone II, III, IV, V. The grade of concrete M30 and grade of steel Fe 415 are considered for study. The model is analysed using linear static analysis and linear dynamic analysis method in ETABS.

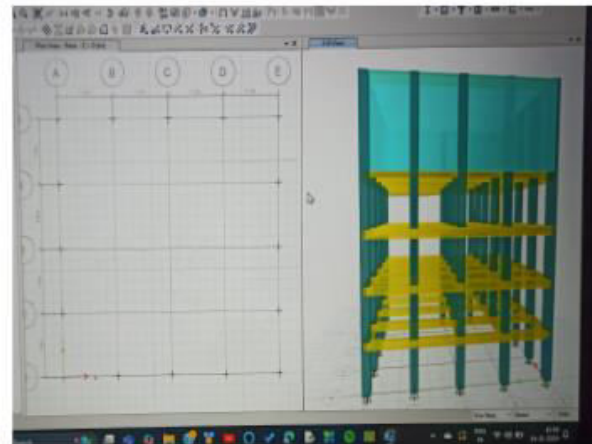
**III. ELEVATED RECTANGULAR WATER TANK**

**TABLE -1: PARAMETERS OF ELEVATED RECTANGULAR TANK**

Particulars	Dimensions
Thickness of wall	400 mm
Free board	0.3m
Lower slab thickness	500 mm
Bottom ring beam	350*500 mm
Size of braces	350*500 m
Column size	500*600 mm
Number of columns	16
Staging height	16m
Height of tank	7m
Zone factor	0.1,0.16,0.24,0.36
Reduction factor	2.5
Importance factor	1.5



**2. ELEVATION**



**1.PLAN**

**IV. METHODOLOGY**

The methodology includes design of elevated rectangular water tank using limit state method as per IS 3370:2009 as well as working stress method and then compared. In this examination the modelling of rectangular RC water tank is done in ETABS software. The manual estimation for seismic analysis has been accomplished using IS 1893:2016 The analysis is carried in two different methods one is linear static method (Equivalent static method) of analysis and other one is linear dynamic analysis method (Response spectrum analysis). The investigation is accomplished for completely filled water condition and empty water condition for various seismic zones and distinctive soil conditions. The logical



examination of a seismic response of raised water tank by response spectrum method by considering the convective mode for an earthquake data also included in the present study.

### V. RESULTS AND DISCUSSIONS

In this study, elevated rectangular tank have been designed using limit state design method (IS 3370:2009) Using ETABS the linearly static investigation and dynamic response spectrum investigation is carried out for empty tank condition and fully tank condition using above mentioned parameters. For each condition separate models have prepared and analysis is done. The results are noted down for base shear, base moment, and displacement at top, axial forces.

### VI. LOADS

This chapter provides loading information as applied to the model.

Table 2 - Load Pattern Definitions

Name	IS Auto Load	Type	Self-weight multiplier	Auto load
LLRF	Yes	Other	0	
Dead	No	Dead	1	
EQ x	No	Seismic	0	IS 1893:2016
EQ y	No	Seismic	0	IS 1893:2016
Live load	No	Live	0	
Water pressure	No	Other	0	
Wind pressure x	No	Wind	0	IS 875:2015
Wind pressure y	No	Wind	0	IS 875:2015

### VII. ANALYSIS RESULT

This chapter provides analysis results.

Table 3 - Base Reactions.

Output case	Case type	Step type	FX KN	FY KN	FZ KN	MX KN/m	MY KN/m	MZ KN/m
Dead	Lin.Static		-16	-16	21600.530	127151.612	-144973.152	-0.009
Water pressure	Lin.Static		0	0	41281.646	241510.565	-281841.974	-3.966
EQ x	Lin.Static		-958.4	0	294.868	1405.647	-9028.194	5628.310
EQ y	Lin.Static		0	-936.3357	294.868	11511.606	-2806.193	-6373.584
Wind pressure x	Lin.Static		-373.838	0	0	-96.873	-1591.322	2229.279
Wind pressure y	Lin.Static	Max	0	0	0	2985.892	-283.299	2229.279
Wind pressure y	Lin.Static	Min	-373.838	-467.2975	0	-96.873	-1591.322	-3623.400
Live Load	Lin.Static		0	0	1029	5999.0413	-7182.405	-0.001
Comb1	Combination		-16	-16	62882.176	368662.178	-426815.127	-3.995
Comb 2	Combination		-1348.2618	-16	64206.045	375969.993	-444617.048	7853.593

Comb 3	Combination	Max	-16	-952.3357	64206.045	389158.717	-437087.025	-4148.300
Comb 3	Combination	Min	-389.838	-1419.6332	64206.045	386075.952	-438395.048	-10000.981
Comb 4	Combination	Max	-1348.2618	-952.3357	64500.914	390467.491	-447706.541	3709.289
Comb 4	Combination	Min	-1722.0998	-1419.6332	64500.914	387384.726	-449014.564	-2143.391

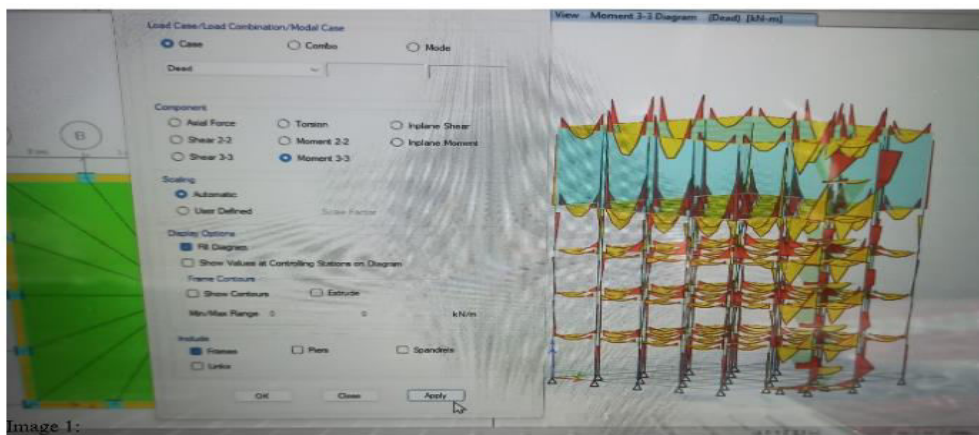


Image 1: Moment

Load Case/Combination Modal Case: The load case selected is "Dead", which represents the self-weight of the structure. Component: The analysis focuses on Moment 3-3, which represents the bending moment about the global Z-axis (typically the vertical axis). Display Options: "Fill Diagram" is enabled to visually represent the moment distribution in the frame members. Structural Representation. The moment diagram for the tank structure is displayed, with colour gradients indicating the magnitude of bending moments. The red regions likely indicate areas of higher moment.

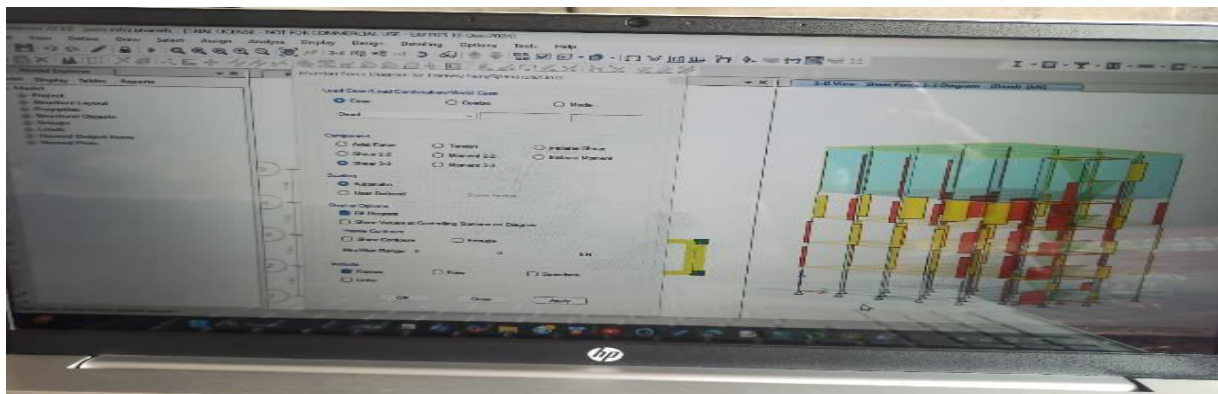


Image 2: Shear

Load Case/Combination Modal case: The load case is still "Dead". Component: This image shows the Shear Force 3-3, representing shear forces parallel to the Z-axis. Display Options: The shear force diagram is displayed, with different colours representing variations in shear magnitude.

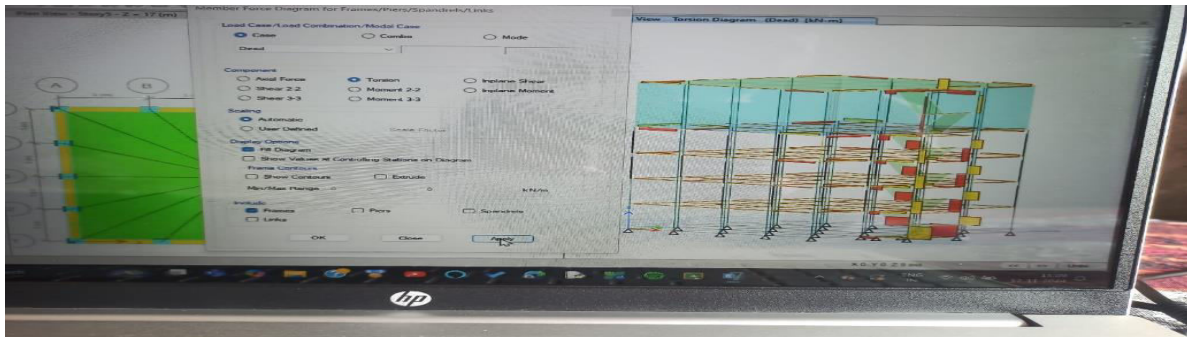


Image 3: Torsion

Load Case/Combination Modal case: The load case remains "Dead" for this analysis. Component: The diagram focuses on Torsion, representing the twisting moment on the structural elements. Display Options: The torsion distribution is shown using fill diagrams with color-coded intensity. Structural Representation: The structural model of the tank highlights regions experiencing torsional stresses, providing insight into load paths and critical sections.

## VIII. CONCLUSIONS

- From results it shows that the area of steel required in limit state method increase when compared to that of working stress method as the allowable stresses in steel were lower.
- From the above outcomes and discussion, the displacement is high in hard soil in full tank conditions compare with the hard soil in empty tank condition because of in full tank condition lateral forces are more.
- From the results we conclude that base shear and base moment for empty tank condition is more compare to full tank condition. Because of water tank is empty hence no water pressure from inside, only earthquake forces are acting from outer side only. Hence more base shear and base moment in empty tank condition.
- Axial forces are increased in the fully tank condition compare with the empty tank conditions. the increased values in full tank condition are very small varying compare to empty tank.
- The critical response of elevated water tanks does not always occur the same conditions as mentioned above, it may vary also due to depending on the earthquake characteristics

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