

Continuity Analysis Of Elevated Storage Reservoir

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Abstract - Elevated water tanks were heavily damaged or collapsed during earthquake. This might be due to the lack of knowledge regarding the tank against dynamic effect. Due to the fluid-structure interactions, the seismic behavior of elevated tanks has the characteristics of complex phenomena. The main aim of this study is to understand the behavior of sloshing effect using IITK guidelines under different seismic zones with STAAD-Pro software. In this paper different H/D ratios are considered with perimeter bracing. Tank responses including base shear, overturning moment and roof displacement have been observed, and then the results have been compared.

keywords - Elevated circular tank, intze water tank, seismic analysis, wind analysis

I. INTRODUCTION

Elevated water tanks consist of huge water mass at the top of a slender staging which is most critical consideration for the failure of the tank during earthquakes. Indian sub-continent is highly vulnerable to natural disasters like earthquake, draughts, floods, cyclones etc. According to IS code 1893 (Part 1):2000, more than 60% of India is prone to earthquakes. Collapse of structures causes people to lose life. Hence badly constructed structures kill people more than earthquake itself. Hence it becomes important to analyze the structures properly. Keeping these problems in consideration 'Bureau of Indian Standards' have published code especially for liquid retaining structures, 'Criteria for earthquake resistant design of structures' IS 1893(Part 2) : 2014 based on the guidelines and suggestions by IITK-GSDMA for seismic design of liquid storage tanks. This study will evaluate all the seismic analysis parameters using the recommended procedure in latest code as well as in IIT-GSDMA guidelines, and is concentrated mainly to the sloshing effect that is happening in the water during earthquake.

Objectives of the Project

An attempt is made in this thesis to evaluate the seismic response of elevated water tanks with varying h/D ratio and seismic zone. The main objectives of the report are

1. To study the seismic performance of the circular and intze elevated water tanks with varying h/D ratio and seismic zone.
2. To study the water sloshing effect on water tank.
3. To study the wind load effect on water tank.
4. To analyze the displacement of the structure along different directions.
5. To study base shear, axial force and moments of the structure along different directions by seismic analysis.
6. To study base shear, axial force and moments of the structure along different directions by wind load analysis.

Methodology

- The analysis is carried out using FEM (STAAD-Pro) Software.
- Seismic analysis is carried out for circular flat base and intze elevated water tank.
- Seismic analysis by IS: 1893-2016.
- Wind analysis by IS: 875-2015-part 3.
- In the analysis special moment resisting frame (SMRF) is considered.
- Elevated water tanks having 500,000 liter capacity with staging height 20 m considering 4 m height of each panel are considered for study.
- Considering normal perimeter bracings for analysis.
- Considering circular shape of column for analysis.
- Elevated water tank is analyzed for H/D ratio 0.4, 0.5, 0.6.
- All four seismic zones are considered in study.

II. PROBLEM STATEMENT

This study deals with the seismic performance of elevated circular and intze water tank for seismic zones II, III, IV and V of India. Varying h/D ratios of 0.4, 0.5, 0.6 for 500,000 liter capacity of elevated water tanks with total staging height is 20m and number of columns are 10. Total twenty four models are made for analysis of elevated water tank. Wind loads are considered for study. This chapter explains the Indian standard codes guidelines for the analysis of such tanks, study the suitability of normal perimeter type of bracing considering tanks constant capacity of container for a varying h/D ratios and seismic zones. Water tank is modeled and analyzed for sloshing forces as per IIT KANPUR guidelines for different Indian seismic zones. Validation of software result with IIT KANPUR Guideline. Also the wind analysis of water tank is done by using IS 875:part3-2015 using FEM Software STAAD-Pro.

Table1: Dimensional Details of Circular Water Tank

h/D	0.4	0.5	0.6
Capacity	500m ³	500m ³	500m ³
Diameter of container	11.25m	11.25m	11.25m
Height of container	4.4m	5.5m	6.6m
wall thickness	0.25m	0.25m	0.25m
base slab	0.3m	0.3m	0.3m
Ring beam Depth	0.75m	0.75m	0.75m
Ring beam width	0.35m	0.35m	0.35m
Staging :			
Diameter of staging C/C	8m	8m	8m
Height	20m	20m	20m
Each staging height =	4m	4m	4m
No of columns =	10	10	10
dia of each column	0.5m	0.5m	0.5m
bracing beam Depth	0.5m	0.5m	0.5m
Width	0.3m	0.3m	0.3m

Table2: Dimensional Details of Intz Water Tank

h/D	0.4	0.5	0.6
Capacity	500m ³	500m ³	500m ³
Diameter of container	10.201m	10.201m	10.201m
Height of container	4.08m	5.1m	6.12m
rise of roof dome	1.8m	1.8m	1.8m
rise of bottom dome	1.28m	1.28m	1.28m
Thickness of wall	0.25m	0.25m	0.25m
Thickness of bottom dome =	0.5m	0.5m	0.5m
Thickness of Bottom spherical Dome	0.3m	0.3m	0.3m
Thickness of roof dome =	0.1m	0.1m	0.1m
Dome Ring beam Width =	0.3m	0.3m	0.3m
Dome Ring beam Depth =	0.3m	0.3m	0.3m
Wall Ring beam Details:			
Wall Ring beam Width =	0.4m	0.4m	0.4m
Wall Ring beam Depth =	0.9m	0.9m	0.9m
Staging :			
Diameter of staging C/C	8m	8m	8m
Height	20m	20m	20m
Each staging height =	4m	4m	4m
No of columns =	10	10	10
dia of each column	0.5m	0.5m	0.5m
bracing beam Depth	0.5m	0.5m	0.5m
Width	0.3m	0.3m	0.3m

III. METHODOLOGY

For determining the seismic performance of water tank with circular and intz tank type are considered for circular shape of columns. Models are analyzed resting on medium soil and with fixed supported base. The model must ideally represent the storey shear and fundamental period. Material properties and Modeling of the structural elements used in the Present study is discussed below.

A reinforced concrete elevated circular and intz water tank with fixed base frame type tank with 500 m³ capacity is considered for present study. It is supported on RC staging consisting of 10 columns. Tank is located on medium soil. Grade of staging concrete is M25 and Fe 415, Density of concrete is 25 KN/m³. The isometric 3D view and elevation of the tank model is shown as below.

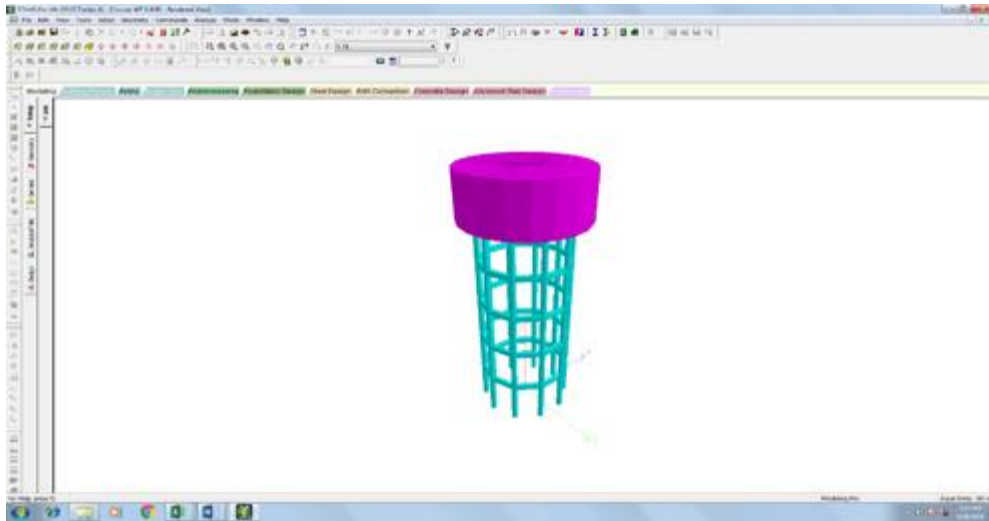


Fig. 1 3D view of circular water tank

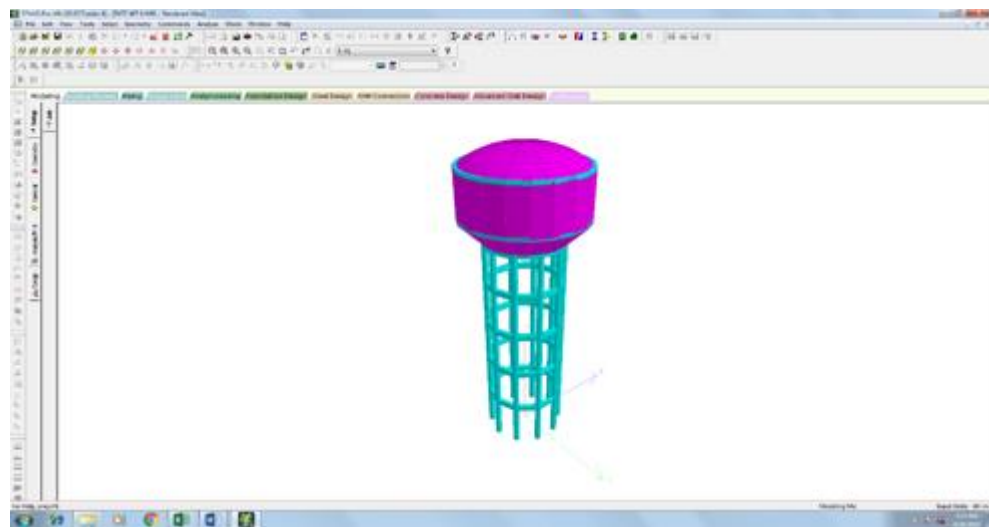


Fig. 2 3D view of Intz water tank

IV. RESULTS

Modeling and analysis is carried out to study the seismic performance of elevated circular and intzwater tank for all seismic zones of India for heights of staging 20 m for 500000 liters capacity of elevated water tanks for H/D ratios 0.4, 0.5, 0.6. Following discussed results are compared for tank empty and tank full filled condition.

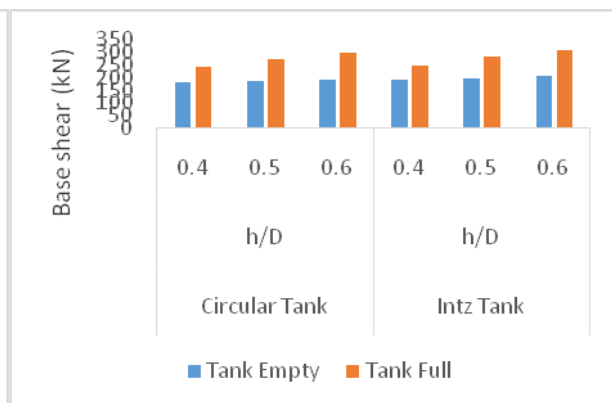
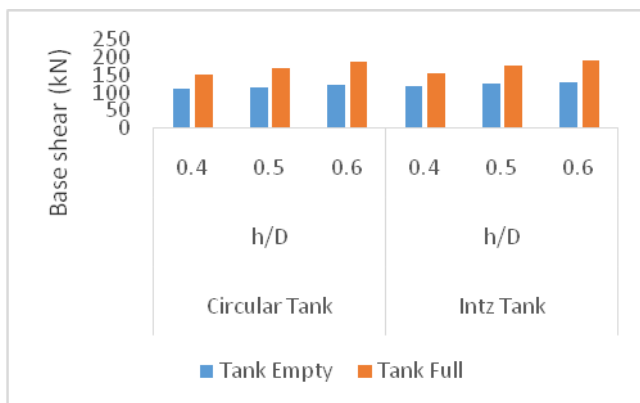


Fig. 3: Base Shear in kN – Zone II Fig. 4: Base Shear in kN – Zone III

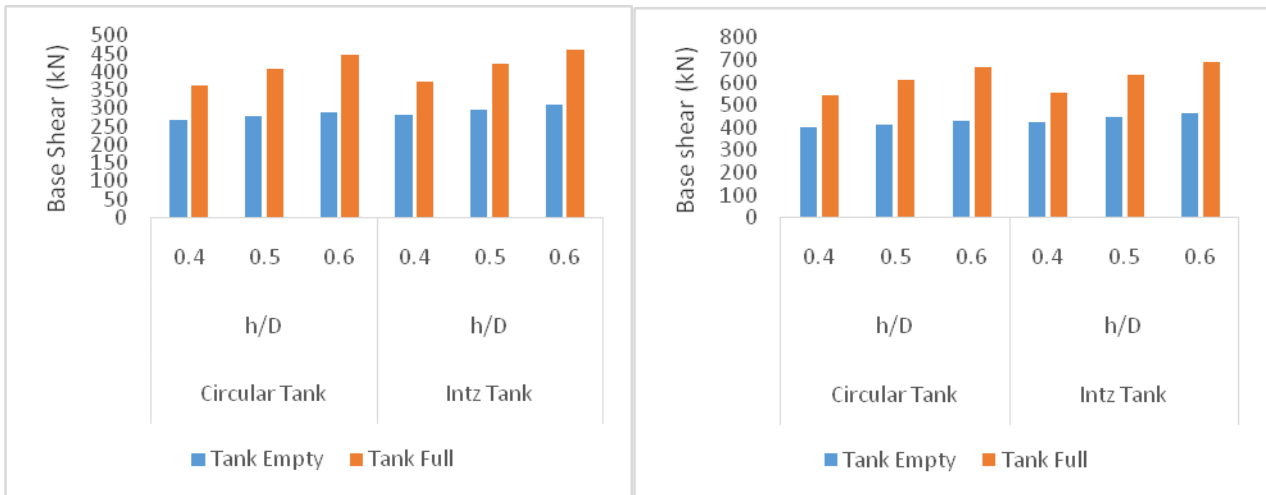


Fig. 5: Base Shear in kN – Zone IV **Fig. 6: Base Shear in kN – Zone V**

Above figure shows base shear of elevated circular and intzwater tank with circular column for seismic zone II, III, IV, V of India for staging 20 m and 500000 liters capacity of elevated water tanks for h/D ratios 0.4, 0.5, 0.6. Base shear is maximum for intztank with h/D ratio 0.6 and minimum for circular tank with h/D ratio 0.4

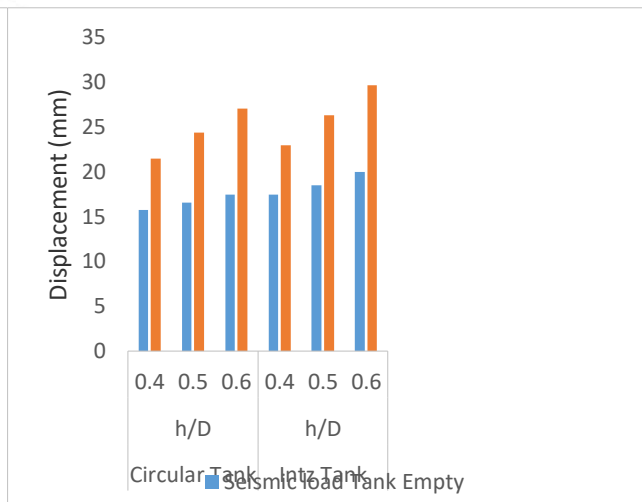
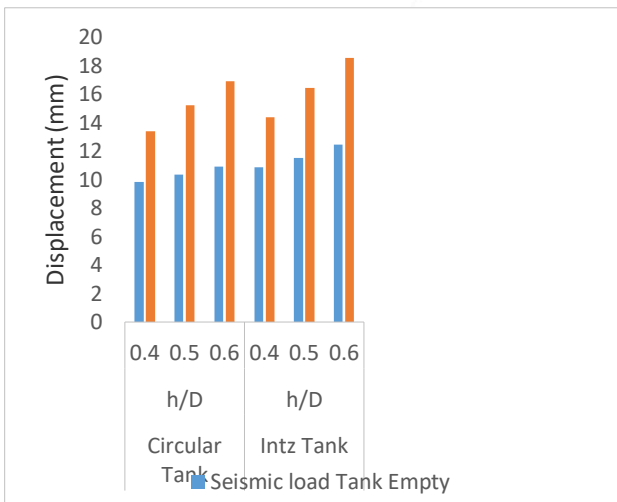


Fig. 7: Maximum Lateral Displacement in mm – Zone II **Fig. 8: Maximum Lateral Displacement in mm – Zone III**

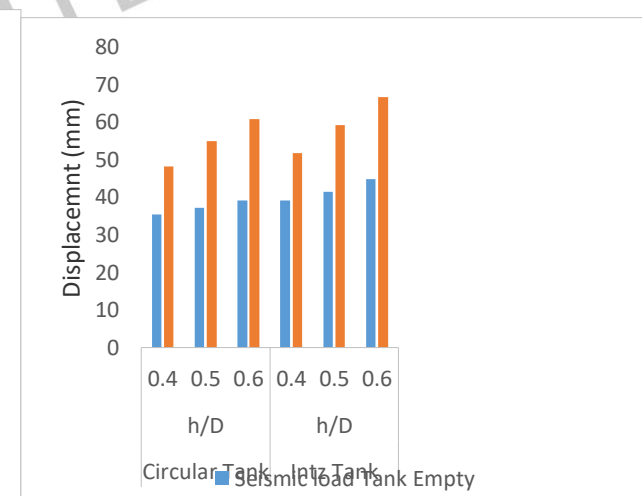
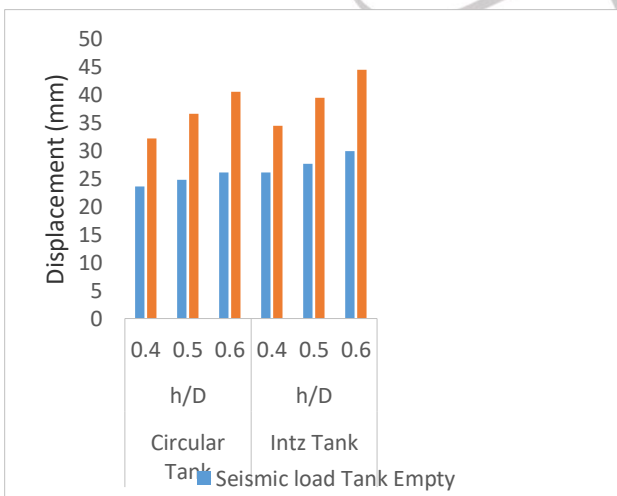


Fig. 9: Maximum Lateral Displacement in mm – Zone IV **Fig. 10: Maximum Lateral Displacement in mm – Zone V**

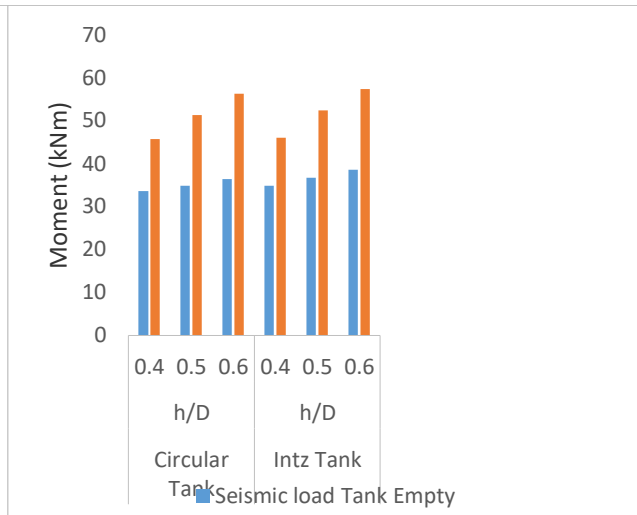
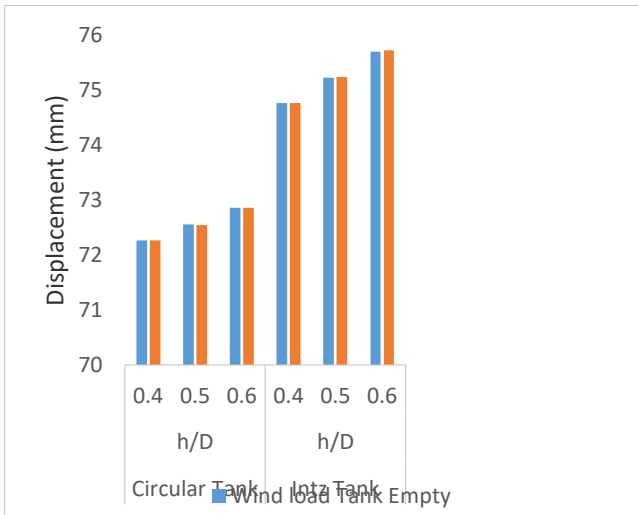


Fig. 11: Maximum Lateral Displacement in mm – Wind load **Fig. 12: Maximum Base Moment in kNm – Zone II**

Above figures shows maximum lateral displacement of elevated circular and intzwater tank with circular column for seismic zone II, III, IV, V of India for staging 20 m and 500000 liters capacity of elevated water tanks for h/D ratios 0.4, 0.5, 0.6. Displacement is maximum for intztank with h/D ratio 0.6 and minimum for circular tank with h/D ratio 0.4

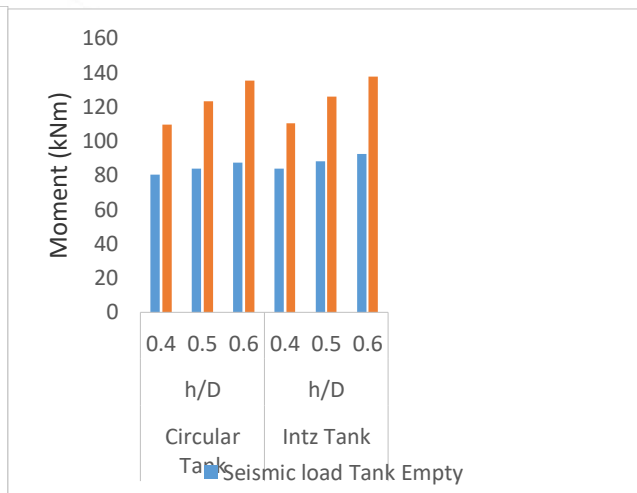
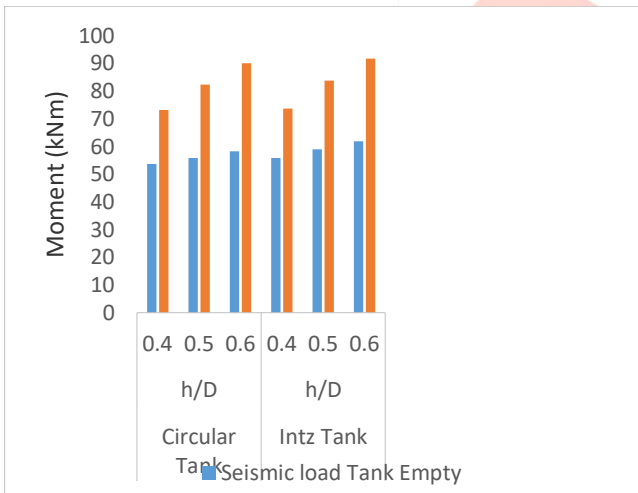


Fig. 13: Maximum Base Moment in kNm – Zone III **Fig. 14: Maximum Base Moment in kNm – Zone IV**

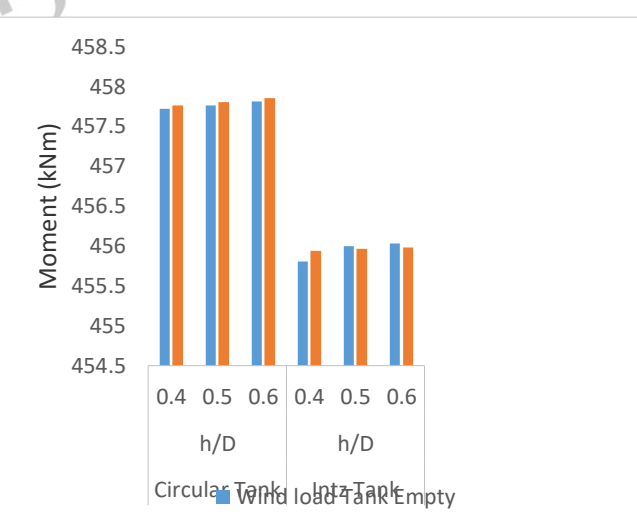
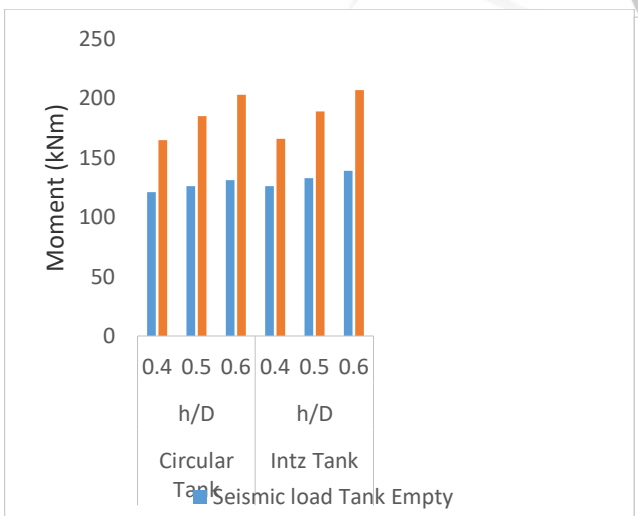


Fig. 15: Maximum Base Moment in kNm – Zone V **Fig. 16: Maximum Base Moment in kNm – Wind load**

Above figures shows maximum base moment of elevated circular and intzwater tank with circular column for seismic zone II, III, IV, V of India for staging 20 m and 500000 liters capacity of elevated water tanks for h/D ratios 0.4, 0.5, 0.6. Base moment is maximum for intztank with h/D ratio 0.6 and minimum for circular tank with h/D ratio 0.4 and vise versa for wind loads.

V. CONCLUSIONS

1. For tank full and tank empty conditions, as h/D ratios increases; Base Shear with Base Moment increases and Roof Displacement increases.
2. For tank full and tank empty conditions, joint displacement is higher as H/D ratio increases for intz tank than circular tank.
3. For tank full and tank empty conditions, Base Moment is higher as H/D ratio increases for intz tank than circular tank.
4. Tank Empty condition has less Base Shear and Base Moment compared to tank full condition.

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REFERENCES

- [1] Ali Akbar Qutubuddin Ali, Deepa P. Telang, "A Survey on Dynamic Analysis of Elevated Water Tank for Different Staging Configuration," International Journal of Computer Science and Mobile Computing, IJCSMC, Vol. 6, Issue. 5, May 2017, pg.194 – 201.
- [2] Anand H Shrigondekar, "Performance of RC Elevated Water Tank for different Bracing Patterns under the effect of Earthquake Excitation," IJIRST –International Journal for Innovative Research in Science & Technology, Volume 2 , Issue 11, April 2016.
- [3] Ankush N. Asati, Dr. MahendraS.Kadu, "Seismic Investigation of RC Elevated Water Tank for Different Types of Staging Patterns," International Journal of Engineering Trends and Technology (IJETT), Volume 14 Number 1, Aug 2014.
- [4] Pavan .S. Ekbote, "Seismic Behavior of RC Elevated Water Tank under Different Types of Staging Pattern," Journal of Engineering, Computers & Applied Sciences (JEC&AS) ISSN No: 2319-5606 Volume 2, No.8, August 2013.
- [5] IS: 1893-(part-1)-2016, "Code of practice for criteria for Earthquake resistant design of structures."
- [6] Guidelines for Seismic Design of Liquid Storage Tanks Provisions with Commentary and Explanatory Examples (IITK), Draft IS: 1893 (Part-II, Liquid Retaining Tanks).