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Elevated Water Tank Design Comparison in Different Seismic Zones

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ABSTRACT- Water is maintained in tall tanks as part of the public water system. Because of a shortage of water or difficulties putting out a fire after an earthquake, the collapse of these water tanks could pose major risks to people. According to draught code Part II of IS 1893:2002, twelve raised circular and H-intake storage tanks with a combined capacity of two lakh litres each would be studied in this study. STAAD Pro V8i is used to conduct a response spectrum analysis of elevated circular and H-shaped water intake tanks in seismic zones II and V. A comparison was made between each collected value for the base shear axial force and lateral displacements. There is a divergence in the H-tank and a negligible variance, according to analysis of a comparison of two water tanks.

KEYWORDS- Elevated Circular Water Tank, Elevated H-Intake Water Tank, Response Spectrum Analysis.

I. INTRODUCTION

Each individual requires water on a regular basis. This type of tank is used to pressurise the water circulation system by retaining water at a predetermined height due to its design. In a variety of diverse designs and models, new ideas and advanced technologies have been created to increase the capacity of water and other fluid substances. There are various methods for liquid capacities, including tanks, floor tanks, and subterranean tanks. Particularly in the Indian subcontinent, severe weather events including tremors, storms, cyclones, and floods are inflicting a lot of damage. Unlucky occurrences frequently affect substantial portions of states and unions, whether they be states[4] or unions. These recurring disasters cause numerous setbacks and property losses. Everybody else is rendered helpless before earthquake vibrations even start to happen. Over than 60% of Indian is prone to tremors, according to seismic code IS: 1893(Part I):2002. Property damage following a seismic tremor can be rectified to some extent, but life-threatening injuries cannot. Massive volumes of water, oil, gasoline, acid, and even gases are kept on hand. Additionally, tanks or containers are needed. These constructions were built using a range of materials, including masonry, steel, reinforced concrete, and pre stressed concrete. Steel and masonry tanks are utilised for capacities below that. Steel water storage tanks are expensive, but they are not thought to be important. In addition to its straightforward structure and design, reinforced concrete tanks are particularly well-liked because They can be manufactured leak-proof, have a They can be manufactured leak-proof, have a monolith structure, and are inexpensive. Water - based In the RCC tanks, stronger concrete is employed to ensure characteristics associated. Many different kinds of waterproofing materials are utilised to make tanks impermeable.

II. LITERATURE REVIEW

Inside this chapter, we examine a few published studies on the reinforced concrete (RC) water tanks' earthquake performance characteristics. Jain and Sajjad [1] found that the seismic design force in IS 1893– 1984 is very low [1]due to the lack of an adequate performance factor, which must be in the range of 3.0-4.5, based on their assessment of seismic codes of other regions and findings of several investigations.[2]

Nitesh Singh,et al According to IS guidelines, water tanks are made to handle dead load + live load, wind load, and seismic loads. In the mistaken belief that tanks will be safe under seismic forces once they have been designed for wind forces, tanks are sometimes prepared for wind forces without even being tested [2]for earthquake loads. This isn't always the case, though. For Indian conditions, a water tank with an H-shaped inlet is considered. The impact of wind on elevated structures is significant because wind flows relative to the earth's surface and places loads on ground-based structures.[3]

Rupachandra et al Water storage areas are utilized by sectors to store, along with other things, chemicals, oil products, and water for public water distribution systems. According to the IS 1893:2002 draught code part II, the behaviour of cylindrical liquid storage tanks under seismic forces has been investigated. Software (STAAD-PRO) that uses critical component modelling (FEM) to estimate the effects of earthquakes on water tanks.

Sonali M. Maidankar Just few seismic disasters in India caused R.C.C. elevated water tanks to be heavily affected or to collapse. Experts claim that the tank's support system broke as a result of a quakes and a base of operations that was improperly built.[19]

A.D.V.S. Uma Maheswari, et al We are aware first from past that numerous high steel and concrete storage tanks either crashed or suffered serious harm as a result of disasters all across the world. General conclusions show that the elevated tank's enhance its effectiveness collapse is more dangerous than the tank's remaining structures.[5]

Prashant Bansode Higher water tanks made of reinforced concrete are incredibly important structures. They were regarded as crucial lifelines both during and following earthquake. An higher water tank is made up of a sizable water mass[7] that is perched on the topmost stage in its construction, similar to an inverted pendulum. It's the most crucial thing to remember in case the tank breaks during a quake.

Nanjunda, et al In the current investigation, which concentrated on its reactivity,[8] a component of the overall water tank was subjected to dynamic stresses. The most crucial factor in assessing whether an overhead water tank will fail after an earthquake is huge water volumes at the top of a short stage[9].

M. Sai Ramya et al The most important structures in the System, its high water containers, are its lifeblood. Elevated water tanks have[10] already suffered damage and collapsed because of earthquakes. The freshwater tank's inadequate support networks and improper staging are to blame for the damages[11].

Ranjit Singh Lodhi,et al Water is the source of all life. Water is necessary for daily life. The overhead liquid storage tank is the most effective type of storage space for a home or business.[12] Depending on where they are in the construction, storage tanks can be characterised as being above, below, or on the floor.[13]

III. SCOPE OF THE WORK

The fem modelling software application STADD Pro V8i was utilised to simulate the water tank for this study. In tanks, the impact of several imaging techniques was examined. For this, seismic evaluations for both full and partial water level conditions were carried out. Using the Frequency Response technique, which takes into account the convective mode of earthquake data, the current study also contains an analytic investigation of the earthquake response of a higher water tank. Similar results from the study's peak displacement and base shear analyses were examined.

IV. METHODOLOGY

The methodology comprises selecting the type of storage tank, fixing the constituent proportions, and doing a linear dynamic analysis (Response Spectrum Method of Analysis) on the chosen water tank using the draught IS 1893-2002 (Part 1) and IS 1893-2002 (Part 2) codes. In this instance, the raised water tanks are circular and H-shaped, each having a capacity of 2 litres, and they are supported by a 12 m tall RCC frame with six columns and horizontal bracing at 4 categories. The elevated water tanks are situated on moderate soil in Zones II and V. Steel grade Fe-415 and concrete grade M30 are taken into account in this investigation. These models were assessed using Response Spectrum Analysis in Staad Pro V8i(See figure 1 to 11 and table 1 to 7).

Table 1: Parameters of Circular Tank

Particulars	Parameter
Thickness of Top Dome	100mm
Rise of Top Dome	1.4m
Top Dome Radius at Base	8.0 m
Size of Top Ring Beam	250mmx250mm
Diameter of Cylindrical Wall	8.0 m
Height of the Cylindrical wall	4m
Dimensions and thickness of the cylindrical walls	150mm
Thickness of Bottom Slab	175mm
Size of Bottom Ring Girder	350mmx350mm
No. of Columns	6nos.
No. of Bracing Levels.	3m,6m,9m,12m
The distance between intermediate Braces	3.0 m
Size of Bracing	0.350mx0.450m
The Size of Columns	0.375mx0.375m

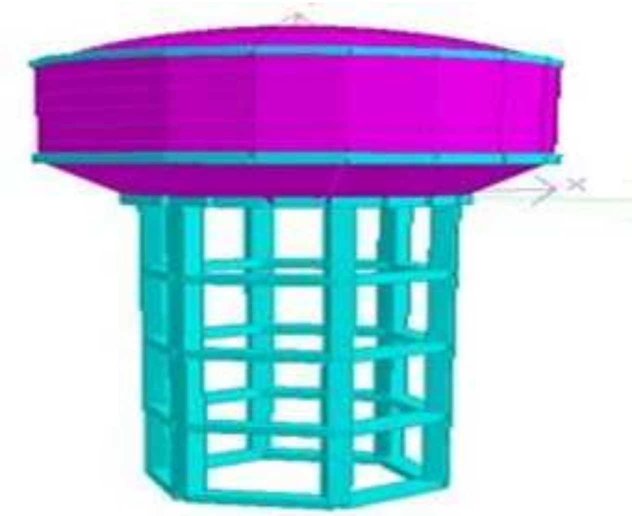

Figure 1: Rendered View of Circular Tank

Table 2: Parameters of elevated H-intake Tank

Particulars	Parameters
ThicknessofTopDome	100mm
RiseofTopDome(h1)	1.4m
SizeofTopRingBeam	250mmx250mm
DiameterofCylindricalWall	8m
HeightoftheCylindrical wall	3.6m
ThicknessofCylindricalWall	150mm
SizeofMiddleRingBeam	350mmx350mm
HeightofConicalDome	1.6m
diameter of the conical dome on the average	6.45m
ThicknessofConicalDome	200mm
RiseofBottomDome	0.9m
RadiusofBottomDome	3.75m
ThicknessofBottomDome	175mm
SizeofBottomRingGirder	375mmx750mm
No.ofColumns	6nos.
No.ofBracingLevels.	3m,6m,9m,12m
Distance betweenintermediateBraces	3m
SizeofBracing	0.350mx0.450m
TheSizeofColumns	0.375mx0.375m

Figure 2: Water Load for Full Tank for HH- intake Tank

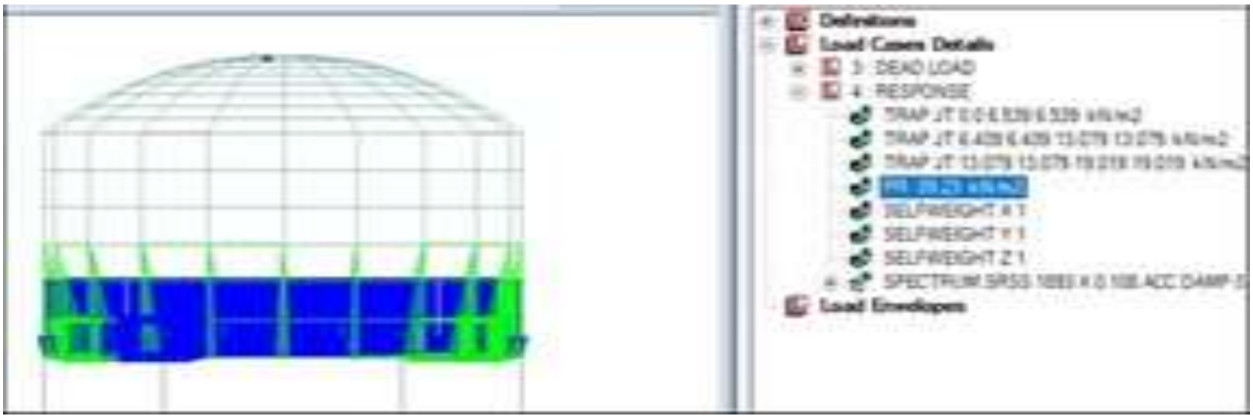

Figure 3: Water Load for Half Tank for Circular Tank

A. Seismic Loads

Based on variables like the zone factor, significance factor, response reduction factor, and more, a seismic reaction spectra analysis is performed. According to IS Code 1893:2002, seismic zones II and V have zone factors of 0.10 and 036, respectively. A factor of 1.5 is assigned to storage tanks for water supply, non-volatile substances, low-flammable petrochemical products, etc. The response reduction factor is influenced by the chosen type of frame. For frames that are not ductile designed, it is believed that the instant reaction is lowered by 1.8. In zone II, it is used. For frames with ductility detail, which implies they have such a special moment-resistance response decrease of zone V, it is used. In order to determine how best to respond to increased water tanks, key variables are researched. Base shear force, nodal displacement, and duration are part of these responses. Analyzing the reaction spectra of full, half-full, and empty storage tanks allows one to gauge the seismic characteristics of rising water tanks. The seismic zones II and V will be taken into consideration as a portion of the investigation.

Base Shear (in KN): Shear wall values again for cyclic and H-intake simulations are calculated using response spectrum analysis in the Stad.pro software(see table 3,table 4,figure 5, and figure 6).

Table 3: Base Shear Values for Zone– V

Water levels in tank	CircularTank	H- intakeTank
	Fx(inKN)	Fx(inKN)
Empty TankLevel	193.66	208.65
HalfTankLevel	207.32	288.38
FullTankLevel	307.21	323.68

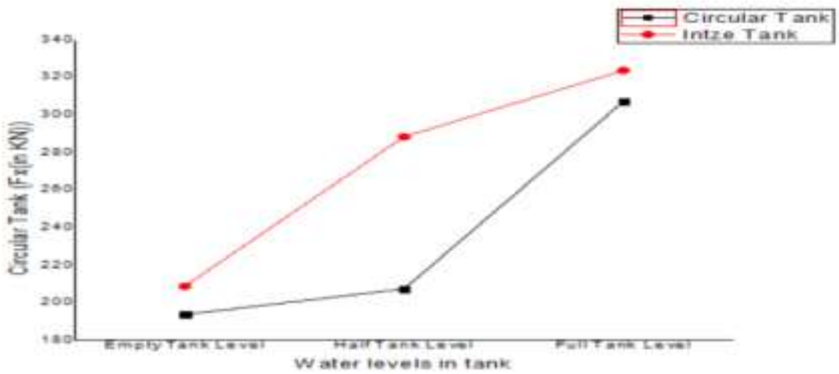

Figure 4: Base shear values for circular tank and H- intake tank in zone V

Table 4: Base Shear Values for Zone– II

Waterlevelsintank	CircularTank	H-intakeTank
	Fx(inKN)	Fx (inKN)
Empty TankLevel	75.31	81.15
HalfTankLevel	81.13	112.17
FullTankLevel	98.14	125.88

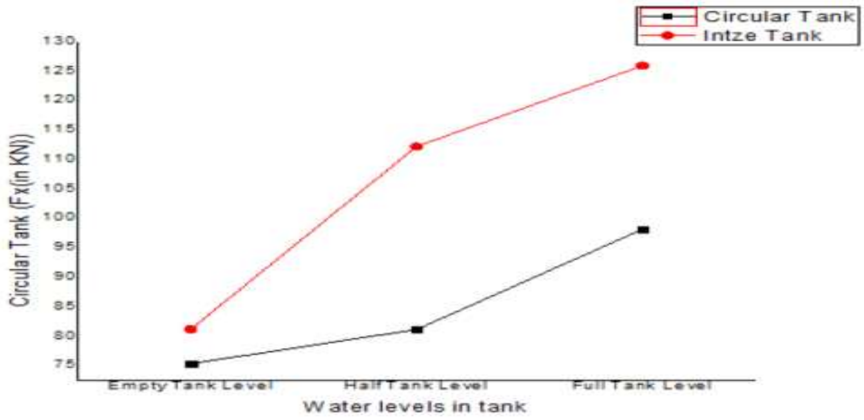

Figure 5: Base shear values for circular tank and H- in take tank in zone II

B. Nodal Displacement

For circular and H-intake models at various water levels, response spectrum analysis from the staad.pro software under seismic zones II and V produces displacement data(see figure 6).

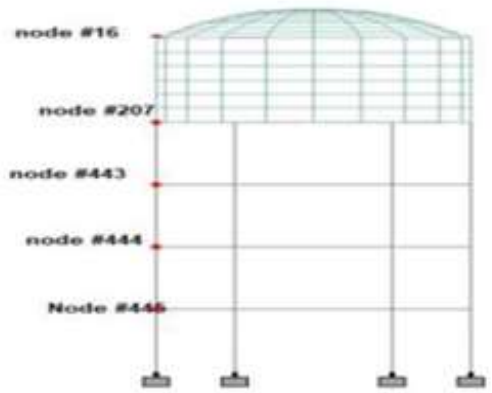

Figure 6: Node numbers in Circular Tank

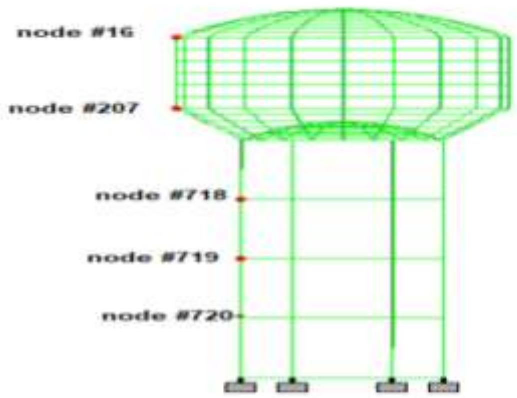

Figure 7: Nodes numbers in Intake tank

Table 5: Displacements in Circular tank in Zone V

Seismic Zone-V			
Response Spectrum Analysis of Elevated Circular Tank			
Node Numbers	Elevated Circular Tank Displacements in mm		
	full	half	empty
445	7.41	7.379	7.365
444	19.55	19.34	19.25
443	34.36	33.58	33.2
207	58.25	55.99	54.90
16	59.26	56.94	55.87

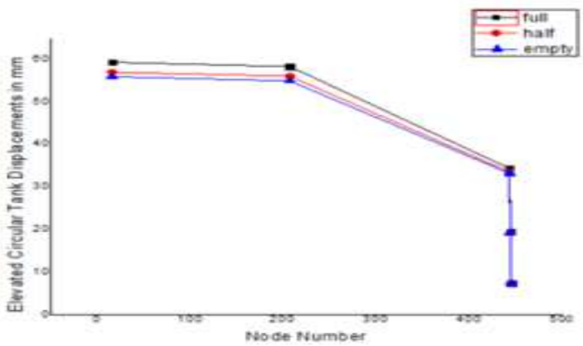

Figure 8: Response Spectrum Analysis of Elevated Circular Tank Displacement in mm

Table 6: Displacements in Circular tank in Zone II

Seismic Zone-II			
Response Spectrum Analysis of Elevated Circular Tank			
Node Numbers	Displacements in mm		
	full	half	empty
445.0	2.85	2.84	2.841
444.0	7.54	7.46	7.429
443.0	13.25	12.97	12.82
207.0	22.46	21.64	21.182
16.0	22.85	22.01	21.557

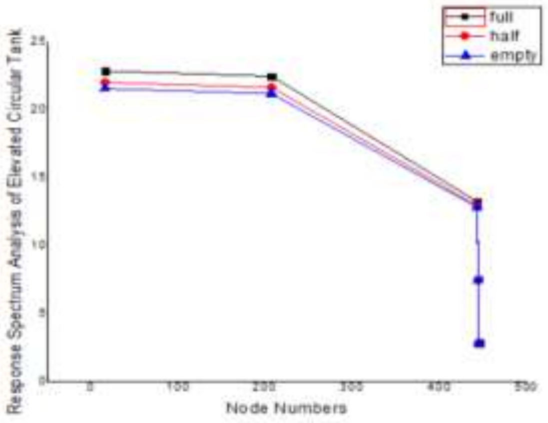

Figure 9: Response Spectrum Analysis of Elevated Circular Tank Displacement in mm

Table 6: Displacements in H-Intake tank in Zone V

Seismic Zone-V			
Response Spectrum Analysis of Elevated H- intake Tank			
Node Numbers	Elevated H- intake Tank Displacements in mm		
	full	half	empty
720.0	6.770	6.4460	6.430
719.0	17.220	16.365	16.247
718.0	29.4670	27.920	27.448
207.0	52.5330	49.495	47.965
16.0	55.3360	52.027	50.669

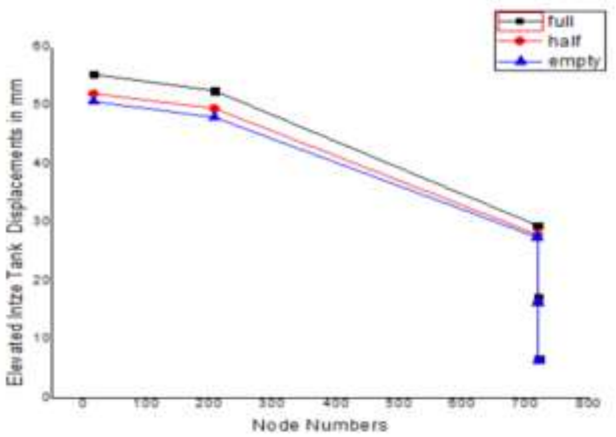

Figure 10: Response Spectrum Analysis of Elevated H-intake Tank Zone-V

Table 7: Displacements in H-Intake tank in Zone II

Seismic Zone-II			
Response Spectrum Analysis of Elevated H- intake Tank			
Node Numbers	Displacements in mm		
	full	half	empty
720.0	2.630	2.48	2.180
719.0	6.690	6.31	5.510
718.0	11.459	10.770	9.620
207.0	20.429	19.090	18.320
16.0	21.519	20.070	19.070

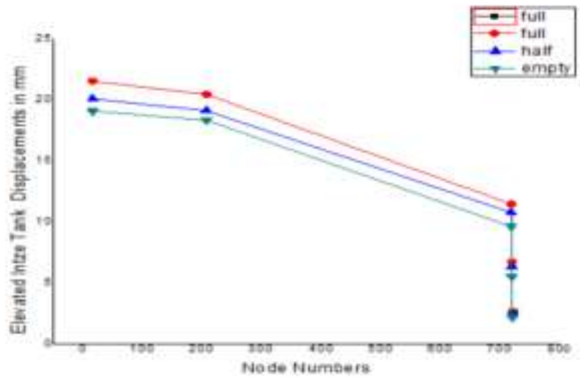

Figure 11: Response Spectrum Analysis of Elevated H-intake Tank

V. RESULTS & DISCUSSION

Base Shear: It has been demonstrated that, when compared to various H/D ratios, the radial staging type with a 0.6 H/D ratio produces the maximum value of base shear for eight columns. Radial staging with a half tank and a full tank has the highest base shear value for empty tanks when compared to other staging techniques. For full, half, and empty tank circumstances, the base shear rises as the number of columns does. Base shear diminishes when the h/d ratio rises.

Axial Force: For full, half-full, and empty tanks, radial staging with a centre column generates the greatest amount of axial force. When h/d=0.6, cross staging with eight column numbers, is used for an empty container, the maximum axial force is achieved. For ten or 12 columns, the axial load decreases as the h/d ratio increases. In comparison to a half-full tank as well as an unfilled tank, the maximum axial force is obtained with a full tank.

Moment-y Direction: The lowest moment-y for eight columns is produced by a regular stage type of 0.7, according to comparisons of h/d ratios. For unfilled and 1⁄2 tank situations, a radial staging type with a 0.5 h/d ratio generates the highest moment-y for ten columns when comparing to certain other h/d ratios. Comparing cross and radial staging with eight, ten, and twelve columns to certain other staged for unfilled and half tanker situations, moment-Y decreases with increasing h/d ratio.

Moment-z Direction: The lowest moment-z for eight column numbers is produced by h/d ratios of 0.7 crossing stage, while the maximum moment-z for the identical amount of columns is produced by h/d proportions of 0.6 crossing setup. When compared to other h/d ratios, the 0.5 h/d ratio cross staging type produces the biggest moment-z for the halfway tank and huge tank situations.

Moment-x Direction (Torsion): The hexagonal staging type, with a ratio of 0.7, has the lowest twisting moment for ten digits of the column h/d ratio for a full tank, half tank, and empty tank condition compared to another h/d ratio. In comparison to another h/d ratio, the 0.5 cross staging type offers a maximum twisting moment for the 10 and 12 numbers of the column for full, half-full, and empty tank situations.

Lateral Displacement: For a full tank, a half tank, and an empty tank, the displacement decreases as the amount of columns rises. We discover that lowest deflections occurs with the hexagon stage type for emptiness, half-filled, and full tanks with 8, 10, and 12 column numbers, respectively.

V. CONCLUSION

If the h/L ration is down to 0.6 for a rectangle water tank that has the same storage capacity but a varied height of tank wall, the base shear, Max. When the h/L ration is between 0.6 and 0.8, the hemodynamic pressure surges abruptly and then falls slowly. Otherwise, the pressure rises gradually. Therefore, an h/L ratio down to 0.6 is practical for the water tank at ground level. The sloshing wave height increases to a certain limit and then gradually decreases for circular and rectangular water tanks with the same amount of storage capacity but different tank wall thicknesses. The impetuous lot of clients factor will increase and the convective participation factor will decrease with an increase in the maximum depth of water to tank diameter (h/D) or (h/L) ratio. In the circular water tank with a h/d ratio of 0.6, the weight engagement factors for convection and impetuous motion are essentially identical. The mass participation factor for impulsive & convective in the scenario of a rectangle storage tank for a h/L ratio of 0.5 is almost equal.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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