Analysis of Elevated Service Reservoir by using Commercial Software

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Abstract - *When designing any high rise structure, wind and seismic forces are the major lateral forces that have to be dealt with. As by the code recommendations, it is very unlikely that maximum wind accompanying maximum earthquake activity, we just have to design the structure for the maximum load which is induced by either wind or seismic. In this present study, a various types of reinforced concrete elevated water tank having same intake capacity of 400 cum are analysed for wind and seismic excitations. Seismic effects are evaluated through P delta analysis. For wind analysis, both along and across wind effects are considered. The node displacement so obtained for all cases ie under seismic and wind effects are then compared to define which tank is having minimum deflection and hence suitable for the intake capacity of 400 Cum. And at last, to recommend suitable water tank for design as per analysis and economical water tank as per elemental propertiwise.*

***Key Words*:** Wind Load, Seismic Load, Circular Tank, Rectangular Tank, Intz Tank, Shell Tank and I.S.Codes etc…

1. INTRODUCTION

A structure must be designed to carry every load during its service life, both horizontal and vertical. Among these, lateral loads should be seen with great caution as it tends more design forces. Wind load and seismic loads are the major lateral loads which are imposing on a structure. Owing to the height, stack attracts a lot of wind forces. And by virtue of its importance, seismic excitation evaluation is also a momentous parameter. Hence, both these have to be carefully investigated. As said earlier, the height may wake various wind behaviors on the stack like vortex shedding, wind buffeting etc. So, assessing the dynamic behavior of the stack also becomes crucial in the analysis. Indian standard clearly proposes that consideration of maximum wind along with maximum seismic is not necessary. On its behalf, we have to determine which lateral force induces maximum load.

1.1 Seismic Load and Wind Load

The loads acting on a structure are mainly the vertical and lateral loads. The vertical load mainly consists of dead load and the imposed loads and the behavior of the structure when subjected to various vertical loads is the same. The lateral load mainly consists of seismic forces, wind load, mooring load, tsunami etc., amongst which the seismic force and the wind force are the common ones. The application of these forces and the behavior of the structure when subjected to these forces varies.

1.1a Seismic Load

Seismic force depends on mass of the structure and the distribution of mass. The load acts at the centre of mass of the structure. The seismic force will be distributed along interior and exterior frames and columns in a structure. i.e., acts at location of masses. A structure having lesser mass will perform good during seismic events since it attracts lesser load and the exposed area has got no influence on the performance during seismic events. The stiffness of the structure influences the seismic force developed The base shear value is more at bottom and it decreases as height increases due to reduction in cumulative .The damping will be considered in the calculation of seismic forces. The inertia of the structure is the main factor which causes seismic force mü+cù+ku =0.The seismic force is mainly generated at the base of a structure. When a structure is subjected to seismic load, torsion will develop if the centre of mass and the centre of stiffness don’t coincide. The storey displacement will be large at upper floors during seismic events and the displacement will be parabolic. The maximum deflection of the structure will be around 0.4%. The codal provision deals with the seismic load are IS 1893-2002and IS13920-1993. Non structural elements inside the building such as furniture’s, storage rack set can cause damage when a structure is subjected to seismic load since it has mass and less stiffness. The seismic force can be artificially generated using a shake table. The seismic force will depend on the focus of earthquake and ground conditions through which the wave travels. The duration of seismic force varies from a few seconds to minutes and we will not get any warning. The area affected by seismic force is large. The prediction of seismic vent is only probabilistic

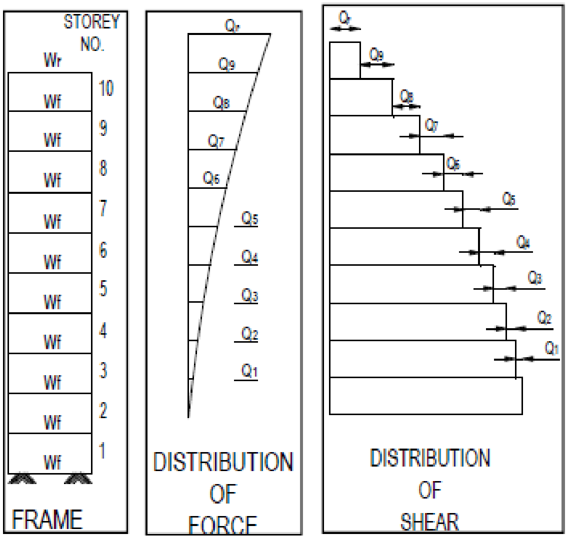


Fig-1 Base Shear distribution

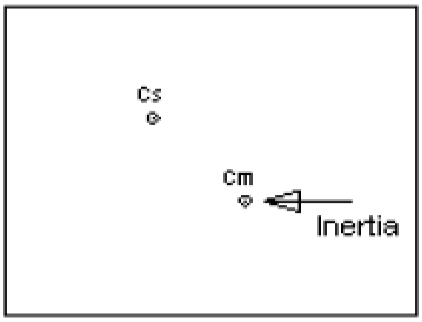


Fig-2 Centre of Mass and Centre of Stiffness are at different points

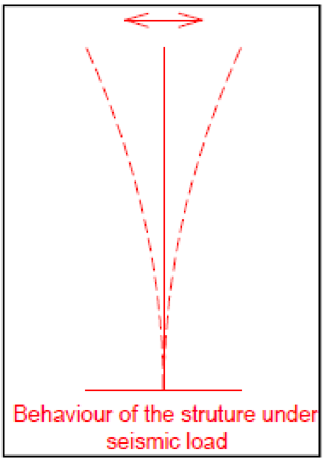


Fig-3 Behavior of the structure under seismic load

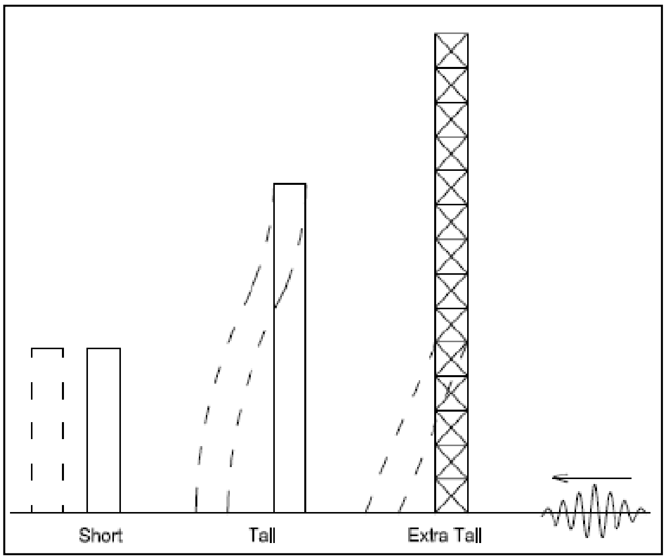


Fig-4 Direction of building under Seismic Load

1.1a Wind Load

Wind force depends on the exposed area of the structure. The wind force will act mainly on exterior (i.e., exposed) frames and it may reduce to interior frames based on the type of structure (Shielding effect). A structure having higher mass will resist the wind load effectively and the structure having lesser surface area will perform better since it attracts lesser wind force. The stiffness of the structure has no influence on the wind force developed. The wind force increases as height increases if the exposed area remains same. The damping will not be considered in the calculation of wind forces in normal conditions (i.e., for static analysis).Inertia has less impact in the generation of wind force ku =F(t) (Depending on case mü, cù may be considered).The wind force is generated at each nodes in the exposed area. Wind load doesn't cause torsion in a structure. The soil type will not have much effect on performance of structures during wind. The performance of a structure can be improved when a wind acts by improving the shape of the structure by providing curved edges so that the wind load will be less. When the wind load acts in a building, negative pressure can act in it due to suction. The deflection will be about the initial static deflected position and the to and fro motion is less compared to seismic force and hence less reversal of stresses. The storey displacement at upper floors will be less compared to seismic forces and the displacement is linear. The maximum deflection of the structure will be around 0.5%.The codal provision deals with wind load is. IS 875(Part3)-1987.The non structural elements such as glazings, claddings etc may get damaged when a structure is subjected to wind load. The wind effects can be artificially modeled in wind tunnels. The wind force will depend on terrain and topography of the location. The duration of wind load varies from minutes to even hours (cyclone) and the warning will be there before it hits. The area affected by wind force is comparatively low (Except cyclones). The formation of storms can be predicted accurately

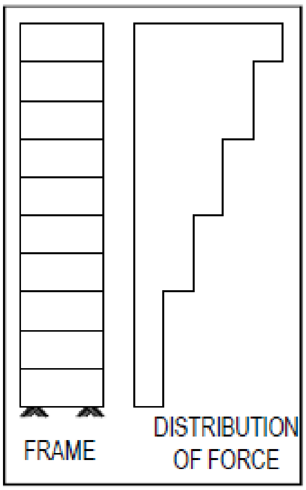


Fig-4 Wind force distribution

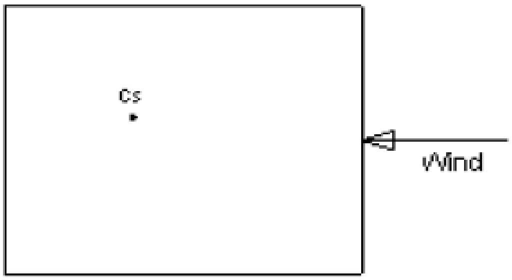


Fig-5 Wind force act at the surface

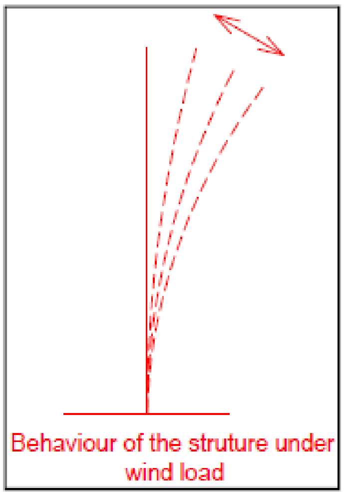


Fig-6 Behavior of the structure under Wind load

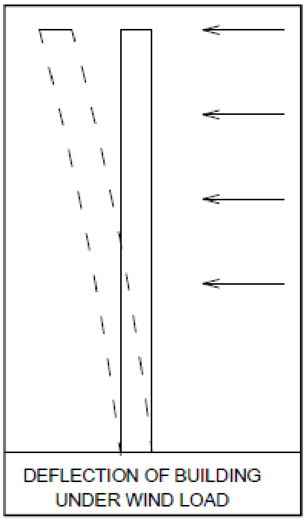


Fig-7 Deflection of the building under wind load

1.2 Scope of Present Work

The main objective of this study is to analyse the various types of elevated water tank to find out the minimum and maximum node displacement due to earthquake and due to wind forces. Liquid storage tanks are used in industries for storing chemicals, petroleum products, and for storing water in public water distribution systems. Behavior of liquid storage tanks under earthquake loads has been studied as per Draft code Part II of IS 1893:2002. A FEM based computer software (STAAD-PRO) used for seismic analysis of tanks which gives the earthquake induced forces on tank systems. Draft code Part II of IS 1893:2002 which will contain provisions for all types of liquid storage tanks. Under earthquake loads, a complicated pattern of stresses is generated in the tanks. Poorly designed tanks have leaked, buckled or even collapsed during earthquakes. Common modes of failure are wall buckling, sloshing damage to roof, inlet/outlet pipe breaks and implosion due to rapid loss of contents. Elevated water tanks should be competent of keeping the expected performance during and after earthquake. It has large mass concentrated at the top of slender supporting structure hence extremely vulnerable against horizontal forces due to earthquake. Staging is formed by a group of columns and horizontal braces provided at intermediate levels to reduce the effective length of the column. In this research, various types of elevated water tanks are analysed by using finite modelling techniques. This paper presents the study of seismic performance and wind load performance of the elevated water tanks for same intake capacity. The effect of elemental properties, earthquake effects and wind effects on nodal displacement have been presented in this paper with the help of analysis of four models for same intake capacity ie 400 Cum. Analysis is carried out by using finite element software STAAD-PRO. Then finally the values are represented in the form of tables and graphs.

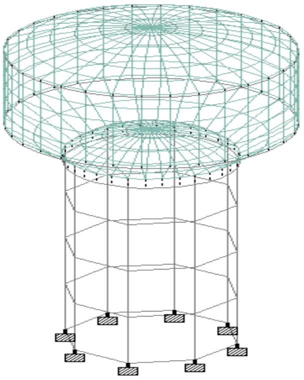
2. LITERATURE REVIEW

Various literatures has presented in the form of technical papers till date on the Wind and Seismic analysis of Elevated Water Tanks. Various issues and the points are covered in that analysis.i.e wind speed of various cities as per seismic zones, hydrodynamic pressure, and dynamic response of framed staging etc. Some of those are discussed below:

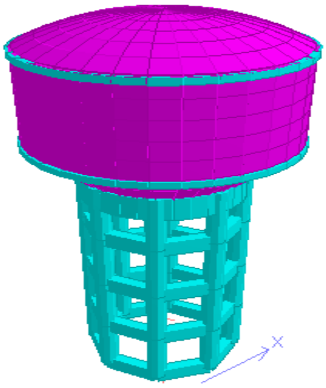
- **Khaza Mohiddin Shaikh and Prof. Vasugi K (2014) conclude that:** Analysis & Design of elevated water tanks against earthquake effect is of considerable importance. These structures must remain functional even after an earthquake. Most elevated water tank are never completely filled with water. Hence, a two- mass idealization of the tank is more appropriate as compared to one-mass idealization.
- **R.K.Prasad and Akshaya B. Kamdi (2012):** BIS has brought out the revised version of IS 3370 (part-1 & 2) after a long time from its 1965 version in year 2009. This revised code is mainly drafted for the liquid storage tank. This paper gives in brief, the theory behind the design of circular water tank using WSM and LSM. Design of water tank by LSM is most economical as the quantity of material required is less as compared to WSM. Water tank is the most important container to store water therefore, Crack width calculation of water tank is also necessary.
- **Hasan Jasim Mohammed (2011), conclude that:** An application of optimization method to the structural design of concrete rectangular and circular water tanks, considering the total cost of the tank as an objective function with the properties of the tank that are tank capacity, width and length of tank in rectangular, water depth in circular, unit weight of water and tank floor slab thickness, as design variables.
- **Pavan S. Ekbote and Dr. Jagdish G. Kori:** During earthquake elevated water tanks were heavily damages or collapsed. This was might be due to the lack of knowledge regarding the behavior of supporting system of the water tanks again dynamic action and also due to improper geometrical selection of staging patterns of tank. Due to the fluid structure interactions, the seismic behavior of elevated water tanks has the characteristics of complex phenomena. The main aim of this study is to understand the behavior of supporting system (or staging) which is more effective under different response spectrum method with SAP 2000 software. In this paper different supporting systems such as cross and radial bracing studied.

3. ANALYSIS OF ELEVATED WATER TANK

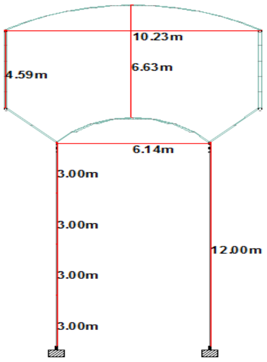
3.1 Analysis of Intz Water Tank



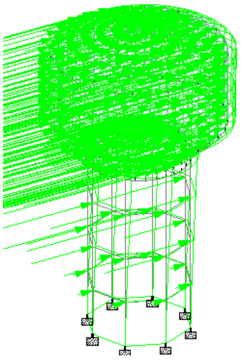
Model 3D



Rendered View



Dimensional View



Whole Structure Load Displacement

3.1a Primary Load Cases

Number	Name	Type
1	EL	Seismic
2	DL	Dead
3	LL	Live
4	HYD.L	Live

3.1b Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
5	1.5 (DL+LL+HYD.L)	2	DL	1.50
		3	LL	1.50
		4	HYD.L	1.50
6	1.2 (DL+LL+HYD.L)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
7	1.2 (DL+LL+HYD.L+EL)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
		1	EL	1.20
8	1.2 (DL+LL+HYD.L-	2	DL	1.20

	EL)	3	LL	1.20
		4	HYD.L	1.20
		1	EL	-1.20
9	1.5 (DL)	2	DL	1.50
10	1.5 (DL+EL)	2	DL	1.50
		1	EL	1.50
11	1.5 (DL-EL)	2	DL	1.50
		1	EL	-1.50
12	0.9 DL+1.5 EL	2	DL	0.90
		1	EL	1.50
13	0.9 DL-1.5 EL	2	DL	0.90
		1	EL	-1.50

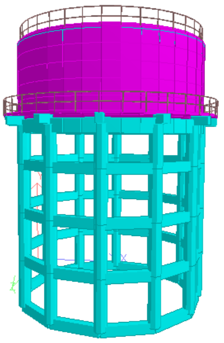
CASE 1	**SEISMIC ANALYSIS IN X DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	353	10 1.5 (DL+EL)	6.636
Min X	353	11 1.5 (DL-EL)	6.636
Max Y	161	1 EL	4.214
Min Y	161	8 1.2 (DL+LL+HYD.L-EL)	5.462
Max Z	9	5 1.5 (DL+LL+HYD.L)	1.673
Min Z	25	5 1.5 (DL+LL+HYD.L)	1.673
Max rX	393	5 1.5 (DL+LL+HYD.L)	1.457
Min rX	409	5 1.5 (DL+LL+HYD.L)	1.457
Max rY	434	12 0.9 DL+1.5 EL	5.119
Min rY	418	10 1.5 (DL+EL)	5.153
Max rZ	519	11 1.5 (DL-EL)	3.769
Min rZ	515	10 1.5 (DL+EL)	3.768
Max Rst	313	11 1.5 (DL-EL)	6.663

CASE 2	**SEISMIC ANALYSIS IN Z DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	17	5 1.5 (DL+LL+HYD.L)	1.673
Min X	1	5 1.5 (DL+LL+HYD.L)	1.673
Max Y	185	1 EL	3.219
Min Y	185	8 1.2 (DL+LL+HYD.L-EL)	4.315
Max Z	337	10 1.5 (DL+EL)	5.106
Min Z	321	11 1.5 (DL-EL)	5.106
Max rX	521	10 1.5 (DL+EL)	2.89
Min rX	517	11 1.5 (DL-EL)	2.89
Max rY	426	12 0.9 DL+1.5 EL	3.921
Min rY	442	10 1.5 (DL+EL)	3.965
Max rZ	417	5 1.5 (DL+LL+HYD.L)	1.457
Min rZ	401	5 1.5 (DL+LL+HYD.L)	1.457
Max Rst	273	11 1.5 (DL-EL)	5.167

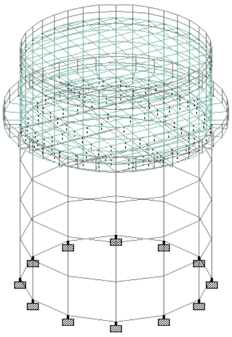
CASE 3	**WINLOAD IN X DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	313	9 1.5 (DL+WL)	2.57
Min X	297	10 1.5 (DL-WL)	2.569
Max Y	161	1 WL	1.485
Min Y	293	5 1.5 (DL+LL+HYD.L)	1.899
Max Z	9	5 1.5 (DL+LL+HYD.L)	1.673
Min Z	25	5 1.5 (DL+LL+HYD.L)	1.673
Max rX	393	5 1.5 (DL+LL+HYD.L)	1.457
Min rX	409	5 1.5 (DL+LL+HYD.L)	1.457
Max rY	528	10 1.5 (DL-WL)	1.047
Min rY	528	9 1.5 (DL+WL)	1.097
Max rZ	417	5 1.5 (DL+LL+HYD.L)	1.457
Min rZ	401	5 1.5 (DL+LL+HYD.L)	1.457
Max Rst	281	10 1.5 (DL-WL)	2.632

CASE 4	**WINLOAD IN Z DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	17	5 1.5 (DL+LL+HYD.L)	1.673
Min X	1	5 1.5 (DL+LL+HYD.L)	1.673
Max Y	185	1 WL	1.182
Min Y	293	5 1.5 (DL+LL+HYD.L)	1.899
Max Z	305	9 1.5 (DL+WL)	2.176
Min Z	289	10 1.5 (DL-WL)	2.176
Max rX	393	5 1.5 (DL+LL+HYD.L)	1.457
Min rX	409	5 1.5 (DL+LL+HYD.L)	1.457
Max rY	524	9 1.5 (DL+WL)	0.929
Min rY	526	9 1.5 (DL+WL)	0.929
Max rZ	417	5 1.5 (DL+LL+HYD.L)	1.457
Min rZ	401	5 1.5 (DL+LL+HYD.L)	1.457
Max Rst	273	10 1.5 (DL-WL)	2.238

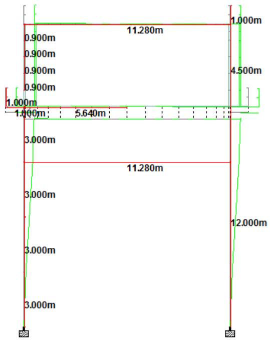
3.2 Analysis of Circular Water Tank



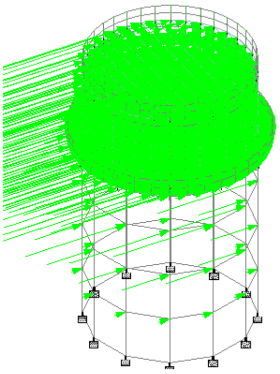
3D Rendered View



Model



Dimensional View



Whole Structure Load Displacement

3.2a Primary Load Cases

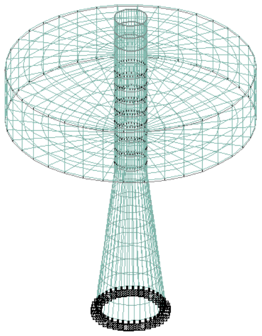
Number	Name	Type
1	WL	Wind
2	DL	Dead
3	LL	Live
4	HYD. L	Live

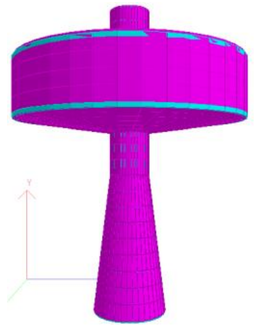
3.2b Combination Load Cases

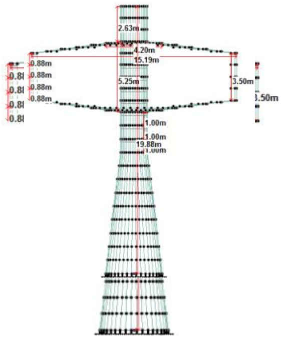
Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
5	1.5 (DL+LL+HYD.L)	2	DL	1.50
		3	LL	1.50
		4	HYD. L	1.50
6	1.2 (DL+LL+HYD.L+WL)	2	DL	1.20
		3	LL	1.20
		4	HYD. L	1.20
		1	WL	1.20
7	1.2 (DL+LL+HYD.L-WL)	2	DL	1.20
		3	LL	1.20
		4	HYD. L	1.20
		1	WL	-1.20
8	1.2 (DL+LL+HYD.L)	2	DL	1.20
		3	LL	1.20
		4	HYD. L	1.20
9	1.5 (DL+WL)	2	DL	1.50
		1	WL	1.50
10	1.5 (DL-WL)	2	DL	1.50
		1	WL	-1.50
11	1.5 (DL)	2	DL	1.50
12	0.9 DL	2	DL	0.90

CASE 1	SEISMIC ANALYSIS IN X DIRECTION		
			Resultant
	Node	L/C	mm
Max X	544	10 1.5 (DL+EL)	5.99
Min X	577	11 1.5 (DL-EL)	6.555
Max Y	650	1 EL	3.79
Min Y	367	5 1.5 (DL+LL+HYD.L)	4.976
Max Z	689	5 1.5 (DL+LL+HYD.L)	0.99
Min Z	695	5 1.5 (DL+LL+HYD.L)	0.991
Max rX	461	5 1.5 (DL+LL+HYD.L)	3.36
Min rX	381	5 1.5 (DL+LL+HYD.L)	3.374
Max rY	542	5 1.5 (DL+LL+HYD.L)	1.29
Min rY	576	11 1.5 (DL-EL)	6.125
Max rZ	482	11 1.5 (DL-EL)	6.367
Min rZ	370	10 1.5 (DL+EL)	6.368
Max Rst	367	10 1.5 (DL+EL)	7.255
CASE 2	SEISMIC ANALYSIS IN Z DIRECTION		
			Resultant
	Node	L/C	mm
Max X	692	5 1.5 (DL+LL+HYD.L)	0.99
Min X	577	5 1.5 (DL+LL+HYD.L)	2.337
Max Y	677	1 EL	3.79
Min Y	367	5 1.5 (DL+LL+HYD.L)	4.976
Max Z	574	10 1.5 (DL+EL)	6.047
Min Z	544	11 1.5 (DL-EL)	6.031
Max rX	461	10 1.5 (DL+EL)	6.367
Min rX	381	11 1.5 (DL-EL)	6.374
Max rY	542	11 1.5 (DL-EL)	6.02
Min rY	576	10 1.5 (DL+EL)	5.973
Max rZ	482	5 1.5 (DL+LL+HYD.L)	3.36
Min rZ	370	5 1.5 (DL+LL+HYD.L)	3.36
Max Rst	367	11 1.5 (DL-EL)	7.255
CASE 3	WINLOAD IN X DIRECTION		
			Res
	Node	L/C	mm
Max X	165	9 1.5 (DL+WL)	2.622
Min X	179	10 1.5 (DL-WL)	2.623
Max Y	222	4 HYD. L	0.051
Min Y	367	5 1.5 (DL+LL+HYD.L)	4.975
Max Z	689	6 1.2 (DL+LL+HYD.L+WL)	1.865
Min Z	695	6 1.2 (DL+LL+HYD.L+WL)	1.897
Max rX	461	5 1.5 (DL+LL+HYD.L)	3.36
Min rX	381	5 1.5 (DL+LL+HYD.L)	3.373
Max rY	335	5 1.5 (DL+LL+HYD.L)	1.376
Min rY	313	5 1.5 (DL+LL+HYD.L)	1.377
Max rZ	482	5 1.5 (DL+LL+HYD.L)	3.36
Min rZ	370	5 1.5 (DL+LL+HYD.L)	3.36
Max Rst	367	10 1.5 (DL-WL)	5.088
CASE 4	WINLOAD IN Z DIRECTION		
			Resultant
	Node	L/C	mm
Max X	692	6 1.2 (DL+LL+HYD.L+WL)	1.825
Min X	686	6 1.2 (DL+LL+HYD.L+WL)	1.826
Max Y	222	4 HYD. L	0.051
Min Y	367	5 1.5 (DL+LL+HYD.L)	4.975
Max Z	154	9 1.5 (DL+WL)	2.53
Min Z	172	10 1.5 (DL-WL)	2.534
Max rX	461	5 1.5 (DL+LL+HYD.L)	3.36
Min rX	381	5 1.5 (DL+LL+HYD.L)	3.373
Max rY	335	5 1.5 (DL+LL+HYD.L)	1.376
Min rY	313	5 1.5 (DL+LL+HYD.L)	1.377
Max rZ	482	5 1.5 (DL+LL+HYD.L)	3.36
Min rZ	370	5 1.5 (DL+LL+HYD.L)	3.36
Max Rst	367	10 1.5 (DL-WL)	5.046

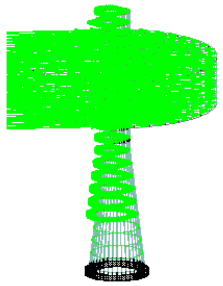
3.3 Analysis of Shell Water Tank


Model


3D Rendered View



Dimensional View


Whole Structure Load Displacement

3.3a Primary Load Cases

Number	Name	Type
1	EL	Seismic
2	DL	Dead
3	LL	Live
4	HYD.L	Live

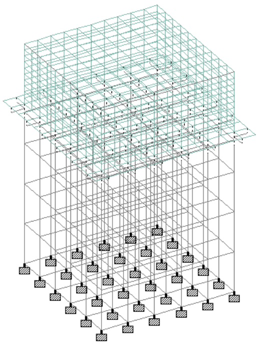
3.3b Combination Load Cases

Comb.	**Combination L/C Name**	**Primary**	**Primary L/C Name**	**Factor**
5	1.5 (DL+LL+HYD.L)	2	DL	1.50
		3	LL	1.50
		4	HYD.L	1.50
6	1.2 (DL+LL+HYD.L)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
7	1.2 (DL+LL+HYD.L+EL)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
		1	EL	1.20
8	1.2 (DL+LL+HYD.L-EL)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
		1	EL	-1.20
9	1.5 DL	2	DL	1.50
10	1.5 (DL+EL)	2	DL	1.50
		1	EL	1.50
11	1.5 (DL-EL)	2	DL	1.50
		1	EL	-1.50
12	0.9 DL+1.5 EL	2	DL	0.90
		1	EL	1.50
13	0.9 DL-1.5 EL	2	DL	0.90
		1	EL	-1.50

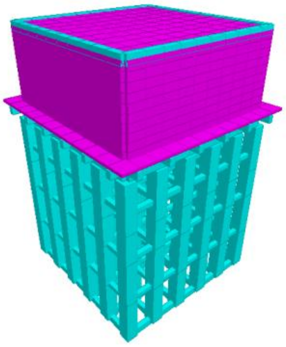
CASE 1	**SEISMIC ANALYSIS IN X DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	26	10 1.5 (DL+EL)	8.316
Min X	749	11 1.5 (DL-EL)	8.316
Max Y	6	1 EL	4.112
Min Y	729	7 1.2 (DL+LL+HYD.L+EL)	13.733
Max Z	348	5 1.5 (DL+LL+HYD.L)	11.646
Min Z	1070	5 1.5 (DL+LL+HYD.L)	11.646
Max rX	402	5 1.5 (DL+LL+HYD.L)	5.076
Min rX	1124	5 1.5 (DL+LL+HYD.L)	5.073
Max rY	375	11 1.5 (DL-EL)	1.016
Min rY	375	12 0.9 DL+1.5 EL	0.882
Max rZ	21	8 1.2 (DL+LL+HYD.L-EL)	6.262
Min rZ	744	7 1.2 (DL+LL+HYD.L+EL)	6.29
Max Rst	725	7 1.2 (DL+LL+HYD.L+EL)	13.925

CASE 2	**SEISMIC ANALYSIS IN Z DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	728	5 1.5 (DL+LL+HYD.L)	11.673
Min X	5	5 1.5 (DL+LL+HYD.L)	11.618
Max Y	1109	1 EL	4.103
Min Y	387	7 1.2 (DL+LL+HYD.L+EL)	13.698
Max Z	1129	10 1.5 (DL+EL)	8.316
Min Z	407	11 1.5 (DL-EL)	8.316
Max rX	402	7 1.2 (DL+LL+HYD.L+EL)	6.272
Min rX	1124	8 1.2 (DL+LL+HYD.L-EL)	6.269
Max rY	33	13 0.9 DL-1.5 EL	0.893
Min rY	755	11 1.5 (DL-EL)	0.999
Max rZ	21	5 1.5 (DL+LL+HYD.L)	5.064
Min rZ	744	5 1.5 (DL+LL+HYD.L)	5.085
Max Rst	383	7 1.2 (DL+LL+HYD.L+EL)	13.889
CASE 3	**WINLOAD IN X DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	2	9 1.5 (DL+WL)	6.86
Min X	725	10 1.5 (DL-WL)	6.861
Max Y	6	1 WL	0.645
Min Y	691	5 1.5 (DL+LL+HYD.L)	11.677
Max Z	348	5 1.5 (DL+LL+HYD.L)	11.646
Min Z	1070	5 1.5 (DL+LL+HYD.L)	11.646
Max rX	402	5 1.5 (DL+LL+HYD.L)	5.076
Min rX	1124	5 1.5 (DL+LL+HYD.L)	5.073
Max rY	1411	5 1.5 (DL+LL+HYD.L)	11.599
Min rY	1135	10 1.5 (DL-WL)	0.58
Max rZ	21	5 1.5 (DL+LL+HYD.L)	5.064
Min rZ	744	5 1.5 (DL+LL+HYD.L)	5.085
Max Rst	691	5 1.5 (DL+LL+HYD.L)	11.677
CASE 4	**WINLOAD IN Z DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	728	5 1.5 (DL+LL+HYD.L)	11.693
Min X	5	5 1.5 (DL+LL+HYD.L)	11.637
Max Y	1071	1 WL	0.68
Min Y	691	5 1.5 (DL+LL+HYD.L)	11.696
Max Z	1105	9 1.5 (DL+WL)	6.854
Min Z	383	10 1.5 (DL-WL)	6.855
Max rX	402	5 1.5 (DL+LL+HYD.L)	5.083
Min rX	1124	5 1.5 (DL+LL+HYD.L)	5.08
Max rY	1411	7 1.2 (DL+LL+HYD.L-WL)	9.426
Min rY	755	10 1.5 (DL-WL)	0.578
Max rZ	21	5 1.5 (DL+LL+HYD.L)	5.071
Min rZ	744	5 1.5 (DL+LL+HYD.L)	5.092
Max Rst	691	5 1.5 (DL+LL+HYD.L)	11.696

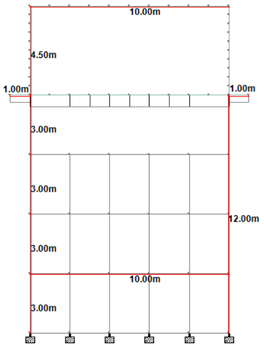
3.4 Analysis of Square Water Tank



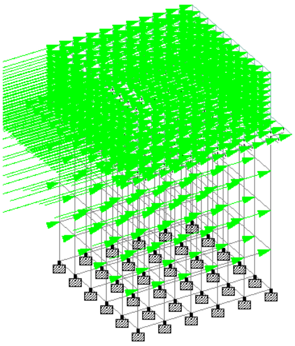
Model



3D Rendered View



Dimensional View



Whole Structure Load Displacement

3.4a Primary Load Cases

Number	Name	Type
1	WL	Wind
2	DL	Dead
3	LL	Live
4	HYD.L	Live

3.4b Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
5	1.5 (DL+LL+HYD.L)	2	DL	1.50
		3	LL	1.50
		4	HYD.L	1.50
6	1.2 (DL+LL+HYD.L +WL)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
		1	WL	1.20
7	1.2 (DL+LL+HYD.L-WL)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
		1	WL	-1.20
8	1.2 (DL+LL+HYD.L)	2	DL	1.20
		3	LL	1.20
		4	HYD.L	1.20
9	1.5 (DL+WL)	2	DL	1.50
		1	WL	1.50
10	1.5 (DL-WL)	2	DL	1.50
		1	WL	-1.50
11	1.5 (DL)	2	DL	1.50
12	0.9 DL	2	DL	0.90

CASE 1	SEISMIC ANALYSIS IN X DIRECTION		
			Resultant
	Node	L/C	mm
Max X	409	10 1.5 (DL+EL)	3.779
Min X	83	11 1.5 (DL-EL)	3.785
Max Y	1020	4 HYD.L	0.173
Min Y	562	5 1.5 (DL+LL+HYD.L)	4.639
Max Z	296	5 1.5 (DL+LL+HYD.L)	1.088
Min Z	186	5 1.5 (DL+LL+HYD.L)	1.085
Max rX	559	5 1.5 (DL+LL+HYD.L)	2.741
Min rX	565	5 1.5 (DL+LL+HYD.L)	2.741
Max rY	396	5 1.5 (DL+LL+HYD.L)	0.817
Min rY	404	5 1.5 (DL+LL+HYD.L)	0.816
Max rZ	589	5 1.5 (DL+LL+HYD.L)	2.739
Min rZ	535	5 1.5 (DL+LL+HYD.L)	2.738
Max Rst	562	11 1.5 (DL-EL)	4.958
CASE 2	**SEISMIC ANALYSIS IN Z DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	400	5 1.5 (DL+LL+HYD.L)	1.079
Min X	72	5 1.5 (DL+LL+HYD.L)	1.091
Max Y	1020	4 HYD.L	0.173
Min Y	562	5 1.5 (DL+LL+HYD.L)	4.639
Max Z	306	10 1.5 (DL+EL)	3.78
Min Z	196	11 1.5 (DL-EL)	3.778
Max rX	559	5 1.5 (DL+LL+HYD.L)	2.741
Min rX	565	5 1.5 (DL+LL+HYD.L)	2.741
Max rY	396	5 1.5 (DL+LL+HYD.L)	0.817
Min rY	404	5 1.5 (DL+LL+HYD.L)	0.816
Max rZ	589	5 1.5 (DL+LL+HYD.L)	2.739
Min rZ	535	5 1.5 (DL+LL+HYD.L)	2.738
Max Rst	562	10 1.5 (DL+EL)	4.955
CASE 3	**WINLOAD IN X DIRECTION**		
			Resultant
	Node	L/C	mm
Max X	409	9 1.5 (DL+WL)	2.757
Min X	83	10 1.5 (DL-WL)	2.777
Max Y	1020	4 HYD.L	0.173
Min Y	562	5 1.5 (DL+LL+HYD.L)	4.639
Max Z	296	5 1.5 (DL+LL+HYD.L)	1.088
Min Z	186	5 1.5 (DL+LL+HYD.L)	1.085
Max rX	559	5 1.5 (DL+LL+HYD.L)	2.741
Min rX	565	5 1.5 (DL+LL+HYD.L)	2.741
Max rY	396	5 1.5 (DL+LL+HYD.L)	0.817
Min rY	404	5 1.5 (DL+LL+HYD.L)	0.816
Max rZ	589	5 1.5 (DL+LL+HYD.L)	2.739
Min rZ	535	5 1.5 (DL+LL+HYD.L)	2.738
Max Rst	562	5 1.5 (DL+LL+HYD.L)	4.639

CASE 4	WINLOAD IN Z DIRECTION		
			Resultant
	Node	L/C	mm
Max X	400	5 1.5 (DL+LL+HYD.L)	1.079
Min X	72	5 1.5 (DL+LL+HYD.L)	1.091
Max Y	1020	4 HYD.L	0.173
Min Y	562	5 1.5 (DL+LL+HYD.L)	4.639
Max Z	306	9 1.5 (DL+WL)	2.602
Min Z	196	10 1.5 (DL-WL)	2.613
Max rX	559	5 1.5 (DL+LL+HYD.L)	2.741
Min rX	565	5 1.5 (DL+LL+HYD.L)	2.741
Max rY	396	5 1.5 (DL+LL+HYD.L)	0.817
Min rY	404	5 1.5 (DL+LL+HYD.L)	0.816
Max rZ	589	5 1.5 (DL+LL+HYD.L)	2.739
Min rZ	535	5 1.5 (DL+LL+HYD.L)	2.738
Max Rst	562	5 1.5 (DL+LL+HYD.L)	4.639

4. CONCLUSION AND RESULTS

Conclusion No 1) Circular Water Tank-

The minimum deflection is 0.051 mm and the maximum deflection is 7.255mm. The average deflection is in between 1.825 to 5.088 mm. Therefore the Circular water tank is suitable for intake capacity.

Conclusion No 2) Intz Water Tank-

The minimum deflection is 0.929 mm and the maximum deflection is 6.663mm. The average deflection is in between 3.219 to 3.768 mm. Therefore the Intz water tank is suitable for intake capacity.

Conclusion No 3) Shell Water Tank-

The minimum deflection is 0.578 mm and the maximum deflection is 13.925mm. The average deflection is in between 6.86 to 6.29 mm. Therefore the Shell water tank is suitable for intake capacity

Conclusion No 4) Square Water Tank-

The minimum deflection is 0.173 mm and the maximum deflection is 4.958 mm. The average deflection is in between 1.079 to 2.739 mm. Therefore the Squarer water tank is suitable for intake capacity.

TYPES OF WATER TANK	DEFLECTION IN MM			
	MINIMUM	MAXMUM	AVERAGE	
CIRCULAR	0.051	7.255	1.825	5.088
INTZ	0.929	6.663	3.219	3.768
SHELL	0.578	13.925	6.290	6.860
SQUARE	0.173	4.958	1.079	2.739

Result No 1)

As per analysis of various types of water tank, suitable and safe water tanks are Intz Water Tank and Square Water Tank. The range of deflection is in between 0.929 to 3.768 mm

INTZ WATER TANK		
ELEMENTS	SIZES IN MM	
PROPERTIES	(THK/DEPTH)	WIDTH
TOP SPHERICAL DOME (THK)		
TOWARDS CENTRE	0.10	
MIDDLE	0.15	
MIDDLE	0.16	
TOWARDS RING BEAM	0.20	
TOP RING BEAM (DXB)	0.50	0.30
CYLINDRICAL WALL (THK)		
TOWARDS TOP	0.30	
TOWARDS BOTTOM	0.32	
BOTTOM CONICAL DOME (THK)		
TOP	0.32	
BOTTOM RING BEAM (DXB)	0.50	0.30
BOTTOM SPHERICAL DOME (THK)		
TOWARDS CENTRE	0.18	
MIDDLE	0.26	
MIDDLE	0.28	
TOWARDS RING BEAM	0.32	
GIRDER BEAM (DXB)	0.50	1.20
COLUMNS (DIA)	0.80	
BRACING (DXB)	0.80	0.50

SHELL WATER TANK		
ELEMENTS	SIZES IN MM	
PROPERTIES	(THK/DEPTH)	WIDTH
CYLINDRICAL WALL (THK)	0.25	
BOTTOM DOME (THK)		
TOWARDS BOTTOM	0.50	
MIDDLE	0.54	
TOWARDS CENTRE	0.50	
TOP DOME (THK)		
TOWARDS CENTRE	0.30	
MIDDLE	0.40	
MIDDLE	0.48	
MIDDLE	0.50	
MIDDLE	0.52	
TOWARDS TOP	0.54	
SHELL (THK)	0.60	
TOP CIRCULAR BEAM (DXB)	0.25	0.25
BOTT CIRCULAR BEAM (DXB)	0.25	0.20
SHELL RING BEAM-MIDDLE (DXB)	0.50	0.54
SHELL RING BEAM-BOTTOM (DXB)	0.10	0.54
SHELL RING BEAM-TOP (DXB)	0.10	0.54

CIRCULAR WATER TANK		
ELEMENTS	SIZES IN MM	
PROPERTIES	(THK/DEPTH)	WIDTH
CYLINDRICAL WALL (THK)	0.36	
BOTTOM SLAB (THK)	0.25	
CANTILIVER SLAB (THK)	0.15	
TOP SLAB (THK)		
TOWARDS BEAM	0.35	
MIDDLE	0.34	
MIDDLE	0.33	
MIDDLE	0.32	
MIDDLE	0.31	
MIDDLE	0.30	

MIDDLE	0.28	
TOWARDS CENTRE	0.26	
TOP CIRCULAR BEAM (DXB)	0.60	0.35
BOTT SLAB BEAMS (DXB)	0.80	0.40
CANTILIVER SLAB BEAM (DXB)	0.50	0.40
COLUMNS (DIA)	0.70	
BRACINGS (DXB)	0.60	0.40

SQUARE WATER TANK		
ELEMENTS	SIZES IN MM	
PROPERTIES	(THK/DEPTH)	WIDTH
TOP SLAB (THK)		
FROM CENTRE	0.26	
	0.28	
	0.30	
	0.35	
	0.38	
BOTTOM SLAB (THK)	0.30	
RETAINING WALL (THK)	0.38	
CANTILIVER SLAB (THK)	0.15	
TOP SLAB BEAM (DXB)	0.50	0.35
BOTTOM SLAB BEAM (DXB)	0.90	0.45
COLUMNS (LXB)	0.75	0.75
BRACINGS (DXB)	0.30	0.30
CANT BEAM (DXB)	0.30	0.45
GIRDER BEAM (DXB)	0.30	0.45

ELEMENT PROPERTIES OF WATER TANK (SIZES IN MM)			
INTZ	SQUARE	INTZ	SQUARE
TOP SPHERICAL DOME (THK)	TOP SLAB (THK)		
TOWARDS CENTRE	FROM CENTRE	0.10	0.26
MIDDLE		0.15	0.28
MIDDLE		0.16	0.30
TOWARDS RING BEAM		0.20	0.35
TOP RING BEAM (DXB)		0.50	0.38
CYLINDRICAL WALL (THK)	BOTTOM SLAB (THK)		0.30
TOWARDS TOP	RETAINING WALL (THK)	0.30	0.38
TOWARDS BOTTOM	CANTILIVER SLAB (THK)	0.32	0.15
BOTTOM CONICAL DOME (THK)	TOP SLAB BEAM (DXB)		0.50
TOP	BOTTOM SLAB BEAM (DXB)	0.32	0.90
BOTTOM RING BEAM (DXB)	COLUMNS (LXB)	0.50	0.75
BOTTOM SPHERICAL DOME (THK)	BRACINGS (DXB)		0.30
TOWARDS CENTRE	CANT BEAM (DXB)	0.18	0.30
MIDDLE	GIRDER BEAM (DXB)	0.26	0.30
MIDDLE		0.28	
TOWARDS RING		0.32	

BEAM			
GIRDER BEAM (DXB)		0.50	
COLUMNS (DIA)		0.80	
BRACING (DXB)		0.80	

Result No 2)

As per element propertiwise the economical water tank is square water tank but as per the analysis the suitable design is recommended for Intz Water Tank

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