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COMPARATIVE ANALYSIS OF ELEVATED STEEL WATER TANK WITH DIFFERENT GEOMETRY

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ABSTRACT

Elevated steel water tanks are one of the most important in the daily requirement. They are vital component in municipal water system, firefighting systems and in many industrial facilities for storage of water. Present study deals with the comparative analysis of three basic shapes of water tank Rectangular, Square and Circular shape tank. The parametric study suggest that the elevated circular tanks performs better than elevated rectangular & square tank. Objective of this paper is to understand the behavior of elevated steel water tanks under seismic & wind loading.

Keywords: Elevated Steel Water Tank, Rectangular, Square, Circular, STAAD Pro Vi8, Seismic Analysis, Wind Analysis.

I. INTRODUCTION

An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to provide sufficient pressure in the water distribution system. The elevated water tank is also known as a water tower. The function of water tower is to pressurize water for distribution. The columns and braces are critical parts so this has to be designed carefully for the wind and earthquake loads. It mainly depends upon the soil condition and dynamic characteristics of the structure. An elevated water tank is important structural aspect used for the water resources for distribution of water with high pressure. It is very necessary for the industrial and factories for the storage of liquid especially in chemical factories.

The steel tank remains totally water tight, when appropriately caulked, while the tank will ceaselessly give inconvenience by spilling. The life of the steel water tank is more than two -fold that of wooden tank. The water tank contains the foundation, column tank and water. The load of water is supported by tank and there both load supported by columns and all these elements will depend on the foundation. The standard code of India IS 875 (part -3) 2015 and IS 1893 (part -1) 2016 is used.

II. METHODOLOGY

In this research, STAAD-PRO Vi8 software is used for the modelling and analysis of different shapes elevated steel water tank in hard, medium & soft soil subjected to seismic & wind load.

Load considered-

1. Dead Load **-**The dead load in a tank includes the self-weight of the structure and all other superimposed dead loads.

2. Water Pressure- The water pressure is triangular or uniformly varying load which is zero at the top and maximum at the bottom of the water tank.

3. Wind Load -Wind load calculations as per IS 875-part3-2015

Basic wind speed (Vb) = 39m/s

Probability factor (k1) =0.97

Terrain category & height factor (k2) =1

Topography factor (k3) = 1

Cyclone factor (k4) =1

Design wind speed (Vz) = Vb*k1*k2*k3*k4 = 37.83 m/s

Design wind pressure (Pz) = 0.6*(Vz)2 = 0.8586 KN/m2

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4. Earthquake load-

Earthquake load calculation (IS 1893-2016 Part-I)

Zone – III

Zone factor (Z) – 0.16

Importance factor (I) – 1

Response Reduction factor (R) – 4

Damping Ratio – 5%

Design horizontal coefficient (An) =Z/2*I/R

= 0.16/2*1/4

= 0.02

Load Combinations-

According to IS 800-2007

Limit state of serviceability

DL±WP

DL± WLX

DL± WLZ

DL± ELX

DL± ELZ

Limit state of strength

1.5(DL+ WP)

1.5(DL± WLX)

1.5(DL± WLZ)

1.5(DL± ELX)

1.5(DL± ELZ)

0.9DL ± 1.5WLX

0.9DL ± 1.5WLZ

0.9DL ± 1.5ELX

0.9DL ± 1.5ELZ

1.2DL ± 1.2WP ± 0.6WLX

1.2DL ± 1.2WP ± 0.6WLZ

1.2DL ± 1.2WP ± 0.6ELX

1.2DL ± 1.2WP ± 0.6ELZ

Model description-

1. Structure - water tank
2. Types – Rectangular, Square and Circular
3. Height – 2.5m
4. Capacity – 70,000 Liters
5. Soil Type – Hard, Medium & soft soil
6. Unit weight of Water (Density) – 10 kN/m3
7. No. of columns –Rectangular-4, Square -4 & Circular – 6
8. Staging height – 8.34 m
9. Bracings – Cross Bracings
10. Material – Steel
11. Supports – Fixed support

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12. Thickness of tank plates – 16mm

Rectangular water tank having the dimension 6.9m x 4.46m with height 2.5m. Similarly Square water tank having the dimension 5.3m x 5.3m with height 2.5m. & Circular water tank having the diameter 5.96m with height 2.5m respectively. The 3D model is done for the analysis and it is considered load pattern accordingly to Indian standards.

III. MODELING AND ANALYSIS

Following are the 3D rendering view of Rectangular, Square & Circular elevated water tank.

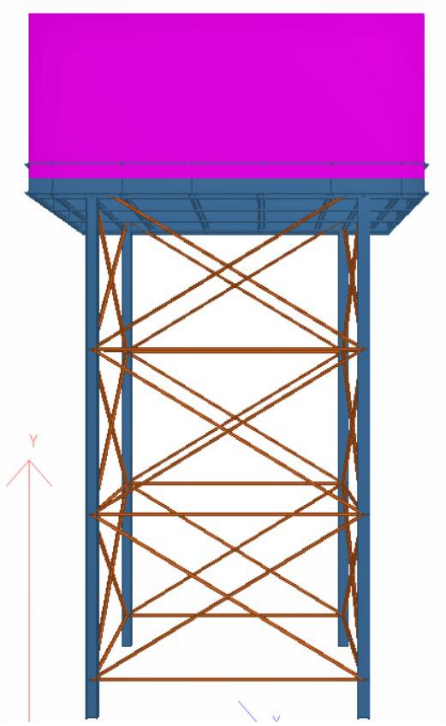

Figure 1: 3D view of Rectangular tank

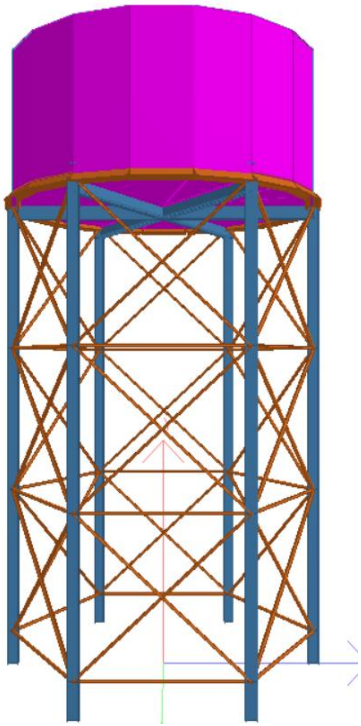

Figure 2: 3D view of Circular tank

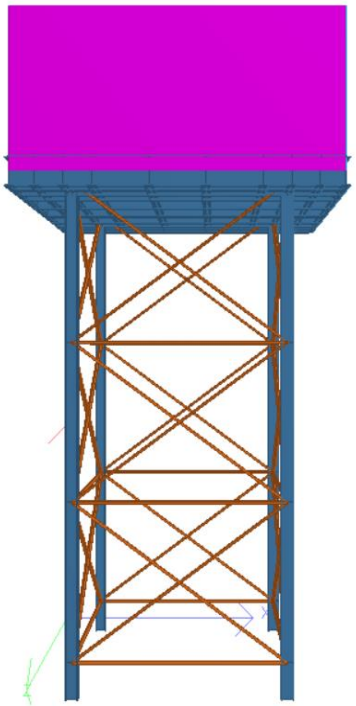

Figure 3: 3D view Square tank

IV. RESULTS AND DISCUSSION

After analysis various models following results were obtained.

Tables & Graph 1. Comparison of Max Axial Forces

	HARD SOIL		
Tanks	Fx	L/c	Beam no
Rectangular	874.783	1.5DL+1.5EQZP	97
Square	1074.55	1.5DL-1.5EQZN	118
Circular	719.257	1.5DL+1.5EQZP	187
	SOFT SOIL		
Tanks	Fx	L/c	Beam no
Rectangular	1079.75	1.5DL+1.5EQZP	97
Square	1331.495	1.5DL-1.5EQZN	118
Circular	913.281	1.5DL+1.5EQXP	188
	MEDIUM SOIL		
Tanks	Fx	L/c	Beam

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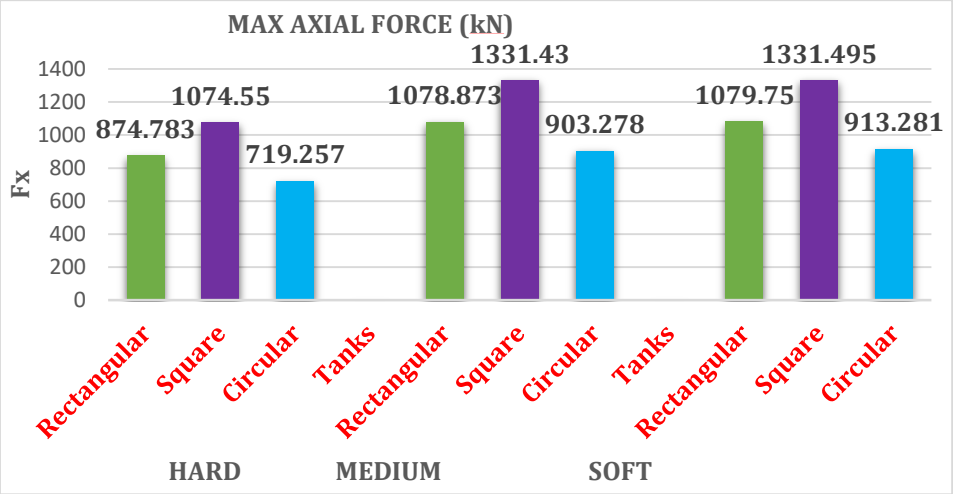
			no
Rectangular	1078.873	1.5DL+1.5EQZP	97
Square	1331.43	1.5DL-1.5EQZN	118
Circular	903.278	1.5DL+1.5EQZP	187



From the above tables and graphs circular tank has lesser axial force value in all hard, medium and soft soil conditions than rectangular and square tank.

Tables & Graph 2. Comparison of Max Shear Forces

	HARD SOIL		
Tanks	Fy	L/c	Beam no
Rectangular	382.593	1.5DL+1.5WP	37
Square	212.383	1.5DL+1.5EQXP	118
Circular	115.41	1.5DL+1.5EQXP	188
	MEDIUM SOIL		
Tanks	Fy	L/c	Beam no
Rectangular	382.51	1.5DL+1.5WP	37
Square	269.037	1.5DL+1.5EQXP	118
Circular	146.331	1.5DL+1.5EQXP	188
	SOFT SOIL		
Tanks	Fy	L/c	Beam no
Rectangular	382.51	1.5DL+1.5WP	37
Square	269.184	1.5DL+1.5EQXP	118
Circular	144.68	1.5DL+1.5EQXP	188

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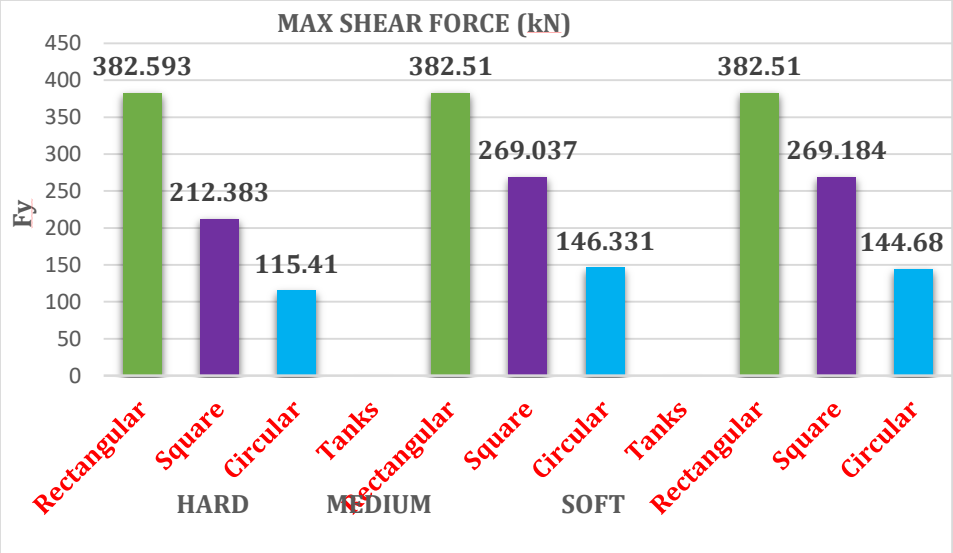

From the above tables and graphs circular tank has lesser shear force value in all hard, medium and soft soil conditions than rectangular and square tank.

Tables & Graph 3. Comparison of Max Bending Moment

	HARD SOIL		
Tanks	Mz	L/c	Beam no
Rectangular	384.373	1.5DL+1.5WP	34
Square	169.613	1.5DL+1.5WP	46
Circular	82.125	1.5DL-1.5EQXN	189
	MEDIUM SOIL		
Tanks	Mz	L/c	Beam no
Rectangular	383.561	1.5DL+1.5WP	34
Square	207.372	1.5DL-1.5EQZN	117
Circular	104.22	1.5DL-1.5EQXN	189
	SOFT SOIL		
Tanks	Mz	L/c	Beam no
Rectangular	383.796	1.5DL+1.5WP	34
Square	200.167	1.5DL-1.5EQXN	117
Circular	98.635	1.5DL-1.5EQXN	190

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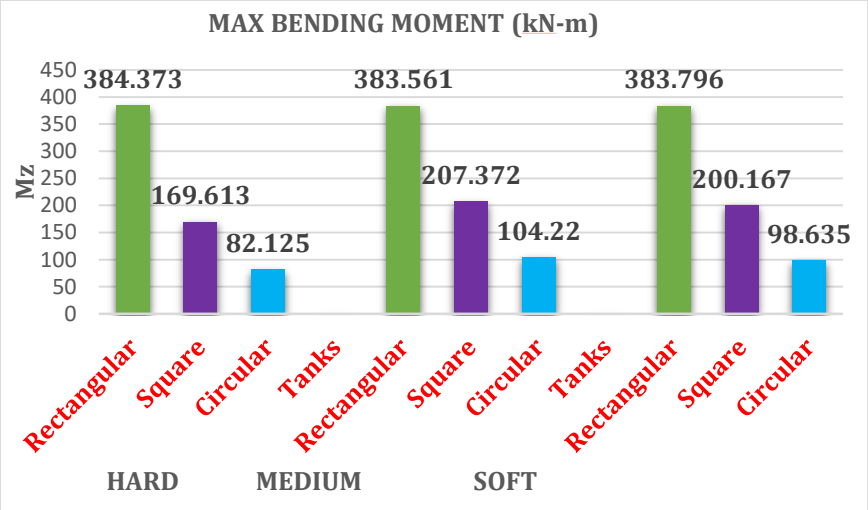

From the above tables and graphs circular tank has lesser bending moment value in all hard, medium and soft soil conditions than rectangular and square tank.

Tables & Graph 4. Comparison of Max Displacement along Z direction

	HARD SOIL		
Tanks	Z	L/c	Node No
Rectangular	16.996	1.5DL+1.5EQZP	11
Square	11.887	1.5DL+1.5EQZP	39
Circular	5.654	1.5DL+1.5EQZP	34
	MEDUIM SOIL		
Tanks	Z	L/c	Node No
Rectangular	21.572	1.5DL+1.5EQZP	11
Square	11.898	1.5DL+1.5EQZP	39
Circular	7.19	1.5DL+1.5EQZP	34
	SOFT SOIL		
Tanks	Z	L/c	Node No
Rectangular	20.468	1.5DL+1.5EQZP	11
Square	12.49	1.5DL+1.5EQZP	39
Circular	6.456	1.5DL+1.5EQZP	34

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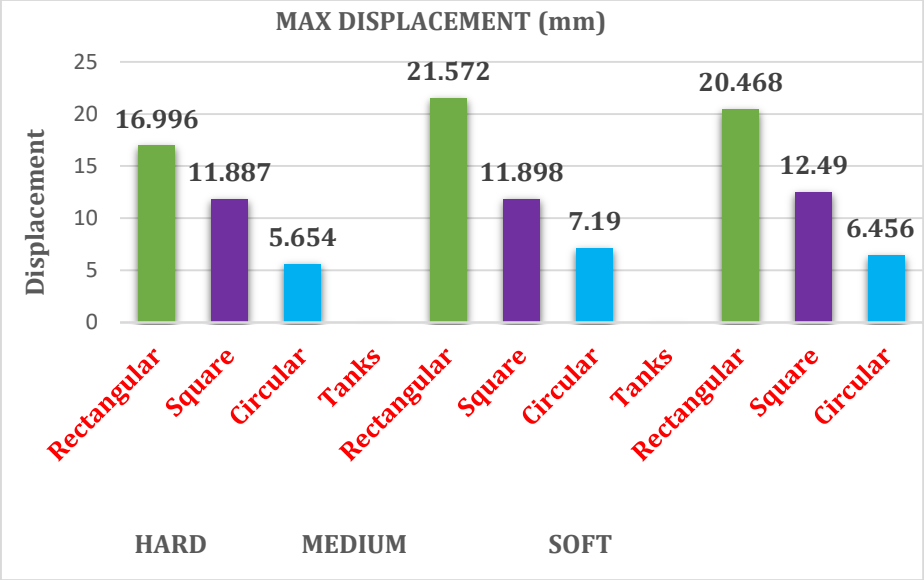

From the above tables and graphs circular tank has lesser displacement value in all hard, medium and soft soil conditions than rectangular and square tank.

V. CONCLUSION

From analysis and above result comparisons following conclusions were drafted

- Change in shape of tank made effect on seismic behavior of tank.
- Change in soil conditions of tank made effect on seismic behavior of tank.
- In the circular elevated water tank with load the displacement, axial force, shear force and bending moment values for hard soil is less compare to rectangular & square tank.
- In the rectangular & square elevated water tank with load the displacement, axial force, shear force and bending moment values for hard soil is less.
- According to soil conditions it conclude that the all structures are stiffer in the hard soil at zone III.
- According to shape circular tank gives better results than rectangular and square tank.

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