Research Paper on Comparative Study on Economical Material for RCC & Steel Water Tank in Different Seismic Zone

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Abstract -Water is kept in tanks that are used as storage bins. Projects involving the supply of water are crucial for the nation's social and industrial growth. One major natural disaster that can disrupt daily life for people is an earthquake. This is because earthquakes harm infrastructure and are a lifeline for all facilities. Elevated water tanks are crucial for providing drinking water and putting out fires since they do not collapse after an earthquake. If we look at the experience of a few earthquakes that happened in India, such as the Bhuj earthquake (2001), we can observe that RCC water tanks elevated were more severely damaged, and some water tanks actually fell. The primary goal of this research is to measure the elevated reinforced concrete water tank's performance under dynamic load. Additionally, variations in dynamic reactions, including base shear, overturning moment, displacement, and others, were also examined in relation to changes in staging height, water tank capacity, seismic zone, and soil conditions. Key Words: water tank, Earthquake

Introduction

The primary function of a water tank is to store water for daily consumption by humans and other living things. The most crucial component for all types of living things in the earth is water. Elevated water tanks are necessary to supply the enormous demand for water with enoughstatic head to reach the appropriate place while being affected by gravity. The rapid growth in the human population raised the need for drinking water. The area covered for water supply determines the height of the elevated water tank. If the area to be covered is larger, the tank's height must be higher. Natural disasters including earthquakes, droughts, floods, and cyclones, among others, affect India quite severely. The worst natural disaster is this earthquake, among others. Natural disasters cause significant property loss and several fatalities each year. It is understood that natural disasters do not necessarily result in mortality; rather, poorly built structures do. elevated water tank with a large mass and a thin supporting structure.

Importance of Research Topic

The frame type structure is the most effective and commonly used for staging in practice. The most important factors of components of frame type staging are columns and the braces. In this system of frame staging, columns are arranged on the periphery and it is connected in such a way that internally by bracing at various levels. These staging acting like bridge between container and foundation for the transfer of loads acting on the tank. In these elevated water tanks, the head requirement for distribution of water supply is satisfied by adjusting the height of the staging portion. This type of frame staging is about superior for shaft type staging for lateral resistance because of there huge redundancy and more capacity to absorb seismic energy through the inelastic actions. These framed staging have many flexural members in the form of braces and columns for to resist lateral loads. The below fig. shows that elevated circular watertank supported on frame staging.

Objective

- To analyzed and design the RCC water tank in different seismic zone.
- To analyzed and design the steel water tank in different seismic zone.
- To calculate the all eight quantity of RCC and steel water tank.
- Comparison of result

Problem Statement

- To design a overhead circular water tank for capacity 150000lit. Design the water tank using M35, fe500 grade of steel, design using RCC & steel compare the result.

Properties

- Height of water tank – 10m
- Diameter of water tank – 10m

Seismic Parameter

Zone	I	II	III	IV
Zone Factor	0.1	0.16	0.24	0.36
Response Reduction Factor	1.5	1.5	1.5	1.5
Important Factor	1	1	1	1
Rock & Soil Silt Factor	1	1	1	1

Load

- EQX
- EQZ
- Dead Load
- Live Load

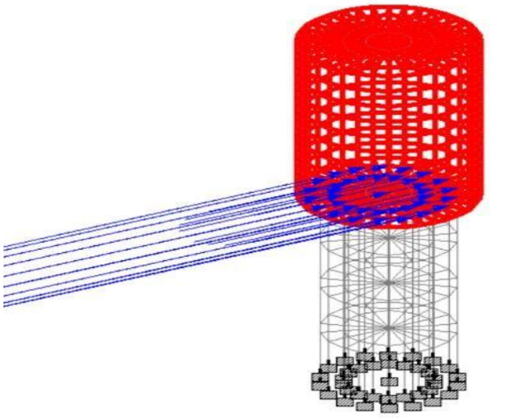

Fig.1 Seismic force in X-direction

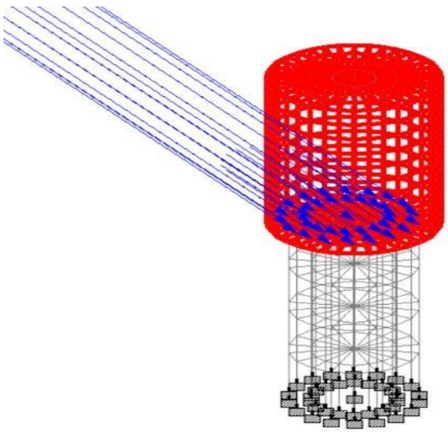

Fig.2 Seismic force in Z-direction

Dead Load

- Dead Load Tank
- Dead Load Tank Staging

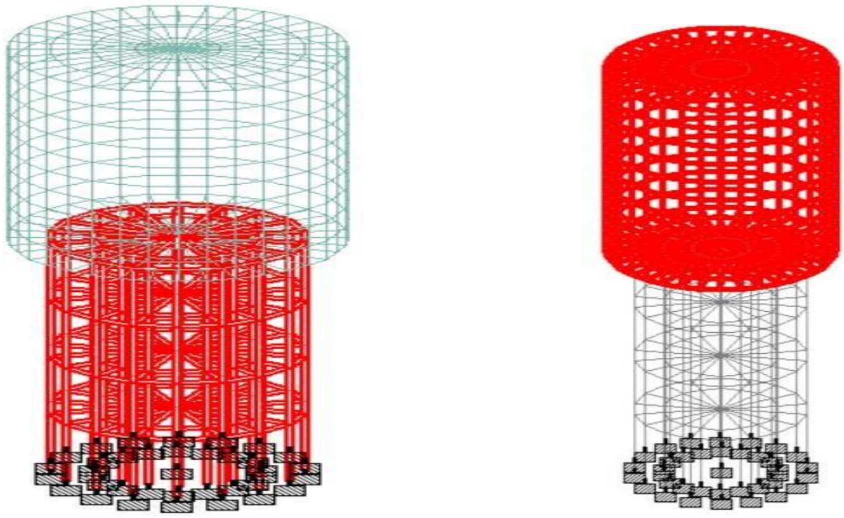

Fig.3 Water tank

Live Load

- Height = 10m
- density = 10KN/m²

➢ Total load of water at base of tank wall = r*H

=10*10

=100KN/m²

➢ Calculation of water pressure at different height

Height	Pressure
0	0
1	10
2	20
3	30
4	40
5	50
6	60
7	70
8	80
9	90
10	100

Load Combination

- The water tank is analyzed for seismic loading. The seismic load is calculated on the tank using criteria as per IS code i.e,

DL of tank + 0.33DL of tank staging

Tank in full condition

- 1.5(DL+LL)
- 1.2(DL+LL+EQX)
- 1.2(DL+LL-EQX)
- 1.2(DL+LL+EQZ)
- 1.2(DL+LL-EQZ)
- 1.5(DL+EQX)
- 1.5(DL-EQX)
- 1.5(DL+EQZ)
- 1.5(DL-EQZ)
- (0.9DL+1.5EQX)
- (0.9DL-1.5EQX)
- (0.9DL+1.5EQZ)
- (0.9DL+1.5EQZ)
- (0.9DL+1.5EQZ)
- **Tank empty condition**
- 1.5DL
- 1.2(DL+EQX)
- 1.2(DL-EQX)
- 1.2(DL+EQZ)
- 1.2(DL-EQZ)

Design of concrete

- Clear-Distance from surface of member to edge reinforcements.
- Beam = 0.025
- Column =0.040
- FC –Compressive strength of concrete = 35MPa
- FY_{main}-Yield strength of main reinforcement = 500MPa
- FY_{sec} -Yield strength of shear reinforcement = 415MPa

Thickness calculation for steel water tank

- Thickness of steel water tank $t = \frac{9.81*H*D}{2n*\sigma}$

$t = \frac{9.81*10*10}{2*0.7*120}$

t = 6mm

Analysis & Design of steel water tank

Zone	II	III	IV	V
Maximum Beam Size	0.23*0.45	0.45*0.23	0.23*0.60	0.23*0.65
Maximum column size	1	1	1.10	1.20

Analysis & Design of RCC water tank

Zone		II	III	IV	V
Maximum Beam Size	Flange Size	800*12	800*12	800*12	1000*12
	Web Size	400*12	500*12	550*12	550*12
Maximum Column Size	Flange Size	800*12	800*12	800*12	1000*12
	Web Size	400*12	500*12	550*12	550*12

RESULT

- Maximum Node Displacement for zone-II RCC STEEL

Node	X - Y - Z	X - Y - Z
20	28.02 - 2.2 - 0.43	48.15 - 7.50 - 2.48
28	27.92 - 4.37 - 0.43	45.18 - 4.84 - 2.48
12	27.99 - 3.71 - 0.41	46.84 - 4.28 - 3.23
4	27.80 - 4.96 - 0.42	43.78 - 4.10 - 2.30

- Maximum Node Displacement Zone -III RCC STEEL

Node	X - Y - Z	X - Y - Z
20	24.51 – 2.87 – 0.58	27.22 – 5.24 – 2.67
28	24.40 – 4.29 – 0.58	25.38 – 7.40 – 2.19
12	24048 – 3.65 – 0.58	26.42 – 3.26 – 2.26
4	24.38 – 4.71 – 0.58	24.52 – 7.81 – 2.55

- Maximum Node Displacement Zone –IV RCC STEEL

Node	X - Y - Z	X - Y - Z
2	13.48 – 1.88 – 0.59	36.49 – 5.00 – 2.42
28	13.40 – 2.79 – 0.59	24.72 – 7.26 – 2.85
12	13.46 – 2.39 – 0.59	25.73 – 6.34 – 2.87
4	13.34 – 3.05 – 0.59	23.88 – 7.76 – 1.85

- Maximum Node Displacement Zone -V RCC STEEL

Node	X - Y - Z	X - Y - Z
20	12.90 – 1.93 – 0.33	20.107 – 4.737 – 3.26
28	12.82 – 2.88 – 0.66	20.12 – 6.80 – 3.69
12	12.88 – 2.45 – 0.66	21.11 – 5.97 – 5.97
4	12.75 – 3.16 – 0.66	19.30 – 7.25 – 3.17

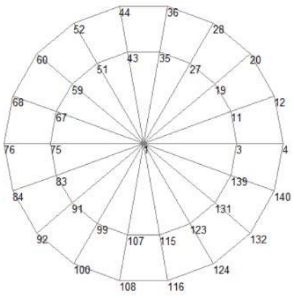

Fig.4 Maximum ENode Displacement

- Column Reaction for Zone-II

Node	RCC	STEEL
726	1812.38	1532.14
727	2147.29	3318.84
728	7766.65	6341.24
729	6341.24	3242.96

- Column Reaction for Zone-III

Node	RCC	STEEL
726	1820.92	1654.78
727	2681.00	3593.53
728	7535.78	5950.90
729	2611.46	3508.00

- Column Reaction for Zone-IV

Node	RCC	STEEL
726	1892.127	1737.61
727	3001.307	3668.76
728	7423.09	3574.67
729	2929.04	5833.27

- Column Reaction for Zone-V

Node	RCC	STEEL
726	491.96	1833.66
727	236.85	3776.17
728	189.56	5753.50
729	241.47	3680.86

Fig.5 Column Node

Bending Moment in X Direction in Column for Zone-II

Node	**RCC**	**STEEL**
726	7.624	6.169
727	4.924	4.585
728	4.668	4.724
729	14.876	4.741

For Zone-III

Node	**RCC**	**STEEL**
726	10.734	7.95
727	9.12	7.21
728	6.62	7.30
729	3.56	7.27

For Zone-IV

Node	RCC	STEEL
726	18.639	12.87
727	12.698	10.71
728	10.466	10.91
729	29.91	10.11

For Zone-v

Node	RCC	STEEL
726	30.05	18.18
727	17.43	16.12
728	16.45	16.39
729	25.28	16.25

Bending Moment in Z Direction in Column For Zone-II

Node	RCC	STEEL
726	25.929	7.899
727	29.153	17.083
728	32.598	9.292
729	37.674	23.699

For Zone-II

Node	RCC	STEEL
726	50.564	11.789
727	30.556	11.62
728	66.924	13.44
729	36.942	11.695

For Zone-IV

Node	RCC	STEEL
726	51.243	18.626
727	43.627	18.589
728	62.32	21.001
729	51.962	18.785

For Zone-V

-Node	RCC	STEEL
726	25.286	26.817
727	31.035	26.642
728	31.928	27.022
729	40.898	26.547

Shear Force for zone-II

Beam	RCC	STEEL
649	1001.186	965.132
650	288.414	1219.754
651	909.113	5286.079
652	315.875	1196.301

For Zone-III

Node	RCC	STEEL
726	10.734	7.95
727	9.12	7.21
728	6.62	7.30
729	3.56	7.27

For Zone-IV

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651	909.113	5286.079
652	315.875	1196.301

Shear Force for zone-III

Beam	**RCC**	**STEEL**
649	825.063	553.063
650	262.147	103.305
651	919.21	220.234
652	304.303	105.233

Beam	**RCC**	**STEEL**
649	31.927	14.323
650	16.761	10.784
651	11.33	11.148
652	95.144	35.834

Shear Force for zone-IV

Beam	**RCC**	**STEEL**
649	1014.036	540.0536
650	263.147	94.713
651	917..886	225.037
652	297.4785	100.792

Shear Force for zone-V

Beam	**RCC**	**STEEL**
649	1725.842	473.684
650	790.147	72.692
651	6291.967	222.491
652	782.161	76.534

Bending moment for zone-II

Beam	**RCC**	**STEEL**
649	13.434	700.06
650	6.673	99.122
651	5.692	350.565
652	71.956	113.59

Bending Moment for Zone-III

Beam	**RCC**	**STEEL**
649	16.975	8.436
650	12.449	7.256
651	7.1	7.379
652	113.228	21.41

Bending Moment for Zone-IV

Beam	**RCC**	**STEEL**
649	31.927	14.323
650	16.761	10.784
651	11.33	11.148
652	95.144	35.834

Bending Moment for Zone-V

Beam	**RCC**	**STEEL**
649	115.77	19.415
650	269.92	16.133
651	920.04	16.552
652	296.44	34.054

Quantity of RCC & Steel

Zone	Zone-II		
Material	RCC		STEEL
	RCC (CU.M)	Steel (M.T)	Steel (M.T)
Quantity	470.2	241.682	1422.620
Cost	4570684.16		90649346.4

Zone	Zone-III		
Material	RCC		STEEL
	RCC (CU.M)	Steel (M.T)	Steel (M.T)
Quantity	473	242.009	2381.745
Cost	4597285.371		151764791.4

Zone	Zone-IV		
Material	RCC		STEEL
	RCC (CU.M)	Steel (M.T)	Steel (M.T)
Quantity	582.1	284.872	2406.184
Cost	5650487.792		153322044.48

Zone	Zone-V		
Material	RCC		STEEL
	RCC (CU.M)	Steel (M.T)	Steel (M.T)
Quantity	707.7	343.309	2478.551
Cost	6868015.171		157933269.72

Conclusion

- Node displacement in all three direction is greater in case of steel water tank in all zone.
- In many column maximum axial force & bending moment in steel structure is gre- ater as compare to concrete structure.
- In many beam maximum axial force & bending moment in steel structure is gre- ater as compare to concrete structure.
- Total cost of construction of RCC water tank is much smaller as compare to steel eater tank.

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