IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 6.252

Volume 2, Issue 6, June 2022

Parametric Analysis of Elevated Service Reservoir (ESR) For Various Capacities

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Abstract: *Elevated reinforced concrete water tanks are an important structural element in both urban and rural regions. It's critical to keep the high reinforced concrete water tank from collapsing in order to keep the water supply running. A reinforced concrete elevated water tank of capacities 56, 191, and 452 cubic meters with a constant h/d ratio is designed and put through various parametric analysis such as displacement, bending moment, and base shear in two different seismic zones i.e., zone III and zone V using STAAD pro. and the results are reported.*

Keywords: STAAD Pro. Software, Circular Overhead Water Tank, Elevated Water Tank

I. INTRODUCTION

A service reservoir is a container that is used to store liquids. Water is an essential requirement for all living organisms and is used for drinking, irrigation, and industry, among other things. It is critical for every individual and community to have access to potable water; as a result, it is necessary to store water for supply, which is then used for domestic reasons. The service reservoirs are classified depending on their shape and location. There are three categories of service reservoirs based on their location. Underground service reservoirs, above-ground service reservoirs, overhead service reservoirs, and elevated service reservoirs are all options. The shape of subterranean and ground resting tanks is frequently rectangular or circular, whereas the shape of overhead service reservoir is determined by aesthetics and design.

Circular tanks, rectangular tanks, intze tanks, square tanks, and conical or funnel-shaped tanks are different types of overhead tanks that are used to store water for various purposes.

The research is being carried out to see if there is a difference in various parameters when the h/d ratio is kept constant and the capacity of the water tank is increased for two different seismic zones. The modeling and analysis of the service reservoir were done with the STADD.Pro Application.

II. BACKGROUND

Some of recent and important studies on elevated liquid tanks are presented in this section.

In comparison to other methods of staging, radial staging provides the highest value of base shear for an empty tank, half tank, and full tank. (Quadri & Sawant, 2017). In the model developed by(Sai Ramya & Sandhya Rani, 2019), diagonal bracing ensures that lateral movement is kept to a minimum for empty, half-filled, and full tanks. For empty, half, and full tank circumstances, the diagonal bracings are more effective than the other types of bracings. Radial staging gives a minimum value of base shear for empty tanks, half tanks, and full tanks (Quadri & Sawant, 2017). As the requisite volume of concrete and steel for construction is less for frame type staging than for shaft type staging, the overall cost of materials will be cheaper. (Gotavade et al., 2021). Diagonal bracing ensures that lateral movement is kept to a minimum(Sai Ramya & Sandhya Rani, 2019). A reinforced concrete raised service reservoir with a capacity of 900 cu m and a height of 32 metres was tested using a seismic record ensemble. In the mean minus standard deviation and mean plus standard deviation ranges, the dispersion of replies was found to be 60 to 70%. Furthermore, earthquake frequency and nature have an effect on the reactions of elevated service reservoirs. The extreme reaction of different parameters such as base shear force, overturning moment, displacement, and hydrodynamic pressure happened under various vessel filling conditions. (Omidinasab & Shakib, 2012). The critical reaction of raised tanks does not necessarily occur in the full case of tanks; depending on the earthquake characteristics, it may occur in a lesser proportion of fluid or even in an empty tank. (Ranjbar et al., 2013).

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III. METHODOLOGY

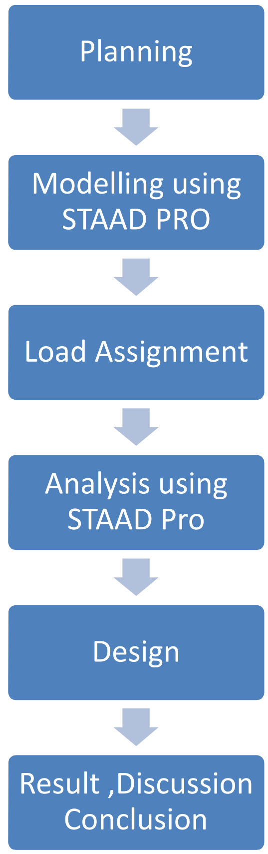

Figure 1

3.1 Modeling

Tank 1:

Capacity 56 cum
Height 2m, Depth 6m

Size of column 300 x 600 mm
No of column: 7

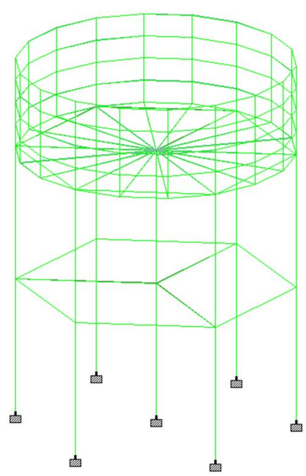

Fig 2: Tank 1 (56 cum)

Tank 2:
Capacity 191cum
Height 3m, Depth 9m
Size of column 300 x 600 mm
No of column:7

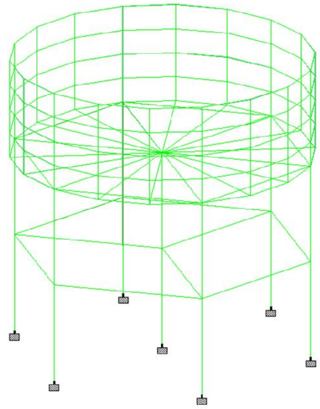

Fig 3: Tank 2 (191cum)

Tank 3:
Capacity 452 cum
Height 4m, Depth 12m
Size of column 300 x 600 mm
No of column:7

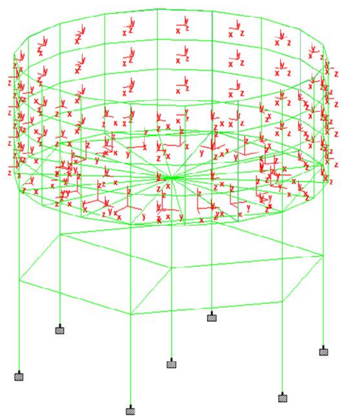

Fig 4: Tank 3 (452 cum)

These three models were studied based on Moment, displacement, and base shear in two different seismic zones i.e., Zone 3, and Zone 5.

3.2 Load Considerations

While applying the loads to the structure self-weight, Dead= 2.5KN/m2 and Live=2.5 KN/m2 has been considered. Seismic loads EQ-x and EQ-y are given in Load patterns directly using Code IS1893:2016. Also, the Wind loads wind-x and wind-y are given using Code IS875:1987, as mentioned in Table1.

Table 1: Load Combinations

Name	**Type**
Dead	Dead
Live	Live
EQ +X	Seismic
EQ –X	Seismic
EQ +Y	Seismic
EQ -Y	Seismic
W +X	Wind
W –X	Wind
W +Y	Wind
W –Y	Wind

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IV. RESULTS

The analysis carried out on three different models in two different seismic zones. Various options are there for reviewing the outputs.

4.1 For Tank 1 (56 cum) Zone 3:

- Permissible displacement H/300 = 2000/300 =6.66mm
- Load case 1.5dead + 1.5 seismic
- Base shear 49.671KN in zone 3
- Displacement 1.748 mm
- Moment

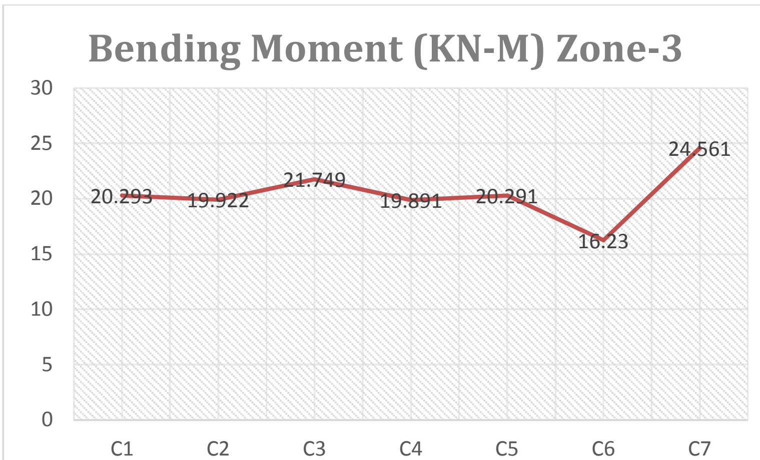

Fig 5: Bending Moment for tank 1

4.2 For tank 2 (191cum) zone 3

- Permissible displacement H/300 = 3000/300 =10 mm
- Load case 1.5dead + 1.5 seismic
- Base shear 119.69 KN in zone 3
- Displacement 4.546 mm
- Moment

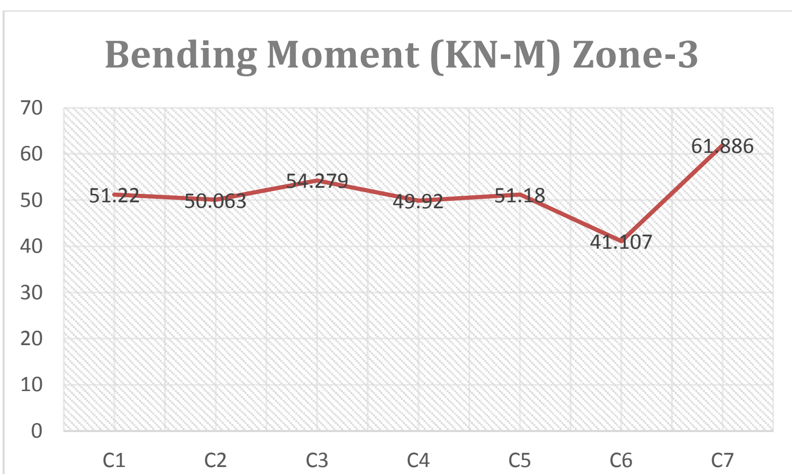

Figure 6: Bending Moment for tank 2

4.3 For tank 3 (452cum) Zone 3:

- Permissible displacement H/300 = 4000/300 =13.33 mm
- Load case 1.5dead + 1.5 seismic
- Base shear 244.211 KN in zone 3
- Displacement 9.914 mm
- Moment

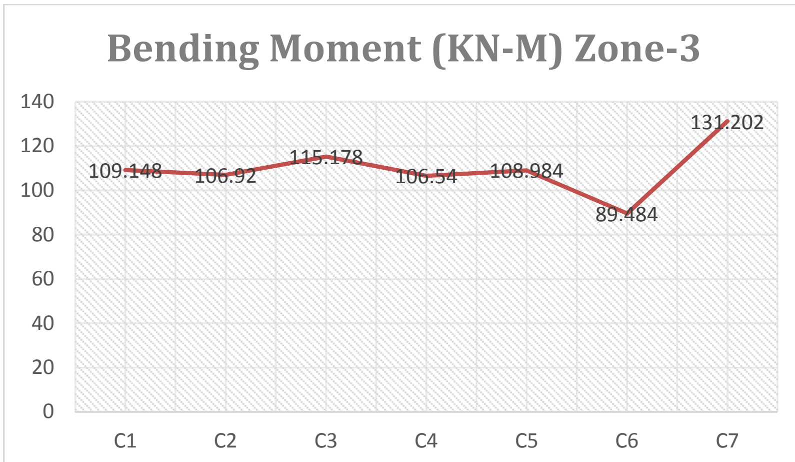

Fig 7: Bending Moment for tank 3

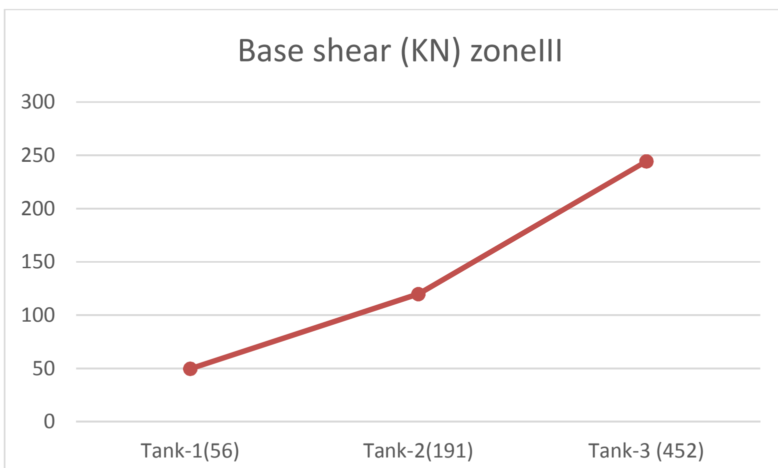

Fig 8: Base Shear zone III

4.4 For tank 1 (56cum) zone 5:

- Permissible displacement H/300 = 2000/300 =6.66mm
- Load case 1.5dead + 1.5 seismic
- Base shear 256.468 KN in zone 3
- Displacement 3.914 mm
- Moment

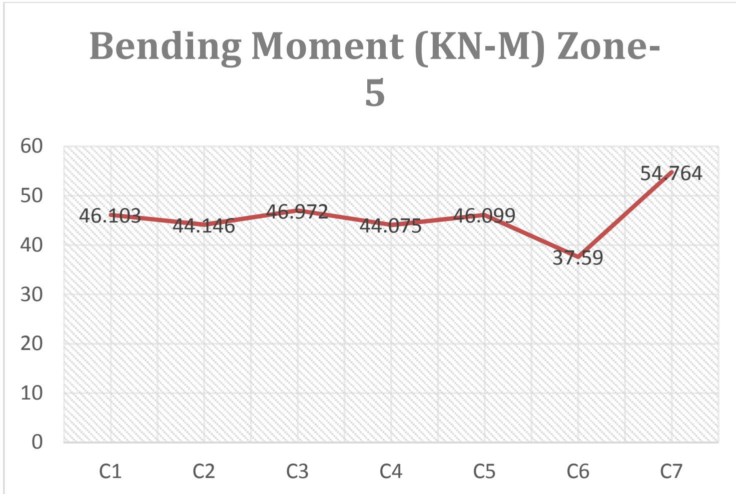

Fig 9: Bending Moment for tank 1

4.5 For tank 2 (191cum) Zone 5:

- Permissible displacement H/300 = 3000/300 =10 mm
- Load case 1.5dead + 1.5 seismic
- Base shear 269.31 KN in zone 5
- Displacement 10.194 mm
- Moment

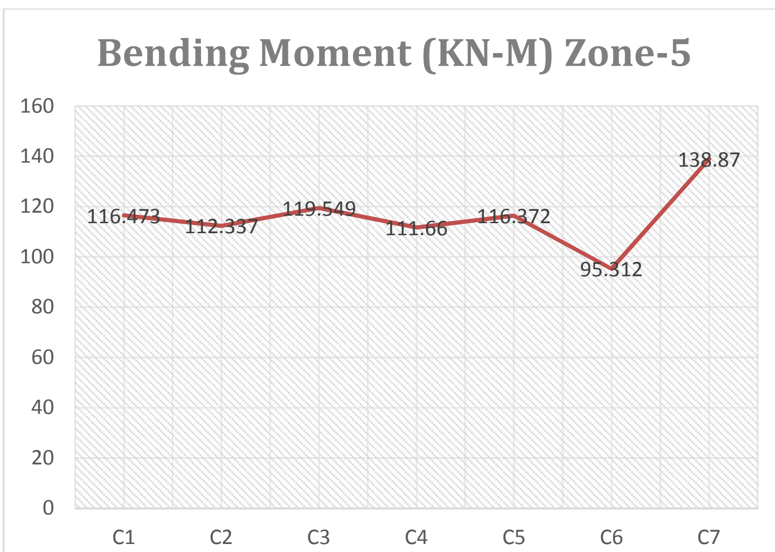

Fig 10: Bending Moment for tank 1

4.6 For tank 3 (452cum) Zone 5:

- Permissible displacement H/300 = 4000/300 =13.33 mm
- Load case 1.5dead + 1.5 seismic
- Base shear 549.479 KN in zone 3
- Displacement 22.225 mm
- Moment

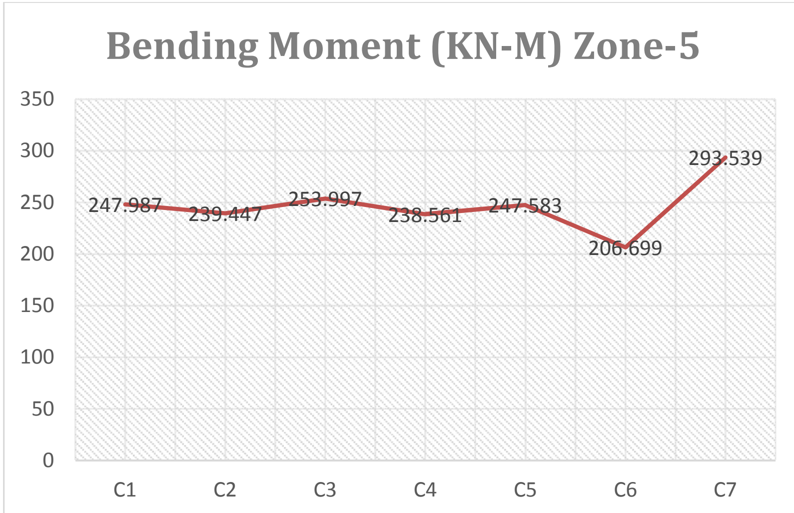

Fig 11: Bending Moment for tank 3

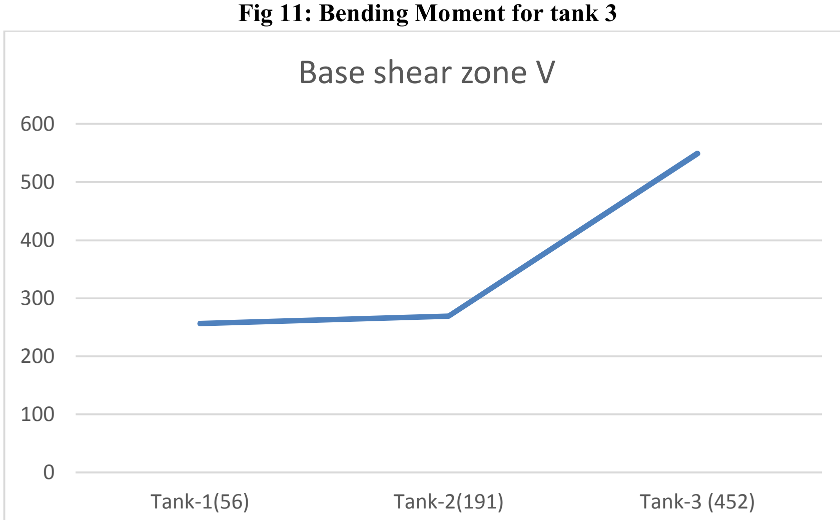

Fig12: Base shear zone V

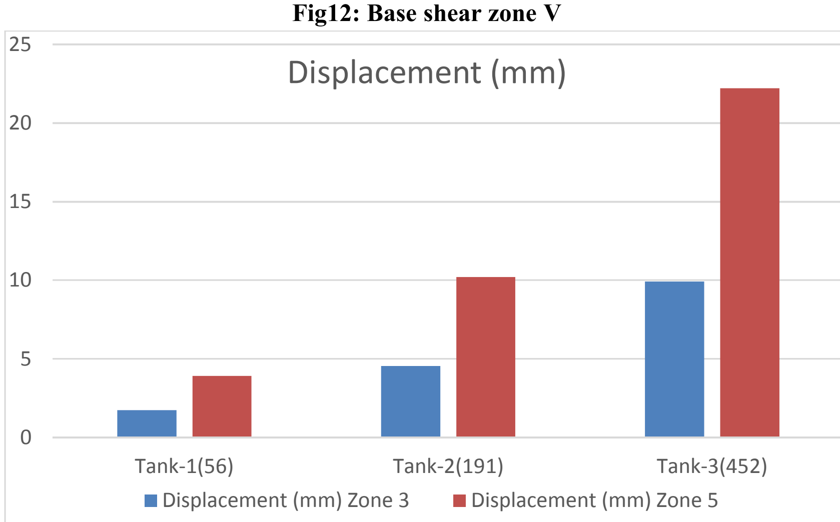

Fig13: Displacement in zone III and Zone V

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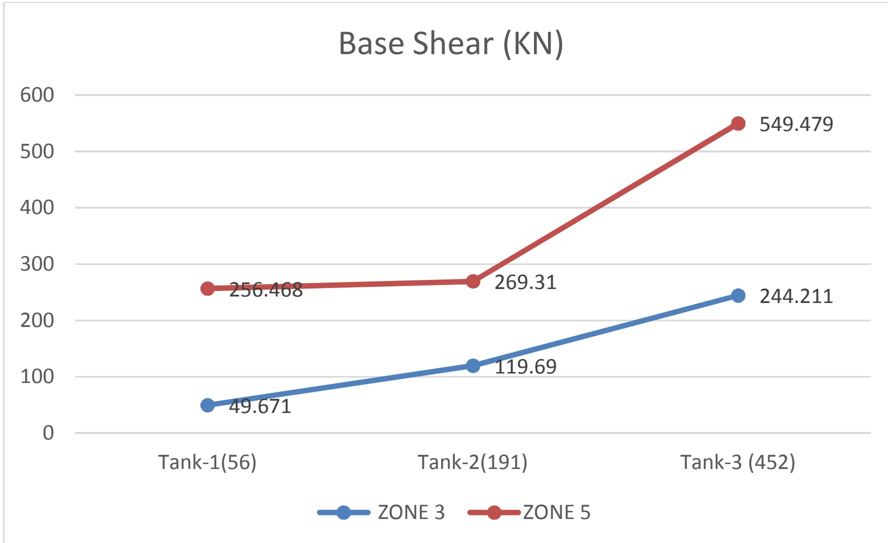

Fig14: Base shear in zone III and zone V

V. DISCUSSION

Column no. 7, which is structurally central, receives the greatest bending moment, while column no. 6, which is a peripheral column, receives the least in all the three-water tank in either zone. Because the maximum water pressure acts at centre of the tank. (fig 5 -11)

According to IS:1893, the maximum permissible displacement is H/300, and the values obtained for displacement are within the permissible range. Zone III is having lesser displacement as compared to zone V. Because lateral displacement is less in zone III. (Fig 13)

On analyzing water tank in zone III and zoneV it has been found that zones V attracts more base shear than zone III. (Fig 14)

VI. CONCLUSION

Three ESR with different capacities (56,191.452 cum) have been analyzed for different parameters i.e., bending moment, displacement, and base shear by keeping h/d ratio constant as 0.5. the results are obtained for reservoir zone III and zone IV that the peripheral columns are subjected to low Bending moment in comparison to the central column. This is due to the fact that entire water pressure acts through the column at center.

Similarly, the displacement in all the three water tanks under considerations are well within the permissible limits as per IS:1893; however, zone V revealed more displacement that zone III due to lower zone factor (0.16) in zone III than the zone factor (0.36) in zone V. It is observed that tank with capacity 452cum fails the displacement criteria in zone V on the other hand base shear also found to be more in zone V than zone III owing to the same reason.

Therefore, it can be suggested that higher capacity water tanks may receive more displacement in zone V, which can be controlled by adjusting h/d ratio

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