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A COMPARATIVE STUDIES ON ELEVATED WATER TANK DUE TO DYNAMIC LOADING

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Abstract— Elevated water tanks are one of the most important in the daily requirement. Dynamic analysis of liquid containing tank is a complex problem involving fluid-structure interaction. Based on numerous analytical, numerical, and experimental studies, simple spring mass models of tank-liquid system have been developed to evaluate hydrodynamic forces. This project is concerned with the performance of two types of elevated water tank with varying heights under seismic and wind induced dynamic loads. Wind loads are considered as per IS 1911-1967, IS 875(part3): 1987 and seismic load as per IS 1893(part1):2002. The FEM analysis of elevated water tank involves modal analysis, equivalent static, response spectrum, and wind analysis with gust factor. The results obtained from the analyses are compared and the conclusions are drawn.

Keywords— Square tank, Circular tank, Modal analysis, Seismic analysis, Wind analysis.

1. INTRODUCTION

A reinforced concrete tank is a very useful structure which is meant for the storage of water, Water is primary concern for human life. Tanks resting on ground are normally circular or rectangular in shape and are used where large quantities of water need to be stored.

Plain concrete members of reinforced concrete liquid retaining structures may be designed against structural failure by allowing tension in plain concrete as per the permissible limits in tension in bending (I S 456-2000) . this introduces the necessary provision to prevent failure due to cracking, however nominal reinforcement shall be provided for plain concrete structural members complying with the requirements.

The scope of the project is to carryout finite element analysis on elevated water tank due to seismic and wind induced dynamic loads. Two types of tanks are considered in this study with varying heights and base widths as given below.

- Square Tank
- Circular Tank

2. CONFIGURATION OF TANK

A elevated water tank is like exposed structure. Its super structure suitably shaped, dimensioned and designed to sustain the external loads acting on the tanks of the super structure itself. The super structure elevated water tank has a tank supporting with columns and ring beam.

3. LOADING CALUCLATION

The loads are calculated as per IS: 1911-1967 for dead load, IS: 875-1987 (part1) for live load, IS: 875-1987 (part3) for wind load and IS 1893 (part1)-2002 for seismic loads.

4. FEM AND ANALYSIS

The FEM and dynamic analysis of two types of elevated water tanks have been carried out using the software STAAD Pro. Different shapes and height are used with different configuration of the tanks are given in table 1. The material properties are given in table 2.

Table 1: Different parameters for all towers

Shape of Tank	**Square**	**Circular**
Height (m)	Length (m)	Diameter (m)
10	2.05	2.25
20	4.20	4.47
30	6.3	6.61
40	8.4	8.45

Table 2: Material properties

Shape of Tank	Square	Circular
Beam	300*450	300*450
Column	300*450	450
Wall	200	200
Floor	200	200
Roof	120	120
Grade Of Concrete	M20	M20
Steel	Fe415	Fe415

The two types of elevated water tank models are shown in fig 1 (a-b).

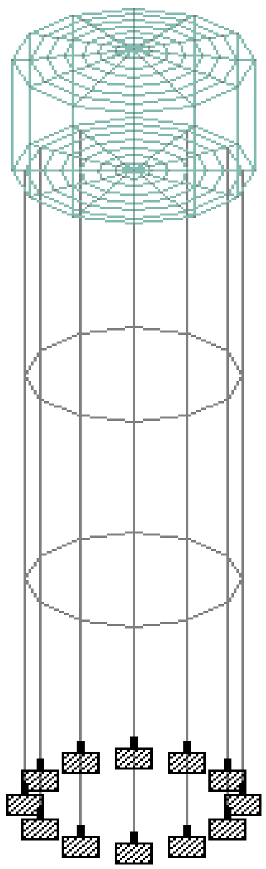

Fig 1(a): Circular tank

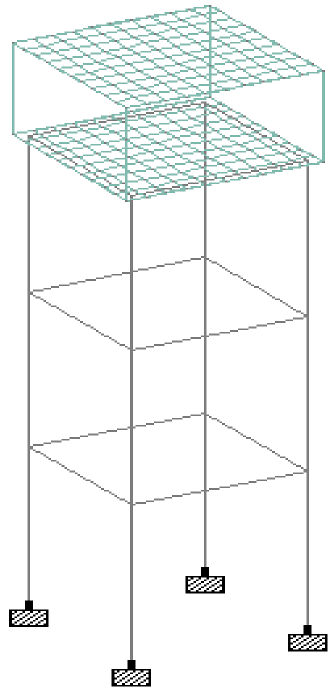

Fig 1(b): Square tank

5. RESULTS AND DISCUSSIONS

5.1 Modal Analysis

The fundamental frequency for all the tanks is obtained from the modal analysis. The first mode shapes for all tanks as shown in fig 2 (a-b).

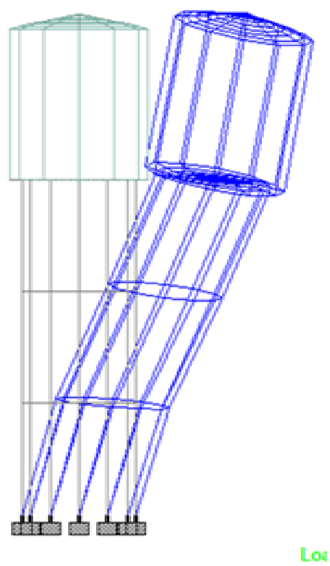

Fig 2 (a): 1st mode for Circular tank

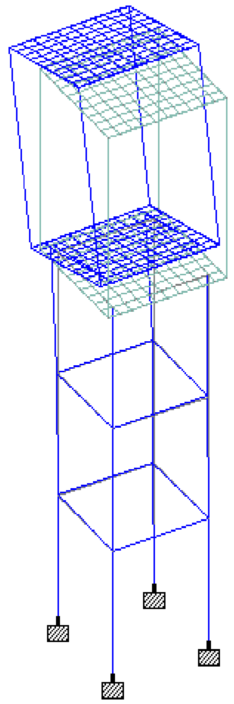

Fig 2 (b): 1st mode for Square tank

5.2 Response Spectrum Analysis

The Response Spectrum analysis is performed on the two types of elevated water tank for all the seismic zones as per IS 1893(part1)-2002 maximum displacements are taken at pivotal points for zone V. Maximum displacements of two elevated water tank and comparison are shown in figure 3(a-f) to respectively.

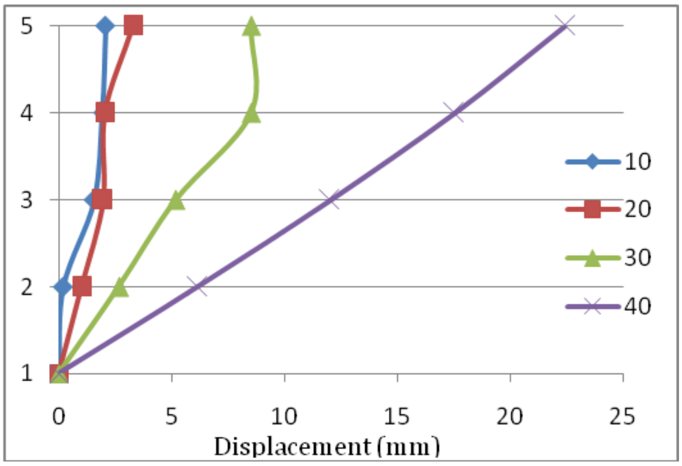

Fig 3(a): Displacement for square elevated tank

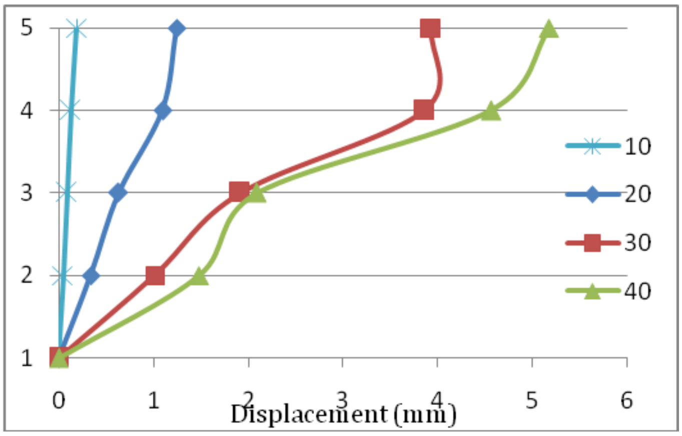

Fig 3(b): Displacement for circular elevated tank

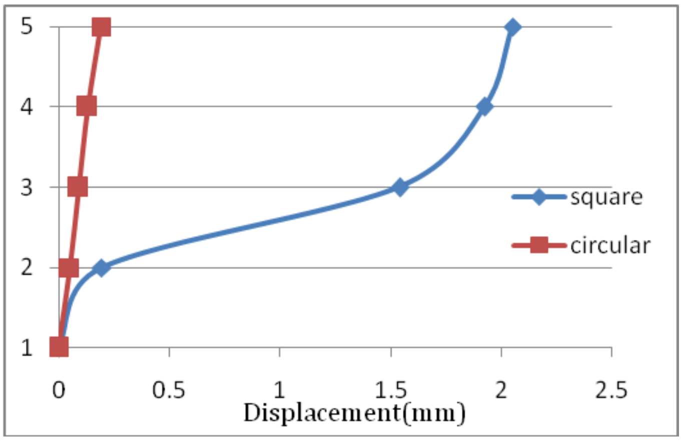

Fig 3(c): 10m comparison for square and circular tank

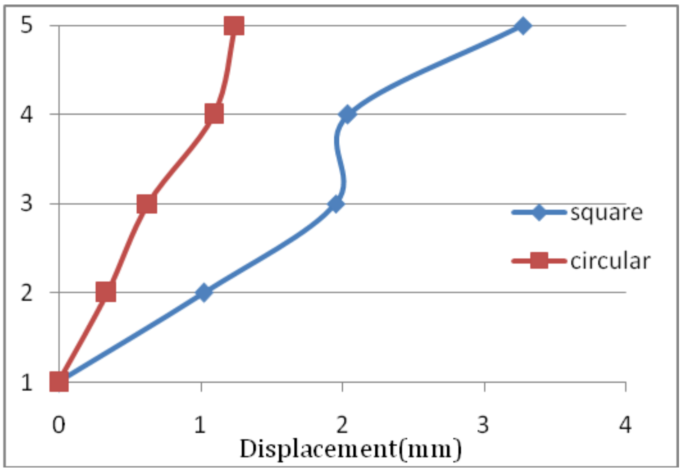

Fig 3(d): 20m comparison for square and circular tank

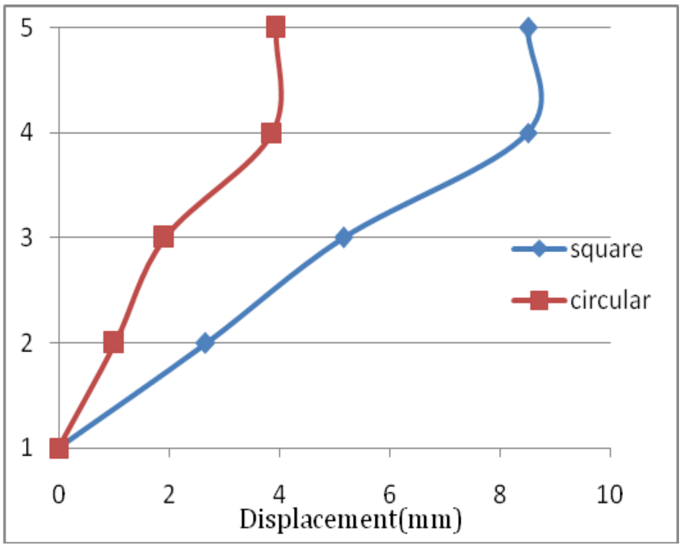

Fig 3(e): 30m comparison for square and circular tank

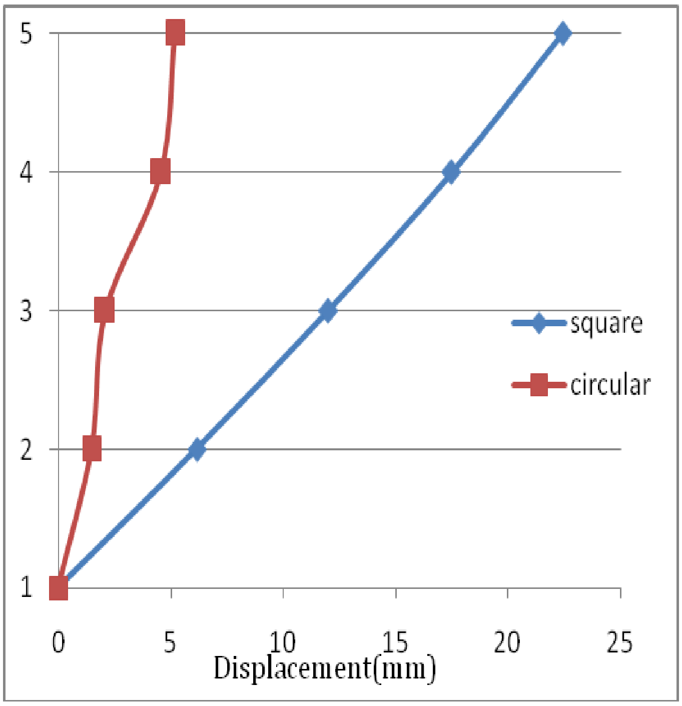

Fig 3(f): 40m comparison for square and circular tank

5.3 Wind Analysis

Wind analysis is performed on all two elevated water tank. The maximum displacements are taken at pivotal points. Maximum displacements of two elevated water tank and comparison are shown in figure 4(a-f) respectively.

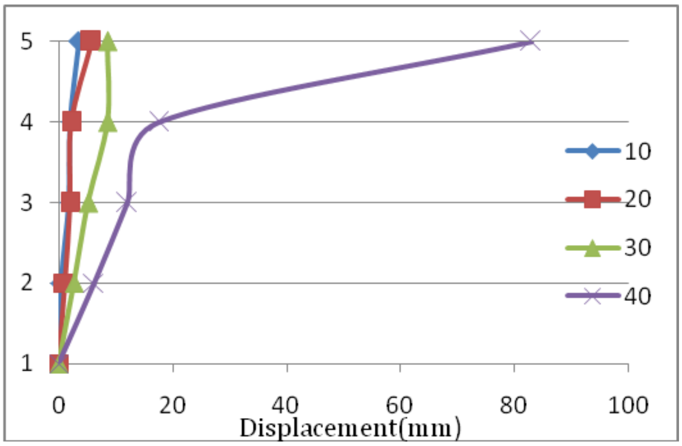

Fig 4(a): Displacement for square elevated tank

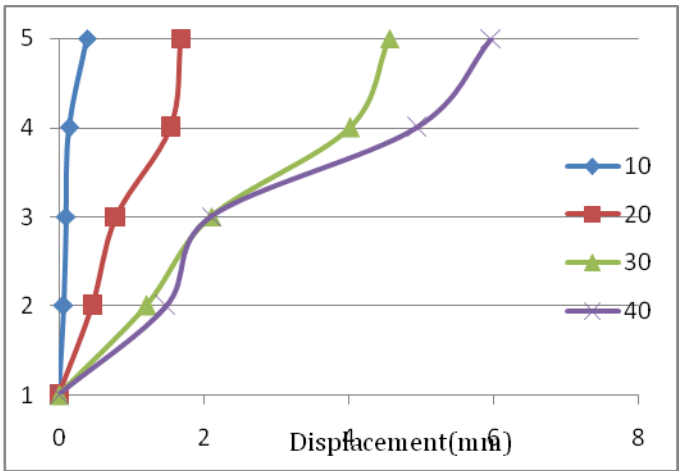

Fig 4(b): Displacement for circular elevated tank

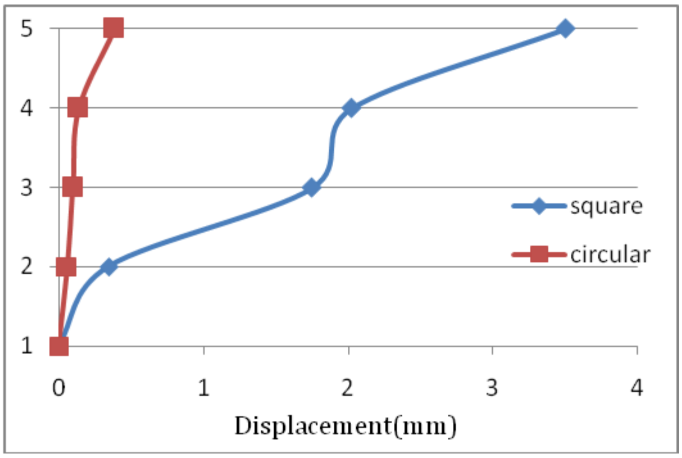

Fig 4(c): 10m comparison for square and circular tank

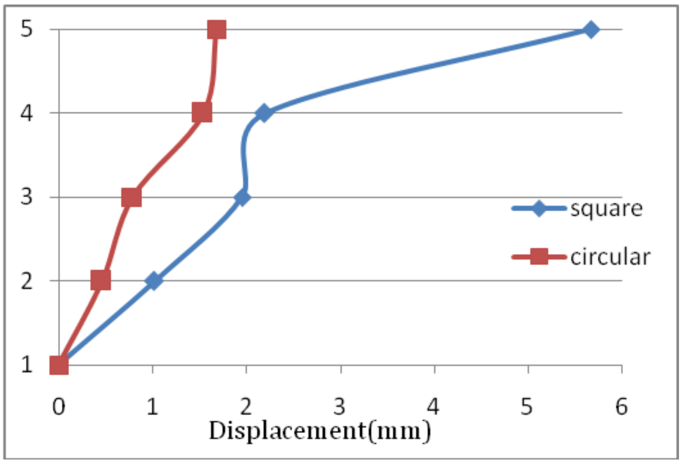

Fig 4(d): 20m comparison for square and circular tank

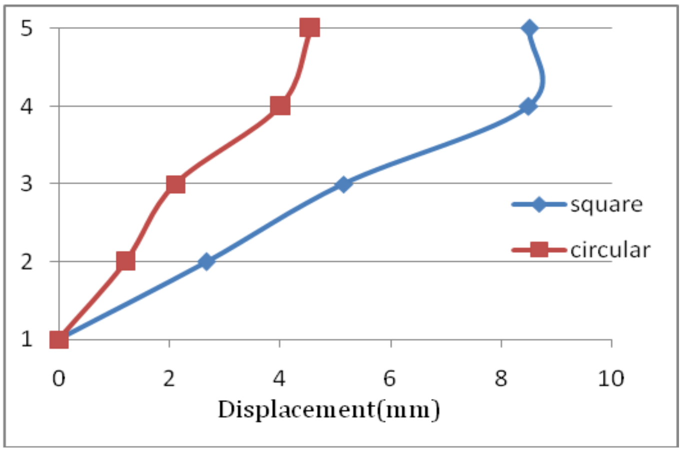

Fig 4(e): 30m comparison for square and circular tank

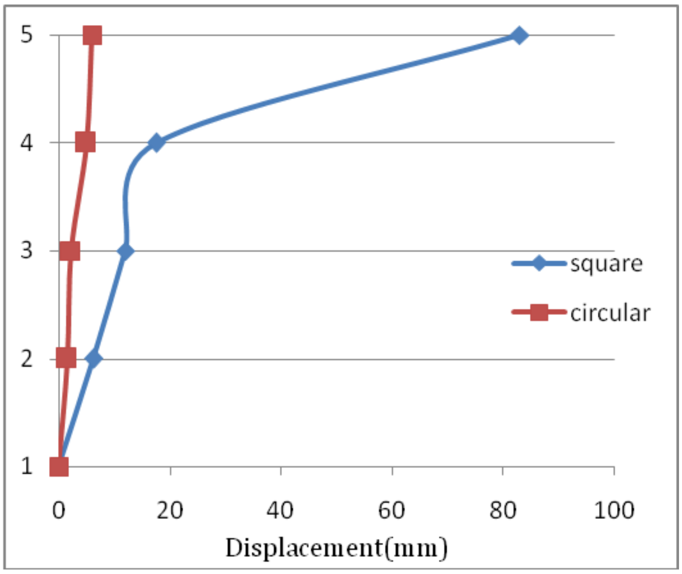

Fig 4(f): 40m comparison for square and circular tank

6. CONCLUSIONS

Result from the modal analysis shows that as the height increases the natural frequencies reduces which shows the reduction in stiffness. The modal frequencies obtain for all the tanks lies in the peak range of response spectrum, which needs to be further analyzed under dynamic loads.

Response spectrum analysis result shows that the displacement increases as the height increases and the displacement for all the tanks are within 5% of tanks height. The increases of displacement in top most member form 10m to 40m height for square is 993.61% and circular is 2610.47% respectively.

Response spectrum analysis result shows displacement increases as the height increases in both square and circular, when compared to square tank circular tanks shows minimum displacement. It indicates circular tank is more effective than square tank.

Wind analysis result shows that as the height increases the displacement increases and the displacement for all the tanks are within 5% of tanks height. The increases of displacement in top most member form 10m to 40m height for square is 2265.94% and circular is 1446.89% respectively.

- Wind analysis result shows that displacement increases as the height increases in both square and circular, when compared to square tank circular tanks shows minimum displacement. It indicates circular tank is more effective than square tank.
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- Wind analysis results are more compared to seismic analysis, which needs further analysis under dynamic loads.

7. REFERENCES

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