Seismic Analysis of Elevated Square Water Tanks with Composite Columns and it's Comparison with Conventional RCC Elevated Square Water Tank

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Abstract – *An Elevated Water Tank is one of the most important structure of Water Distribution System on which human life depends. Most of the Elevated Water Tank are situated in seismic/earthquake zones. To avoid the damage to life and property Elevated Water Tank should be strong enough to survive the high intensity/magnitude earthquake. To increase the structural strength and stability against earthquake researchers have done various experiments with varying parameters like aspect ratio (H/D ratio), container shape, and with different staging configuration. In the same direction of improvement of structural strength ,stability of Elevated Water Tank against earthquake ,the RCC column of elevated water tank are replaced with the composite columns. Composite columns have high performance in terms of strength, stiffness, slenderness and buckling resistance. Seismic analysis of elevated rectangular water tank with composite columns has been done and its result/response is compared with conventional RCC elevated squarer water tank. The parameters compared are Maximum Story Displacements, Maximum Story Drifts, Story Shear, Story Overturning Moment ,Story Stiffness.*
The Analysis is done by Etabs 2015 Software.

Key Words: Rectangular Elevated Water Tank, RCC Conventional Column, Filled Steel Box/Tube Section Column, Filled Pipe Section Column, Rectangular Encased I Section, Circular Encased I Section, Seismic Analysis, Etabs 2015.

INTRODUCTION-For efficient working of Water Distribution System the water tank should be placed at certain height and should be properly designed. Usually the life of elevated water tank is 60-70 years. Most of the elevated water tank are located in seismic zones . If the earthquake of high magnitude occurs it causes the damage to elevated water tank due to which there is loss of life and property . Even after the occurance of earthquake people will face lots of problem due to no supply of water as water distribution system fails completely. To avoid this elevated water tank should be so designed that it can resist earthquake/seismic forces. To increase the strength and stability researchers have done comparative study by varying parameters like aspect ratio, shapes of containers and with different staging configuration. In this work the RCC columns of elevated water tank are replaced with composite columns. Composite columns are more efficient and effective as compared to RCC columns. A steel concrete composite column is a compressive member either a concrete encased hot rolled steel section or a concrete filled tubular section of hot rolled steel and is generally used as a load bearing member in a composite framed structure. In a composite column both the steel and concrete would resist the external loading by interacting together by bond and friction. The lighter weight and higher strength of steel permit the use of smaller and lighter foundations. The advantages of composite columns are high strength, high stiffness causing reduction in slenderness and increased buckling resistance, fire resistance and protection from corrosion, etc. In this work RCC columns of Elevated Square Water Tank are replaced by composite columns of Different Sections like Filled Steel Box/Tube Section Column, Filled Pipe Section Column, Rectangular Encased I Section, Circular Encased I Section And Seismic Analysis of all 5 Models is done And results are compared using Etabs 2015 Software. The parameters compared are Maximum Story Displacements, Maximum Story Drifts, Story Shear, Story Overturning Moment, Story Stiffness. The Material Of Steel Section Used Is A992Fy250 also known as ASTM A992 steel is a structural steel alloy often used in the US for steel wide flange and I beams. Like Other carbon steel the density of ASTM A992 steel is approximately 7850 kg/m3. Filler Material is M30 Grade Concrete.

METHODOLOGY-

In this Work 5 Models Of Same Tank Capacity, Beam Size And Heights are used with different composite columns like RCC Conventional Column, Filled Steel Box/Tube Section Column, Filled Pipe Section Column, Rectangular Encased I Section, Circular Encased I Section. And Seismic Analysis of all 5 Models is done and their results/responses are compared.

MODELS DESCRIPTION-

Tank Dimensions	4mx4mx4.5m
Tank Capacity	72m^3
Height Of Tank	13.5m
Height of container	13.5m

Thickness of base slab	150mm
Thickness of wall slab	100mm
Grade of concrete	M25
Grade of steel	Fe350
Density of concrete	25 KN/m3
Beam/Bracing size	300mm x 400mm
Steel Section material	A992Fy250
Filler Material	M30

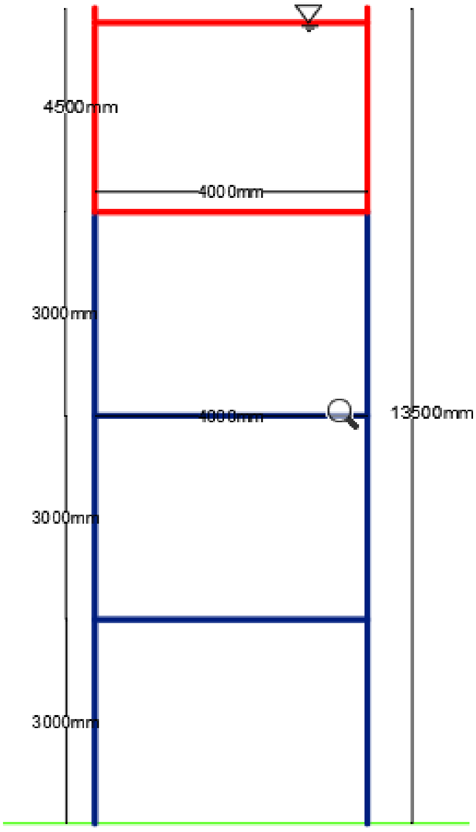

Fig -1: Rectangular Elevated Water Tank

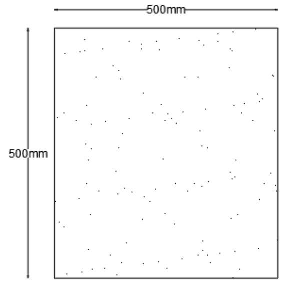

Fig -2: Rectangular RCC Column

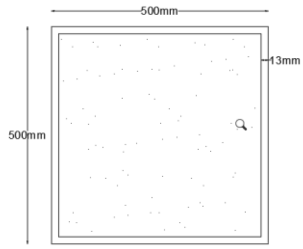

Fig -3: Filled Box/Tube Section Column

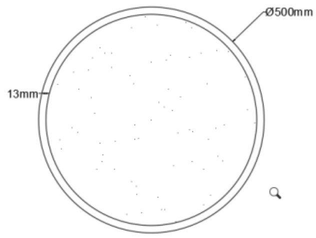

Fig -4: Filled Pipe Section Column

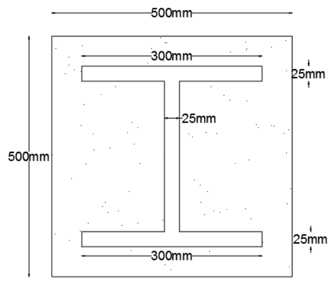

Fig -5: Rectangular Encased I Section Column

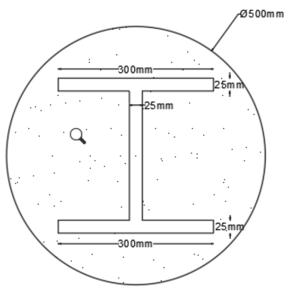

Fig -6: Circular Encased I Section Column

SEISMIC ANALYSIS DATA-

Seismic Design Code	IS 1893:2002 Part (1)
Seismic Zone	Zone II
Seismic Zone Factor	0.10
Site Type	III
Importance Factor	1.5
Reduction Factor R	2.5
Damping Ratio	5%

Above data is used for seismic analysis of all 5models.The Earthquake loads considered are E_x=2.5kN/m² and E_y=2.5kN/m²,Water Pressure Load on Base Slab =10kN/m²,and Self Weight of tank. Water Pressure on side wall of tank is neglected and load combinations are not considered.

Analysis of Tank with RCC Conventional Columns on Etabs Software-

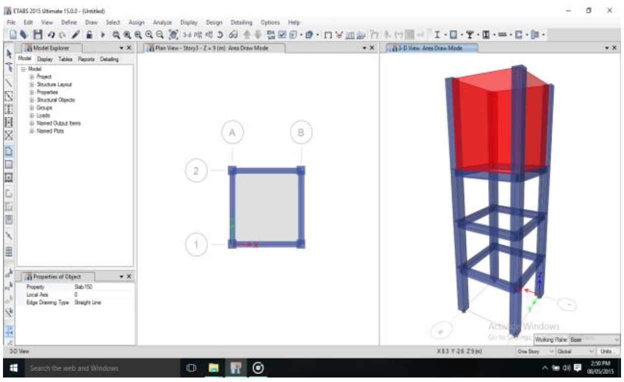

Fig -7: Screenshot Of Tank Model On Etab

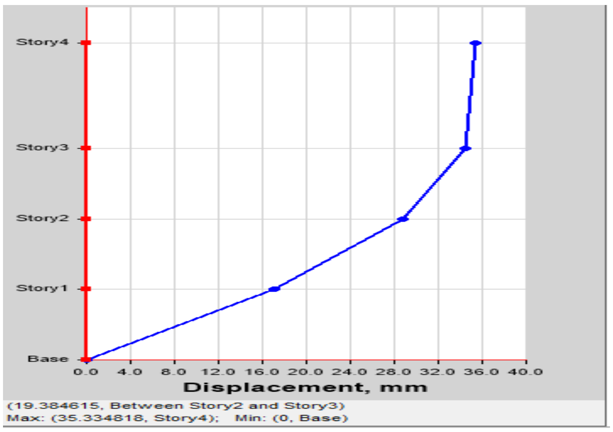

Fig -8: Maximum Story Displacement due to E_x

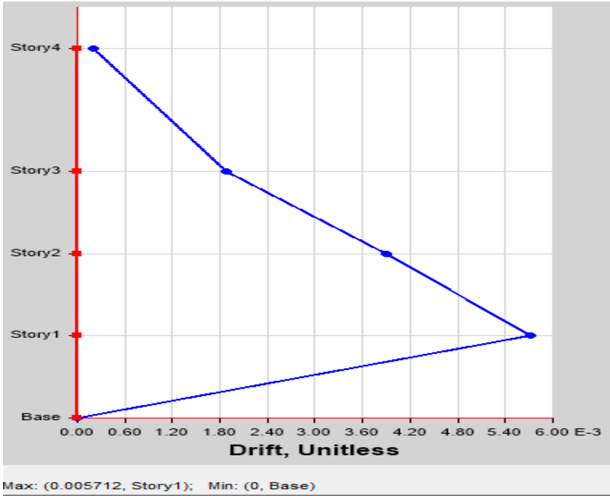

Fig -9: Maximum Story Drift due to E_x

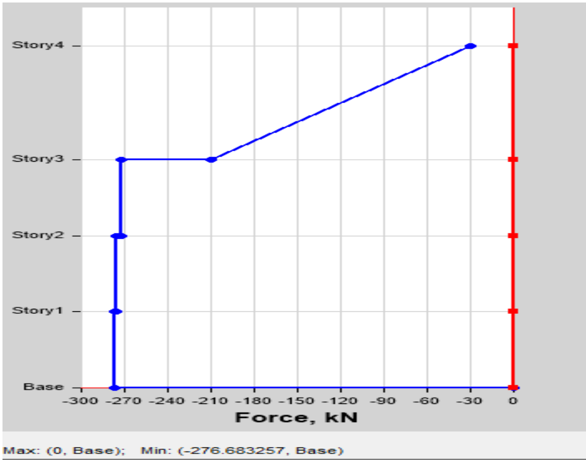

Fig -10: Story Shear due to E_x

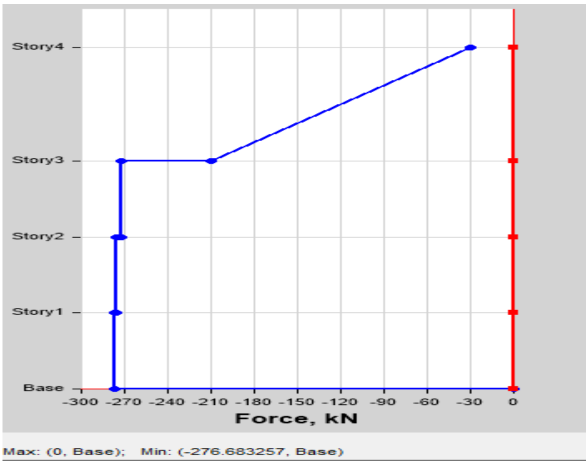

Fig -11: Story Overturning Moment due to E_x

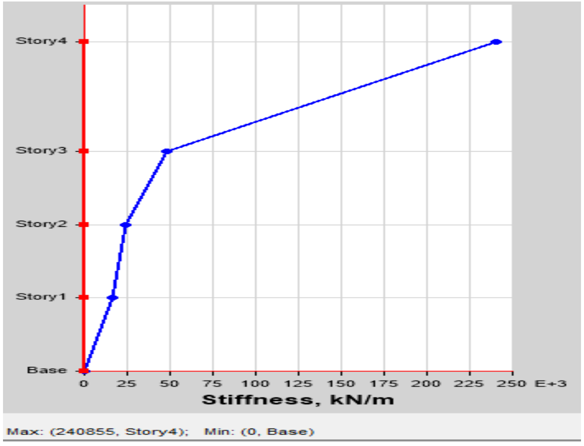

Fig -11: Story Stiffness due to E_x

Similarly above parameters for E_y are considered. And in the same way remaining 4 Tank Models are analyzed.

RESULTS-

Table -1: Results of all 5 models

Column Sections	Maximum Story Displacement		Maximum Story Drifts		Story Shears		Story Overturning Moment		Story Stiffness	
	Ex	Ey	Ex	Ey	Ex	Ey	Ex	Ey	Ex	Ey
RCC Column	35.33 mm	35.05 mm	0.0057	0.0056	-276 kN	-274 kN	-3012 kN-m	-2987kN-m	240855 kN/m	241542 kN/m
Filled Steel Box/Tube Section	10.28 mm	10.28 mm	0.0015	0.0015	-274 kN	-274 kN	-2976 kN-m	-2976 kN-m	421873 kN/m	421873 kN/m
Filled Pipe Section	14.02 mm	14.01 mm	0.0020	0.0020	-268 kN	-268 kN	-2913 kN-m	-2912 kN-m	348203 kN/m	348202kN/m
Rectangular Encased I Section	6.74 mm	7.24 mm	0.0008	0.0009	-138 kN	-115 kN	-1518 kN-m	-1518 kN-m	115609 kN/m	115253 kN/m
Circular Encased I Section	16.36 mm	18.91 mm	0.0023	0.0027	-268 kN	-268 kN	-2915 kN-m	-2914 kN-m	356630 kN/m	357483 kN/m

Above table shows the value of Seismic Responses (Maximum Story Displacement,Maximum Story Drifts,Story Shears,Story Overturning Moment and Story Stiffness) of all 5 models subjected to Earthquake Load E_x and E_y.

3. CONCLUSIONS

Following are the conclusions observed from the above analysis and their results.

1. Rectangular Encased Section I Section has minimum value of Maximum Story Displacement (=6.74mm & 7.24mm) followed by Steel Box/Tube Section ,Circular Encased I Section,Filled Pipe Section,And Conventional RCC Columns.
2. Rectangular Encased Section I Section has minimum value of Maximum Story Drifts ((=0.0008 & 0.0009) followed by Steel Box/Tube Section ,Circular Encased I Section,Filled Pipe Section,And Conventional RCC Columns.
3. Rectangular Encased Section I Section has minimum value of Story Shears (=-138 kN & -115kN).
4. Rectangular Encased Section I Section has minimum value of Story Overturning Moment (=-1518 kN-m & -1518 kN-m).
5. Rectangular Encased Section I Section has minimum value of Story Stiffness (=115609kN/m & 115253 kN/m).
6. From above observations it is found the Rectangular Encased I Section is found out to be most effective.

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Code books

1. **IS 1893 (Part 1):2002** Criteria for earthquake resistant design of structures.
2. **IS: 1893(Part II) (2005)** Draft Criteria for Earthquake Resistant Design of Structure (Liquid Retaining Tanks), in this draft two mass modal is illustrate for analysis of liquid storage tank.
3. **IS: 3370 (part II-IV)-1965** Code of practice for concrete structures for the storage of liquids, in this code general requirement and stress for design of liquid storage tank is illustrated.

4. **IS: 3370 (Part II) – 1965** code of practice for concrete structures for the storage of liquids

5. **IS: 11682-1985** Criteria for design of RCC staging for overhead water tanks, in this code analysis and design for both type of staging frame staging and shaft staging has illustrate.

6. **IS: 456-2000** plain and reinforced concrete code of practice, in this code all design parameter for RCC design of different component of elevated water tank.

Text Books

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2. Anil.K.Chopra , “Dynamics of Structures” Prentice Hall, 1995