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Performance based Seismic Analysis on RCC Framed Elevated Circular Tanks with Flat and Domical Bases

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Abstract

Objectives: This paper replicates the comparative study of RCC staged circular water tanks with flat base and domical base of same capacity of 320m^3 under seismic conditions. **Method**: Analysis is carried out for dynamic responses, with inclusive variables as height of staging, soil condition, damping factor, seismic zones adhering to IS 1893-2002. Layout of staging frame and circular tank is with accordance to IS 11682-1985 and IS 3370 accordingly. Series of analysis has been done using Staad pro v8i as a tool for Modal analysis and Response spectrum analysis adhering to IS 1893-2002, and response is depicted in the form of graphs for each zone. **Findings:** Graphs sketched for the governing design criteria i.e. Base Shear, for each height and type of tanks considered under the pertaining conditions for each zone perspicuously delivers the basic idea to the structural designer fellows for the ease of selection of water tank's configuration and height for optimum performance under seismic loading prior to designing in order to work out for a better and optimum design. **Improvements:** Different conditions has been incorporated as variables for precise and discreet graphs for each zone that is additive to the selection process of the structure.

Keywords: Circular Water Tanks, Damping Factor, Height of Staging, Modal Analysis, Response Spectrum, Staad pro v8i,

1. Introduction

Circular water tanks are taken for the study for its effective performance over others as material needed for the construction of rectangular water tank is comparatively more than those required for circular ones[1]. Circular tanks are again categorised with flat base and domical base which in turn gives different responses under seismic conditions, when tank full condition is considered for modal and response spectrum analysis. Base slab is supported on circular beam arrangement on periphery consists of rectangular cross-section, which in turn supported on a number of columns[2]. It is intended to know about the optimum type of structure before constructiont for ease.

Ajagbe, Adedokun and Oyesile did a comparative study on the design of elevated rectangular and circular concrete water tanks[1], Devadanam, Ratnam, Raju choose a circular water tank of different heights for study under seismic loading[3]. Modal and response spectrum analysis is done for tank full condition using staadpro v8i[4] as a tool strictly adhering[5], so that most optimum configuration and height fortank can be selected before designing for the given site location using the graphs generated between maximum base shear and the given parameters for the tanks for all the five seismic zones.

2. Modelling of Tanks

2.1 Modelling in Staad Pro

Finite element model is modelled in staad pro v8i with attributes mentioned in Table 1.

Staging frame is chosen and modelled by strictly adhering to **IS 11682-1985** while tanks[6] are modelled in accordance with **IS 3370-2009**. Figure 1 depict[7] the staad pro model.

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Table 1. Section properties of members

Components	Dimensions (mm)
Wall thickness	250
Slab thickness	250
Braces	450*400
Column diameter	600
Floor beam	450*400

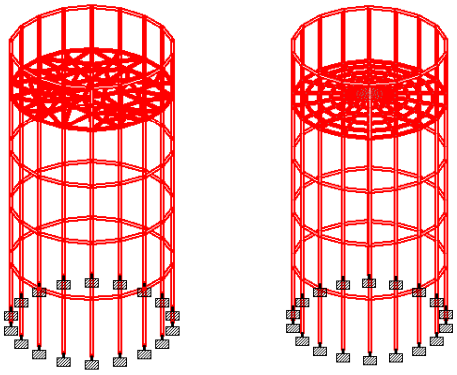

Figure 1. Staad pro model of mater tanks flat and domical base.

2.2 Parameters involved in the Study

Type of tank with different heights of staging, damping factor, soil condition and value of z (zone factor) as per IS 1893-2002, is used for modal response spectrum analysis.

3. METHODOLOGY

3.1 Analysis Procedure

Modal and Response spectrum analysis is considered in accordance with IS1893:2002 part 1 and 2. Modal analysis is done as dynamic analysis for understanding the effect of seismic loading under response spectrum analysis[8], which includes the finding of natural periods and periods in each mode of vibration with other quantities like Modal participation factor, modal mass in each mode and storey shear in each mode which is to be used for further analysis. Parameters are being input in staad for the analysis shown in Figure 2.

3.2 Output from Staad's results

Staad after analysis generates output file (Figure 3) having data like calculated frequencies, peak storey shear, base shears, support reactions, modal analysis results.

Base shear is calculated by considering clause 7.8.4.2 of IS 1893:2002, for the number of modes to be used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90 per cent of the total seismic mas.

CSM method for modal combination of base shear is used as for most of the cases modes were closely packed.

Mode shapes obtained during analysis are in Figure 4.

4. Results

Value of base shear is obtained for each combination of input as per Table 2 and graphs are drawn for each seismic zone for effortless selection of tanks before designing as per given site location. The graphs are sketched for all 4 zones with base shear values vs. type and varying height of tank with site conditions (Figures 5–8).

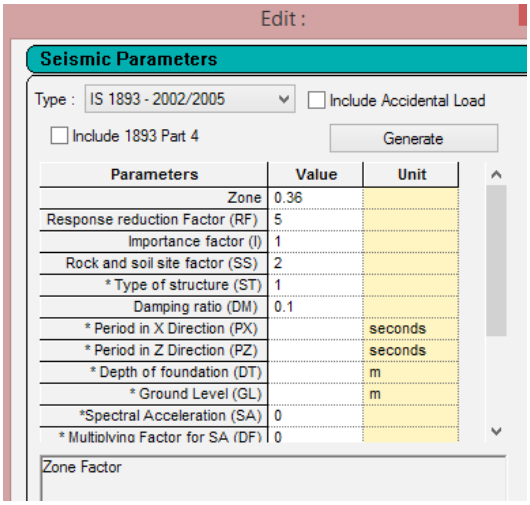

Figure 2. Parameters Input in Staad

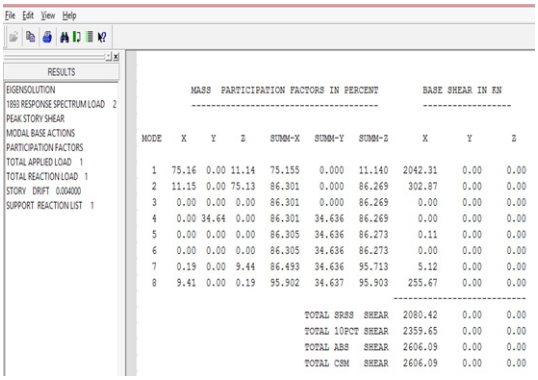

Figure 3. Output file from Staad for base shear.

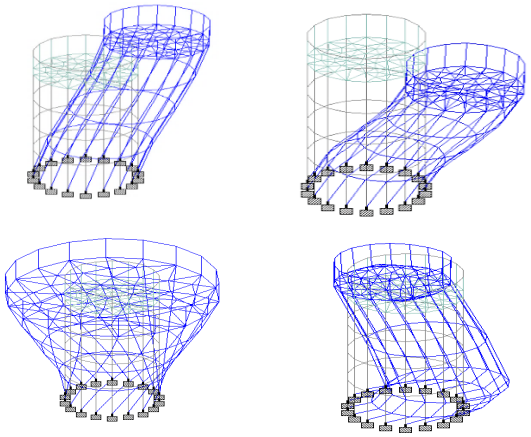

Figure 4. Mode shapes obtained during analysis.

Table 2. Different parameters involved in analysis

Type of tank	Height of tank (m)	Seismic zones as per IS 1893-2002	Damping factor (%)	Soil condition
Circular flat base	16 12 8	1&2 3 4 5	5 7 10	Hard Medium Soft
Circular domical base	16 12 8	1&2 3 4 5	5 7 10	Hard Medium Soft

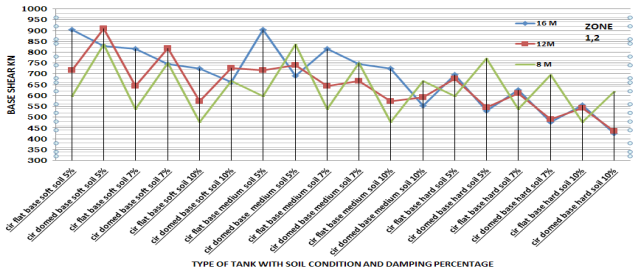

Figure 5. Base shear values vs. type and varying height of tank with site conditions for zone 1 and 2.

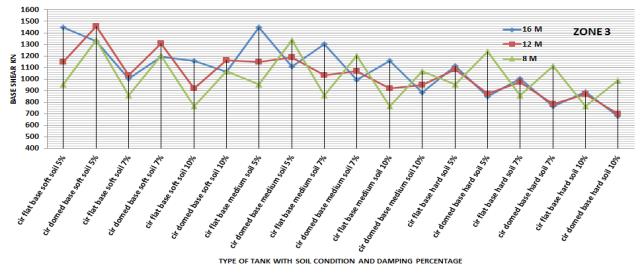

Figure 6. Base shear values vs. type and varying height of tank with site conditions for zone 3.

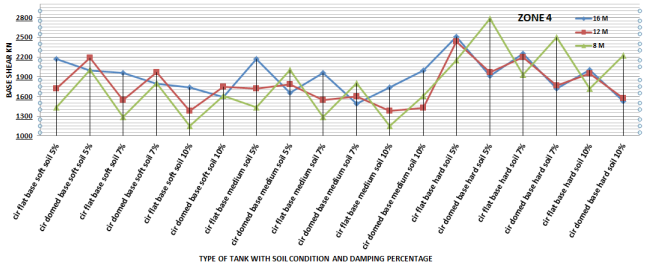

Figure 7. Base shear values vs. type and varying height of tank with site conditions for zone 4.

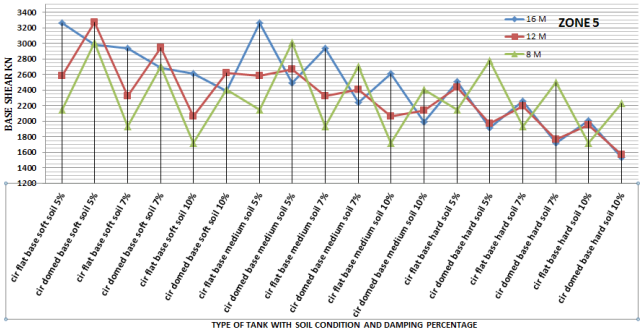

Figure 8. Base shear values vs. type and varying height of tank with site conditions for zone 5.

5. Discussion

The outputs in form of graphs can be used to deduce the selection of water tanks prior to designing w.r.t. their configuration (flat base and domical base), heights and damping conditions for optimum performance under seismic condition as per the location of site of construction and its soil condition.

Designer fellow(s) may use the results for effortless selection of tank prior to designing as it gives approximate idea to them just going through the graphs.

6. Conclusion

From the series of analysis done for different combinations (Table 2) viz, type of water tank, height of staging, zone factor, damping values and soil conditions following interpretation can be done:

1. Base shear value increases for all conditions as severity of zone increases i.e. zone 1 to 5.
2. For soft soil condition tank with lesser height is preferable while for more height more damping may be accredited to structure.

3. For soft soils a critical height of either 12 M or 16 M can be found out that may be avoided for that particular value of damping conditions in each zone.
4. For medium soil a critical height of 16 M is there for low damping value, hence it should be avoided.
5. For hard soil a critical height of 8 M is present for circular flat base type of tanks that should be avoided.
6. Tanks with domical base and higher height should be avoided in soft soils or more damping can be provided in case height is perquisite.
7. In medium soil, circular domical base type may be used for higher height perquisite with low damping.
8. Circular domical base type can always be used in hard soil for all zones for higher heights.

Though attempt has been made to find relation between various factors used for designing of water tanks with staging for seismic loading, base shear is one of them; there are always many designing factors that can be evaluated for other type of tank geometry w.r.t. site location and conditions.

7. References

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