Soil Structure Interaction Effects onSeismic Behaviour of Elevated Water Tank with Different Staging Configuration

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***Abstract*—The frame staging with a single row of columns placed along the periphery of a circle, they are generally adopted for elevated water tanks to support the tank container. Apart from the usual staging configurations, some alternate configurations are also practiced. These alternate configurations are made by adding few structural members to the usual configurations. The present paper aims to observe the effect of soil–structure interaction on elevated water tank with seismic forces. This report presents the study of seismic performance of the elevated water tanks for various seismic zones of India for different staging heights and different types of soil configuration models are analyzed using finite element-based software Etabs by considering. Tank responses including base shear, overturning moment, roof displacement, shear forces and bending moments in columns have been compared with the aim of recommendation of best staging configuration for earthquake zones in India.**

***Index Terms*: soil–Structure interaction, overturning moment, lasers, templates, journals, ETABS, bending moments**

INTRODUCTION

Water is human basic needs for daily life. Sufficient water distribution depends on design of a water tank in certain area. There are different ways for the storage of liquid such as underground, ground supported and elevated. An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to pressurize the water distribution system. Liquid storage tanks are used extensively by industries for storing inflammable liquids and other chemicals. Hence water tanks are very important components of lifeline. The liquid storage tanks are particularly subjected to the risk of damage due to earthquake-induced vibrations. Seismic safety of liquid tanks is of considerable

LITERATURE REVIEW

1.Hitesh Kumar; and Sandip Kumar Saha:- in this paper Seismic performance of elevated liquid storage tanks, considering soil–structure interaction (SSI) are investigated. The effects of considering SSI on the peak seismic responses, as well as on the seismic fragility of elevated tanks, are presented the base-isolation system works more effectively for slender geometry of elevated tanks when SSI is considered. Elevated slender tanks are seismically more vulnerable than broad tanks, irrespective of soil stiffness, period of staging, and presence of isolation system

2.Somnath Dutta, Aparna Mandal, Sekhar Chandra Dutta
The present paper aims to observe the effect of soil–structure interaction on two dynamic characteristics namely, the impulsive lateral period which regulates lateral seismic behaviour and the impulsive torsional-to-lateral period ratio which regulates torsional vulnerability of the structure. The analytical expressions for these two dynamic characteristics have been derived considering the effect of soil-flexibility in elevated water tanks with the alternate configurations. These formulations have been validated against the results of finite element analysis for a few example tanks. A parametric study with limited example tanks based on these formulations shows that the

frame staging with all kind of alternate configurations having less panel height, more number of columns, larger column diameter and stiffer circumferential beams compared to columns encounters the strongest influence of soil– structure interaction effect.he present study highlights the importance of soil–structure interaction and its impact on seismic design of elevated tanks with alternate staging configurations. The analytical formulations as well as the variation curves presented in the study may prove useful to the design engineers to incorporate the effect of soil–structure interaction on dynamic characteristics of elevated tanks supported by alternate frame staging configurations, very conveniently

3.Ankush N. Asati , Dr.Mahendra S.Kadu and Dr. S. R. Asati:- In this paper, the seismic behavioural effect of circular elevated water tank is studied for specific capacity of tank for various staging arrangements in plan, variation in number of periphery columns and variation in number of stages in elevation. Two mass idealizations suggested by Gujarat State Disaster Management Authority are considered here. Under earthquake loads; a complicated pattern of stresses are generated in the tanks. Total 36 combinations were analysedwith SAP2000 using Response Spectrum Method (RSM) and results are presented. It is observed that increase in number of columns, does not assure the increase in the improvement of structural responses. Radial arrangement with six staging levels are found to be best for the number of columns used.

4.Bhakti B. Jani, Vimlesh V. Agrawal and Vishal B. Patel This paper presents time history analysis of intze elevated liquid storage tanks supported on RC framed structure with different capacities, different Staging configuration and full and empty condition on three different soil types (Hard rock, Medium soil, Soft soil). Tank responses including base shear, overturning moment and roof displacement have been observed, and then the results have been compared. Results state that the dynamic analysis replies as base shear, over-turning moment and displacement are vastly influence. Radial bracing configuration attracts more seismic forces in tank full condition and results in higher base shear and less tank displacements compared to other bracing pattern. The Static and Dynamic analysis replies as base shear and displacement are vastly influenced.

5.Ayazhussain M. Jabar and H. S. Patel: - The main aim of this study is to understand the behaviour ofsupporting system which is more effective under different earthquake time history records with SAP 2000 software. Here are two different supporting systems such as radial bracing and cross bracing is compared with basic supporting systems for various fluid level condition. For later conditions water mass has been considered in two parts as impulsive and convective suggested by GSDMA guidelines. In empty condition, higher base shear for cross bracing pattern in Loma Prieta time history. For basic staging overturning moment is highest in half-full condition for Loma Prieta having high PGA value. Higher Roof displacement values are obtained in full fill up condition for all patterns.

6.Sekhar Chandra Dutta a, Somnath Dutta a and Rana Roy: - The present paper attempts to examine the failure/damage of a few reinforced concrete elevated water tanks consequent upon the occurrence of the same in the event of moderate to severe seismic shocks. The investigation, in the initial phase, evaluates primary dynamic characteristics, viz., impulsive lateral period, and impulsive torsional-to- lateral period ratio of such system incorporating the effect of soil–structure interaction. The analytical formulations developed and validated herein for this purpose, may also be considered as a user-friendly contribution of the paper. Further, the study exploring the failures as summarized, identified the deficiencies in the prevailing design strategy and proposes simple yet improved design procedures. The soil–structure interaction increases the impulsive lateral period and decreases the impulsive torsional-to-lateral period ratio strongly for elevated tanks supported by shaft staging with lesser heights, larger staging radius, thicker shaft wall, smaller ratio of the radii of foundation and staging and softer subgrade medium.

Thus, consideration of soil–structure interaction effect, at least for the design of these categories of tanks, seems to be extremely essential. e context of failure of a few reinforced concrete shafts supported tanks, the present investigation identifies that it is the tank-empty condition that regulates the possibility of generation of axial tension in the tank staging, though base shear is primarily governed by tank-full condition. Further, the effect of soil–structure interaction may cause a significant increase in tension at one side of the supporting staging as compared to the same obtained from a fixed base analysis. Such possibility is more pronounced, particularly at tank-empty condition.

7.Kashyap N. Patel and Jignesh A. Amin: - In this paper orderly approach is deputed to determine the seismic response factor of elevated water tank having different soil flexibility. For nonlinear static pushover analysis finite element method is used. The capacity curve of each model is generated and the 'R' factors are obtained such wise. The impact of soil flexibility on seismic response factor of RC framing tank is evaluated. 'R' factors are determined for existing tanks at two performance level.
The impact of the SSI in case of soft and medium soil reduces values of 'R' factor as much as 22% and 38% for the considered tanks respectively as compared to fixed base condition. The impact of the soil-flexibility is the least in case of hard soil. The actual value of 'R' expected to be lower than what is evaluated here, because of several reasons, such as, due to dimensions disproportion may lead to moderate torsional effects, due to deficiency in construction, not following the IS provisions for ductile detailing

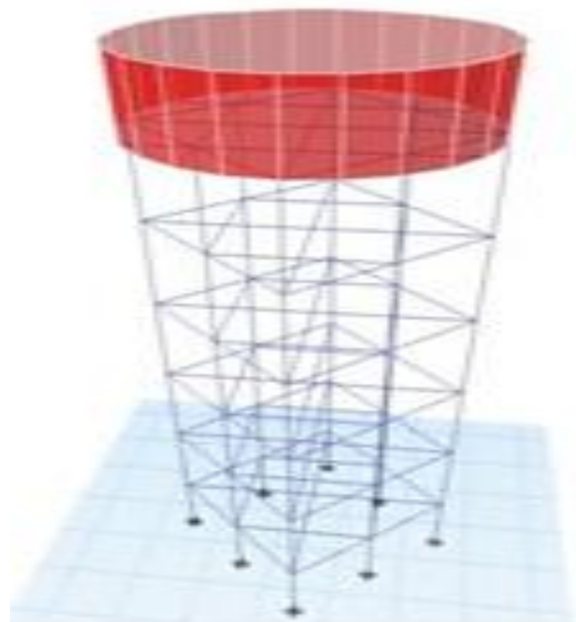
METHODOLOGIE

At the starting of any project some preliminary study is required. These preliminary studies are required to know the exact behavior of the structure, to know the property of the structure and various load conditions of the structure. Analyzing the small structure concern to respective project study does these types of studies.In this chapter software modeling, wind load calculations by static and dynamic methods for Circular type of Water Tank as per IS 875 (part 3)- 1987 has been done. Then application to calculated wind loads to software models and analysis will be studied.

3.1 Methodology

The methodology worked out to achieve the above-mentioned objectives is as follows:

1 Extensive literature survey by referring books, technical papers or research papers carried out to understand basic concept of topic.
2 Identification of need of research.
3 Formulation of stages in analytical work which is to be carried out.
4 Data collection.
5 Water Tanks of 24m,20m, &16m is considered for the analysis.
6 The model has prepared on Etabs for the Circular shaped Tanks.
7 Comparative studies done for axial loads on Water tank shear, lateral story displacement, storydrift, for the tank
8 Interpretation of results and conclusion.



STRUCTURAL GEOMETRY & MODELLING

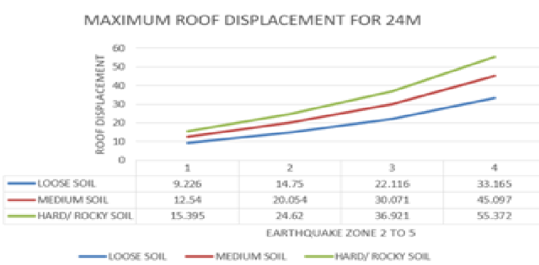
The frame type is the most commonly used staging in practice. The main components of frame type of staging are columns and braces. In frame staging, columns are arranged on the periphery and it is connected internally by bracing at various levels. The staging is acting like a bridge between container and foundation for the transfer of loads acting on the tank. In elevated water tanks, the head requirement for distribution of water is satisfied by adjusting the height of the staging portion. A reinforced elevated water tank having different staging arrangements and staging levels has been considered for the presentstudy

Table 1. Structural Data for Water Tank

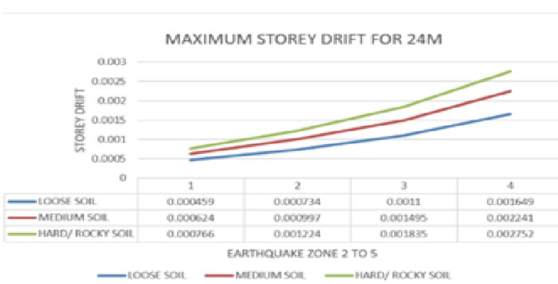
Tank Vessel property		-	
Capacity of Tank	235m^3	No. of Column	8
Diameter of tank	10 m	Column Diameter	0.45 m
CylindricalHeight Wall	3 m	Column Height	16 m, 20 m,24 m
Top Dome Rise	2.2 m	Staging Diameter	6.5 m
cal DomeRise	2 m	Bracing Interval	4 m
om DomeRise	1.3 m	Beam Bracing Size	0.23 m x 0.0.45 m
Top ring Beam	0.23 x 0.45 m	Material	30 Grade ofConcrete
Bottom ring beam	0.23 x 0.45 m	Type of Bracing	NormalCrossRadial
Lower Circularring beam	0.350 x 0.750 m		
Top domeThickness	0.1 m	Seismic Data	
indrical Wall Thickness	0.20 m	Zone	II, III,IV,V
onical dome Thickness	0.2 m	Response Reduction Factor	2.5
ottomdome Thickness	0.1 m	Soil Type	Soft Medium Rocky

RESULTS AND DISSCUSION

1. As the Earthquake zone increases thus the Roof displacement and maximum storey prepared drift also increases.
2. We prepared 9 Models for the analysis and analyzed them for 9 conditions,
   - 16m ht tank and three different types of soil
   - 20 m ht tank and three different types of soil
   - 24 m ht tank and three different types of soil
3. As the Height of structure increases from 16m to 20m and 20m to 24m maximum Roof displacement and maximum storey drift increases.
4. From the chart we can see that soil type for medium is most suitable for construction ofwater tank.



Graph No. 1 MAXIMUM ROOF DISPLACEMENT FOR 24M



Graph No. 2 MAXIMUM STOREY DRIFT FOR 24M

Graph No. 3 MAXIMUM ROOF DISPLACEMENT FOR 20M

Graph No. 4 MAXIMUM STOREY DRIFT FOR 20M

CONCLUSION

1. Lower Earthquake zone gives the lower Roof displacement and lower maximum storey drift
2. And also gives lower shear force and bending moment.
3. As the Height of structure increases from 16m to 20m and 20m to 24m maximum Roof displacement and maximum storey drift increases. So, Height of water tank should be less as far as possible
4. From the chart we seen that soil type for medium is most suitable for construction of water tank.
5. The soil structure interaction (SSI) show increase in values of displacement and Time period when compared with fixed base analysis due to soil flexibility, hence SSI needs to be considered.
6. The maximum displacement increases with seismic zones and maximum displacement is observed in soft soils.
7. In soft soils the displacement values are higher compared to medium and hard soils and use of bracings are recommended in softsoils only.

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