Static Analysis of Water Tank under various Conditions of Bracings

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Abstract- Elevated water tanks are one of the most significant water storage facilities. The increasing demand for water tanks in main towns and rural areas constitutes an integral part of the system for water delivery. In this study the measurement of seismic forces in high water tanks for example. Circular tank with a structure configuration, low with exclusive parameters such as seismic depth and specific velocities of wind. Also measured for the seismic intensity of the tank is the convergence of the IS:1893-2002 seismic model. five kinds of water tank layout designed here, water tank with soil and without soil and water tank with various bracings system used in water tank designed. With the help of Ansys Water tank designed with soil and without soil conditions and different types of bracings used in water tank using ANSYS. In the present study try had been made to take a look at the impact of soil shape interaction at the overall performance of water tank and stability of water tank with different conditions of bracings. ANSYS Software is used in three dimensional FEA. In the study in question, the mode type, natural frequency and characteristics of stress pattern are illustrated using different parameters.

Keywords: Water tank, ANSYS, Soil structure, Bracings, FEM.

I. INTRODUCTION

A water tank is a container for storing liquid. The need for a water tank is as old as civilization, to provide storage of water for use in many applications, drinking water, irrigation, agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses. A water tank is a structure used to store water to tide over the daily requirement. Cost, shape, size and building materials used for constructing water tanks are influenced by the capacity of water tank. Shape of the water tank is an important design parameter because nature and intensity of stresses are based on the shape of the water tank. The study of damage histories revealed damage/failure of reinforced concrete elevated water tanks of low to high capacity. Damage of the important lifeline facility like elevated water tanks often results in significant hardships even after the occurrence of the disaster, claiming human casualties and economic loss to build environment. Investigating the effects of wind has been recognized as a necessary step to understand the natural hazards and its risk to the society in the long run. Most water supply systems in developing countries, such as India, depend on reinforced cement concrete elevated water tanks. The strength of these tanks against lateral forces, such as those caused by wind, needs special attention. In general, for a given capacity, circular shape is preferred because stresses are uniform and lower compared to other shapes. Lesser stresses imply, lower quantities of material required for construction which brings down the construction cost of water tanks. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. Investigating the effects of wind has been recognized as a necessary step to understand the natural hazards and its risk to the society in the long run. Most water supply systems in developing countries, such as India, depend on reinforced cement concrete elevated water tanks. The strength of these tanks against lateral forces, such as those caused by wind, needs special attention. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential.

II. ANSYS

A package of ANSYS will be used to evaluate all models. ANSYS is a powerful program for the modeling and design of building details. ANSYS reflects the structural analysis and design methodology that covers all facets of structural engineering, such as model design, research, design, testing and visualization. It is based on simultaneous engineering principles. One can build your model, graphically track it, evaluate and design it, check the results, sort and search the data and generate a report in the same graphic environment.

1. ANSYS Analysis and design
2. ANSYS Graphics Input Generation
3. ANSYS Graphical Post processing

III. Finite Element Analysis

Finite element analysis is a method of piece-wise analysis in which the model or system is divided into mall elements of finite size called finite elements and then taken into account as a combination of those variables related to different joints called nodal points or nodes, the original model or structure. The variation of the ground variable in one finite part can be approximated by a simple method, since the real variance in subject variables such as displacement, tension, temperature, pressure or speed are not defined within a continuum. Such evaluation functions are defined according to the values of the field node variables called interpolation models. Changeable field nodal specifications are achieved through the solution of the field equations, which generally take the form of matrix equations.

IV. Geometry of sections

Here are two types of water tank construction, soil and soil-free. The soil is engineered and without soil contact with the assistance of Solid work Water Tank. The following is defined geometry of soil and no soil interaction. Use System Development of Solid work Importation Water Tank. Water tank Igs file at ANSYS. Figure shows the size of the soil or water tank. The elevated tank resting on a pile foundation is considered for the parametric study. It has a capacity of 295 m^3 with the top of water level at about 16.25 m above ground. The tank is spherical in shape, 9.60 m in diameter and 7.75 m in height at its center. The support consists of 6 vertical circular columns and the columns are connected by the circumferential beams at regular intervals, at 4,8,12 and 16 m.

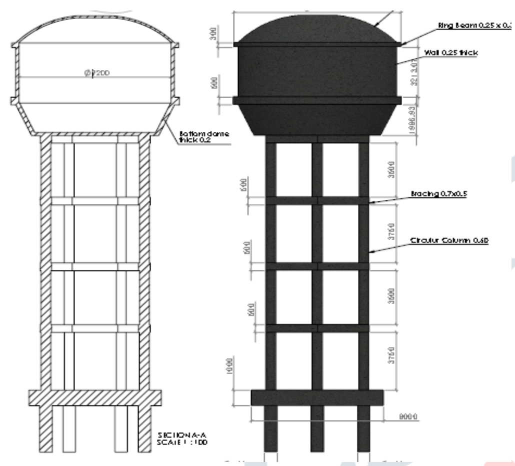

Figure 1: Water tank with circular bracings

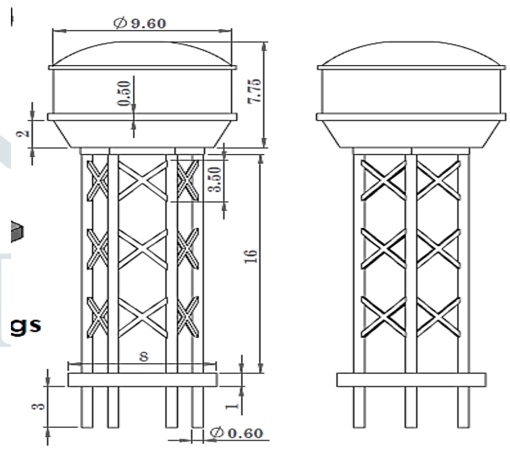

Figure 2: Water tank with Cross bracings

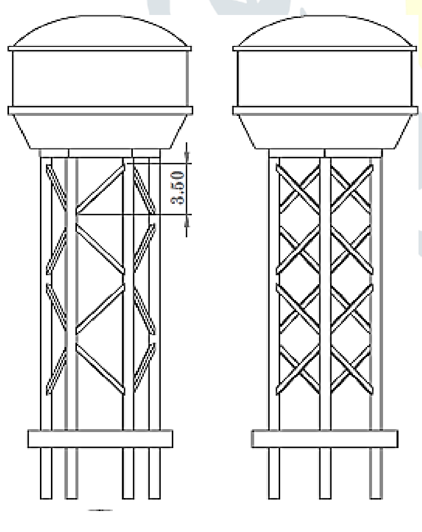

Figure 3: Water tank with Zigzag bracings

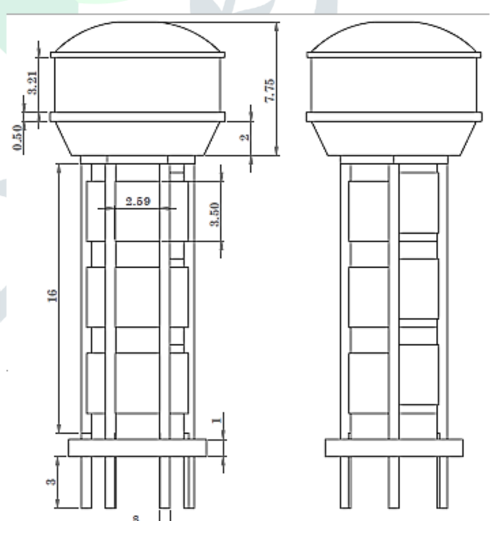

Figure 4: Water tank with Plate bracings

V. Modeling of Water tank

Modeling of the designs of water tank structure using ANSYS Workbench has been explained in detail. The intention of finite element investigation is to reconstruct the mathematical behavior of an actual engineering structure. The Water tank model comprises all the nodes, elements, material properties, real constants, boundary conditions and additional features that are used to characterize the physical system. First model be generated then specific boundary conditions will be applied on the specific nodes then final analysis will be conducted.

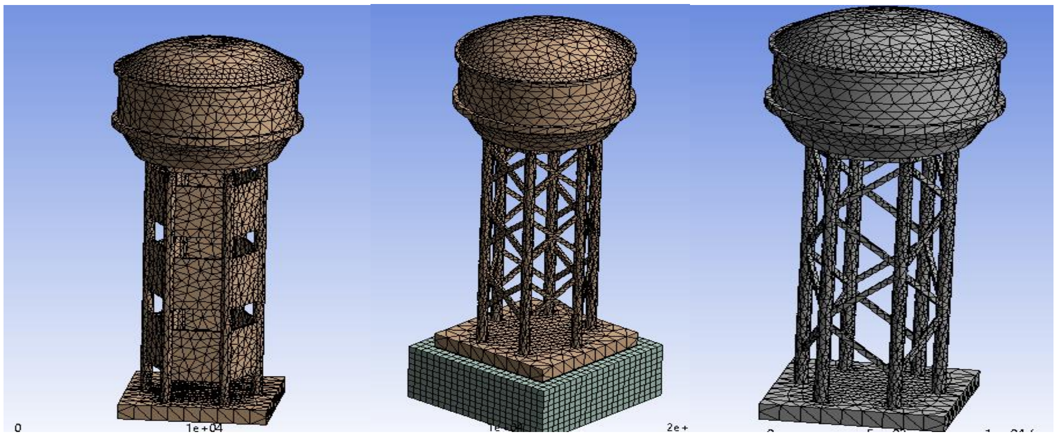

Figure 5: Meshed design model of Water tank various types bracings

VI. Material Properties

The next step in creating the model involves defining and assigning material and section properties to the part. Each region of a deformable body must refer to a section property, which includes the material definition. In this model linear elastic materials are created for both concrete pile and soil.

1) Grade of concrete for beam, column = M20
2) Grade of concrete for pile = M40

Table 1: Section, Material and Profile.

Sr. No.	Section Created	Material Assigned
1	Beam	M-20
2	Column	M-20
3	Pile	M-40
4	Pile Cap	M-20
5	Soil	Soil
6	Circular Tank	M-20

Table 2: Properties of concrete pile.

Young's Modulus	Mass Density	Poisson's Ratio
EC=0.3605*10^8 kpa	2504	0.15

Table 3: Properties of beam, column, circular tank and pile cap

Young's Modulus	Mass Density	Poisson's Ratio
EC =0.25491*10^8 kpa	2452	0.15

Table 4: Properties of Soil.

Young's Modulus	Mass Density	Poisson's Ratio
EC =20000 kpa	2000	0.2

Applying Boundary conditions

Using Model design of Water tank from Solid work import. Igs file of Water tank in ANSYS. Figure shows the design of Water Tank with or without soil interaction. Applying boundary conditions on water tank, Base of Tank structure kept fixed support and on overall tank body Standard earth gravity applying 9.81 m/s^2. Figure 6, and shows the applying boundary conditions on the Water tank structure with or without soil interaction.

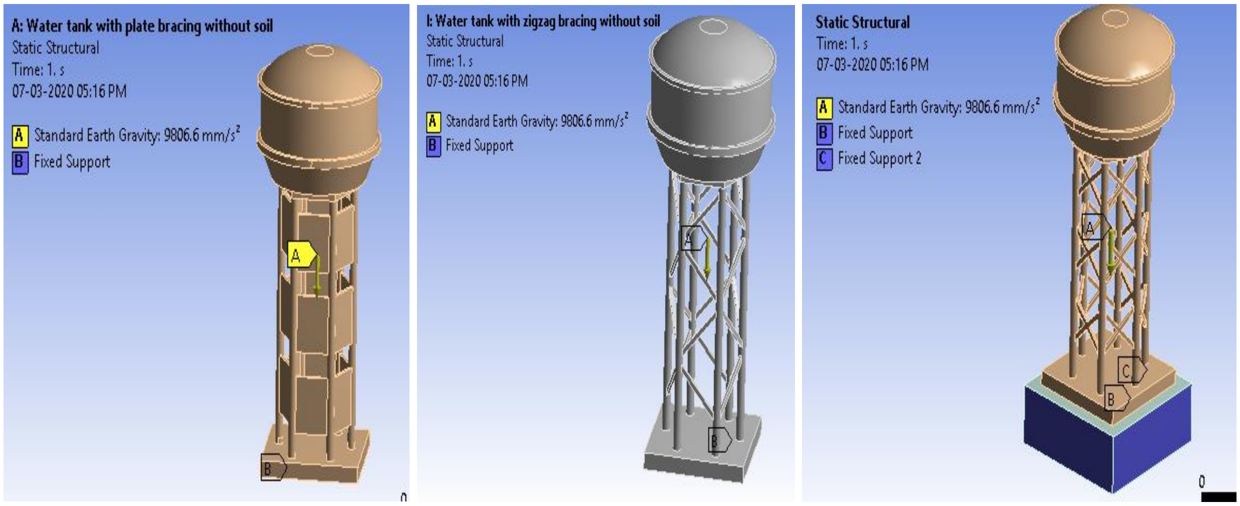

Figure 6: Applying Boundary condition of tank with various bracings structure

VII. Results and Discussion

Comparison of the soil structure interaction parameters for an Elevated water tank without soil and soil and validation of the tank with replacement system approach is performed. All joint points from bracings are considered from an Elevated water tank frame with soil and without soil for comparison purposes following examination.

As per Study it is found that the deformation found on water tank with soil structure is 7.36 mm and without soil structure deformation found 3.78 mm. hence it is shows that tank structure with soil interaction is best arrangement against seismic conditions. Stresses found on water tank shows that maximum stress found 11.63 MPa with soil structure of water tank.

Table 5: Comparison of results

Water Tank Designs	Soil Interaction Type	Stress (MPa)	Deflection(mm)
	with soil	1.79	1.79
Crossed Bracings	without soil	2.15	0.85
	with soil	1.7	2.07
Zigzag Bracings	without soil	1.73	0.86
	with soil	2.22	3.16
Plate Bracings	without soil	2.28	0.81

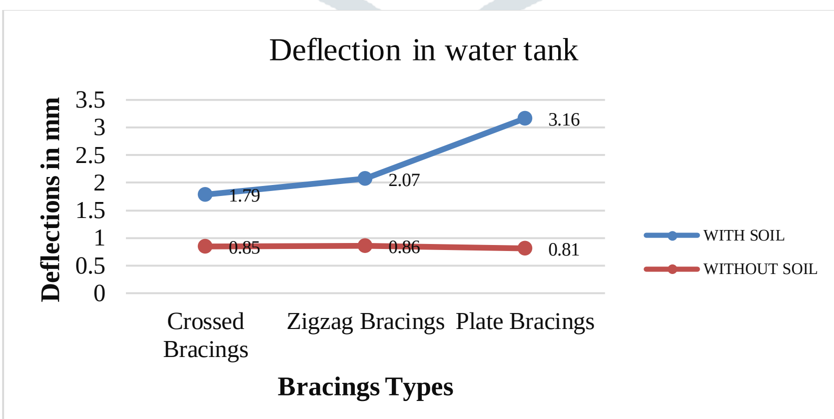

Figure 4: Comparison of Deflections with various bracings structure

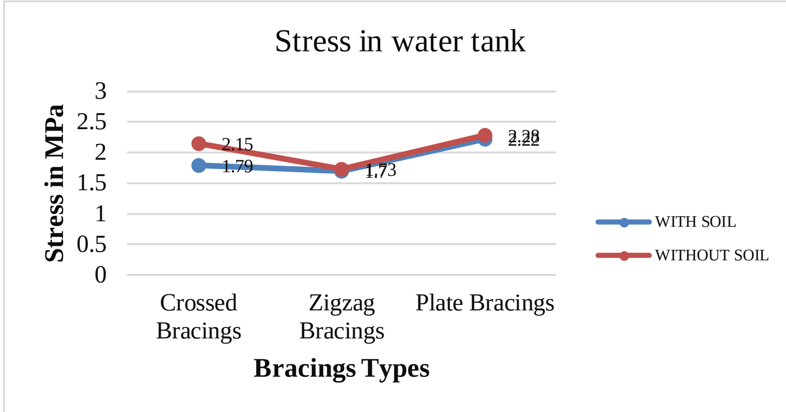

Figure 5: Comparison of stresses with various bracings structure

Table 6: Weight of Tanks

Bracings Types	Weight(kg)
Crossed Bracings	386000
Zigzag Bracings	379000
Plate Bracings	442000

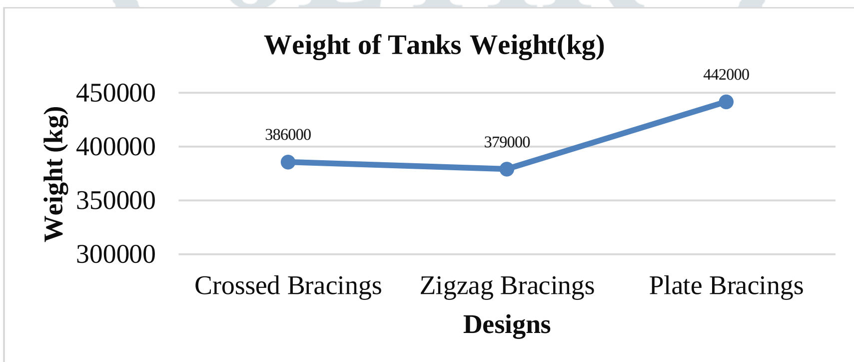

Figure 6: Weight comparison of water tank

VIII. Seismic analysis of designed Water Tank Structure at different modes

For comparison purpose after analysis all junction points from bracings are considered from elevated water tank frame with soil and without soil with various types of bracings used in structure. All six columns and bracings joints at each height of base with three bracings types are considered i.e. plate bracings, zigzag bracings and cross bracings respectively.

Table 7: Various frequencies modes of crossed bracings tank structure with soil and without soil structure.

Crossed Bracings with soil		Crossed Bracings without soil	
Freq	Deflection	Freq	Deflection
3.5222	0.047	2.5143	0.088
3.6795	0.047	2.6272	0.087
4.585	0.051	3.2798	0.094
15.38	0.058	10.979	0.108
16.28	0.061	11.629	0.113
20.512	0.137	14.707	0.252

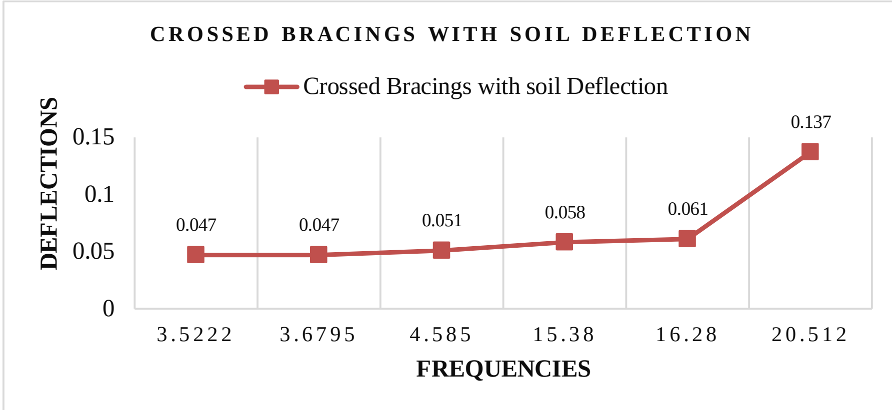

Figure 7: Deflection with respect to frequencies of cross bracings with soil interaction

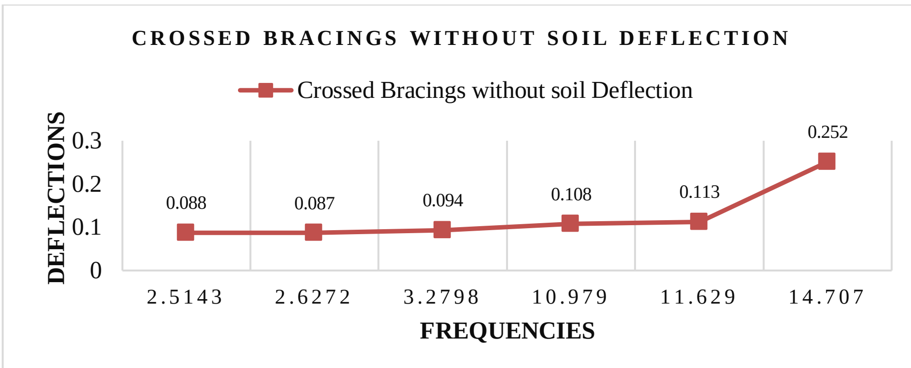

Figure 8: Deflection with respect to frequencies of cross bracings without soil interaction

Table 8: Various frequencies modes of Plate bracings tank structure with soil and without soil structure.

Plate Bracings with soil		Plate Bracings without soil	
Freq	**Deflection**	**Freq**	**Deflection**
4.5294	0.05	3.2367	0.092
4.7935	0.049	3.424	0.091
7.6786	0.049	5.4996	0.09
18.341	0.048	13.114	0.09
19.48	0.047	13.917	0.087
26.373	0.09	18.773	0.167

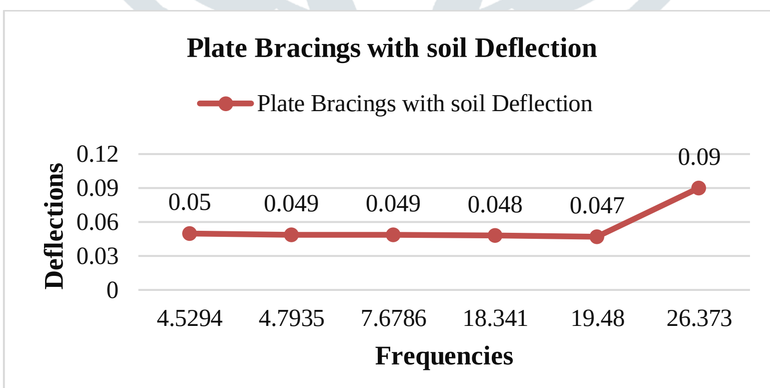

Figure 9: Deflection with respect to frequencies of Plate bracings with soil interaction

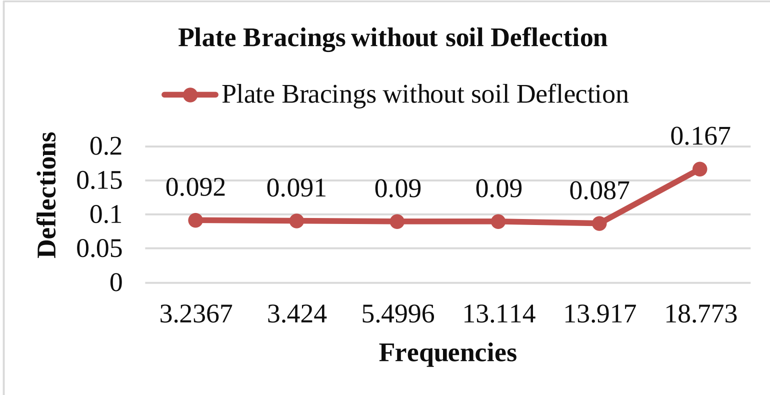

Figure 10: Deflection with respect to frequencies of plate bracings without soil interaction

Table 9: Various frequencies modes of Zigzag bracings tank structure with soil and without soil structure.

Zigzag Bracings with soil		Zigzag Bracings without soil	
Freq	Deflection	Freq	Deflection
2.418	0.087	2.4184	0.087
2.5569	0.086	2.5586	0.086
3.1436	0.094	3.1447	0.093
9.4981	0.098	10.033	0.17
9.4983	0.098	10.624	0.163
10.033	0.17	12.294	0.294

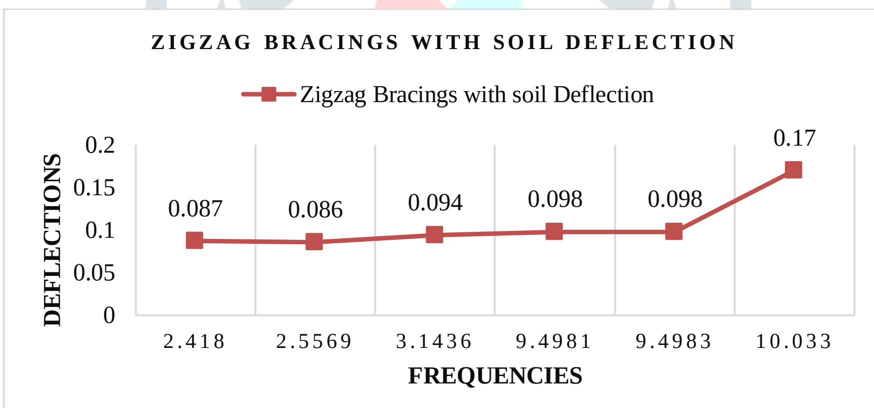

Figure 11: Deflection with respect to frequencies of Zigzag bracings with soil interaction

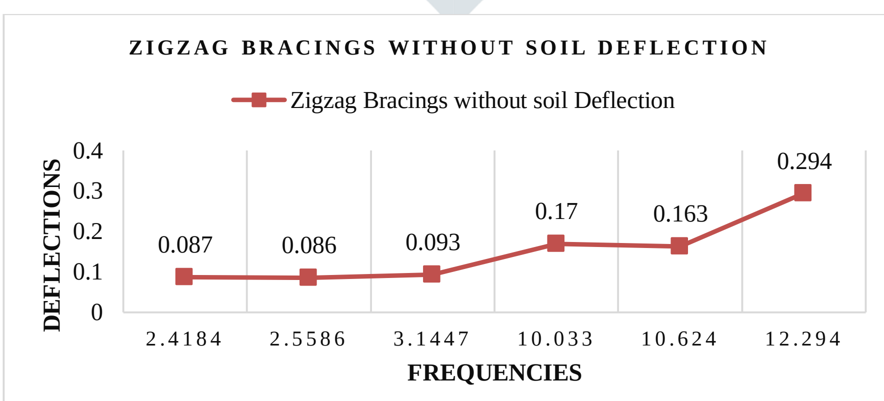

Figure 12: Deflection with respect to frequencies of Zigzag bracings without soil interaction

Conclusions

The above study can provide a useful design and help to improve the Life of Water tank structure. From the above result, from our study of various design patterns for different materials we have observed that the maximum deformation found on plate bracings water tank with soil structure is 3.16 mm and without soil structure deformation found 0.81 mm. minimum deformation found on the water tank with crossed bracings using with soil structure is 1.79 mm and water tank without soil interaction is 0.85 mm deformation found. In zigzag type bracings having deflection in with soil interaction is 2.07 mm and without soil integration is 0.86 mm.

so as per study we can say that water tank with crossed bracings having better stability with minimum deformation and water tank with plate bracings having maximum deformation. as per comparison of water tank with the soil interaction we found minimum deformation on without soil interaction of tank model also it shows better stability of water tank with plate bracings in without soil interaction. while we compare weight of water tank in study results shows maximum weight of tank found on plate bracings and minimum weight found on zigzag type bracings used in tank model. hence it is shows that tank structure with soil interaction is best arrangement against seismic conditions.

Stresses found on water tank shows that maximum stress found 2.28 MPa with water tank using plate bracings.

From the above study work the following conclusions are made:

- It can be seen that for respective levels almost all columns show same displacement for corresponding modes.
- Considerable variation in displacement is observed in the structure with and without Soil structure. Maximum displacement found on water tank using plate bracings with soil structure.
- From the obtained results it may be concluded that for relatively heavy structures on soft oil Soil structure analysis must be carried out.
- ANSYS software can be used efficiently to investigate the effect of with soil or without soil on the structures, further different soil and structural models can be incorporated to improve the accuracy.

References

1. Tiruveedhula Chandana, S.V. Surendhar, "Comparative Seismic and Cost Analysis of RCC Circular, Rectangular and Intze Elevated Water Tank", International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-8 Issue-8, June, 2019.
2. Vyankatesh, More Varsha, "Comparative Study on Dynamic Analysis of Elevated Water Tank Frame Staging and Concrete Shaft Supported ", OSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 14, Issue 1 Ver. I, 2017.
3. Ashish Vajir, Dattatray Jadhav, Ritesh K Jain, "Analytical and Numerical Analysis of Composite Material Storage Tank under Seismic loading", SSRG International Journal of Mechanical Engineering, Volume 4, Issue 5, May 2017.
4. N Beemkumar, Karthikeyan, Reddy,"Analysis of Thermal Energy Storage Tank by ANSYS and Comparison with Experimental Results to Improve its Thermal Efficiency", Materials Science and Engineering, 197, 2017.
5. Karthika J Prasad, 2Chinnu Sara Prasad, "Seismic Analysis and Design of Strengthening Techniques of Steel Storage Tank", International Journal of Advance Engineering and Research Development, Volume 4, Issue 5, May-2017.
6. Kavita Chaudhari, S L Bhilare, G R Patil, "A Study of Dynamic Response of Circular Water Tank with Baffle Walls", International Research Journal of Engineering and Technology (IRJET), Volume: 04, Issue: 08, Aug -2017.
7. Dhruv Saxena, "Study of Continuity Analysis in INTZE Type Tank using Conventional and Finite Element Method", American Journal of Engineering Research (AJER), Volume-6, Issue-11, pp-128-134, 2017.
8. Thorat, Pawar, "Nonlinear Analysis of RCC Open Square Elevated Storage Reservoir with Discrete Modelling by using Ansys", International Journal of Engineering Trends and Technology (IJETT), Volume 36, Number 6, June 2016.
9. Maheswari, Sravani, "Performance of Elevated Circular Water Tank In Different Seismic Zones", International Journal For Technological Research In Engineering Volume 3, Issue 5, January-2016.
10. Naveen V M, Maria Gomez, "Study of Hydrodynamic Effects on RC Elevated Water Tank under Seismic Excitations", IJEDR, Volume 3, Issue 3, 2015.
11. Dhumal, Suryawanshi, "A Study of Effect of Baffle Wall on Dynamic Response of Elevated Water Tank using Ansys 16", IJIRST – International Journal for Innovative Research in Science & Technology, Volume 3, Issue 01, June 2016.
12. George, Joseph, "Dynamic Analysis of Elevated Cement Concrete Water Tank", IJIRST –International Journal for Innovative Research in Science & Technology, Volume 3, Issue 03, August 2016.
13. Jingyuan Li, Xiaochuan You, Hongcheng Cui,"Analysis of large concrete storage tank under seismic response", Journal of Mechanical Science and Technology, Springer, 29, 2015.
14. Anumod, Harinarayanan, S.Usha, "Finite Element Analysis of Steel Storage Tank Under Siesmic Load", International Journal of Engineering Research and Applications (IJERA), Trends and Recent Advances in Civil Engineering, 2014.
15. Boshra Eltaly, Gada Saudi, Reham Ali,"Experimental and FE Modal Analysis for Elevated Steel Water Tanks", International Journal of Engineering Research & Technology (IJERT), Vol. 3, Issue 1, January - 2014.
16. Sarokolayi, Neya, H. Tavakoli, "Dynamic Analysis of Elevated Water Storage Tanks due to Ground Motions' Rotational and Translational Components", Arab Journal Science Engineering, Springer ,2014.
17. Dhamak, Rathi, Ladhane, "Dynamic response of an Elevated water tank", International journal of Engineering & Technology, Volume 3, Issue 8, 2014.