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# STATIC ANALYSIS OF WATER TANK WITH AND WITHOUT SOIL INTERACTION USING ANSYS

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***Abstract- Elevated water tanks are one of the most important lifeline structures in earthquake prone regions. In major cities and also in rural areas elevated water tanks forms an integral part of water supply scheme. This study presents the evaluation of seismic forces acting on elevated water tank e.g. circular water tank with frame staging affected by different parameters viz., seismic intensity, different wind speeds. Seismic forces acting on the tank are also calculated changing the seismic zone of IS:1893-2002 for seismic design has been referred. Two types of water tank design here, water tank with soil and without soil designed. With the help of Solid work Water tank designed with soil and without soil interaction using ANSYS. In the present study attempt have been made to study the effect of soil structure interaction on the performance of water tank. Three dimensional FEA is carried out using ANSYS Software. In the present study use different Parameter to define mode shape and natural frequency and different type of stress pattern.***

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

## I. INTRODUCTION

Liquid storage tanks are used extensively by municipalities and industries for storing water, inflammable liquids and other chemicals. Water tanks are very important for public utility and for industrial structure having basic purpose of to secure constant water supply at the longer distance with sufficient static head to the desired destination under the effect of gravitational force. It is also essential to ensure that requirements such as water supply is not hampered during an earthquake and should remain functional in the post-earthquake period. In such situations the elevated tanks may prove handiest tool for the purpose of water distribution and fire protection. Elevated water tank is a large elevated water storage container constructed for the purpose of holding a water supply at a height sufficient to pressurize a water distribution system. In major cities the main supply scheme is augmented by individual supply systems of institutions and industrial estates for which elevated tanks are an integral part. These structures have a configuration that is especially vulnerable to horizontal forces due to the large total mass concentrated at the top of slender supporting structure. 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. Water storage tanks should remain functional in the post-earthquake period to ensure potable water supply to earthquake-affected regions and to the need for fire fighting. The reinforced concrete circular water tanks are mainly subjected to direct tension in the form of hoop force. The tension is carried primarily by steel, and concrete is considered to provide protective cover to the steel reinforcement. In such structures, the values of allowable stresses in steel and concrete are restricted so that the strains in steel and concrete are not high, consequently crack widths are limited. This provision minimizes the danger of corrosion of steel. On the other hand, in the tanks with fixed bases, the walls are subjected to bending tension. The members under the direct tension are designed by elastic theory and those subjected to bending tension are designed.

## II. ANSYS

Analysis of all the models is carried out with the help of ANSYS software. ANSYS is a powerful Building information modelling and design software. ANSYS stands for structural technique for analysis and design which addresses all aspects of structural engineering i.e. model development, analysis, design, verification and visualization. This is based on the principles of concurrent engineering. One can build his model, verify it graphically, perform analysis and design, review the results, sort and search the data and can create a report within the same graphics based environment. Following are the main options available from the concurrent graphics environment.

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

## III. FINITE ELEMENT ANALYSIS

The finite element analysis is a technique of piecewise estimated in which the model or element is divided into small elements of finite dimensions referred to as finite elements and then the original model or the structure is taken into consideration as an assemblage of those factors related at various number of joints called nodal points or nodes. because the actual variation of subject variables like displacement, stress, temperature, pressure or velocity inside the continuum are not identified, the variation of the ground variable within a finite part can be approximated by a easy function. These estimate functions called interpolation models are defined in terms of the values of the field variables of the nodes. The nodal standards of the field changeable are obtained by solving the field equations, which are typically in the form of matrix equations.

## IV. GEOMETRY OF SECTIONS

Two types of water tank design here, water tank with soil and without soil designed. With the help of Solid work Water tank designed with soil and without soil interaction. Geometry of with soil and without soil interaction are described below. 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. 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, 10 m in diameter and 7.5 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.

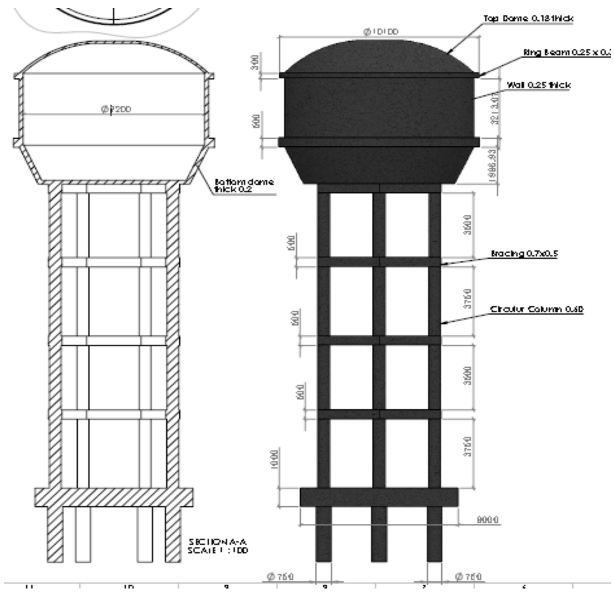



Figure 1: Dimensions of Water tank

## V. *MODELLING OF WATER TANK*

Modelling 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 behaviour 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.

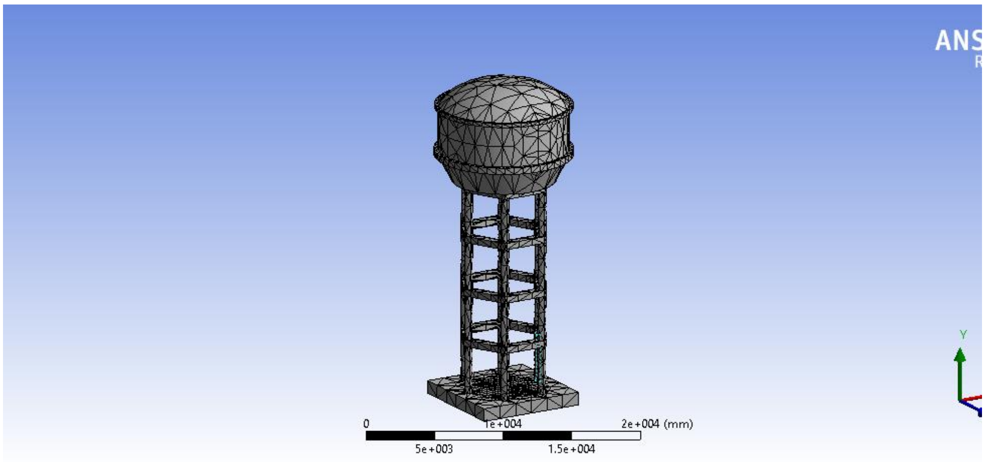



Figure 2: Design model of Water tank

## 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 4.6, and Figure 4.7 shows the applying boundary conditions on the Water tank structure with or without soil interaction.

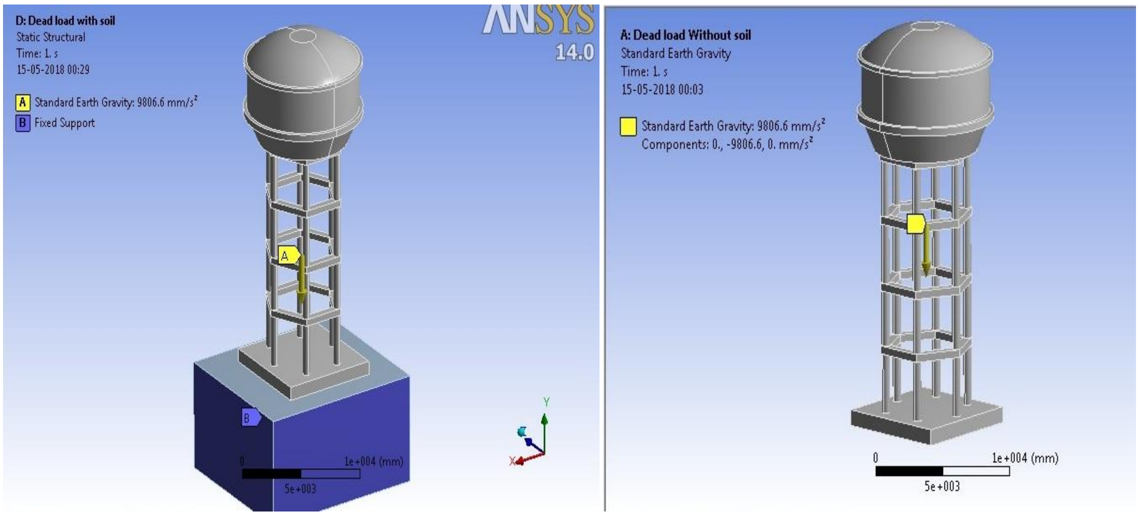



Figure 3: Applying Boundary condition of tank with and without soil structure

## VII. RESULTS AND DISCUSSION

Comparison of different parameters of soil structure interaction for an Elevated water tank without soil and with soil is done and analysis validation for tank is done by using substitute frame method. For comparison purpose after analysis all junction points from bracings are considered from elevated water tank frame with soil and without soil.

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

| **Results** | **With Soil** | **Without Soil** |
|---|---|---|
| Total deformation | 7.36 mm | 3.78 mm |
| Equivalent Stresses | 11.63 MPa | 8.12 MPa |

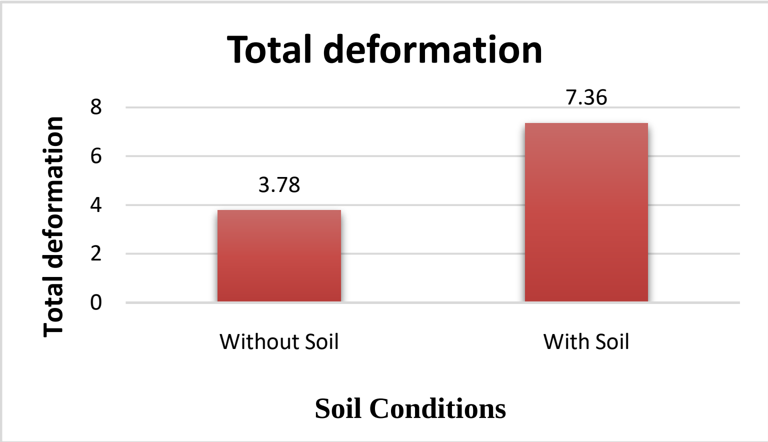


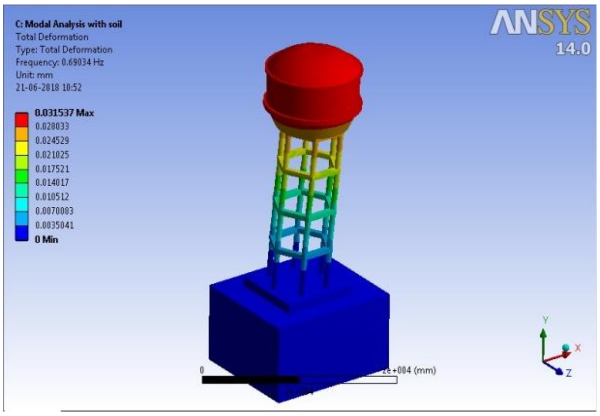

Figure 4: Comparison of Tank Structure with soil and without soil structure

## VIII. SEISMIC ANALYSIS OF DESIGNED WATER TANK STRUCTURE AT DIFFERENT MODES

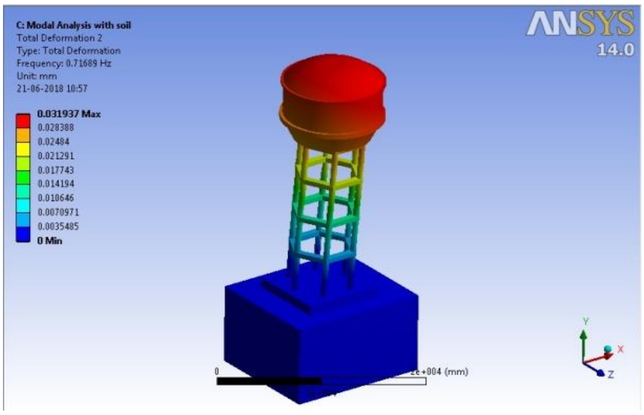
For comparison purpose after analysis all junction points from bracings are considered from elevated water tank frame with soil and without soil. All six columns and bracings joints at each height of base frame are considered as level 1, 2, 3, 4 and 5 respectively.

### A. Frequency Modes of Water Tank with Soil Structure

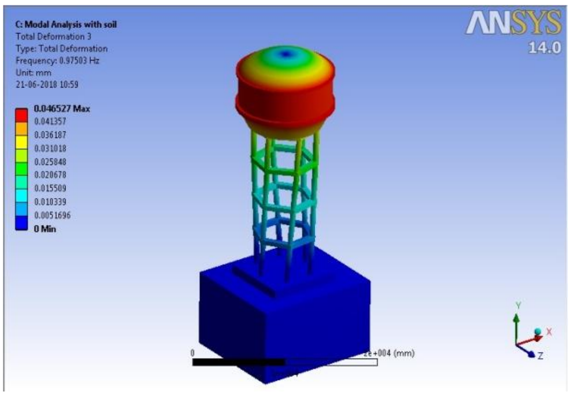
Comparison of different parameters of soil structure interaction for an Elevated water tank without soil and with soil is done and analysis validation for tank is done by using substitute frame method.



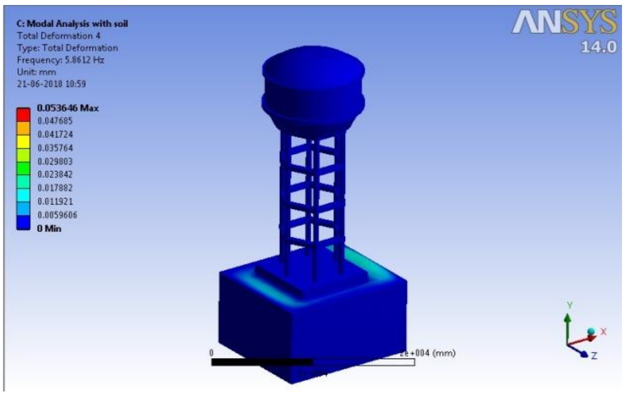

a): Mode 1 for tank with soil



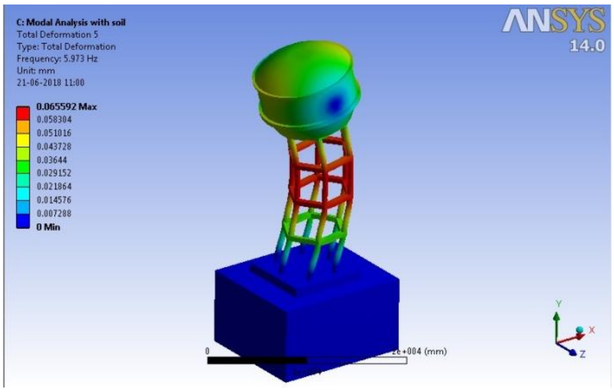

b): Mode 2 for tank with soil



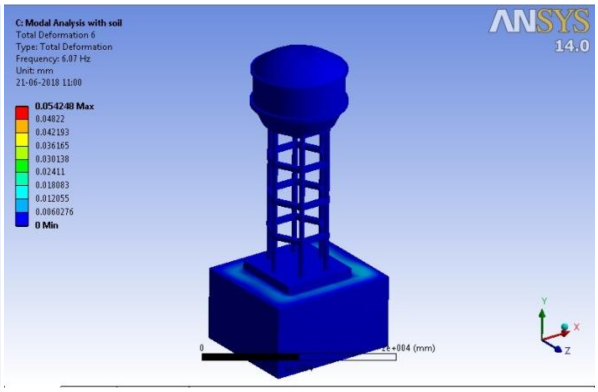

c): Mode 3 for tank with soil




d): Mode 4 for tank with soil




e): Mode 5 for tank with soil

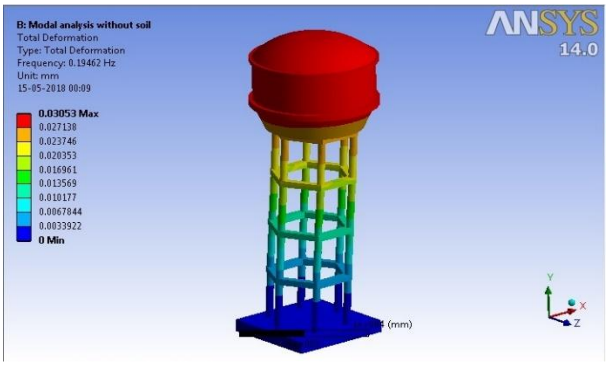



f): Mode 6 for tank with soil

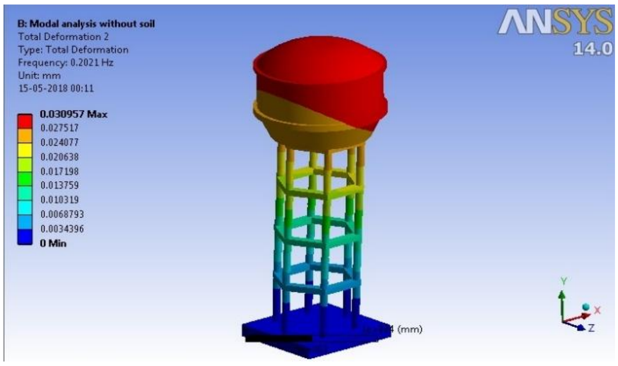
Figure 5: Frequency modes of water tank with soil structure

### 1) B. Frequency Modes of Water Tank without Soil Structure

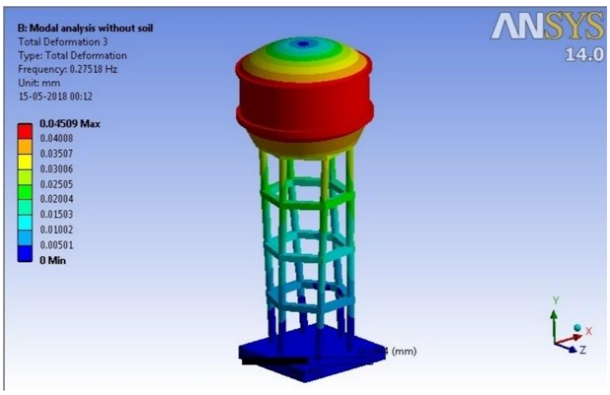
By keeping other parameter constant, the natural frequencies increase with the increase in the mode number of tank. the effect of damping on dynamic response of liquid storage tanks can be studied. in this study, only a constant value for damping was assumed. Following figures shows firs six modes & corresponding frequencies for water tank without soil and with soil respectively.



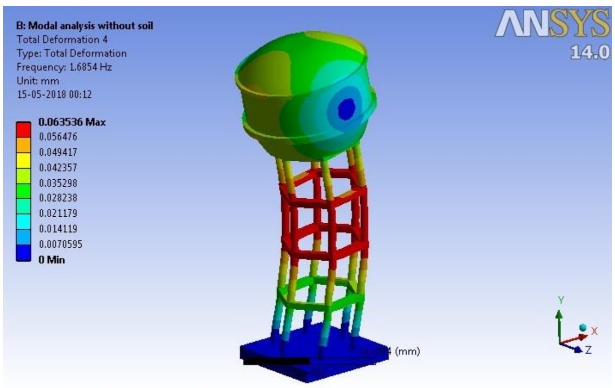

a): Mode 1 for tank without soil



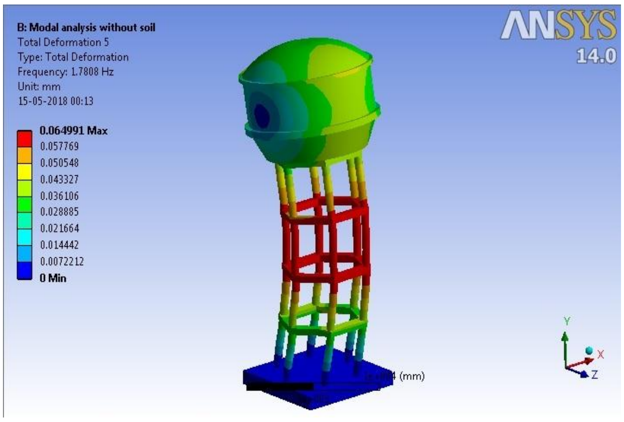

b): Mode 2 for tank without soil



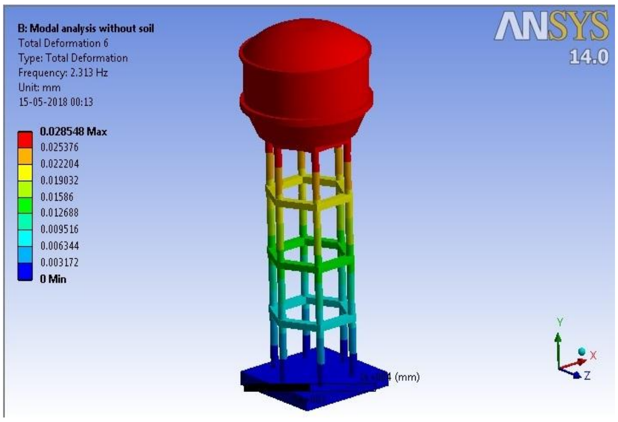

c): Mode 3 for tank without soil




d): Mode 4 for tank without soil




e): Mode 5 for tank without soil




f): Mode 6 for tank without soil

Figure 6: Frequency modes of water tank without soil structure

Results show various frequencies modes of water tank structure with soil and without soil structure.

Table6: Frequencies at various modes

| **Modes Number** | **Frequencies at various Soil Interaction** | |
|---|---|---|
| | **Without Soil** | **With soil** |
| 1 | 0.194 | 0.69034 |
| 2 | 0.202 | 0.71689 |
| 3 | 0.275 | 0.97503 |
| 4 | 1.685 | 5.8612 |
| 5 | 1.78 | 5.973 |
| 6 | 2.313 | 6.07 |

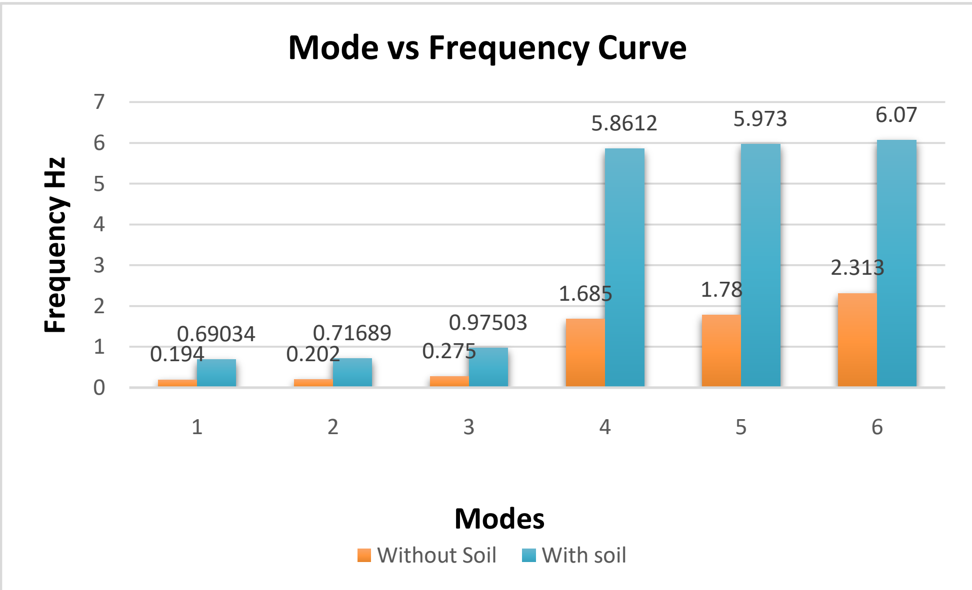



Figure 7: Frequencies at different modes of vibration

## 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 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

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.
- 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.

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