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Design and Analysis of Intez type Water Tank using SAP 2000 Software

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Abstract: Now a days, need of water is so essential due to increase in population, there might be depletion of water. So that storing of water is very much required for the people to cope water crisis. In order to store the water, the use of water tank is needed. The construction of water tanks are very important, different loads are acting on the tank and the tank should resist such loads and should have more life. In this work, analysis and design of intez water tank is performed using SAP 2000 analysis software. Total analysis is done by using Indian Standard Codes. Such as dead load, hydrostatic load, earthquake load, wind load and time history loads are used. These types of loads are very important and tank should be designed by considering worst possible load combinations. This work is mainly concentrated on capacity of the tank, height of wall, hopper height and bottom dome diameters. Using deformation, bending stress, base shear and base moment optimum parameters to construct the tank is proposed and this study is useful to the structural engineer to construct the water tank. Resonance is a main considerable parameter in high raised structures to know the resonance of the structure and model analysis is performed to find out the natural frequencies.
Keywords: Intez type water tank, SAP2000, Base shear, Base moment, Mode shapes, Deformations, wind load, Earthquake load.

I. INTRODUCTION

A water tank is used to store water to tide over the daily requirement. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential. The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio. The increase in water cement ratio results in increase in the permeability. The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. Cracks can be prevented by avoiding the use of thick timber shuttering which prevent the easy escape of heat of hydration from the concrete mass the risk of cracking can also be minimized by reducing the restraints on free expansion or contraction of the structure.

A. Introduction to SAP2000

SAP2000 software is used for structural analysis. It is general purpose software; we can use it for analysing most of the structures. Even we can model foundations with sap2000 software. The SAP name has been synonymous with state-of-the-art analytical methods since its introduction over 30 years ago. SAP2000 follows in the same tradition featuring a very sophisticated, intuitive and versatile user interface powered by an unmatched analysis engine and design tools for engineers working on transportation, industrial, public works, sports, and other facilities. From its 3D object based graphical modelling environment to the wide variety of analysis and design options completely integrated across one powerful user interface, SAP2000 has proven to be the most integrated, productive and practical general purpose structural program on the market today. This intuitive interface allows you to create structural models rapidly and intuitively without long learning curve delays. Now you can harness the power of SAP2000 for all of your analysis and design tasks, including small day-to-day problems.

Complex Models can be generated and meshed with powerful built in templates. Integrated design code features can automatically generate wind, wave, bridge, and seismic loads with comprehensive automatic steel and concrete design code checks per US, Canadian and international design standards.

II. METHODOLOGY

Now days, demand for water is very high throughout the year. To supply the water for everyone, we need some criteria such as build water tank. If the life of the storage tank needs to be more, tank selection is very important. INTEZ water tank is one of the best choices and has top dome, cylindrical, wall hopper and bottom dome. The entire structure depends on high strength column.

In this work, initially 600, 800, 1000 and 1200m3 water tanks are planned and individual sizes and thickness are calculated which depends on IS code. The formulas for each part such as top dome, wall thickness, hopper and bottom dome, heights and thickness calculated formulas are presented below.

III. ANALYSIS OF INTEZ WATER TANK

In this chapter the intez water tank have been modelled and analyzed in SAP2000.

A. Procedure

1) Open SAP2000V14
2) Go to file and click on new model then dialog box will opens.

In this we can select the required models like stairs, cooling towers, multi storey building etc. Here selection cross section is important for beam and column. Here concrete model has selected for both column and beams. Rectangular cross section is selected. Here material selection is important. Different types of materials are available in SAP 2000 software. Indian, concrete 4000 si grade has selected in this present work. Here rebar material selection is important. Different types of materials are available in SAP 2000 software. Indian, Fe415 grade has selected in this present work.

Mesh generation is the practice of generating a mesh that approximates a geometric domain.” Common uses are for rendering to a computer screen such as finite element analysis . Meshing is a common term to demote the pre-processing phase of the Finite Element Analysis (FEA). It is a tool that engineers use to complete their analysis of a particular design.

a) Now select all the bottom nodes of the structure with the help of set select mode tool to assign fixed supports.
b) Go to Assign, joint, restrain then restrains dialog box opens click on fixed supports, then fixed supports were assigned to model
c) Go to assign and click on surface loads.
d) Select distributed loads.
e) Then frame distributed loads dialog box will opens
f) Load pattern name is dead load.
g) Click on add to existing loads.

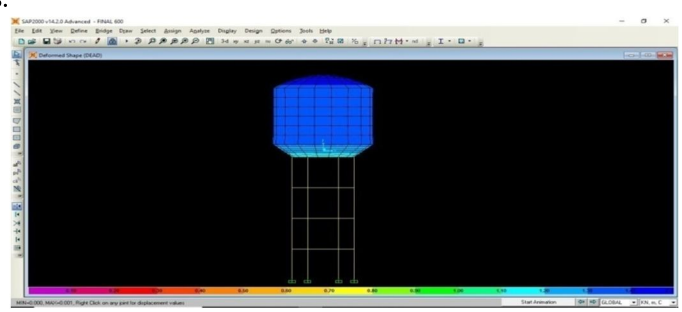

Fig1: Dead load deflection of Intez water tank.

In the above image shows the total deformation of intez water tank.dead load applied on entire structure and the red indicate the minimum deformation and blue indicates maximum deformation. Maximum deformation occurs at the bottom dome. Minimum deformation appears at columns and we can clearly able to see in the above image. All together maximum deformation is 1.4 mm.

IV. MODAL ANALYSIS

Any physical system can vibrate. The frequencies at which vibration naturally occurs, and the modal shapes which the vibrating system assumes are properties of the system, and can be determined analytically using Modal Analysis. Modal analysis is the procedure of determining a structure's dynamic characteristics; namely, resonant frequencies, damping values, and the associated pattern of structural deformation called mode shapes. It also can be a starting point for another, more detailed, dynamic analysis, such as a transient dynamic analysis, a harmonic response analysis, or a spectrum analysis.

Modal analysis in the SAP family of products is a linear analysis. Any non linearities, such as plasticity and contact (gap) elements, are ignored even if they are defined. Modal analysis can be done through several mode extraction methods: subspace, Block Lanczos, Power Dynamics, Reduced, Unsymmetrical and Damped. The damped method allows you to include damping in the structure.

A. Uses of Modal Analysis

Modal analysis is used to determine the natural frequencies and mode shapes of a structure. The natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions. They are also required to do a spectrum analysis or a mode superposition harmonic or transient analysis. Another useful feature is modal cyclic symmetry, which allows reviewing the mode shapes of a cyclically symmetric structure by modelling just a sector of it.

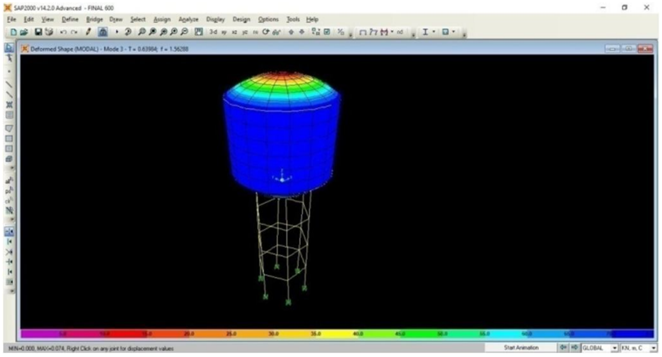

Fig2: Mode shape of intez water tank

The above image shows the 2nd mode shape of intez water tank. Second mode natural frequency observed as time period as 0.63.

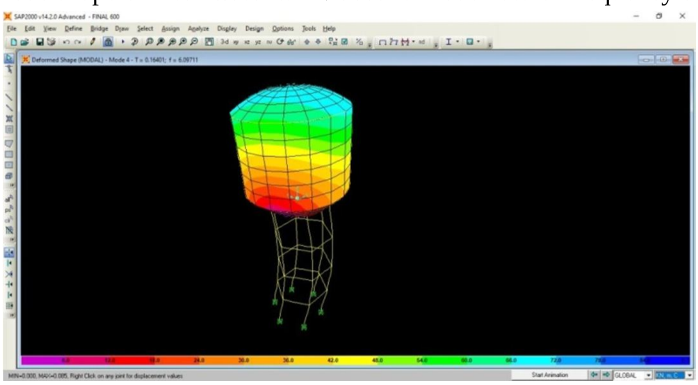

Fig3: Mode shape of intez water tank

The above image shows the 3rd mode shape of intez water tank. 3rd mode natural frequency observed as time period as 0.16.

Designing water tanks to act elastically at some point of earthquakes without harm can also render the mission economically unviable. Accordingly, it may be vital for the structure to undergo harm and thereby dissipate the electricity input to it all through the earthquake.

Slight shaking with minor damage to structural elements, and a few damage to non-structural factors; and thus, seismic layout balances reduced price and ideal harm, to make the task viable. This cautious balance is arrived primarily based on giant research and detailed put up earthquake damage assessment research. A wealth of this record is translated into specific seismic layout provisions. In assessment, structural damage isn't acceptable beneath layout wind forces. Because of this, layout in opposition to earthquake results is referred to as earthquake-resistant layout and now not earthquake-proof design.

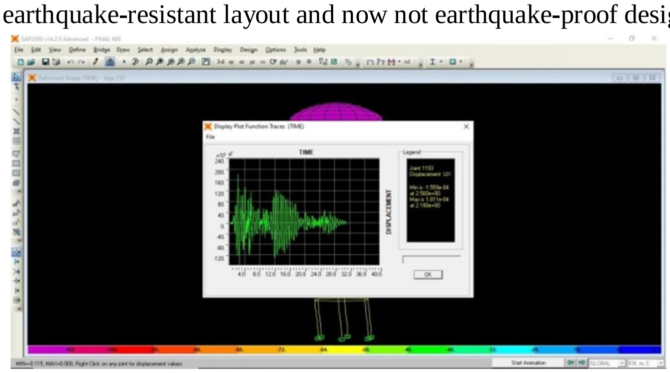

Fig4: Deformation of water tank with time.

V. RESULTS AND DISCUSSION

To find out the optimum parameters in the intez water is analyzed by considering the dead load of the water tank and hydrostatic pressure depends on water tank capacity, wind loading according to IS 875 and seismic loading using IS 1893 and 2002. After running the analysis, the main concentration is done on deformations, stresses, base movement and base shear due to wind loading and earthquake loading are noted and plotted below in graphs and tables.

The total work is classified as tank capacity, tank cylindrical wall height, tank hopper wall height and bottom dome diameters of the tank. Using these four parameters, different analysis was performed to find out the optimum parameters in tank.

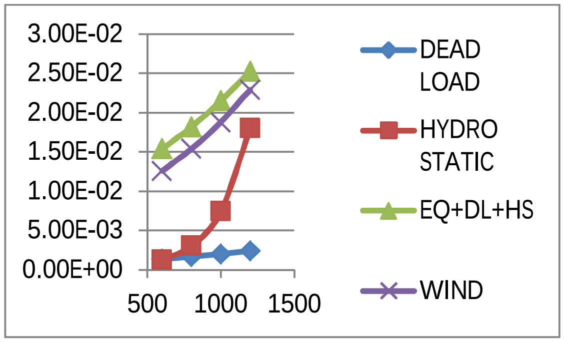

Fig5: Deformation for different load

Tabel-I:
Stress results for water tank

VOLUME	DEAD LOAD	HYDRO STATIC	EQ+DL+HS	WIND
600	1.40E+00	4.26E+00	3.52E+00	9.80E-01
800	1.68E+00	7.80E+00	8.40E+00	1.19E+00
1000	2.02E+00	1.42E+01	2.00E+01	1.45E+00
1200	2.41E+00	2.61E+01	4.77E+01	1.74E+00

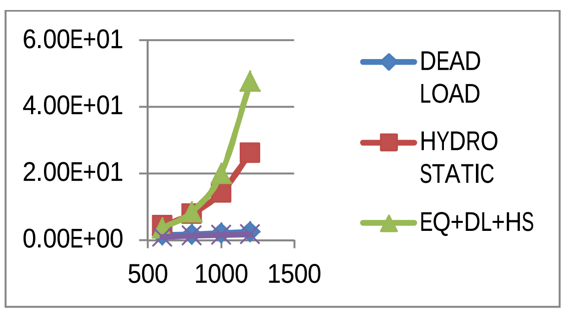

Fig6: Stress for different load

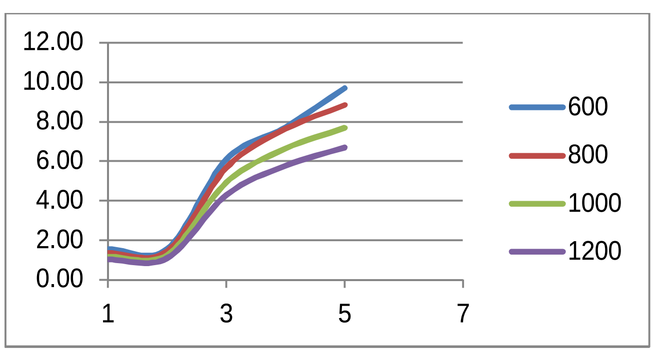

Fig7: Natural frequency of water tank

VI. CONCLUSION

Water tank is essential structure for industrial or domestic purposes. Elevated water tanks are used to store high water capacity to fulfil the people or industrial needs. So the structure must have good design. In this work, analysis is done on capacity of the water tank, height of cylindrical wall, hopper height and bottom dome diameter. Different loads are considered such as dead load, hydrostatic load, wind load, earthquake load and time history.

The outputs are deformation, bending stress, base shear and base moment. If the water tank capacity increases, the deformation and bending stresses also increases. Maximum damage occurs in earthquake and combination loads. Due to dead load, in structure we have negligible deformations. The deformation due to hydrostatic loading increases four times from 600Cum to 1200Cum. Base shear due to earthquake loading will create maximum damage than wind load. If capacity of the water tank increases, the base shear will also increases. The base moments due to wind load increases than wind load, if the tank capacity increases.

Cylindrical wall height, hopper height, bottom dome diameter increases, the deformation increases. Finally conclude that tank capacity should be low, wall height, hopper height and bottom dome diameter should be maintained as per designed calculation using IS codes. Vibration analysis is done and found that low tank capacity has high natural frequency range. Frequency is directly proportion to the stiffness of the structure. Also in according to vibration, less quantity of tank capacity is preferable to improve the life of intez water tank.

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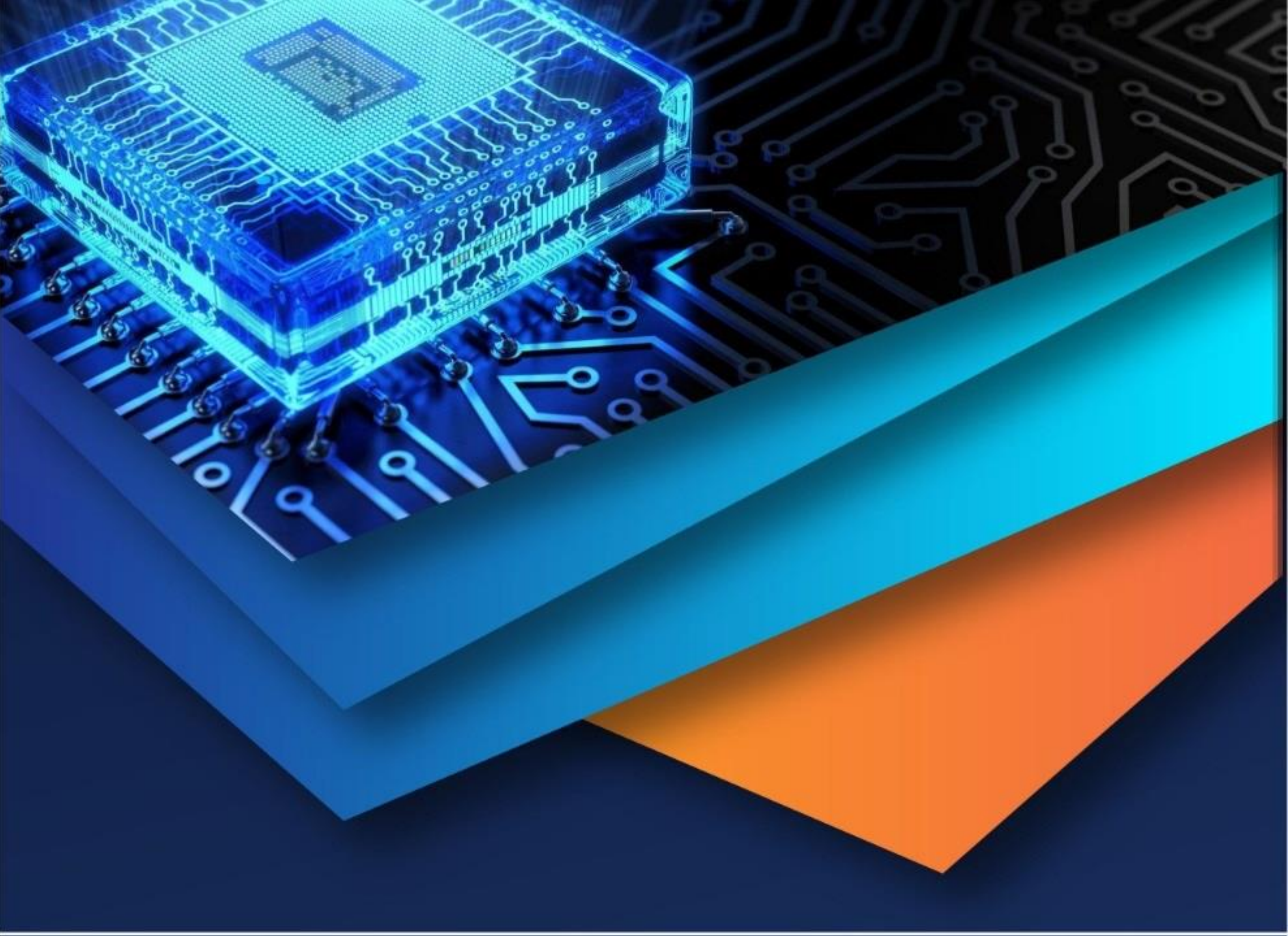

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