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DESIGN OF INTZE TANK AND SEISMIC ANALYSIS WITH THE HELP OF SAP2000

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ABSTRACT: *A large number of overhead water tanks damage due to earthquake induced vibrations. Majority of water tanks were shaft staging while a few were on frame staging. In this work I have compared seismic behaviour of Intze tank considering frame and shaft types of staging with the help of SAP 2000. In this study the tank is first conventionally designed and then seismically analysed with the help of SAP 2000. The tank is designed to resist stresses as per IS: 3370(Part II) - 1965, seismic design as per IS: 1893-2002.The tank has been designed for capacity and conditions presently prevailing in a city like Jabalpur. This work includes pushover behaviour of structure, displacement behaviour in full water condition, stress variation along the height and evaluation of base shear to accomplish the seismic analysis of the structure. Along with these parameters Time period study has also been carried out and various load combinations have been considered. It has been observed that time period for the frame staging is higher than that of the shaft staging.*

Key Words: Intze water tank, AutoCAD, SAP2000, Frame staging, Shaft staging, Base shear, bending moment, displacement, Acceleration. Shear stress, normal stress.

1. INTRODUCTION

1.1 GENERAL

Water is basic human needs for daily life. Sufficient water distribution depends on design of a water tank in certain area. An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to pressurization the water distribution system. There are many different ways for the storage of liquid such as underground, ground supported, elevated etc. Liquid storage tanks are used extensively by municipalities and industries for storing water, inflammable liquids and other chemicals. Thus Water tanks are very important for public utility and for industrial structure.

Elevated water tanks are critical and strategic structures and damage of these structures during earthquakes may endanger drinking water supply, cause to fail in preventing large fires and substantial economical loss. Since, the elevated tanks are frequently used in seismic active regions also hence, seismic behaviour of them has to be investigated in detail. Due to the lack of Knowledge of supporting system some of the water tank were collapsed or heavily damages. So there is need to focus on seismic safety of lifeline structure using with respect to alternate supporting system which are safe during earthquake and also take more design forces. Overhead water tank is constructed as a necessary structure at an elevation to consider fire demand of city also

1.2 INTZE TANK

Intze tank is generally preferred for inward radial thrust of the conical base to balance an outward radial thrust of the spherical lowest components. This can be discovered to store considerable amount of water for a raised spherical tank to provide flat floor slab expectations work out to an uneconomical configuration. The main principle of these floor slab turns into excessively thick to more tanks of diameter, it suits to best for Intze tank under this condition. An Intze tank basically made of top dome (roof), floor slab and the cylindrical shaped wall which may be a consolidation for base spherical dome and conical dome. Subjected to regulate compression, the thickness of conical floor slab considerably meet expectations and a chance to prove another economical flat slab floor. The proportions of base dome and conical dome are arranged to outward thrust with bottom domed and floor only balances the internal thrust because of conical dome. The diameter of lowest components of dome is preferably about 65 to 70% of the diameter of the tank. Incline of conical dome is in between 50 to 55 degree level according to consideration.

1.3 INTRODUCTION TO SAP2000

SAP2000 considers 3D object based graphical modelling environment to the wide variety of analysis and design options completely integrated across one powerful user interface. This intuitive interface allows us to create structural models rapidly and intuitively without long learning curve delays. We can perform simple small 2D static frame analysis to a large complex 3D nonlinear dynamic analysis, large deformation analysis, Eigen and

Ritz analyses based on stiffness of nonlinear cases, buckling analysis, progressive collapse analysis etc.

1.4 SCOPE OF THIS STUDY:-

- To understand the behaviour of supporting system which is more effective under different response spectrum method with SAP 2000 software.
- To analyse the two types of staging provided in water tank with consideration and modelling of impulsive and convective water masses inside the container.
- To carry out the study based on the parameters like Time period, base shear, moment, shear stresses, hydrodynamic stresses and deflections under various load combinations.

2. DESIGN STEPS AND MODEL DESCRIPTION

2.1 Design procedure of Intze tank

- Design of top dome and top ring beam.
- Design of cylindrical wall.
- Design of ring beam at the intersection of cylindrical shaped wall to conical dome.
- Design of conical dome and bottom spherical dome.
- Design of bottom ring beam.
- About staging i.e. the design of supporting structure.
- About foundation design.

2.2 Problem Description

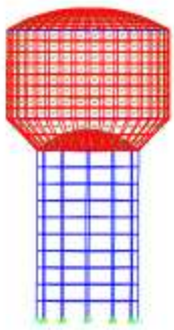
Que. An Intze tank having 2396 m3 capacity is supported on RC staging of 12 columns with horizontal bracings of 300 x 600 mm at nine levels. Details of staging configuration are shown in Figure. Staging conforms to ductile detailing as per IS 13920. Grade of concrete and steel are M20 and Fe415, respectively. Tank is located on hard soil in seismic zone IV. Density of concrete is 25 kN/m3. A FEM structural software SAP 2000 is used to model the elevated intze water tank. Columns and beams in the frame type support system are modelled as frame elements (with six degrees of freedom per node). Conical part, bottom and top domes and container walls are modelled with thin shell elements (with four nodes and six degrees of freedom per node). Other dimensions of the elevated tanks are illustrated in Table 1.

DIMENSIONS	FOR FRAME STAGING	FOR SHAFT STAGING
Thickness of the top spherical dome	0.1 m	0.1 m
Rise of the top spherical dome	2 m	2 m
Size of the top ring beam	0.48m x 0.4m	0.48m x 0.4m
Diameter of the cylindrical portion	16 m	16 m
Height of the cylindrical wall	8.5 m	8.5 m
Thickness of the cylindrical wall	Linearly varying from 0.4m at the top to 0.54m at bottom	Linearly varying from 0.4m at the top to 0.54m at bottom
Size of the middle ring beam	0.9m x 1.2m	0.9m x 1.2m
Thickness of the conical dome	0.85 m	0.85 m
Rise of the bottom spherical dome	2 m	2 m
Thickness of the bottom dome shell	0.4 m	0.4 m
Size of bottom ring beam	0.6m x 1.0m	0.6m x 1.0m
Staging details	12 columns of dia 1.0 m with bracing size 0.3m x 0.6m	Shell having thickness 0.22m

2.3 SAP2000 MODEL OF THE TANK-

Two mass model for elevated tank was proposed by Housner (1963) which is more appropriate and is being commonly used in most of the international codes including Draft code for IS 1893 (Part-II). The pressure generated within the fluid due to the dynamic motion of the tank can be separated into impulsive and convective parts. When a tank containing liquid with a free surface is subjected to horizontal earthquake ground motion, tank wall and liquid are subjected to horizontal acceleration. The liquid in the lower region of tank behaves like a mass that is rigidly connected to tank wall. This mass is termed as impulsive liquid mass which accelerates along with the wall and induces impulsive hydrodynamic pressure on tank wall and similarly on base Liquid mass in the upper region of tank undergoes sloshing motion. This mass is termed as convective liquid mass and it exerts convective hydrodynamic pressure on tank wall and base. For representing these two masses and in order to include the effect of their hydrodynamic pressure in analysis, spring mass model is adopted for ground-supported tanks and two-mass model for elevated tanks.

SAP 2000 MODEL FOR INTZE TANK WITH FRAME STAGING



SAP 2000 MODEL FOR INTZE TANK WITH SHAFT STAGING

3.RESULTS AND DISCUSSION

3.1 CALCULATED VALUES FOR VARIOUS PARAMETERS

S.No.	Component	Frame Staging	Shaft Staging
1	TIME PERIOD a)Impulsive mode b)Convective mode	0.935 sec 4.0 sec	0.177 sec 4.0 sec
2	BASE SHEAR a)Impulsive mode (b)Convective mode	1065.518 kN 110.584 kN	2439.25 kN 112.822 kN
3	OVERTURNING MOMENT (a)Impulsive mode (b)Convective mode	23960.633 kN-m 2761.043 kN-m	55381.25 kN-m 2813.80 kN-m
4	HYDRODYNAMIC PRESSURE ON THE WALL (a)Impulsive mode b)Convective mode	0 (Top) 2030.18N/m^2(Bottom) 1146.38N/m^2(Top) 278.85 N/m^2(Bottom)	0 (Top) 4804.42N/m^2(Bottom) 1146.38N/m^2(Top) 278.85 N/m^2(Bottom)
5	HYDRODYNAMIC PRESSURE ON THE BASE a)Impulsive mode (b)Convective mode	0 (Top) 805.14 N/m^2(Bottom) 0 (Top) 278.01 N/m^2(Bottom)	0 (Top) 1680.56N/m^2(Bottom) 0 (Top) 278.01 N/m^2(Bottom)

4.CONCLUSION

- Time period of elevated tank supported on frame staging is 5 times that of elevated tank supported on shaft staging. Since the lateral staging of the shaft staging is 25 times that of the frame staging.
- Due to higher lateral staging of the shaft staging, lateral stresses are also high as compared to frame staging. The study shows that the base shear of the tank supported on the shaft staging is approximately 2 times higher than that of the tank supported on the frame staging.
- Impulsive hydrodynamic pressure in the shaft staging is 2.3 times higher than the frame staging, while convective hydrodynamic pressure is same in both types of staging.
- The conventionally designed tank (without considering earthquake forces) has low strength as compared to the tank designed on the basis of earthquake forces.

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