Time History Analysis of Circular Water Tank Using Sap 2000

Tejashree S Gulve[1], Rutuja S Kothawade[2], Mitali S Balapure[3], Shivani S Mirajkar[4]
[1]Asst. Prof
[1, 2, 3, 4] Dr. D Y Patil institute of engineering management and research Pune

Abstract- *The water tank is a container for storing water. Water tanks are used to provide storage of water for use in many application, drinking water, irrigation, agriculture, fire suppression, etc. The seismic analysis of the ground supported water tank resting on soft soil consisting of mass of roof, mass of tank wall, mass of water and mass of base slab is carried out. It has been found that under influence of seismic forces with increasing ratio of maximum depth of water to the diameter of tank (h/D) the more mass of water will excite in impulsive mode while decreasing ratio of (h/D) more the mass of water will excite in convective mode. The Time period of Impulsive mode increase with increase in (h/D) ratio and Time period in convective mode decrease with increase in (h/D) ratio. This project gives the idea about investigating optimum level of water tank analytically under seismic loads by Time History Analysis using SAP2000. The tank will be considered as resting on ground. The design of Circular water Tank will be considered for different water level conditions under seismic loads.*

Keywords- elevated water tank, baffle wall, SAP 2000

I. INTRODUCTION

1.1 Introduction of the Project Work

Water tanks are the storage containers for storing water. These tanks are usually storing water for human consumption. The need for water tanks is old as civilized man. Water tanks provide for the storage of drinking water potable, irrigation, agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses. Water tank parameters include the general design of the tank, and choice of construction materials, linings.

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. Analysis and design of such tanks are independent of chemical nature of product. They are designed as crack free structures to eliminate any leakage. Adequate cover to reinforcement is necessary to prevent corrosion. 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. Water tanks are very important components of lifeline. They are critical elements in municipal water supply, firefighting systems and in many industrial facilities for storage of water.

Water is human basic 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.

Many new ideas and innovation has been made for the storage of water and other liquid materials in different forms and fashions.

Types of Water Tank:-

In this section, the types of water tanks are discussed in detail. There are different type of water tank depending upon the shape, position with respect to ground level etc.

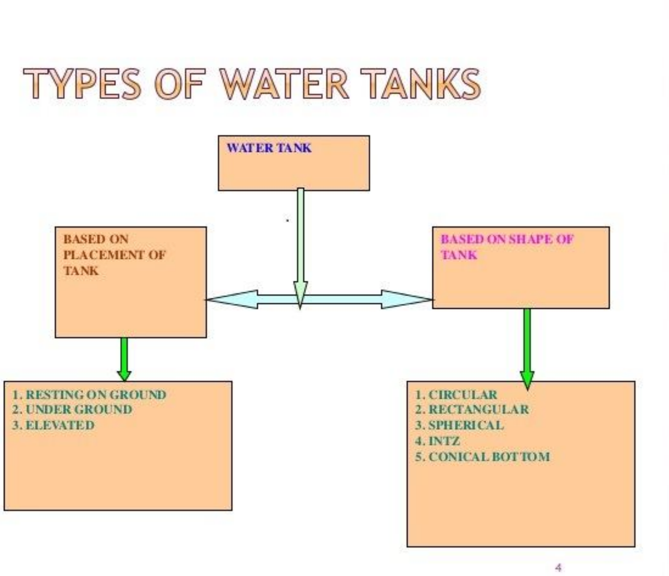


Fig 1.1.1 Types of Water Tank

- From the position point of view, water tanks are classified into three categories. Those are,

a) Underground tank
b) Tank resting on ground
c) Overhead water tank

a) Underground water tank:-

Fig.1.1.2 Underground Water Tank

An Underground storage tank (UST) is a storage tank that is placed below the ground level. Underground water storage tanks are used for underground storage of potable drinking water, wastewater & rainwater collection. So whether you call it a water tank or water cistern, as long as you are storing water underground these are the storage tanks for you. Plastic underground water tanks (cistern) is a great alternative to concrete cisterns.

b) Tank resting on ground:-

Fig 1.1.3 Tank Resting on Ground

In this section, we are studying only the tanks resting on ground like clear water reservoirs, settling tanks, aeration tanks etc. are supported on ground directly. The wall of these tanks are subjected to pressure and the base is subjected to weight of water. These tanks are rectangular or circular in their shape.

Due to hydrostatic pressure, the tank has tendency to increase in diameter. This increase in diameter all along the height of the tank depends on the nature of joint at the junction of slab and wall as shown in Fig.

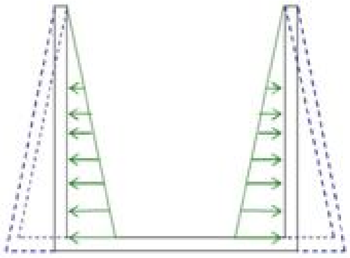


Fig 1.1.4 Tank with flexible base

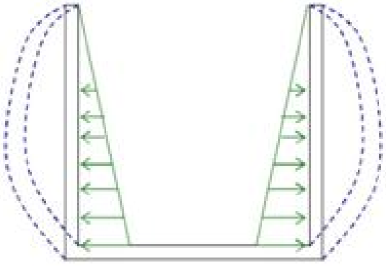


Fig 1.1.5 Tank with rigid base

c) Overhead water tank:-

Fig 1.1.6 Overhead Water Tank

Overhead water tanks of various shapes can be used as service reservoirs, as a balancing tank in water supply schemes and for replenishing the tanks for various purposes. Reinforced concrete water towers have distinct advantages as they are not affected by climatic changes, are leak proof, provide greater rigidity and are adoptable for all shapes.

- From the shape point of view, water tanks may be of several types. These are,

a) Circular tank
b) Conical or funnel shaped tank

c) Rectangular tank
d) Intze tank

a) Circular tank:-

Fig 1.1.7 Circular Water Tank

Circular tanks are usually good for very larger storage capacities the side walls are designed for circumferential hoop tension and bending moment, since the walls are fixed to the floor slab at the junction. The coefficient recommended in IS 3370 part 4 is used to determine the design forces. The bottom slab is usually flat because it's quite economical.

b) Conical or funnel shaped tank:-

Fig 1.1.8 Conical Water Tank

This tank is best in architectural feature and aesthetic this tank has another important advantage that its suitable for high staging the tank's hollow shaft can be easily built. It can be economical and rapidly constructed using slip from processing of casting. They can also be built using pre-cast concrete elements.

c) Rectangular tank:-

Fig 1.1.9 Rectangular Water Tank

The walls of Rectangular tank are subjected to bending moments both in horizontal as well as in vertical direction. The analysis of moment in the wall is difficult since water pressure results in a triangular load on them. The magnitude of the moment will depend upon the several factors such as length, breadth and height of tank, and conditions of the support of the wall at the top and bottom edge. If the length of the wall is more in compression to its height the moment will be mainly in vertical direction i.e. the panel will bend as a cantilever. If, however, height is larger in comparison to length, the moments will be in horizontal direction, and the panel will bend as a thin slab supported on the edges. The wall of the tank will thus be subjected to both bending moment as well as direct tension.

d) Intze Water Tank :-

Fig 1.1.10 Intze Water Tank

A water tower built in accordance with the Intze Principle has a brick shaft on which the water tank sits. The base of the tank is fixed with a ring anchor (Ring Anker) made of iron or steel, so that only vertical, not horizontal forces are transmitted to the tower.

e) Spherical Water Tank:-

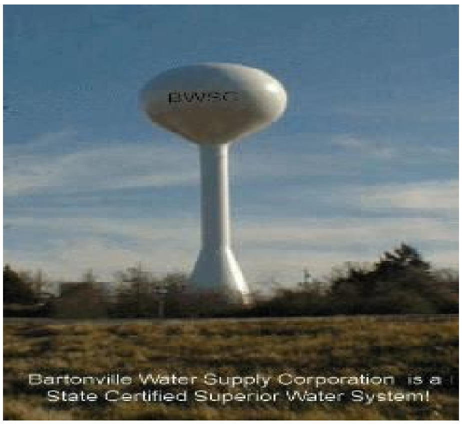


Fig 1.1.11 Spherical Water Tank

BAFFLE WALLS IN WATER TANK


Fig.1.1.13 Baffle Walls in Water Tank

Baffle wall systems are specifically designed for potable water and wastewater treatment flow control. Baffle walls control the flow of water and increase residence time while partition walls separate zones or enhance mixing. Baffle and partition walls are pre-engineered and composed of fiberglass panels, angles, and framing members. With a superior combination of strength and corrosion resistance, Enduro baffle wall systems offer industry-leading design flexibility and light weight making them an excellent choice for both new projects and retrofits.

1.2 OBJECTIVE AND SCOPE

1. To study the analysis and design of water tanks.
2. To know about the design philosophy for the safe and economical design of water tank.
3. To study the effect of circular water tank under earthquake excitations.

II. CODAL PROVISIONS

IS 1893:2002-Part 2 is used for calculation of dynamic response of water tank. Hydrodynamic forces exerted by liquid on tank wall shall be considered in the analysis in addition to hydrostatic forces. These hydrodynamic forces are evaluated with the help of spring mass model of tanks.

When a tank containing liquid vibrates, the liquid exerts impulsive and convective hydrodynamic pressure on the tank wall and the tank base in addition to the hydrostatic pressure. In order to include the effect of hydrodynamic pressure in the analysis, tank can be idealized by an equivalent spring mass model, which includes the effect of tank wall – liquid interaction. The parameters of this model depend on geometry of the tank and its flexibility.

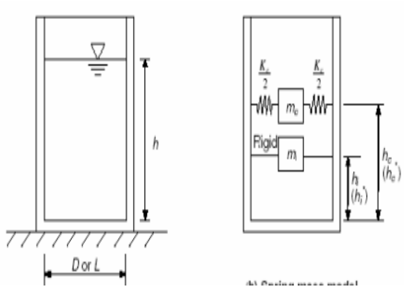


Fig 1: Spring Mass Model for Circular Tank (Ref: IS 1893 Part II)

For circular tanks, parameters mi, mc, hi, hi, hc h*c and Kc shall be obtained from graphs given in IS 1893 Part II. In the spring mass model of tank for circular tanks, hi is the height at which the resultant of impulsive hydrodynamic pressure on wall is located from the bottom of tank wall. On the other hand, hi* is the height at which the resultant of impulsive pressure on wall and base is located from the bottom of tank wall. Thus, if effect of base pressure is not considered, impulsive mass of liquid, mi will act at a height of hi and if effect of base pressure is considered, mi* will act at hi*. Heights hi and hi, are as shown in fig below.

Similarly, hc, is the height at which resultant of convective pressure on wall is located from the bottom of tank wall, while, hc* is the height at which resultant of convective pressure on wall and base is located. Heights hc and hc* are described in Figures. Hence, the value of hi and hc shall be used to calculate moment due to hydrodynamic pressure at the bottom of the tank wall. The value of h*i and h*c shall be used to calculate overturning moment at the base of tank.

III. PROBLEM STATEMENT

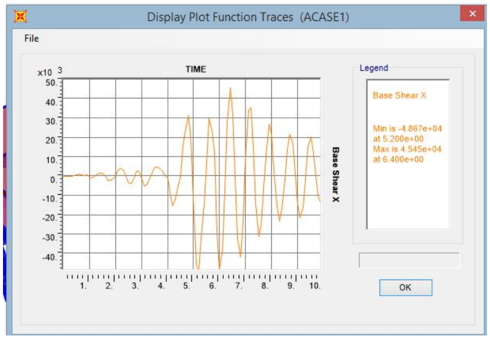
In the present study watertank is designed for laxmi township at ranjangaon MIDC .

Fig No.2 Layout of township

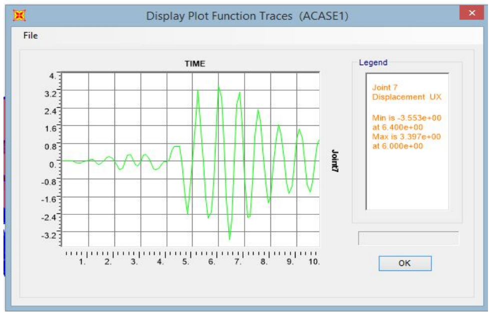
Total Structure=200
Minimum water capacity required=200*5*135=135000 lit.
Considering 10% commercial use extra.
Total Capacity=150000lit. =150m3
Staging Height=20m
Assume height of tank=4m (Ref.IS 3370)
Thickness of baffle wall=180mm
Thickness of base slab=200mm
For rectangular water tank:
CAPACITY=L*B*H
150=L*B*4
Assume aspect ratio L/B=2
Therefore
L=9m
B=4.5m
For circular water tank:
CAPACITY=3.14/4*D2*4
Diameter -6.9m
Beam size-230x600
Column size-230x650
Earthquake zone-III
Time history –Bhuj
Soil –medium stiff
Depth of foundation-1.5m

IV. RESULTS AND DISCUSSION

From the above methodology two models are prepared at initial stage 20m x10m for staging height 16m and following models are prepared



Graph No.1



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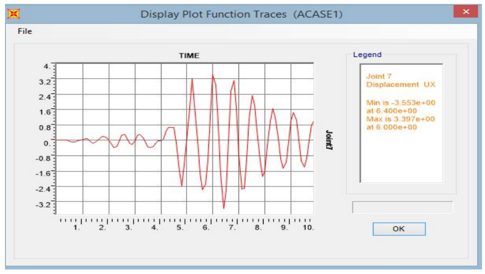

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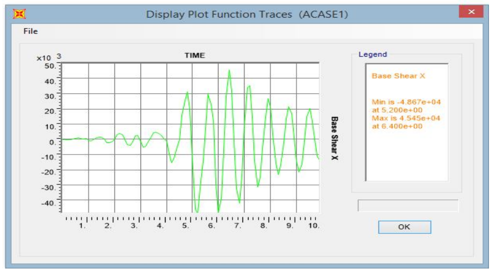

Graph No.4

V. CONCLUSION

In this project elevated water tank subjected to sloshing due to time history analysis is done and following conclusions are made:

- The elevated water tank with single bracings are having 24% less deformation than water tank without deformation in both x and y direction
- The elevated water tank with single bracings are having less base shear generated due to specific ground moton than water tank without deformation
- The natural frequency and time period in circular water tank with bracing and difference 27%

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