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Analysis of INTZE Water Tank Supported on RC Shaft

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***Abstract:** The storage reservoirs and overhead tanks are used to store water, liquid petroleum products and other similar liquids. In this research work, the five different cases of elevated shaft type intze water tank were studied having diameter (6m, 7m, 8m, 9m and 10m) with similar capacity. The diameter and height of the water tank changes to maintain same capacity in different cases. The seismic analysis of water tank was performed as per IS: 1893:2014 (Part II) in which the impulsive and convective pressure were also considered. The analysis of tanks were also done using SAP v20 as per IS: 1893-2002. Comparison between analytical results and SAP results was also carried out. With considering the data of analysis, the economical section of water tank was found. From the results it is concluded that the 8m diameter of water tank is economical in all aspects.*
***Keywords:** Elevated Intze water tank, RC Shaft, Sap2000, Economical section, Analysis.*

I. INTRODUCTION

INTZE OHSR (Overhead service reservoir) is normally used for liquid storing and elevated reservoir. OHSR storing tanks are utilized to store water to hold over the day by day requirements. To meet these requirements, size of the water tank is such that it is economical and also fulfils the requirements of the society.

Now a days, while analysis any structure, seismic analysis plays a vital role. Earlier, seismic analysis of water tanks were carried out by code [1] which was based on seismic analysis of buildings. However, a revision was carried out to make a new analysis code [2]which is only based on liquid retaining structures. In this research work, this analysis code is used to calculate base shear and base moment for different cases of water tanks for both empty condition and fully filled condition.

In this research work, impulsive and convective pressure is also considered while analysis of water tanks in SAP v 20. These pressures increases the base shear and base overturning moment in large extent. After considering the results of SAP and analytical results, economical size of water tank was found.

Various researchers work in the field of seismic analysis of water tanks. Sezen [4] explored the dynamic examination and seismic investigation for the fluid containing tanks situated at the Habas plant with a pinnacle ground speeding up of 0.32g. The crumbled tank was 85% full with melted oxygen and undamaged tank was 25% full with condensed nitrogen gas. Disentangled and limited component dynamic examinations were performed to investigate the outcomes.

Livaoglu [6] investigates the effects of incorporation of the foundation on the seismic behavior of the elevated system from the fluid cistern with a structural structure that supports the reservoir containing the fluid. The analysis included both the crushing effects of the fluid-soil-structure interaction of the elevated tanks located in these six different terrains.

Dutta [7] studies two types of tanks including in water container with R/C column and water container cylindrical shaft. The study also explored the impact of soil structure interaction that was ignored in design earlier. They used finite element analysis to validating the results. They originate that analytical formulation made in study can be used in design offices to include the effect of soil–structure interaction in seismic design of elevated containers. Moslemi [8] primary focal point of the examination was to assess the execution of elevated tanks under seismic stacking. In this examination, the limited component (FE) procedure was utilized to research the seismic reaction of fluid filled tanks. The liquid space was demonstrated utilizing uprooting based liquid components. Both time history and modular examinations were performed on a raised tank. Sambary [9] in this paper manual seismic investigation of OHSR (Overhead storage reservoir) water container is done as per IS: 1893-1984 and IS: 1893-2002 (Part-2) code. Two diverse soil writes hard soil and soft soil and tank is situated in III and V. The seismic investigation of this tank has been done by two unique strategies right off the bat according to IS: 1893-1984 (lumped mass model) and furthermore according to IS: 1893-2002 (two mass model).

Ghateh [10] studied the impact of dissimilar container sizes on the reinforced concrete pedestal in elevated water container. They used the finite element technique to consider the non-linear seismic response by means of push-over analysis. The result of different parameter such as fundamental period, height to diameter ratio and seismic design category were presented. The test result shows that for same size tank size, taller tank provides maximum base shear than that of smaller tank.

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II. PROBLEM STATEMENT

Table. 1 Preliminary Data

Size of various components (in mm)	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
Dia of Tank	6000	7000	8000	9000	10000
Height of water in tank	8000	5800	4300	3300	2550
Height of cylindrical wall	8400	6200	4700	3600	2850
Rise of top Dome	1200	1100	1700	1600	1700
Top Dome	120	120	120	120	120
Top Ring Beam	250 x 300	250 x 300	250 x 300	250 x 300	250 x 300
Cylindrical Wall Thickness	200	200	200	200	200
Bottom Ring Beam	500 x 400	500 x 400	500 x 400	500 x 400	500 x 400
Circular Ring Beam	500 x 600	500 x 600	500 x 600	500 x 600	500 x 600
Bottom Dome	200	200	200	200	200
Rise of bottom dome	1200	1200	1300	1700	1700
Height of conical dome	1500	1500	1500	1500	1500
Conical Dome	250	250	250	250	250
Diameter of the shaft	4000	5000	6000	7000	8000

III. METHODOLOGY

This section deals with the analysis of elevated intze tank with RCC shaft. The general analytical analysis of elevated intze tank is carried out as per [2] in both empty and full condition. For analysis of structure, zone factor is taken as 0.24, Response reduction factor 2.5, importance factor 1.5 and damping 5 percent.

A. Analysis for tank as per IS: 1893-2014 part-2

1) Base Shear

Base shear at the bottom of staging, in impulsive mode,

$V_i = (A_h)_i\ (m_i + m_s)\, g$

Similarly, base shear in convective mode,

$V_c = (A_h)_c\, m_c\, g$

Total base shear at the bottom of staging,

$$V = \sqrt{V_i^2 + V_c^2}$$

2) Base Moment

Overturning moment at the base of staging in impulsive mode,

$M_i^* = (A_h)_i [\, m_i\ (\, h_i^* + h_s\,) + m_s\, h_{cg}\,]\, g$

Similarly, overturning moment in convective mode,

$M_c^* = (A_h)_c . m_c (\, h_c^* + h_s\,)\, g$

Total overturning moment,

$$M^* = \sqrt{M_i^{*2} + M_c^{*2}}$$

Where,

$(A_h)_i$ = horizontal seismic coefficient for impulsive mode

$(A_h)_c$ = horizontal seismic coefficient for convective mode

m_c = Connective mass of liquid

m_i = Impulsive mass of liquid

m_s = Mass of empty container

h_i^* = Height of impulsive mass above bottom of tank wall
h_s = Structural height of staging
h_{cg} = Height of centre of gravity of the empty container of elevated tank
h_c^* = Height of impulsive mass above bottom of tank wall
g = Acceleration due to gravity.
M_i^* = Moment in impulsive mode
M_c^* = Moment in convective mode

B. Analysis for Tank Using SAP 2000

After analytical calculations, water tanks were analyzed by using SAP v 20 to obtain the base shear and overturning moment. The analysis of water tank using SAP was carried out using IS: 1893-2002. The model of water tank analyzed in SAP is shown in Figure 1.

Fig. 1 Elevated Water Tank Model in SAP2000

IV. RESULTS AND DISCUSSIONS

Results obtained from analytical calculations for base shear (KN) and base moment (KNm) are presented in Table 2 for both tank empty condition and tank full condition. Comparison between results for different cases is presented in Figure 2 and 3.

Table. 2 Base shear and Base moment as per IS: 1893 (Part-II)-2014

Case	Tank empty condition		Tank Full condition	
	Base Shear	Base Moment	Base Shear	Base Moment
Case 1	308.21	6127.30	699.24	14121.16
Case 2	341.90	6797.00	703.99	14158.38
Case 3	373.07	7416.71	654.21	13170.18
Case 4	410.31	8156.94	602.17	12191.40
Case 5	449.09	8927.85	613.56	12389.22

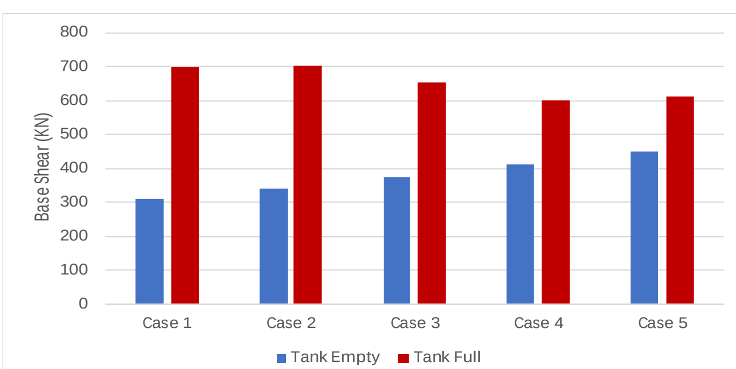

Fig-. 2 Values of Base Shear as per code

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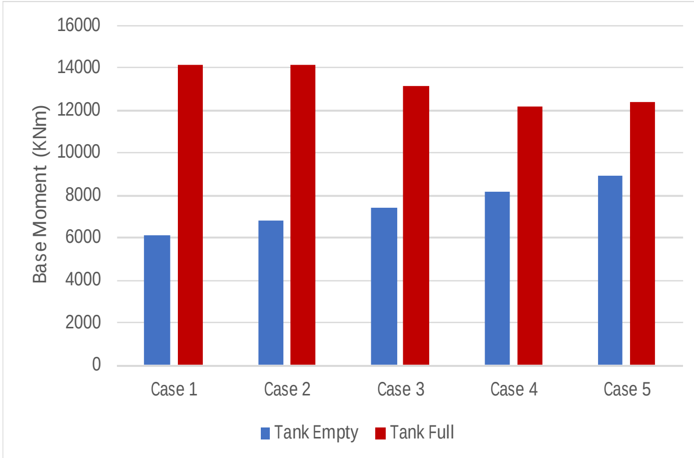

Fig. 3 Values of Base Moment as per code

In these calculations, the self-weight of the container, one third weight of staging and weight of water on impulsive and convective pressure of the tank are considered.

Results obtained for base moment and base shear were also calculated for tank empty and tank full condition in the SAP2000. These results are presented in Table 3 and comparison between results for different cases is presented in Figure 4 and 5.

Table. 3 Base shear and base moment from Sap2000

Case	Tank empty condition		Tank Full condition	
	Base Shear	Base Moment	Base Shear	Base Moment
Case 1	559.60	11663.56	893.62	17444.87
Case 2	626.75	12092.35	635.55	11560.32
Case 3	357.77	6646.21	1121.17	19732.97
Case 4	992.32	17787.41	891.61	17787.41
Case 5	1321.22	23042.81	1707.79	29649.01

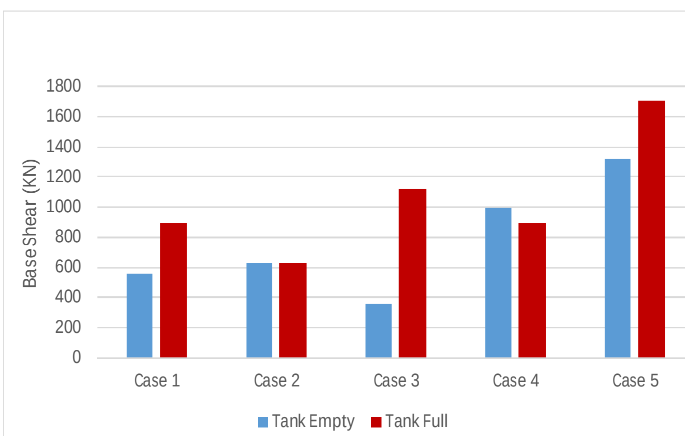

Fig. 4 Values of base shear from Sap2000

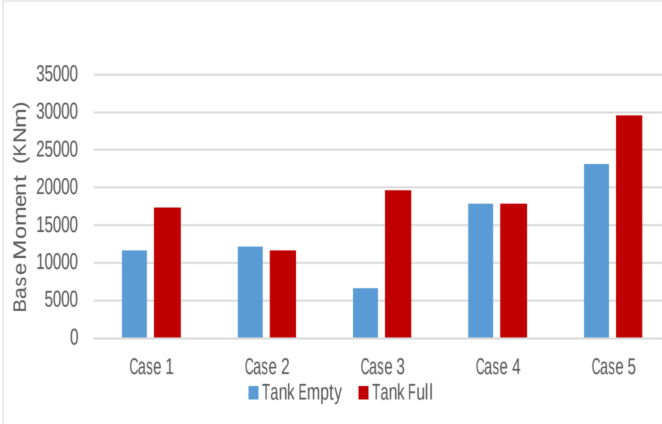

Fig. 5 Values of base moment from Sap2000

In these calculations, the deal load of the tank structure, imposed live load on the tank, effect of impulsive and convective pressure of the tank and earthquake forces are considered.

V. CONCLUSIONS

In analytical analysis, Base shear and base moment increasing from case 1 to case 5 in empty condition however, it decreases from case 1 to case 5 with slight variations in tank full condition. This is because the effect of h/d ratio.

Normally, the case of tank empty condition is critical condition for design but in general we select critical one by comparison between them. If we design the case 1 and case 2, it results uneconomical section in tank full condition however, if we design the case 4 and 5, it results uneconomical in both conditions. So the case 3 is most economical case.

Analytical work done by IS: 1893-2014 part-2 is economical than SAP results obtained using IS: 1893-2002. Due to impulsive and convective pressure.

For tank full condition, the value of base shear and base moment is greater than for tank empty condition due to lack of forces exerted by water on walls of tank in tank full condition.

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BIOGRAPHIES

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