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Comparative Study of Intze Type of Water Tank for Different Bracing Pattern under Wind and Seismic Load

Shivprasad Dundage[1], Prof. N.P. Phadtare[2]
[1]*Student, Civil Engineering Department, P.V.P.I.T. Budhgaon , Sangli , Maharashtra India*
[2]*Professor, Civil Engineering Department, P.V.P.I.T. Budhgaon , Sangli, Maharashtra India*

Abstract ***Overhead water tank is a water storage facility supported by a tower and constructed at an elevation to provide useful storage and pressure for a water distribution system. Safety as well as working of such structures is considered as very crucial during earthquakes, since they put up for necessities like drinking water, firefighting during fire accidents, etc. Such structures should stay in operating condition even after several earthquakes. This RC overhead water tanks involves huge water mass supported on the top of tank supporting system known as staging. This investigation is basically to discover the seismic behavior of RC overhead water tanks. In this study, a FEM based model is used for finding out the nonlinear seismic performance of RC overhead water tanks with several staging variations. The staging that is different bracing patterns considered in this study in lateral and vertical direction, which relatively increases the strength and stiffness of tank in supporting system. Staad models are prepared and analyze for different seismic zones as well as for cyclonic regions and observed the parameters such as base shear, base moment and lateral displacement. The commercial software STAAD.Pro is used for structural analysis. Since the seismic response of water tank structure depends on its dynamic properties and frequency of ground motion. This seismic analysis of overhead water tank structure cannot be carried out on the basis of maximum value of ground acceleration because of non-availability of ground acceleration data at every location. Hence for seismic analysis of overhead water tank, earthquake response spectrum analysis is widely used. While using this method, smooth design spectra is used to determine the value of displacement and forces in members at every mode of vibration. Octagonal, Radial, Cross, Alternate tie , Diagonal and X- type bracings are used to analyze the structure under all the seismic zones viz. II, III, IV & V. Also observed the behavior of tank for cyclonic region where wind load is increased by 30%. Analysed the overhead water tanks of same capacity for different bottom dome deviation angles and concluded.***

I. INTRODUCTION

Tanks are the liquid storage structures and also used to store other important things like grains etc. In human life water is the most important liquid. capacity of tank is based on the requirement. There are different types of water storage tanks like underground, Above ground and overhead tanks. Out of all these types of tanks, overhead water tank is widely used tank. it play very important role to full fill the demand of public, industries etc because of its large storing capacity of tank. Liquid storage structure is important structure, so the seismic and wind analysis and its design plays very important role because most of tank damages occur due to lack of knowledge about staging of tank.

In the flat bottom slab, the thickness of slab and reinforcement is found to be heavy. In the domed bottom, though the thickness and reinforcement in the dome is normal, the reinforcement in the ring beam is excessive. In cases of large diameter tanks, an economical alternative would be to reduce its diameter at its bottom by conical dome. Such a tank is called as Intze tank and is very commonly used. The main advantage of such a tank is that the outward thrust from the top of the conical part is resisted by the middle ring beam, while the difference between the inward thrust from the bottom of conical dome and the outward thrust from the bottom dome are resisted by bottom ring beam. The conical wall and the bottom dome are so arranged in the way that the inward thrust from conical wall balances the outward thrust due to the bottom dome.

Generally, the supporting structure of the overhead water tanks can be classified as reinforced concrete frame, steel frame, masonry pedestal and reinforced concrete shaft. Reinforced concrete (RC) frame supported overhead water tanks commonly have two main configurations. In the first type, which is called as “Overhead Concrete Tank”, both staging frame and tank are constructed from reinforced concrete.

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While the second type consists of a RC staging frame and welded steel tank above it is called as "Overhead Composite Steel-Concrete Tank" or simply "composite Overhead tank". In this configuration, both frame and tank are constructed of reinforced concrete circular. Reinforced concrete overhead water tanks consist of huge mass of water at the top of slender staging which is critical condition for the failure of the tank during the lateral loads like wind and seismic loads. Earthquakes are one of the major natural disasters which have a potential to affect human life by causing disturbance to infrastructure and lifeline facilities. Water tanks are part of prime services in many cities. Their functionality and safety is critical concern during strong earthquakes as they contribute for essential requirements i.e. drinking water, water for fire accidents, etc. Hence, these structures should not collapse even after earthquake. 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. Design of new tanks and safety evaluation of existing tanks should be carried out with a high level of accuracy because the failure of such structures, particularly during an earthquake, may be disastrous. The main aim of study is to understand the behavior of different staging under different seismic zones and strengthening the conventional type of staging by proper arrangement to give better performance during earthquake.
The staging or bracing plays a very important role which provides more stiffness and safety to structure and as well as to control the storey displacement of the structure. Bottom dome deviation angle is also play important role in the seismic analysis.

II. LITERATURE REVIEW

A. Jayesh Malaviya , Prof. P. H. Andharia (2021) [1]

In this paper, parametric study of circular elevated water tank has been done using STAAD Pro v8i (SS6) for 500m3 capacity of tank. Overhead water tank is a major structure ,it should be accurately and precisely analysed and designed in earthquake prone regions. The seismic behavioural effect has been observed considering various bracing patterns, variation in h/d ratio, variation in number and sizes of periphery columns. A Comparative study has been done assuming above mentioned different parameters and the optimum results in terms of displacement and base shear is to be taken into account. Total 12 combinations were analysed for full and empty tank conditions using Response Spectrum Method. Overhead circular water tank which consist of diagonal bracing, h/d ratio as 0.7 and no. of columns as 6 gives the best results as this combination provides the minimal values of base shear and displacements.

B. Prashant Bansode, Chandrasen Rajemahadik (2019) [2]

In this paper, they have analysed the intze type of water tank for different bracing patterns.
RC Overhead water tank structures should stay in operating condition even after several earthquakes. RC elevated water tanks involves huge mass of water supported on the top of tank supporting system called as staging. This study has been carried out to discover the seismic behaviour of RC elevated water tanks. It is noticed that, RC elevated water tanks shows effective results with frame staging, rather than shaft staging. In this study, a FEM based model is used for finding out the nonlinear seismic performance of RC elevated water tanks with several staging configuration. The staging configuration considered in this study consists of beams, columns and bracing beams in lateral and vertical direction, which relatively increases the strength and stiffness of tank supporting system. Tank observed for different parameters such as base shear, base moment, lateral displacement and time period of vibration. The commercial software STAAD.Pro is used for structural analysis. Since the seismic response of structure depends upon its dynamic properties and frequency of ground motion. This seismic analysis of water tank structure cannot be carried out on the basis of maximum value of ground acceleration. For seismic analysis, earthquake response spectrum analysis is widely used for water tank structures. They have concluded that, among all bracing patterns considered in this study of Water tank with lateral cross bracing and vertical X - bracing performs well during earthquake.

C. Vishal D Pawde (2019) [3]

In this paper they have compared base for different staging systems. Reinforcement concrete overhead water tanks are very important and useful structures. An overhead water tank behaves like an inverted pendulum which consists of huge amount of water at the top of staging. In many places of world collapse of tank happens due to earthquakes. due to this reason many studies done for dynamic behaviour of water containers, most of them are concern with cylindrical tanks. The economic lifetime of this RC overhead tanks are usually in the range of 25-75 years. Staging of tank is responsible for lateral resistance for complete structure. Response spectrum analysis of staging configuration is carried out on different types of bracing system of elevated water tank in all zones by using STAAD Pro V8i.

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D. Vishal Rokade, Shriram Salunkhe , Pranay Shinde (2019) [4]

The waves released due to earthquake as seismic wave is propagated from the epicentre to the earth surface. This seismic wave causes the ground shaking which causes severe damages to the structure overlying on the ground surface. During the propagation of wave it has to travel through soil with different prperties and of variable depth. According to the IS codes for earthquake resistant design (IS: 1893), the seismic force depends on the zone factor (Z) and type of structure and the average response acceleration coefficient (Sa/g) of the soil types at 30m depth with suitable modification depending upon the depth of foundation. As per IS 1893, only 3 types of soils (soft, medium and hard) is considered without any consideration for the site specific soil parameters. In this paper, they studied response spectra using site specific soil parameters for some sites in seismic zone V, i.e. Arunachal Pradesh and Meghalaya. Then generated response spectra is used to analyse some water tank structures using commercial software STAAD Pro.

E. Mohammad Quais Khan , Mr. Babar Hussain (2019) [5]

This paper represents analysis and design of Intze type of water tank as Per IS: 3370 & IS: 456 -2000 using STAAD Pro Software. Overhead Water tanks are important public utility and industrial structure. The design and construction methods in RCC are influenced by the prevailing construction practices, physical property of the material and the climatic conditions. The analysis of tank is conducted as per the specifications of IS 3370, IS 800:2002, IS 875, IS 1893. Design of top dome, top ring beam, Cylindrical walls, middle Ring beam, conical wall , bottom ring beam, bottom dome,Columns with bracings and foundations as per IS 3370 -Part III will be done by using 2-Dimensional STAAD model for 3,00,000 Litres capacity tank .Different loads acting on the tank such as Dead Load, Live Load, Wind load and seismic Load have been applied on STAAD model. These overhead water tanks are especially vulnerable to lateral forces such as wind and seismic forces.

F. A. H. Shrigondekar (2017) [6]

Overhead water storage tanks are the structures of more importance which are considered as main lifeline structures that should be safe until its design life i.e. operational during and after the earthquakes. Thus researchers, in recent years, have focused on studying seismic behaviours of these water tanks, particularly ground tanks, while only few of these researches have concerned with the overhead tanks and even less with the reinforced concrete overhead water tanks. In this research, a sample of a reinforced concrete overhead water tank with 400 m3 have been studied and analysed by linear dynamic method and seismic response such as tank displacement, base shear under tank empty condition for different type of staging configuration have been calculated and then results have been compared.

G. Shubham Gautam (2017) [7]

This paper represents the the seismic analysis of Reinforced cement concrete intze type elevated water tank subjected to live load, dead load and seismic load as per IS codes. In past,maximum water tank damages due to the earthquakes. So the seismic analysis of overhead water tank is important as well as wind analysis. The reason behind damage of the water tank is due to lack of knowledge about staging of tank or bracing part of the tank which plays an important role during earthquake. The staging of tank or bracing pattern plays a very important role which provides higher stiffness and safety to structure. It also controls the storey displacement of the structure. Bottom dome deviation angle of tank is also plays an important role in the seismic analysis. In this paper , for study of bottom dome angle deviation in which the angle of bottom dome selected are 35 and 50 degree for same capacity of water tank of 1000 m3 . So the elevated intze type water tank is analysed for all seismic zones as per IS: 1893 and also analysis with different staging pattern like octagonal, octagonal+plus, octagonal+cross with under empty,half and full flling conditions using STAAD.Pro software.

H. Nitesh J Singh , Mohammad Ishtiyaque (2015) [8]

In this paper , they have studied the behaviour of overhead water tank under lateral loads. Every type design of Water Tanks are subjected to Dead Load + Live Load and Wind Load or Seismic Load as per IS code. Most of the times tanks are designed for Wind loads and not even checked for Earthquake forces considering that the tanks will be safe under seismic forces once designed for wind loads. In this study Wind loads and Seismic loads acting on Intze type of Water tank for Indian conditions are studied. The effect of wind forces on the elevated reservoir structures is of prime importance as Wind flows relative to the ground surface and generates loads on the structures standing on ground. The Indian Standard Code IS 875 (Part-3) 2003 and IS 1893-2000 for Wind & Seismic effect is used for this study. The Elevated Structure is analysed for different wind forces that is 39 m/s, 44 m/s, 47 m/s & 50 m/s and the same is cross checked with different Seismic Zones that is Zone-II, Zone-III, Zone-IV, & Zone-V by ‘Response Spectrum Method’ and the maximum governing condition from both the forces is further used for analysis of staging.

I. Miss. Sonali M. Maidankar , Prof. G.D. Dhawale , Prof. S.G. Makarande (2015) [9]

In this paper, they studied the behaviour of different staging, under different loading conditions and strengthening the conventional type of staging to give better performance during earthquake. From the very upsetting experiences of few earthquakes, like Bhuj earthquake (2001) in India, R.C.C overhead water tanks were heavily damaged or collapsed due earthquake. For three different types of bracing systems, applied to the staging of overhead circular water tank for seismic zones. Analysis is done using SAP2000 v15. 27 models are used for calculating nodal displacements and base shear for staging with normal bracing, radial bracing and cross bracing in staging. Variation in staging height is 12m, 16m and 20 m at 4m each. After calculating nodal displacements and base shear of 27 models for empty and full tank combination of loads applying with different types of bracing patterns which gives minimum base shear as well as considerable displacement for measure seismic zones .In the analysis response spectrum method is used for seismic analysis of structures. Sloshing forces and base shear was calculated from IITK guidelines, the results obtain from software was compared with manual calculations. Hydrodynamic pressure for impulsive and convective mode was calculated and applied for analysis.

J. Pradnya V. Sambary , D.M. Joshi (2015) [10]

This paper represents the analysis of water tank for different seismic zone and different soil types with frame and shaft type staging. Elevated water reservoir structures have large mass concentrated at the top of slender supporting structures and are especially vulnerable to lateral forces. Elevated water tanks should remain functional even after the earthquake disaster. In this paper manual seismic analysis of elevated circular water tank is done in accordance with IS: 1893-1984 (i.e. lumped mass model) and IS: 1893-2002 (Part-2) (i.e. two mass model). The tank is considered for analysis in zones III and V and on two different types of soil i.e. hard rock and soft soil. Hence there are total 4 cases. Further comparison between the frame type and shaft type staging is done as per manually calculated responses such as base moment and base shear. Analysis is carried out for two different tank filling conditions i.e. tank full as well as empty conditions. In the analysis, response spectrum method has been used for seismic analysis of tank. Seismic responses such as base shear, base moment and hydrodynamic pressure(convective and impulsive) are evaluated and compared.

III. METHODOLOGY

Following method are using for proposed work

1) Study of IS codes and national, international papers.
2) Study of design parameters of STAAD pro.
3) Preparation of different STAAD models of water tanks.
4) Analysis and Discussion
5) Conclusion

IV. CONCLUSIONS

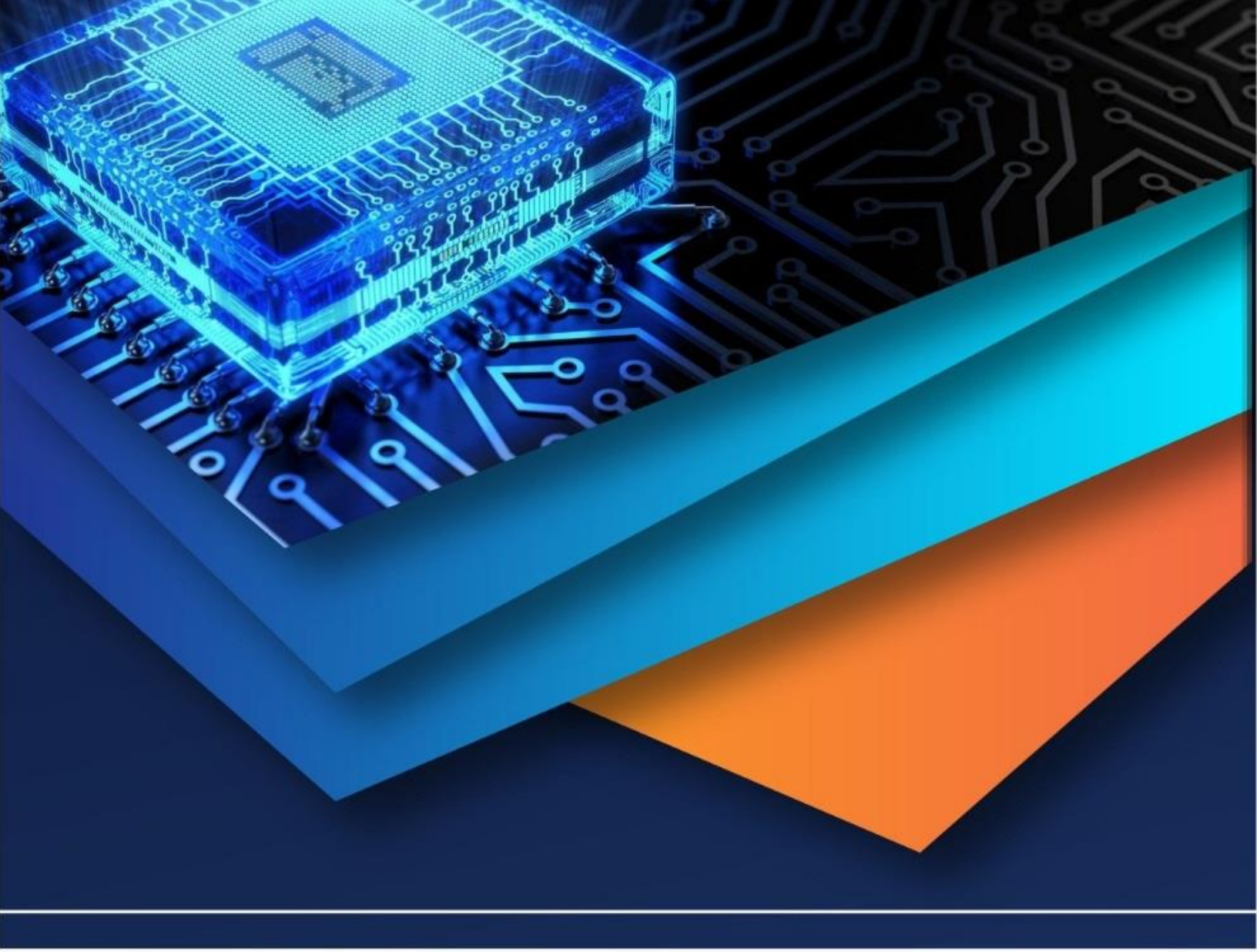
1) Bracing plays an important role during lateal loads.
2) Bracings increases stiffness of the structure.
3) For different bottom dome deviation angles , stresses in bottom dome varies and it affects the design bottom dome.
4) Vertical bracings are more effective than lateral bracings.
5) Under tank full and tank empty condition, base Shear increases as the level of bracing increases from octagonal or normal bracing to vertical diagonal bracing and from vertical diagonal bracing to vertical X – bracing.
6) Total base shear and base moment in tank full condition are more than those in tank empty conditions.

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