SEISMIC ANALYSIS OF THE ELEVATED WATER TANK FOR VARIATION IN BRACINGS PATTERNS AND WATER FILL CONDITIONS

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Abstract- The earthquake of 26 January 2001 in Gujarat was unprecedented not only for the state of Gujarat but for the entire country in terms of the damages and the casualties. As the public learnt for the first time that the scale of disaster could have been far lower had the constructions in the region complied with the codes of practice for earthquake prone regions. Seismic activity prone countries across the world rely on "codes of practice" to mandate that all constructions fulfill at least a minimum level of safety requirements against future earthquakes. Water tanks and especially the elevated water tanks are structures of high importance which are considered as main lifeline elements that should be capable of keeping the expected performance i.e. operation during and after earthquakes. Thus researchers, in recent years, have focused on studying seismic behaviors of these tanks, particularly ground tanks, while only few of these researches have concerned withthe elevated tanks and even less with the reinforced concrete elevated tanks. The economic lifetime of concrete or steel tanks is usually in the range of 40 to 75 years. In this project, reinforced concrete elevated water tanks with constant volume, elevation and H/D ratio but different staging patterns have been studied and analyzed by equivalent static method or in static condition and calculate seismic response such as base shear ,displacement, shear force and bending moment under tank full and empty condition and then results have been compared.

Indian seismic code IS 1893:1984 had some very limited provisions on seismic design of elevated tanks. This code did not cover ground-supported tanks. Draft code Part II of IS 1893:2002 which will contain provisions for all types of liquid storage tanks. Earthquake analysis of liquid containing tank is a complex problem involving fluid-structure interaction. Under earthquake loads, a complicated pattern of stresses is generated in the tanks. Poorly designed tanks have leaked, buckled or even collapsed during earthquakes. Common modes of failure are wall buckling, sloshing damage to roof, inlet/outlet pipe breaks and implosion due to rapid loss of contents.

Keywords- Earthquake, Water Tank, Shear Force

I. INTRODUCTION

In seismic analysis the mass of liquid should be considered separately as convective mass and impulsive mass. It is caused by any disturbance to partially filled containers. If the liquid is allowed to slosh freely, it can produce additional hydrodynamic pressure in case of storage tanks. Hence considerations of these forces are necessary, during analysis. Lateral stiffness of staging Lateral stiffness of staging is defined as the force required to be applied at the CG of tank so as to get a corresponding unit deflection.

For most mixing applications the ideal liquid level to tank Height diameter ratio is 0.8, to 1-to-1 is sufficient. A ratio that is too small does not allow proper axial mixing in the tank. H/D ratio less than 0.6 ratios should be avoided. When the ratio is in excess of 1.4, dual impellers should be employed. Any time that the liquid level to tank diameter ratio exceeds 2.0 the tank selection should be re-evaluated, as these slim tanks are not the most cost-effective solutions for mixing. STAAD pro software is using to model the staging. Different methods are employed to predict the seismic response of an externally excited tank.

II. LITERATURE SURVEY

1. Ranjit Singh Lodhi, Dr. Abhay Sharma, Dr. Vivek Garg
Intze type tank is commonly used overhead water tank in india. these tanks are designed as per is: 3370 i.e.code of practice for concrete structures for storage of liquids.bis implemented the revised version of is 3370 (part 1& 2) after a long time from its 1965 version in year 2009. presently large number of overhead water tanks is used to distribute the water for public utility. in which most of the water tanks were designed as per old is code: 3370-1965 without considering earthquake forces. the objective of this dissertation is to shed light on the difference in the design parameters of (a) intze water tanks without considering earthquake forces (b) intze water tanks designed with earthquake forces. first design is based on Indian standard code: 3370- 1965 and second design is based on indian standard code: 3370-2009 and draft code1893-part 2, (2005) considering two mass modal i.e. impulsive and convective mode method. intze tank supported on frame staging is considered in present study.

2. Nitesh Singh,Mohammad Ishtiyahaque Any design of Water Tanks is subjected to Dead Load + Live Load and Wind Load or Seismic Load as per IS codes of Practices. Most of the times tanks are designed for Wind Forces and not even checked for Earthquake Load assuming that the tanks will be safe under seismic forces once designed for wind forces. In this study Wind Forces and Seismic Forces acting on an Intze Type Water tank for Indian conditions are studied. The effect of wind on the elevated structures is of prime importance as Wind flows relative to the surface of ground and generates loads on the structures standing on ground. Most of the designers consider the wind effect and neglect the seismic effect on the structure. The Indian Standard Code IS 875(Part-3) 2003 and IS 1893-2000 for Wind & Seismic effect is used in this study. The Elevated Structure is designed for various Wind forces i.e. 39 m/s, 44 m/s, 47 m/s & 50 m/s and the same is cross checked with different Seismic Zones i.e. 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 design & analysis of staging. It is found from the analysis that the Total load, Total moments and Reinforcement in staging i.e. Columns, Braces & also for Raft foundation varies for Case-1, Case-2, Case-3 & Case-4.

3. Rupachandra Aware, Vageesha Madhada Liquid storage tanks are used in industries for storing chemicals, petroleum products, and for storing water in public water distribution systems. Behaviour of Cylindrical liquid storage tanks under earthquake loads has been studied as per Draft code Part II of IS 1893:2002. A FEM based computer software (STAAD -PRO) used for seismic analysis of tanks which gives the earthquake induced forces on tank systems. Draft code Part II of IS 1893:2002 which will contain provisions for all types of liquid storage tanks. Under earthquake loads, a complicated pattern of stresses is generated in the tanks. Poorly designed tanks have leaked, buckled or even collapsed during earthquakes. Common modes of failure are wall buckling, sloshing damage to roof, inlet/outlet pipe breaks and implosion due to rapid loss of contents. Elevated water tanks should be competent of keeping the expected performance during and after earthquake. It has large mass concentrated at the top of slender supporting structure hence extremely vulnerable against horizontal forces due to earthquake. Staging is formed by a

group of columns and horizontal braces provided at intermediate levels to reduce the effective length of the column. In this research, a circular cylindrical elevated water tank is analysed by using finite modelling techniques. This paper presents the study of seismic performance of the elevated water tanks for various heights and various seismic zones of India. The effect of height of water tank, earthquake zones on Nodal displacement have been presented in this paper with the help of analysis of 20 models for same parameters. Analysis is carried out by using finite element software STAAD-PRO.

4. Divya Mandhavi, J Keerthana,Ranga Raju As we know from past records, many of reinforced concrete elevated water tanks were heavily damages or collapsed during the earthquakes all over the world. General observations are pointing out the reasons towards the failure of supporting system which reveals that the supporting system of the elevated tanks has more critical importance than the other structural parts of tanks. Most of the damages observed during the seismic events arise was might be due to the lack of knowledge regarding the proper behaviour of supporting system of the tank against dynamic effect and also due to improper geometrical selection of staging patterns. The main objective of this study is to understand the behaviour of supporting system which is more effective under different earthquake characteristics or earthquake zones with STAAD. Pro V8i software. A sample of a reinforced concrete elevated water tank (Intz type), with 900 cubic meters and with a height of 18m from ground level is considered. Here two different staging patterns such as radial bracing and cross bracing are compared with basic supporting system for various fluid filling conditions. The seismic zones of Zone-III & Zone-V and the corresponding earthquake characteristics have been taken from IS 1893 (PART 1)-2002 & draft code IS 1893 (Part 2**).** Consequently the water mass has been considered in two parts as impulsive and convective suggested by GSDMA guidelines. Tank responses including base shear, overturning moment and roof displacement have been observed, and then the results have been compared and contrasted. The result shows that the structure responses are exceedingly influenced by the presence of water and the earthquake characteristics. Finally study discloses the importance of suitable staging configuration to remain withstands against heavy damage or failure of elevated water tank during seismic events.

5. Manish Gandhi,Ancy Rajan From the very upsetting experiences of few earthquakes in India, R.C.C. elevated water tanks were heavily damaged or collapsed. This was might be due to the lack of knowledge regarding the proper behavior of supporting system of the tank due to the earthquake effect and also due to improper geometrical section of staging. The main of this study is to understand the behavior of different staging pattern in bracing to strengthening the conventional type of staging, to give better performance during earthquake. Equivalent static analysis for staging with different types of bracing system applied to the staging of elevated circular water tank in zone V is carried out using STAAD Pro. Comparison of base shear and maximum displacement in X, Y &Z direction of circular water tank is done. Different model is used for calculating base shear and maximum displacement for staging with cross bracing, staging with diagonal bracing, staging with K-type bracing, staging with V- type bracing staging with chevron bracing and alternate cross bracing in staging, alternate K- type bracing in staging, alternate V-type bracing in staging alternate diagonal bracing in staging and alternate chevron bracing in staging.

6. Prashant Bansode Reinforced concrete elevated water tanks are very important structures. They are considered as main lifeline elements during and after earthquakes. An elevated water tank behaves like an inverted pendulum, which consist of huge water mass at the top of a slender staging. This is most critical consideration for the failure of the tank during earthquakes. Basically, supporting system, so called staging is formed by a group of columns and horizontal braces provided at intermediate levels to reduce the effective length of the column. Staging is responsible for lateral resistance of complete structure. The objective of this study is, to understand the behavior of different staging system, under different tank conditions. Response Spectrum Analysis is carried out on three different types of bracing systems of elevated water tank in all zones by using STAAD Pro V8i 2007. Comparison of base shear and nodal displacements of elevated water tank for empty and full condition is done. The spring mass model as per IS 1893:2002 Part 2 has been used for the analysis.

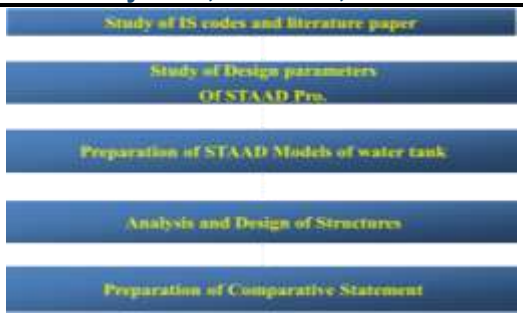
7. Nanjunda, Avinash Deshpansde,Shylaja The present investigation centers around the reaction of the elevated circular water tanks to dynamic powers. Overhead water tanks comprise of enormous water mass at the highest point of a slender staging which are most critical consideration for the failure of the tank during earthquakes. Tanks of different frame staging with different numbers of columns is displayed utilizing SAP2000 programming. The examination is carried out for two cases to be specific, tank full and empty tank level condition thinking about the hydrostatic impact. The models were analysed with SAP2000 utilizing Response Spectrum Method (RSM) and results are displayed. It is watched that increasing in number of columns, does not guarantee the increment in the stability of the structural responses .The tanks withstood the acceleration with the displacements within the permissible limits. The peak displacement and base reactions got from the analysis were also compared. total 18 models were examined with SAP2000 utilizing Response Spectrum Method (RSM) and results are displayed.

8. M. Sai Ramya and J. Sandhya Rani Elevated water tanks are the structures of greater importance which are considered as the main lifeline elements.Many displeasing experiences have taken place earlier due to the damage and collapse of elevated water tanks due to the occurrence of earthquakes. The reason behind the damage is lack of providing proper supporting system to the water tank to withstand the dynamic loads and also due to improper selection of staging. The main objective of the present study is to evaluate the seismic response of elevated rectangular water tank with different staging patterns and different water level conditions (full, half and empty). Four types of bracing systems of elevated water tank such as normal bracing, diagonal bracing, V bracing, and cross bracing are considered for the analysis with various water level conditions.A total of 12 combinations were analysed and base shear, base moment and roof displacement for the fixed models were calculated with SAP2000 v 20.0.0 software using Response Spectrum Method (RSM) and results are presented.

9. Ranjit Singh Lodhi, Dr. Abhay Sharma, Dr. Vivek Garg The water is source of every creation. In day to day life one cannot live without water. The overhead liquid storing tank is the most effective storing facility used for domestic or even industrial purpose. Depending upon the location of the water tank, the tanks can be name as overhead, on ground and underground water tank. The tanks can be made in different shapes like rectangular, circular and intze types. The tanks can be made of RCC or even of Structural steel. Steel tanks are widely used in railway yards. Overhead tanks and storage reservoirs are used to store water, liquid petroleum and similar liquids. Reservoir is a general term used to liquid storage structure and it can be below or above the ground level. Reservoirs below the ground level are normally built to store large quantities of water. The overhead tanks are supported by the column which acts as stage. This elevated water tanks are built for direct distribution of water by gravity flow and are usually of smaller capacity. After a long time IS 3370 is revised in year 2009 from its 1965 version. In present work intze tank is analyzed and designed for two cases. Case: 1 is design of Intze tank as per IS: 3370 (1965) without considering earthquake forces & case: 2 is design of intze tank as per IS 3370: (2009) with considering earthquake forces as per Draft IS: 1893-2005. M30 grade concrete and Fe 415 steel is used in the design. The value of permissible concrete stresses in calculation relating to resistance to cracking (for direct tension) are 1.5 N/mm2and the value of permissible limit of stresses of Steel (in direct tension, bending and shear) in IS 3370 :(1965) is 150 N/mm2and in IS 3370:(2009) is 130 N/mm2

III. METHODOLOGY

- The methodology fixing the dimensions of components, for the selected water tank and performing linear static analysis by IS: 1893-1984 and IS: 1893-2002 (Part 2) draft code.
- It is analyzed for four different zones (zone-II to V) and for tank-fill and tank empty conditions, i.e. both conditions.
- Lastly, the results of the analysis of tanks performed on the basis of IS: 1893-1984 and IS: 1893-2002 (Part 2) by using the software STAAD PRO.



IV.CONCLUSION

- Parametric study is carried out by using different patterns of bracings in staging of an elevated water tank. base shear for different bracing pattern it is clear that the base shear value, reduces for alternate bracing pattern in staging. This is apparent because of the reduction of overall stiffness of the structure.

- From the observations made above it can be concluded that Cross Bracing in staging most effective in reducing Displacement due to lateral loading reducing displacement effectively by 81.09 % in X direction and 92.98 % in Z direction from that of structure without bracings.

- From the comparision between displacement for different bracing system and displacement for different alternate bracing it is conclude that cross bracing pattern gives the minimum value of displacement.

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