Review On Seismic Analysis Of Intze Water Tank With Different Types Of Staging Configuration

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ABSTRACT

Water is essential element for life as well as its uses in other types of work including construction. The demand of water is not constant every time and it varies from time to time. For continue supply of water, we need to store the water at some place. In order to store the water, we use a structure known as elevated water tank. Intze type water can store large capacity of water for regular supply. Hence, these types of structures are huge in shape and size so these water tanks are very vulnerable to earthquake. Various researches has been done to find the effects of loads and forces such as wind, earthquake etc. acting on water tank with help of software like STAAD PRO, SAAP, ETABS etc. to minimize the collapse and any types of damage to the structure. The main objective of this paper is to analyse the earthquake effects and loads acting on the elevated water tank and to study its performance and behaviour under these conditions having different types of staging configuration in the structure of water tank with parameter like base moment, base shear, displacement, time period for empty tank, half-filled and completely filled water tank considering different types of soil and different seismic zones.

Keywords

water tank, seismic analysis, staging, seismic zone, Response spectrum method, shear force, overturning moment, deflection
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Introduction

Water tanks are widely used as a storage tank for the water. Water tank are used for agriculture, fire fighting, drinking etc. earthquakes acts as major role for failure of water tank. So, it's very necessary for an engineer to design any structure like it can provide a good resistance to the earthquake forces. So, in the following paper, we are going to study about the different types of forces including earthquake forces and its impact over the structure in the particular seismic zones. Here, we analyse the intze water tank with different staging configuration under the impact of different types of loading condition. These analysis works can be done over the software called as STAAD PRO V8i.

Literature Review

1. Ajmal Tokhi et. Al (2019) studied with empty tank, half-filled tank and fully filled tank in seismic zones III and V by using STAAD PRO V8i software. The capacity of all tanks is 45000 litres holds up on RCC frame of stage height 27m.The soil type is medium and M30 grade concrete is used with steel of Fe415 grade. In the seismic zone 3 in all condition, base shear in rectangular and circular tank is less than that of intze water tank and the rectangular water tank has more base shear than intze and circular water tank in seismic zone 5. Time period is more in intze tank others in full filled condition and is dependent of zones. Design of elevated tank is complex and requires a lot of calculation and time consumption.

2. Chetanagari et. al (2019) studied the seismic analysis of water tank with different staging configuration in seismic zones 2,3,4 by response spectrum method using STAAD PRO V8i. Analysis is done on empty tank first and also with fully filled tank. Method involves the calculations if dynamic response spectrum by plotting curves of (SDOF) and earthquake frequency which is calculated by equation. The result analysis of empty and filled tank includes following parameter as displacement in tank, bending moment in tank, shear force in tank, base shear in tank individually. Base shear, shear force increases for higher seismic zones and displacement cause is reduce due to horizontal brace and bending moment value are changing in staging due to different bracings.

3. R. Uma Maheshwari Rao et. al (2018) studied and evaluate the effects of lateral forces (seismic and wind) on tank. This paper throws some light

on the aspects of structure like axial forces, bending moment; shear forces etc. and these aspects are compared to different structural components of the tank. Analysis is done by using STAAD PRO V8i software. Here finite element method is used for analysis. In the particular study, it includes development of elevated water tank with help of numerical modelling by using STAAD PRO V8i software. The analysis is done on the main structure of tank. The conclusion we obtain is that for column maximum bending moment is 511.863 kNm with shear force of 252.673 kN. Maximum bending moment at the bottom of tank is 382.35 kNm with shear force of 355.039 kN. Bending moment at the top of the tank is 29.086 kNm with shear force of 28.59 kN.

4. Mr. Shivkumarhallale et al. (2018) studied by using overall twelve combinations and these were analysed by using a method known as dynamic analysis. Firstly, the with different staging configuration are used and parametric study were performed on these models to evaluate the lateral stiffness, time period and displacement etc. the water tank condition considered as an empty, half-filled and full filled. It is considering the shear wall on 6 sides of these tank conditions. The height of tank was taken as 5m, 10m and 20m. As a conclusion, height of tower increases time period also increases. In all the condition, the moment cause by a shear wall is less in radial and cross strut than the moment caused by shear wall at higher than that of 5m and 10m. but for the 20m height of the wall, the radial staging causes the base shear which decreases and at particular point and it again increases in some amount that of shear wall as height of tower increases displacement increases.

5. ISSAR Kapadia et al. (2017) studied structural elements used and design is as per the IS code as it includes the design of the dome, ring beam supporting the dome, cylindrical walls, ring beam at the junction of cylindrical walls and the conical wall, conical slab, floor of the tank, ring girder, column and foundation. The hydrostatic load acting the water tank is analysed by creating its 3D models in STAAD PRO and final result include actual view, deflected shape, beam stress and shear bending due to hydrostatic pressure. So, the conclusion we get from this, whenever structure height increases, it causes the moment to increase and we have given the inclination to the staying of water tank.

6. Prashant A Bansode et al. (2017) studied the structure which is analysed by response spectrum method over three different types of staging configuration. Structure was analysed with respective of all the seismic zones by using software called STAAD PRO V8i. In this paper, nodal displacement and base shear were compared for empty and full filled tank conditions. As per IS 1893:2002-part 2 spring mass model has been used for analysis. Bracing system is used as diagonal bracing, X bracing and without any bracing. As a result, the parameter like base moment, base shear, time period of vibration and lateral displacement were obtained for X bracing as well as for without bracing. The conclusion obtained was base shear increases as level of bracing increases because it put extra mass to the system. Base moment also increases level of bracing increases from diagonal to X. because the bracing system increases the stiffness of the structure so that time of vibration and lateral displacement were reduced.

7. ShriramNagarao Bengal et al. (2017) studied the elevated water tank such as rectangular tank, circular tank of constant height staging of 12m under the impact of seismic forces acting on it by method called seismic response reduction factor under the IS 1893:1984/2002 for design of structure for seismic loads. The design of the tank was done by using STAAD PRO V8i software. Capacity of circular tank is 100 cubic meter and rectangular tank is 100 cubic meters. Tanks must be analysed on empty and full filled conditions. As conclusion, we get that in the respective seismic zone 2 and 5, base shear increases for full filled tank and empty tank. Base shear in full tank is slightly higher than that of empty tank. Shear force generated is slightly higher in full filled tank than that of empty tank.

8. Ayush, Dr. Amritpal Singh (2017) studied the structure in seismic zone 4. They prefer shaft staging and framed staging structure and analysed by using response spectrum method. As per IS code 1893 (part 2) 2014, the behaviour of these structure was analysed. The parameter analysed were base shear, overturning moment, stress variation and area of steel. The software used to analysis was STAAD PRO V8i.The total mass

divided into two mass, convective mass and impulsive mass. Capacity of overhead water tank was 500 cubic meter and height was 16m for any situation of nodal displacement, the frame staging had nodal displacement higher than its original displacement. Shaft type staging tank has more overturning moment than that of frame type staging tank. Time period of shaft type water tank is less than the frame types staging water tank for impulsive node time period.

9. Sonali M Pole et al. (2017) studied different staging pattern with different storage capacity of the tanks, she used two staging system cross bracing and radial bracing and these two were compared for various fluid level with simple basic supporting system. These were performed on STAAD PRO V8i software. As a conclusion, the parameter includes were overturning moment, base shear and roof displacement. Finally, she concluded that, the base moment and base shear in empty tank was less than that of completely filled water tank.

10. Pranjal N Dhage et al. (2017) studied about the dynamic analysis of RCC elevated tank by considering two cases of the same tank of identical capacity of tank changes in geometric feature of container shows the response change of water tank. She concluded that static response has more scale value as compared to that of dynamic response. The following results were obtained by taking the different time period. The hydrodynamic factors lead the collapse of the structure so that it was ignored.

11. S.S.Quadri et al. (2017) studied total 36 models include empty, half-filled and completely filled water tank. They include parameter like storage capacity of water. The height of water tank was considered as consistent and includes the H/D ration variation in number segment. The staging pattern was considered like hexagonal staging, normal staging, cross staging and radial staging. They used finite element method for analysis on software. STAAD PRO V8i software was used for the work. The analysis was done by checking the parameters like base shear, lateral displacement, axial forces, bending moment responses of every water tower respect of another tower. The behaviour of tower was described with the help of graphs. There was increase in stiffness of tower because it was free at the top and fixed at the base and also it causes the magnitude change in base shear and lateral displacement.

12. Kumar swamy et al. (2016) studied the existing elevated water tank in India is designed by using IS 1893:1984 needs to be checked for its safety as per IS CODE 1893:2002. The aim of this paper is to understand seismic behaviour of the tank as different seismic zones. For intz type tank the water capacity above 200 cubic meter and up to the 800 cubic meter must be require. The design of the tank from both codes for comparison one by one. For result the shear, overturning moment, impulsive and convective hydrodynamic pressure max hydrodynamic pressure and sloshing wave height for different seismic zone 3, 4, 5 with empty and filled tank. The impulsive hydrodynamic pressure on wall is lower when compared to zone 4 is 33% and zone 5 is 55%. For the recent code bade shear and overturning moments is less from that reinforcement reduced.

13. Urmila Ronad et al. (2016) studied with help of a method known as dynamic response spectrum using the process of finite element model-based software called ETABS as per IS 1893:2002 for an empty and fully filled water tank. Frame staging with hexagonal plan for structure was carried out for study for an empty tank and fully filled tank. The soil medium was taken as soft, medium and hard with respect to 2, 3, 4 and 5 seismic zones. The capacity of the tank was 250 cubic meter, column height was 16m and tank height was 7.8m, zone factor was 2.5 and importance factor was 1.5. Result includes the parameter of base shear and base moment for empty and filled tank individually for all seismic zones and for all types of soil. The conclusion obtained was that the base moment and base shear for fully filled tank was more than the empty tank. Base moment and base shear also increase if tank was located in higher seismic zones. The soil types also cause change in base moment and base shear.

14. Ankush N. Asati et al. (2016) studied about a liquid containing tank involving the fluid structure interaction by dynamic analysis method. In the following paper, they conduct the behavioural study of circular water tank over the effect of seismic forces for specific capacity of tank with various staging configuration like normal, cross and radial. Total 36 combinations were analysed

with SAP2000 using response spectrum method. Some basic approaches such as lagarangian method, added mass method were used for problem investigation related to fluid structure. Storage capacity of tank was 500 cubic meters. As conclusion it is observed that radial arrangement with six staging levels were best for 6,8,10 and 12 number of columns with respect to bracing like normal and cross bracing. It can be said that sometimes it's better to optimise the structure after the proper assumption of its responses rather than increasing the column numbers for stiffened of structure safety.

15. Prasad S. Barve et al. (2015) studied the elevated water tank and analyse the effects cause by the ratio of its height variation and diameter (h/d) and tank capacity on parameters like time period, base shear, base moment and hydrodynamic pressure for both the modes. Loads studied were dead loads, wind loads, seismic loads, vibration forces and hydrodynamic pressure imposed on the tank. The study was according to IS 1893-2002(part 2), in parametric study seismic analysis of the tank having different capacity was done by changing the height to diameter ratio from 0.4 to 0.5.The capacity consider was ranging from 500 cubic meter to 1000 cubic meter. Earthquake zone 3 was included and soil type was of medium type. In impulsive mode, base moment and base shear was increases with increase in height/diameter ratio of the water tank. Hydrodynamic pressure also varies such as it decreases in convective mode and increases in dynamic mode in height/diameter ration when compared to seismic zone was about 33% and for seismic zone 5 it was 55%. For the recent code base shear and overturning moment was less from that reinforcement reduced.

16. Neha N. Walde et al. (2015) studied by considering effects of seismic responses base shear, base moment, direction of seismic forces, effect of vertical ground acceleration, maximum hydrodynamic pressure, sloshing wave, height were parameters. The analysis was done on seismic zone 5 by response spectrum method by using SAP2000 software. Different staging heights were taken such as 12m,15m,18m,21m,24m and 27m for seismic zone 5 and soil medium taken as soft soil and medium soil. Capacity of tank was about 50 cubic meter and 260 cubic meter considering 3m height of each panel. Stiffness of staging for different height is obtained. As conclusion, time period will not depend on type of soil site. Base shear for tank in full filled condition will be increases with increase in stiffness. Tank in empty condition will decreases. But shear and overturning moment for tank full condition will be increases with increase in stiffness and tank in empty condition will decrease.

17. Cherukupally Rajesh and Sudip Jha (2015) studied the behaviour of elevated water tank under the different types of loads and design structure. They consider the changing behaviour of wind load on elevated tank and also consider these changes with responses to parameters like base displacement and base shear. Their study shows the impact of wind load and the importance of proper supporting system to resist these impacts causes the damage of water tank. Parameters like roof displacement, base shear and overturning moment caused by the excitation of responses due to wind loads.

18. Miss Ankita R. Patel et al. (2014) studied the main component frame type staging were column and braces. The analysis was done on SAP 2000 software by response spectrum method. The three different heights of tanks were used as 12m, 16m and 20m height with different types of strut as normal configuration, radial configuration and cross configuration. The result includes the stiffness variation, roof displacement variation, base shear variation and overturing moment variation. More stiffness was found for radial configuration than that of normal, cross and deflection configuration. For a fully filled tank for all configurations, overturning moment and base shear increases with increases in the staging height from 12m to 16m with increase in seismic zone 2 to zone 5. Radial configuration is better in terms of performance.

19. Dr. Suchita Hirde et al. (2011) studied over elevated water tank for different height for various capacity of storage under different seismic zones for different medium of soil. They used 20 models to obtain the values of different parameters. SEPL Esr-Gsr software has been used to analyse the tank. Impulsive and consecutive parts were used in analysis. Due to dynamic motion of the tank, pressure generated within the fluid can be separated in these two convective and impulsive

parts. R.C.C elevated tank with M20 grade concrete and Fe 415 grade steel were considered. Capacity of the tank is 500000 litre and 100000 litres.If staging height was taken as 12m,16m,20m,24m,26m and 28m then the 4m height of each panel was considered. As a conclusion, we get that the change in seismic forces affects opposite to change in seismic zone hence it is inversely proportional to it and seismic forces are directly proportional to storage capacity of the tank.

20. R.Livaglu, A.Dogangun (2007) studied the different types of supporting system and cylindrical shell supporting system. Conclusion obtained from the analysisshowed that change in seismic behaviour of elevated tank considerably changes by changing the supporting systems of the tank. These researchers investigate the dynamic response of fluid elevated tank system. Displacement base LaGrange approach was selected to model the fluid interaction tank interaction in this study the fluid elements was defined by eight nodes with three translational degree of freedom at each node. The elevated tank with 900cubic meter of vessel volume was considered. The thickness and radius were about 0.3 and 4.3m from result, the maximum response was obtained between 9 and 10 second for frame support and 5 and 10 second for shaft support. Roof displacement is higher than the shaft support. The cylindrical shaft system has an important advantage over the commonly used frame system so that it may be used for a design having seismic risks.

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