Seismic Protection of Water Tank Using Supplemental Devices

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Abstract- *Civil engineering structures such as building, bridge and towers may be damaged under earthquake loads or even collapsed. Design of structures has been concern of the civil engineers for resistance against seismic damages. Despite many efforts and progresses in the applied codes, structures are always vulnerable to earthquake. The reason is that the designed structures with the common methods have limited resistance capacity. Major resistance of the structures is based on the negligible stiffness and damping of the materials applied in them for waste of energy. These structures are inactive because they are not adaptable based on the applied loads. To confront against earthquake load, resistance and ductility of structure increase but provision of the materials for such goals is expensive. Increase in dimensions of cross section applies more forces to them and as a result, it will have larger dimensions. Generally, seismic control methods are divided into four subgroups in terms of performance type. a)Seismic separation. b) Inactive control method. c) Semi-active control method. d) Active control method In separation method, by increasing natural periods and predicting dampers following it , we reduce dynamic response of the structure. In the structures of tank, major part of mass is located in considerable distance of foundation. Analysis of these structures under lateral forces can be important and considerable particularly for security and keeping efficiency of these structures. Since period of these structures is usually high, it can be important to select suitable analytic method which can recognize performance of system at time of applying lateral forces.*

Keywords- Intze water tank, Nonlinear time history, Seismic analysis, Friction damper, Base Isolater, fix base

I. INTRODUCTION

Water is human basic needs for daily life. Sufficient water distribution depends on design of water tanking 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 indifferent forms and fashions. There are many different ways for the storage of liquid such as underground, ground supported, elevated etc. 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. Elevated water tanks consist of huge water mass at the top of a slender staging which are most critical consideration for the failure of the tank during earthquakes. Elevated water tanks are critical and strategic structures and damage of these structures during earthquakes may endanger drinking water supply, cause to fail in preventing large fires and substantial economical loss. Since, the elevated tanks are frequently used in seismic active regions also hence; seismic behavior of them has to be investigated in detail. Due to the lack of knowledge of supporting system some of the water tank were collapsed or heavily damages. So 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. The draft code for liquid retaining structures is one of the outcomes of the project. The present study is an effort to identify the behavior of elevated water tank under different acceleration time history with consideration and modeling of impulsive and convective water masses inside the container using structural software SAP2000.

II. LITERATURE SURVEY

[1] Ayazhussain M. Jabar, H. S. Patel(2012) in this paper discuss elevated water tank under different staging pattern and earthquake characteristics. Here three condition of water tank: full water tank, half-full water tank, empty water tank. and four types earthquake is apply. finally results In empty condition, higher base shear for cross bracing pattern in Loma Prieta time history.. For Kobe earthquake, lower base shear and overturning moment in cross bracing and radial bracing pattern respectively in empty condition. In case of half- full condition, lowest base shear and overturning moment for Radial Bracing in Loma Prieta and Kobe earthquake intensity respectively. For basic staging overturning moment is highest in half-full condition for Loma Prieta having high PGA value. In case of Full condition, highest base shears obtained for radial bracing in Imperial Valley having low PGA value. Roof displacement is considerably decreases with increase in PGA value of earthquake time history and also noted higher value in Imperial Valley. Higher Roof displacement values are obtained in full fill up condition for all patterns.

[2] Prof. Dipak Jivani, Dr. R.G. Dhamsaniya, Prof.M.V. Sanghani (2017) This work is done by software SAP 2000 Time history analysis of elevated RC reservoir under Different ground motion. Here, eight types of earthquake is used and 12m,16m,20m staging height of elevated water tank. Time history analysis is carried using above mentioned parameters. For each capacity separate model are prepared according to staging height and all mentioned time histories are applied with scale factor to each model for tank full condition and results are noted down in form of Base Shear, Base Moment, and Maximum Displacement. On the basis of the results obtained after time history analysis of tank with different staging configurations, following conclusions can be drawn. The major system responses such as; base shear, overturning moment, slab displacement are highly scattered. This shows that the system is vastly influenced by the characteristics of the earthquake records. For the design of such system, earthquake records must be considered as the non-stationary random process. The critical response depends on the earthquake characteristics and particularly frequency content of earthquake records. The water tank structure attracts less seismic forces as the height of staging increases. Roof Displacement increases with the increase in staging height. But, Roof displacement is considerably decreases with increase in PGA value of earthquake Base overturning moment is decreases with the increase in staging height. That might be due to decrease in base shear with increase in height.

[3] Arathy S, Manju P.M. (2016) The purpose of this paper is to study the performance of friction pendulum devices during their service life. These bearings are characterized by the capability to undergo large displacements despite their compact size and high re-centering capacity. These properties make this device superior among other commonly used isolation devices such as lead-rubber bearings or spring type isolation systems. In these supports the friction produced during sliding of the surfaces exclusively dissipates the seismic motion while the seismic isolation is obtained by the shifting of the natural period of the superstructure. The restoring forces developed on double and triple friction pendulum bearings were 1.22 and 11.04 times that of single friction pendulum bearing respectively. For building with base isolation, the base shear, drift, displacement and overturning moment values are considerably reduced due to the higher time period resulting in lower acceleration acting on the structures. Numerical study was conducted on a 25 storied real structure considering fixed base and isolated base with single, double and triple pendulum isolators. The triple pendulum isolator was found superior among the three in terms of story drift, displacement, moment and base shear. But none of the above structures confirmed to the safety limit described in IS 1893-2002, in terms of drift and displacement together. To make the proposed structure stable, floor isolation along with the base isolation using FPS have to be provided at suitable heights.

[4] N. Vinay, Dr. Gopi Siddappa and Dr.G.S. Suresh (2012) this paper is study about push over analysis of elevated water tank. The pushover is expected to provide information on many response characteristics that cannot be obtained from an elastic static or dynamic analysis. The following are the examples of such response characteristics: The realistic force demands on potentially brittle elements, such as axial force demands on columns, force demands on brace connections, moment demands on beam to column connections, shear force demands in reinforced concrete beams, etc. Estimates of the deformations demands for elements that have to form in elastically in order to dissipate the energy imparted to the structure. Estimates of the inter storey drifts that account for strength or stiffness discontinuities and that may be used to control the damages and to evaluate P-Delta effects. Identification of the strength discontinuous in plan elevation that will lead to changes in the dynamic characteristics in elastic range. The non-linear response of RCC frame of an elevated circular liquid storage tank using SAP 2000 under the loading has been carried out with the intention to study the relative importance of several factors in the non-linear analysis of RC frames. The frame behaved linearly elastic up to a base shear value of around 310 kN. At the value of base-shear 910 kN, it depicted non-linearity in its behavior. Increase in deflection has been observed to be more with load increments at base-shear of 910 kN showing the elastic-plastic behavior. The joints of the structure have displayed rapid degradation and the inter storey deflections have increased rapidly in non-linear zone. The frame has shown variety of failures like beam-column joint failure, flexural failures and shear failures. Prominent failures are joint failures.

[5] A. Samanta and P. Banerji (2008) In this study, a finite element method was employed to investigate the nonlinear seismic response of RC pedestals in elevated water tanks. Since the elevated water tanks are built in various tank capacities and pedestal heights, a combination of the most commonly constructed tank sizes and pedestal heights in industry were selected for investigation. 3D finite element models were developed for all prototypes and the pushover curves and corresponding bilinear approximations were constructed accordingly by conducting pushover analysis. In addition, the cracking propagation pattern was analyzed for several prototypes. The over strength and ductility factor were calculated based on pushover curves and the effect of various parameters such as fundamental period, height to diameter ratio, seismic design category, and tank size on the seismic response factors of elevated water tanks was studied. The results of the study showed that for the same tank size, taller tanks demonstrate much lower maximum base shear (Vmax) comparing to shorter tanks. Accordingly, two types of cracking propagation were observed during the pushover analysis. Elevated water tanks with a pedestal height to mean diameter ratio (h/dw) of above 2 demonstrated flexure–shear cracking pattern which initiate sat the opposite top and bottom corners of RC pedestal. However, for h/dw ratio less than 2, the cracking propagation was due to web-shear cracking which starts near the base, parallel to the lateral load direction and gradually extends to the top of pedestal. These patterns could be employed for seismic rehabilitation and strengthening of existing elevated water tanks which are located in high seismicity regions and do not comply with current codes and standards.

[6] Poonam S. Sutar, Dr. S. C. Potnis (2013) this is the paper of Earthquake response of the liquid storage tank with various isolation systems. The effectiveness of seismic isolation increases with the increase of bearing flexibility and damping. The proposed approximate methods accurately predict the peak response of the isolated elevated steel tank with significantly less computational efforts. Examination of maximum hydrodynamic pressure resulting from the convective and impulsive modes showed that the maximum pressure occurs at the lower levels of water free surface. Since impulsive pressure is dominant in these levels, maximum pressure occurs at the bottom of full tank. The isolation system is more effective for rigid type tower structure. Analytical and numerical calculation approaches are compared on the example of typical tank geometry, taken the relevant interaction effects into account. The effectiveness of isolation systems for tanks increases with the increase of the flexibility of the sliding systems. All the codes suggest quite similar expressions for evaluating maximum sloshing wave height. For Indian code IS 1893 the provisions for seismic analysis of tanks suggested by Jainand Medhekar (1994, 1994), need to be modified. These modifications are particularly needed to include simplified mechanical models for flexible tanks, to include the effect of vertical acceleration, and to include simple expressions for sloshing wave height.

[7] Ankush N. Asati, Dr. Mahendra S.Kadu (2014)this paper is discuss about water tank staging As known from past upsetting experiences, adequately designed elevated water tanks were heavily damaged or collapsed during earthquakes. This might be due to the lack of knowledge regarding the behavior of supporting system of the tank; and also due to improper geometrical selection of staging patterns. For certain proportions of the tank and the structure, the sloshing of the water during earthquake may one of the dominant factor. In this paper, the seismic behavioral effect of elevated circular water tank is studied for constant capacity and constant number of columns; for various types of staging arrangement in plan, and variation in number of stages in elevation by using finite element method based software SAP 2000. Two mass idealizations suggested by Gujarat State Disaster Management Authority (GSDMA) guideline are considered here. Total nine combinations were analyzed using Response Spectrum Method (RSM) and results are presented. Radial arrangement with six staging levels is found to be best for ten numbers of columns. Radial arrangement with six staging levels is best suited for ten numbers of columns followed by cross and normal. Full tank condition shows critical response than empty tank conditions. But we can't neglect empty tank condition.

III. CONCLUSION

1) All the three base isolation systems are found to be effective in reducing the earthquake force of the liquid storage tanks. However, the N-Z system is found to be better in comparison to the LRB and FPS systems.
2) The base isolation is found to be more effective for slender tanks in comparison to broad tanks for all isolation systems. There is also increase in the sloshing displacement for slender tanks due to base isolation.
3) The base shear, sloshing displacement and bearing displacement obtained from exact and approximate analysis are closely matches. Thus, the proposed approximate analysis of the base isolated liquid storage tanks provides satisfactory response under earthquake excitation.
4) The proposed approximate analysis is found to perform better in case of broad tanks in comparison to slender tanks.
5) The effectiveness of seismic isolation systems increases
6) With the increase in the time period of isolation systems. However, the bearing displacements are also relatively higher for the higher values of isolation period.
7) The variation dispersion of slab displacement for tank full condition is for all the Staging height and capacity. Roof displacement increases linearly with the increase in staging height.
8) A non-dimensional parameter in form of ratio of Base shear to total Weight has been considered to check the effect and variation of base shear with respect to staging height.. It is observed that the base shear coefficient (Base shear/Weight) is decrease with the staging height. The dispersion of base shear variation also has been reducing with the increasing in staging height.

9) For study and observation purpose a non-dimensional parameter has been considered in form Base Moment / (Weight x C.G. Distance from base) and comparison for the same with staging height. It is also been observed that the base overturning moment is decreases with the increase in staging height. That might be due to decrease in base shear with increase in height.

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