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Review on Evaluation of Response Reduction Factor for RC Elevated Water Tank Using Non Linear Static Analysis.

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ABSTRACT: Whereas seismic design based on deformations is a concept that is gaining ground existing codes are fundamentally force-based, with a final check on deformation. A central feature of force-based seismic design is the response modification factor (R). The response modification factor plays a key role in the seismic design of the structure. To date, the values assigned to this factor are based on engineering judgment and have little sound technical basis. Any improvement in the reliability of modern earthquake resistant structure will require the systematic evaluation of the response characteristics that most affect values assigned to the factor. Currently, R factor assigned is based on several assumptions that are for regular structures. The R factor depends on ductility factor, over strength factor, structural redundancy and damping associated with structure. Thus this study aims to evaluate and compare the response modification factor for overhead water tank and water tank with varying capacity and seismic zone for tank full, tank empty and partially filled condition.

KEYWORDS:- Response Modification Factor, Seismic Design, Elevated Water Tank.

I. INTRODUCTION

Elevated water tanks are used to store water for daily requirements in both urban and rural areas and it is most important part of domestic water distribution system. Being important lifeline system, safety of water tank is critical and restoring water line is need of the hour during natural calamities like floods and earthquakes. Elevated service reservoir (ESR) is key for water storage and distribution in municipalities in India. Elevated tanks are large elevated water storage containers for the purpose of storing water source at sufficient height for enabling pressurized water distribution to prolonged distances. ESR's comprises large container and supporting tower (staging). Commonly staging are used in the form of reinforced concrete shaft and in the form of concrete column base frame.

1.1 Nonlinear Static Analysis

The use of the nonlinear static analysis (pushover analysis) came in to practice in 1970's but the potential of the pushover analysis has been recognized for last two decades years. This procedure is mainly used to estimate the strength and drift capacity of existing structure and the seismic demand for this structure subjected to selected earthquake. This procedure can be used for checking the adequacy of new structural design as well. The effectiveness of pushover analysis and its computational simplicity brought this procedure in to several seismic guidelines (ATC 40 and FEMA 356) and design codes (Euro code 8 and PCM 3274) in last few years. (Virkhare et al. 2015)

Pushover analysis is defined as an analysis wherein a mathematical model directly incorporating the nonlinear load-deformation characteristics of individual components and elements of the building shall be subjected to monotonically increasing lateral loads representing inertia forces in an earthquake until a target displacement is exceeded. Target displacement is the maximum displacement (elastic plus inelastic) of the building at roof expected under selected earthquake ground motion. The structural Pushover analysis assesses performance by estimating the force and deformation capacity and seismic demand using a nonlinear static analysis algorithm. The seismic demand parameters are storey drifts, global displacement (at roof or any other reference point), storey forces, and component deformation and component forces. The analysis accounts for material inelasticity, geometrical nonlinearity and the redistribution of internal forces. (Patel et al. 2014)

1.2 Concept of Response Reduction Factor

The concept of R factor is based on the observations that well detailed seismic framing systems can sustain large inelastic deformations without collapse and have excess of lateral strength over design strength. Response reduction (R) factors are essential seismic design tools, which are typically used to describe the level of inelasticity expected in lateral structural systems during an earthquake. The response reduction factor (R) is depends on Over strength (R_s), Ductility (R_μ), Redundancy (R_R). According to ATC-19, it is described as

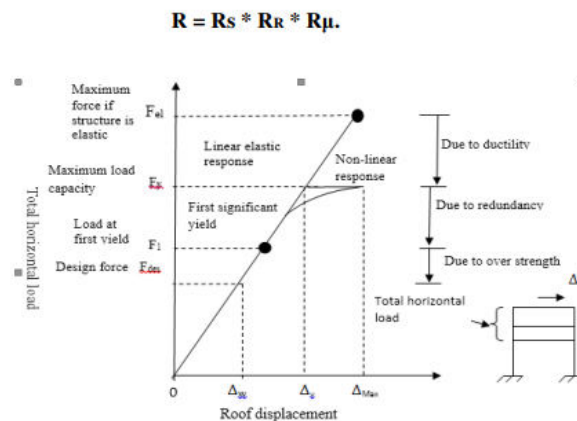


Figure 1: Conception of response reduction factor

Over strength factor (R_s) accounts for the yielding of a structure at load higher than the design load due to various Partial safety factors, strain hardening, oversized members, confinement of concrete. Non-structural elements also contribute to the over strength. Ductility factor (R_μ) is a ratio of ultimate displacement or code specified permissible displacement to the yield displacement. Higher ductility implies that the structure can withstand stronger shaking without collapse. Redundancy factor (R_R) depends on the number of vertical framing participate in seismic resistance. Yielding at one location in the structure does not imply yielding of the structure as a whole. Hence the load distribution, due to redundancy of the structure, provides additional safety margin. The Over strength factor, Ductility factor and Redundancy factor can be workout on the basis of generalized pushover curve shown in figure 1.

II. LITERATURE REVIEW

2.1. Habibullah& Pyle, (1998), Performance Of Pushover Procedure In Evaluating The Seismic Adequacy Of Reinforced Concrete Frames”.

In this presented simple steps for performing pushover analysis using SAP2000 software. The SAP2000 static pushover analysis capabilities, which are fully integrated into the program, allow quick and easy implementation of the pushover procedures prescribed in the ATC-40 and FEMA-273 documents for both two and three-dimensional buildings

2.2. Moghadam& Tso, (2000), Pushover Analysis for Asymmetric and Set-Back Multi-Story Buildings.

This study extended pushover analysis to cover plan eccentric buildings and took the three-dimensional torsional effect into account. Because of torsional deformation, floor displacements of the building will consist of both translational and rotational components. Torsional effect can be particularly damaging to elements located at or near the flexible edge of the building where the translational and rotational components of the floor displacement are additive. In view of the damage observed in many eccentric buildings in past earthquakes.

2.3. Koller Martin G., Malhotra Praveen K., (2004), “Seismic Evaluation of Unanchored Cylindrical Tanks”.

In this study the seismic resistance of seven existing unanchored cylindrical oil storage tanks was calculated according to Euro-code (EC) 8, part 4, Appendix A [1]. Five of these tanks, with H/R ratios (H = height of liquid, R = radius of

tank) of 1.12, 1.14, 1.75, 2.16 and 3.48, were also calculated with the non-linear pushover analysis proposed by Malhotra [2]. All tanks are located in Switzerland. None of them was designed to resist earthquakes. From this study it was concluded that seems to be overly conservative for tanks with slenderness ratios $H/R > \sim 1.5$. This might be of little importance for the design of new tanks, as the additional cost of an overdesign may remain small.

2.4 N. Vinay, SiddappaGopi, G.S. Suresh, (2012), “Pushover Analysis for an Elevated Water Tanks”.

The purpose of this project is to summarize the basic concepts on which the pushover analysis can be based, assess the accuracy of pushover predictions, identify conditions under which the pushover will provide a adequate information and perhaps more importantly to identify cases in which the pushover predictions will be inadequate or even misleading. The aim of this project is to provide relevant information and implementation of Non- linear Static [pushover] analysis for elevated water tanks.

From this study it was concluded that 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 behaviour. Increase in deflection has been observed to be more with load increments at base-shear of 910 kN showing the elastic plastic behaviour.

2.5. Patel Tejash, Amin Jignesh, Patel Bhavin, (2014), “Evaluation Response Reduction Factor of RC Framed Staging Elevated Water Tank Using Static Pushover Analysis”.

In the present study efforts are made to evaluate the response reduction factors of RC framed staging elevated water tanks having staging height of 12 m but having varying capacities. The effects of seismic zone and fundamental time period of water tank on the Response reduction factor are also discussed. Displacement controlled nonlinear pushover analysis is used to evaluated the base shear capacity and ductility of tanks.

From this study it was concluded that the response reduction factor is considerably affected by the seismic zone and fundamental time period of water tanks. It reduces as the seismic zone increases and increases as the fundamental time period increases. The values of response reduction factor for a given RC framing system should vary between seismic zones. Also the reinforcement detailing requirements should vary with seismic zone. Estimation of response reduction factor with exact analysis will help in an economical design. It is observed that response reduction varies from 2.63 to 4 for tank in full condition in seismic zone V.

2.6. VirkhareDhiraj, VairagadeLaxmikant, Nair Vikrant, (2015), “Pushover Analysis of Water Tank Staging”.

The present study investigates the behaviour of an elevated circular water tank by Pushover Analysis. It is carried out by considering various parameters like water storage capacity and staging height which are constant, different types of h/d ratio, various types of staging arrangement and variation in number of columns. By inter-combining each of these parameters 54 models of tank was created. All tank models have their locality in earthquake zone III. We have made use of SAP 2000 computer program.

The pushover curve which is a plot of base shear versus roof displacement, gives the actual capacity of the structure in the nonlinear range. The structural behaviour remains same for plastic hinge formation, different water storage capacity, staging heights and different number of columns.

2.7. BinduL.Chaya, Sai Kumar A.V, (2016), “Effect Of Staging Height On The Seismic Performance Of RC Elevated Water Tank”.

This study is mainly focused in understanding the seismic behaviour and vulnerability of elevated reinforced concrete water tanks and supporting structures for various seismic intensities, soil conditions, staging heights etc. with respect to the provisions of IS1893 Part2.

From this study it was concluded that the regular RC buildings located on soft soils have been found more vulnerable when compared to medium and hard soils due to amplification of waves in soft soil. The probability of damage in RC buildings is found to be high when setbacks were introduced at middle storey compared with RC buildings with setbacks at other stories. Also it is observed that setbacks introduced at middle storey of RC buildings the probability of damage is 20% more than the RC buildings without infill.



2.8. Gondalia Rupal, Patel Dhananjay, (2017), “Non-Linear Static (Pushover) Analysis on Elevated Storage Reservoir (ESR)”.

This paper presents nonlinear static analysis for evaluate seismic demand for 250m³ and 500m³ capacity of tank with zone II, zone III, zone IV, zone V in empty case and full water load condition. This gives the plastic hinge formation and plots the total base shear versus top displacement curve, which is known as ‘capacity curve’ of the structure. The Purpose of this paper is to carry out non-linear behaviour of different type of staging height with empty and full water condition of Elevated Storage Reservoir, using CSI SAP2000 software package, and to evaluate the performance and failure mechanism of the ESR. And compare the reduction factor with assumed R factor.

From this study it was concluded that the Base shear is decreases as the staging height increases that is due to increase in Time period and the dispersion of base shear is increased when the percentage of the filling in the storage tanks are increasing. The response reduction factor is considerably affected by the staging height of water tanks. It reduces as the height of water tank is increasing. R factor is highly dependent on seismic zones. For various seismic zones R factor also changes. Time period and Redundancy of elevated tank will remaining same for all zones of same height of tank. Base shear will increasing by changing the zone from II to V for the same height of elevated tank.

2.9. Kumbhar S. A., Bunage G. V., Taware R. S., Kolekar A. S., Gaikwad A. I., (2018), Review On Retrofitting & Rehabilitation Of Elevated Water Tank By Using Sap 2000”.

In this paper elevated storage tank of staging height 12m is taken into account with capacity 70 m³. Analysis has been done using SAP-2000. The Rehabilitation of the existing damaged Elevated storage reservoir with pile foundation is employed during this work to judge the effectiveness of retrofitting techniques, known as FRP wrapping. Economic aspects square measure studied for various innovative water tanks staging systems with reference to typical frame type and shaft kind staging of ESR.

From this study it was concluded that After reviewing it has been concluded that damaged water tank lose its concrete strength and as per original design it require to improve quality and serviceability of tank by retrofitting of tank .The life of the elevated water tank will be improved by providing the proper retrofitting and will be economical. The elevated water tanks performance will be improved by retrofitting. This can be analysed by SAP2000.

III. ACKNOWLEDGEMENT

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IV. CONCLUSION

From the literature review, the following conclusions can be drawn:

1. There is no past research available for analysis of large water tank against lateral forces, gravity forces and hydrostatic pressure.
2. The safety of large scale elevated service reservoir are questioned in lateral forces. Requirement of such analysis meets the research gap for large scale capacity.
3. The researcher like Habibullah, Pyle and S.A Kumbhar which studied the water tank which capacity have one, two and three lac Liter.
4. As increasing storage capacity and height, nonlinear analysis is must require.

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