Analytical Investigation of Response Reduction Factor (R) For R.C. Elevated Water Tank With Non-Linear Static (Pushover) Analysis

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Abstract- *The present study investigates the formulation of key factors for seismic response reduction factor of RC framed staging of elevated water tank. The analysis revealed that four major factors, called Over strength (Rs), Ductility (Rμ), Redundancy (RR),Damping factor (Rἐ) affects the actual value of response reduction factor and therefore they must be taken into consideration while determining the appropriate response reduction to be used during the seismic design process. The evaluation of response reduction factor is done using static nonlinear (pushover)analysis. Pushover analysis is an advanced tool to carry out static nonlinear analysis of framed structures. It is used to evaluate non linear behavior and gives the sequence and mechanism of plastic hinge formation. Here displacement controlled pushover analysis is used to apply the earthquake forces for RC elevated rectangular water tank. The pushover curve which is a plot of base shear versus roof displacement, gives the actual capacity of the structure in the non linear range.*

Keywords- Response reduction factor, Seismic analysis, Static nonlinear pushover analysis.

I. INTRODUCTION

Earthquakes are one of the most dangerous natural hazards causing damage and collapse to livelihood and they are the result of ground shaking caused by sudden release of energy in earth's lithosphere. Due to Earthquake ground motions, there is heavy economic and life loss. Most of the losses are due to collapse of structures such as buildings, bridges, water retaining structures etc. Elevated water tanks are vital structures in water supply systems. Their protection presentation is an important task during strong earthquakes. They should not fail after earthquake, so that they can be used in important necessities like providing drinking water and quenching fire.[1]

Generally staging support system type causes over head tanks collapse in earthquake. It is very important to consider earthquake load in design of elevated tank. Response reduction factor is very important to find out earthquake load. The response reduction factor reflects the capacity of structure to dissipate energy by inelastic behavior. The values of response reduction factor of R.C. elevated water tank are given in IS 1893 code, which is arrived at empirically based on engineering judgment. The value of response reduction factor is fixed 2.5 for frame supported R.C. elevated tank. One constant value for elevated water tank cannot reflect the expected inelastic behavior of all elevated water tanks located in different seismic zone and having different capacities. So it is required to find out perfect value of response reduction factor for various type of R.C. elevated water tank individually.[2]

The response reduction factor or force modification factor R reflects the capacity of structure to dissipate energy through inelastic behavior. It is a combined effect of over strength, ductility and redundancy. Response reduction factors play a key, but controversial, role in the seismic design process in India. No other parameter in the design base shear equation impacts the design actions in a seismic framing system as does the value assigned to R. Despite the profound influence of R on the seismic design process, and ultimately on the seismic performance of buildings in India, no scientific basis exists for the values of R adopted in seismic design codes in India.[3]

Without such a basis, it will be difficult to advance the practice of force-based seismic design in its current form. Numerous design codes have recommended that the effect of soil flexibility can reasonably be neglected for the seismic analysis of structures .This conventional simplification is valid for certain class of structures and soil conditions, such as light structures in relatively stiff soil. Unluckily, the assumption does not hold true always, but the different soil properties and its contact with superstructure can have a detrimental effect on the response of structure, and neglecting the effect of soil flexibility in the analysis may lead to unsafe design for both the superstructure and the foundation.[4]

The actual earthquake force in considerably higher than what the structures are designed for. We cannot design the structures for the actual value earthquake intensity because the cost of construction will be too high. The actual intensity of earthquake is reduced by a factor called response reduction factor ‘R’. The value of ‘R’ depends on how we design the frame members. From previous study it is noted that the ‘R’ factor depends on ductility factor (Rμ), strength factor (Rs), structural redundancy (R_R) and damping (Rέ) associated with structure.[5]

$$R = Rs \times R_R \times R\mu \times R\dot{\varepsilon} \quad \text{———— eq.1}$$

State of development – The main objective of this study is to examine the behaviour of overhead rectangular water tank supported on frame staging considering different modeling systems. All the cases are analyzed for non linear static analysis. The analysis is carried out using SAP 2000 software.

Non Linear Static (pushover) Analysis- In a nonlinear static analysis procedure, the structure model incorporates directly the nonlinear force-deformation characteristics of individual’s components and elements due to inelastic material response.

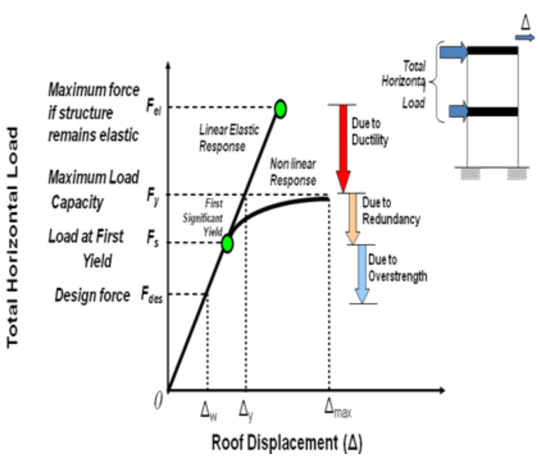

Fig no.1

The nonlinear force-deformation characteristics of the structure obtained by subjecting the structure model to monotonically increasing lateral forces or increasing displacements, distributed over the height of the structure. The maximum displacements likely to be experienced during a given earthquake are determined using non linear static (pushover) analysis. In the present work, efforts are made to calculate the response reduction factor for elevated overhead water tank of different soil types. The influence of soil types, time period and seismic zones on response reduction factor is studied.

With the help of software, displacement controlled non-linear pushover analysis is carried out to evaluate the base shear and ductility factor of water tank. It is observed that the value of Response reduction factor is affected by seismic zones, soil type, and time period of the water tank.Three different types of soil conditions representatives of hard soil, medium soil and soft soil has been considered in this study. The effects of seismic zone and fundamental time period of water tank on the Response reduction factor are also discussed.

II. CONCLUSION

This paper focuses only on the literature review of previously published studies. The finding of this study shows that value of Response reduction factor is affected by seismic zones, soil type, and time period of the water tank. Three different types of soil conditions representatives of hard soil, medium soil and soft soil has been considered in this study. The effects of seismic zone and fundamental time period of water tank on the Response reduction factor are also discussed.

There is no mathematical basis for the response reduction factor tabulated in Indian design codes A single value of R for all structures of a given framing type, irrespective of plan and vertical geometry, cannot be justified. But for ESR staging (beam,column, frame or shaft), where the basic system of framing and behavior is more or less common, the method can be derived to evaluate response reduction (R) factor. Similar effort has study here. So it is important to study the non linear static nature of structure.

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