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# Parametric Study of Different Staging Pattern with Pushover Analysis of Water Tank

Ganesh G. Tembhurne[1], Sanjay K. Bhadke[2]
[1]*M-Tech Research Scholar (Structure), Civil Engineering Department, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, MH. gtembhurne@gmail.com*
[2]*Asst. Professor, Civil Engineering Department, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, MH.*

***Abstract:*** *The present study investigates the formulation of key factors for the modifying factor of the seismic response of the RCC framed staging of the elevated water reservoir. The analysis revealed that three main factors, called reserved force, ductility and redundancy, affect the real value of the response change factor and therefore must be taken into account when determining the change of the appropriate response to be used during the seismic design process. The evaluation of the response modification factor is carried out using a non-linear static pushover analysis. Pushover analysis is an advanced tool for performing static nonlinear analyzes of framed structures. It is used to evaluate non-linear behavior and provides the sequence and mechanism for forming the plastic hinge. Here, displacement-controlled displacement analysis is used to apply seismic forces in C.G. of container. The thrust curve, which is a basic cut graph relative to the displacement of the roof, provides the effective capacity of the structure in the non-linear range.*

*This could be due to the lack of knowledge about the correct behavior of the tank support system due to the dynamic effect and also due to the inadequate geometric selection of the staging. The objective of this study is to understand the behavior of different stages, under different load conditions and to reinforce the conventional type of staging, in order to obtain better performance during an earthquake. This paper presents a seismic analysis of elevated water tanks supported in different staging models with different tank storage capacities. Here we compare two different support systems, such as radial reinforcement and transverse reinforcement, with the basic support system for various fluid level conditions. Eleven models are used to calculate the shearing of the base and the nodal displacements for staging with STAAD pro. After calculating the base cut and the nodal displacements of eleven models for empty and complete conditions. Three different types of staging systems were analyzed.*

***Keywords:****Response reduction factor, Seismic design, Static nonlinear pushover analysis, SAP 2000,STAAD Pro****.***

## I. Introduction

The earthquake can induce large horizontal forces and overturns in high water tanks. These tanks are quite vulnerable to earthquake damage due to their basic configuration which involves a large mass concentrated in the upper part with a relatively thin support system. When the tank is in complete condition, seismic forces almost govern the design of these structures in areas of high seismic activity. It is important to ensure that the essential requirements, such as water supply, are not damaged during earthquakes. In extreme cases, the total collapse of the tanks will be avoided. However, some repairable damage may be acceptable during agitation without compromising the functionality of the tanks.

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Water is a basic human need for everyday life. The distribution of sufficient water depends on the design of a water tank in a given area. A raised water tank is a large water storage container built to maintain water supply at a certain height to pressurize the water distribution system. Many new and innovative ideas have been created for storing water and other liquid materials in various forms and fashions. There are many different ways of storing liquids like underground, supported on the ground, overhead, etc. Municipalities and industries use liquid storage tanks to store water, flammable liquids and other chemicals. Therefore, water tanks are very important for public utility and for the industrial structure. Water tanks are very important components of the lifeline. They are critical elements in municipal water supply, fire extinguishing systems and many industrial water storage facilities.

**Fig. 1 Collapse of water tank in Bhuj**

**Fig. 2 Flexure cracks in staging**

**1.1. Objectives:**

An attempt is made in this thesis seismic response and optimization of a high-water reservoir under different setup model with variations in tank volume. The main objectives of the relationship are

- To study the seismic behavior of elevated water tanks in different set-up models with variations in the tank volume.
- Study the optimization of the water tank.
- Analyze the displacement of the structure in different directions using the seismic coefficient method.
- Study of the cutting of the base, of the axial force and of the moments of the structure in different directions using the seismic coefficient method
- Calculation of the base cut, base moment and displacement of the water tank roof for various water level conditions.
- Compare the results.

## II. Literature Review

A.R. K. Ingle[1]in this document, the structure of the water tank on the head is designed with the P-DELTA effect. According to IS: 456, the final design forces must include the deformation effect (P-DELTA effect) and say nothing about the calculation of these additional forces. According to IS: 11682, evaluate the actual length of the column and calculate these forces because of its slenderness ratio. According to the ATC code, the consideration of the P-DELTA effect is necessary if the stability index is greater than 0.1, which depends on the drift ratio, the height of the floor, the vertical and horizontal forces. For the study, different shapes of the column and its arrangement that is tangential or radial are considered. And these agreements play an important role in reducing drift and stability index. Static tank analysis is performed using Arya [3,4] or the matrix method. It is believed that the structure of the space box has six degrees of freedom in each node.

B.S.C. Dutta[2]High water tanks have failed during previous earthquakes, including Kern County in 1952 and the recent Killari earthquakes of 1993 due to a large torsion response. So, these earthquakes have highlighted the importance of this problem. It has been shown that these structures can have a twisted torsion-induced rotation if their relationship between natural torsional and lateral is close to 1 and also the displacement of structural elements due to the coupled lateral torsional vibration if J is between 0.7 and 1, 25. The goal of this work is to evaluate its torsional vulnerability. In 1993, Killari, an earthquake in India, a high RC water tank collapsed vertically downward, burying the six support columns directly beneath the bottom plate of its container due to torsional vibrations.High water tanks with a very asymmetrical geometry and mass distribution should not have considerable eccentricity between the center of mass and the center of rigidity. However, the asymmetrical positioning of water scales and pipes, the separation of the water mass during agitation and the lack of uniformity in construction can introduce a small accidental eccentricity between the center of the mass and the center of the stiffness.

HasanJasim Mohammed[3]proposed the optimization method for the structural design of rectangular and circular cement water tanks, considering the total cost of the tank as an objective function with the tank properties, which are the capacity, width and length of the rectangular tank, the water depth in a circular shape, the unit water weight and the thickness of the tank slab, as project variables. A computer program was developed to solve numerical examples using the equations of the IS code: 456-2000 from India. The results show that the tank capacity has assumed the minimum total cost of the rectangular tank and has been eliminated for the circular tank. The thickness of the tank floor required the minimum total cost for two types of tanks. The unit weight of the water in the tank took the total minimum cost of the circular tank and lowered for the rectangular tank

Samer A. Barakat[4]Proposal for an optimization procedure based on the evolution for the design of reinforced concrete tanks. The cost of the tank material including concrete, reinforcement and formwork needed for walls and floors was chosen as an objective function in the formulation of the nonlinear optimization problem. The thickness of the wall (in the lower and upper part), the thickness of the base, the depth of the water tank and the inclination of the wall were considered as project variables. Three advanced optimization techniques have been studied to solve the problem of nonlinear structural optimization. These methods are: 1) shuffled complex evolution (SCE), 2) simulation ringing (SA) and genetic a logarithm (GA). Several tests were performed to illustrate the robustness of these techniques and the result was encouraging for the SCE method. The SCE method proved to be superior to the SA and GA methods to obtain the best solutions discovered. He concludes that the robust research capability of the SCE algorithm techniques is adequate to solve the structural problem in question.

Snehal Wankhede[5]in the present study, the optimization of the costs of the high circular water tank is presented. The goal is to minimize the total cost in the circular tank design process considering the cost of materials. The design variables considered for minimizing the cost of the elevated water tank are the wall thickness, the depth of the slab, the depth of the floor beam (for example, X1, X2, X3, respectively). The optimization problem is characterized by having a combination of continuous, discrete and whole design variable sets. For optimization purposes, the MATLAB software is used with SUMT (sequential minimization technique without restrictions), which is able to identify the minimum project variables directly with high probability.

Ankush N. Asati[6]has known from very upsetting experiences, the poorly designed raised tanks have been damaged or collapsed during earthquakes. This could be due to the lack of knowledge of the behavior of the tank system and also to an improper selection of the staging model geometry. For certain proportions of the tank and the structure, the water lapping during the earthquake can be one of the dominant factors. The dynamic analysis of the reservoir containing the liquid is complex and involves the fluid-structure interaction. In this document, the seismic behavior of the high circular water tank is designed for the specific capacity of the tank for various staging arrangements in plan, variation in the number of peripheral columns and variation in the number of stages in elevation. Here are considered two mass idealizations suggested by the Disaster Management Authority of the State of Gujarat. Under the loads of the earthquake; a complicated pattern of stress is generated in the tanks.

Manish N. Gandhi[7]Water tanks are very important for public utility and for the industrial structure. Water tanks are very important components of the lifeline. Critical elements in municipal water supply, fire protection systems and in many industrial plants for water storage. From the very troublesome experiences of some earthquakes in India, the high-water tanks of R.C.C have been damaged or collapsed. This could be due to the lack of knowledge about the correct behavior of the tank support system due to the dynamic effect and also due to the inadequate geometric selection of the staging. The main objective of this study is to understand the behavior of different stages, under different load conditions and to reinforce the conventional type of stages, to provide better performance during an earthquake.

## III. Research Methodology

The proposed work is planned to be carried out in the following manner

- ❖ Seismic behavior of Water Tank with various Staging Pattern.
- ❖ Model the selected in seismic behavior of water Tank with various various Staging pattern
- ❖ Linear seismic analysis of selected water Tank.
- ❖ Design of steel building using SAP2000/STAAD Pro.
- ❖ Parametric Study of various Staging pattern & Seismic analysis of water Tank
- ❖ Carry out Seismic analysis & seismic behavior of various Staging pattern of water tank using SAP2000.

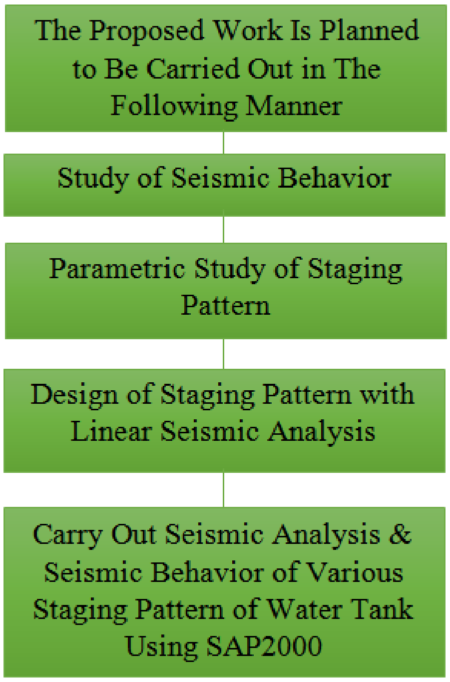


**Fig.3**

## IV. Problem Formulation

To study the seismic performance of a high circular water tank for the seismic zone III of India for a height of 20 m for various capacities of 500 m3, 800 m3 and 1000 m3 of elevated water tanks for different staging models. total models for the analysis of the elevated water tank. The seismic analysis is carried out by means of the seismic coefficient method. To study the guidelines of India's standard codes for the analysis of said tanks, to study the suitability of different types of reinforcements considering the tanks for different staging models and different capacities of the circular water tank. To study the seismic analysis of the water tank using the seismic coefficient method using FEM Software STAAD pro. The water tank is modeled and analyzed for different capacities with different staging models. The comparison between the cutting of the base and the maximum displacement / nodal displacement of the container will be carried out.

## V. Modeling

The tank was modeled as a 3D spatial structure model with six degrees of freedom in each node using the STAAD-pro software for the stimulation of gravity behavior and seismic load. The isometric 3D view and the height of the tank model are shown as a figure. The support condition is considered totally fixed.
A complete analysis of the dead load, the live load and the seismic load is performed with STAAD-pro. All combinations are considered according to IS 1893: 2016 part II.

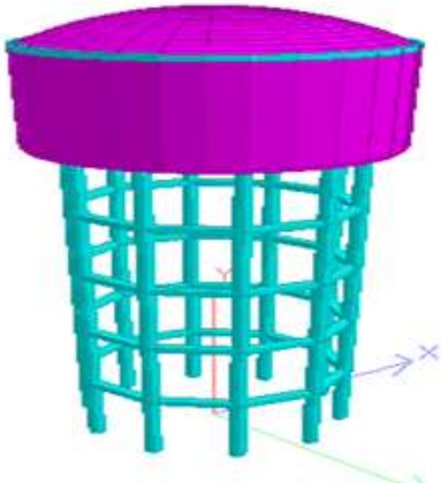


**Fig.4 Model with Frame Type of Staging**

## VI. Conclusion

1.There is no mathematical basis for the reduction factor of the tabulated response in the Indian design codes.
2. A unique value of R cannot be justified for all buildings of a given type of structure, regardless of the plan and vertical geometry. However, for the staging of ESR (beam-column or axis frame), in which the framing and behavioral system is more or less common, it is possible to derive the method to evaluate the R factor. Such an effort is been done here.
3. To ensure the constant level of damage, R values should depend on both the fundamental staging period and the type of soil.
4.The values assigned to R for a given framing system must vary between the seismic zones. Even the detailed requirements vary depending on the area.
5.In this project, the emphasis is on the study of the intrinsic characteristic of the solution of the seismic coefficient method in STAAD pro V8i. This method provides the values of the time period and the basic cut, which are very much in agreement with the values of the results calculated manually.
6.The design of the water tank is a very boring method. In particular, the design of the elevated water tank involves many mathematical formulas and calculations. It is also a long time. Therefore, STAAD pro provides all results, such as moving the basic cut node, etc.
7.The type of cross arrangement has a greater deflection than the frame and less in radial, and vice versa is the rigidity.
8.For full and empty tank conditions, the base cut is more for the layout of the frame, so it is crossed and followed by a radial arrangement.
9.The parametric study is performed using different staging schemes of a high-water tank.

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