

**Optimization of elevated water tank**Hardik Patel¹, Jasmin Gadhiya², Abhishek Raturi³

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Abstract — Water Storage Structures are used to store water to tide over the daily requirement of water by localities, industries, campuses, towns & cities, etc. These structures are usually of three kinds: Tanks resting on ground, Underground tanks and Elevated tanks. RCC tanks are used for small & large capacity of storage. An Elevated tank serves as an important architectural feature, and is therefore, shaped to suit the aesthetical requirement of the surroundings. Optimization is the act of obtaining the best result under given circumstances. In the simplest case, an optimization problem consists of maximizing or minimizing a real function by systematically choosing input values from within an allowed set and computing the value of the function. In this work optimization can be done by the different parameters like column proportionality, panel size etc. And design an elevated water tank with its defined parameter and optimize it.

Keywords-elevated water tank, column proportionality, seismic zone, optimization

I. INTRODUCTION

Water is life line for every kind of creature in this world. All around the world liquid storage tanks are used extensively by municipalities and industries for water supply, fire fighting systems, inflammable liquids and other chemicals. Thus Water tanks plays a vital role for public utility as well as industrial structure having basic purpose to secure constant water supply from longer distance with sufficient static head to the desired location under the effect of gravitational force. With the rapid increase of human population, demand for drinking water has increased by many folds. Also due to shortage of electricity at many places in India and around the developing nations, it is not possible to supply water through pumps at peak hours. In such situations elevated water tanks become an important part of life.

Economy and safety is very important parameters for all so that make a structure in economy and safe are the first criteria for all. So that optimization is the best way by which we can make a structure in economy and safe in design. Here optimization of water tank can be done by taking different parameters as column proportionality, panel size, different seismic zone etc. For optimize the elevated water tank one single structural data taken for the all models. Models can be design based on different column pattern (circular, square, rectangle wide, rectangle deep) and different panel size. After that analysis can be done in different seismic zone (I, II, III, IV, V). Comparing the all results we can find out our optimize design for the elevated water tank.

II. LITERATURE REVIEW**Roof Displacement, base shear**

Chirag N. Patel, Shashi N. Vaghela, H. S. Patel (2012)^[1] explained the seismic behaviour of the elevated water tank under alternate column proportionality under different time history records using finite element software SAP 2000. It considered water as two mass idealizations suggested by Gujarat State Disaster Management Authority (GSDMA) guideline. A reinforced elevated water tank with different types of column system with full water level in the container had been considered. The storage capacity of water tank was 1000 m³. Finite element model of elevated water tank was prepared in SAP2000. Tanks were supported by fixed base frame type staging system with different column proportionality had been considered with considering two-mass water model, seismic responses including sloshing displacement and displacement of tank at various locations from bottom to top were assessed under four earthquake records. The seismic responses of tank had been determined using time history analysis in three cases, i.e. 3-panel, 4-panel, 5-panel. They concluded that amongst all type of column proportionality, rect_wide has been proving highly competitive to with stand against sloshing displacement under different earthquake characteristics. Sloshing displacement had been increase towards higher number of panels and Sloshing displacement was increase in the panel number and increase against high frequency earthquake. The result of sloshing displacement under various time history records were shown in below table. And graph shows the sloshing displacement for different column proportionality and time history records.

No. of Panel	Time history	Sloshing Displacement			
		Rect_deep	Circular	Square	Rect_wide
3 - Panel	Northridge	0.3407	0.3443	0.3447	0.3446
	Lomapieta	1.1055	1.1053	1.1053	1.1052
	Imperial valley	0.2661	0.2670	0.2669	0.2669
	Kobe	0.1341	0.1335	0.1335	0.1335
4 - Panel	Northridge	0.3627	0.3634	0.3627	0.3625
	Lomapieta	1.1337	1.1214	1.1199	1.1194
	Imperial valley	0.2713	0.2662	0.2556	0.2654
	Kobe	0.1416	0.1408	0.1407	0.1406
5 - Panel	Northridge	0.3519	0.3576	0.3575	0.3577
	Lomapieta	1.1763	1.1520	1.1496	1.1465
	Imperial valley	0.2764	0.2756	0.2752	0.2746
	Kobe	0.1487	0.1446	0.1442	0.1435

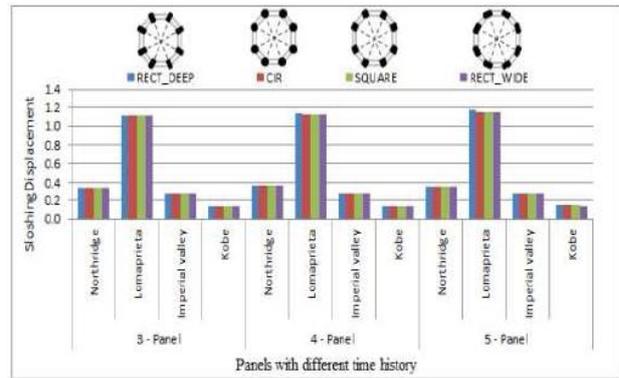


Table 1: sloshing displacement vs time history

chart 1: sloshing displacement for column proportionality

Ankush N. Asati, Dr. Mahendra S.Kadu (2014)^[2] studied on seismic investigation of RCC elevated water tank for different types of staging patterns. In this paper, the seismic behavioural 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. The storage capacity of water tank was 500 m³ considering ten number of columns with staging height 16 m, seismic zone III and medium type soil. Finite element model of tank is modelled in SAP 2000. In the present study three types of arrangements have been considered i.e. normal, radial and cross. They can be conclude that For tank full and empty conditions, as staging levels increases; base shear with base moment increases with decrease in roof displacement. For tank full and empty conditions, base shear and base moment is more for radial arrangement then cross and followed by normal type of arrangement. Tank empty condition had less base shear and base moment compared to full tank condition. Vice versa for the Roof displacement. And Radial arrangement with six staging levels is best suited for ten numbers of columns followed by cross and normal.

We can conclude that base shear and displacement are increase in the tank in empty condition. And rectangle wide type column is giving best result in amongst all type of column proportionality and proving highly competitive to with stand against sloshing displacement under different earthquake characteristics.

Computer approach

Snehal Wankhede, Prof. P. J. Salunke, Prof. N. G. Gore (2014)^[3] studied cost optimization of elevated circular water storage tank. And they were studied computer approach to the optimal design of elevated circular water tank is presented. The resulting optimum design problems were constrained non-linear programming problems and had been solved by SUMT. In SUMT the constraint minimization problem is converted into unconstrained one by introducing penalty function. In the present work is of the form, $f(x, r)$ is the penalty function $f(x)$ is the objective function r is the non-negative penalty parameter, and m is the total number of constraints. The penalty function (x, r) is minimized as an unconstrained function of x and r , for a fixed value of r . It had been shown that with the help of computer programming and giving a safe design with minimum cost of the elevated circular water storage tank, the design of the tank can be more economical, reliable and simple.

Veeresh Varur, Dr. S. B. Vankudre, Prabhavati P. (2014)^[4] gives idea for safe design with minimum cost of the tank and gives the designer the relationship curve between design variable thus design of tank can be more economical, reliable and simple. The paper helps in understanding the design philosophy for the safe and economical design of water tank. They worked on rectangular water tank with open top is required to store 24000 litres of water. First of all they did manually calculation and after that designed by MATLAB software. And coding did by N Pandian method. They can conclude that the result obtained from the optimization method by N Pandian method is capable of obtaining the optimum solution. It had been observed that the area of steel which we get from optimum design was less than the normal design.

MATERIAL	NORMAL DESIGN	OPTIMUM DESIGN	MINIMUM VALUES
AST in mm ²	10480	9620	5970
Steel in kg	684	621	342
Volume of concrete in m ³	9	8.44	7

Table 2: obtained results

Swathi C. Naik and M.S. Bhandiwad (2016)^[5] studied the only elevated rectangular tanks. They presented the seismic analysis of an elevated rectangular water tank with mid frame staging and was compared by changing the seismic zone as per IS: 1893-2002 (Part-2) and wind speeds for different soil conditions such as hard, medium and soft soil. The elevated water tank, capacity of 190000 litres was modelled in finite element software ETABS. For optimization purpose the mathematical formulas were taken from the N Pandian method. In this paper, an effort was put to study the seismic behaviour of an elevated rectangular water tank for different seismic zones of India and for different soil conditions. It was studied for various parameters like base shear, overturning moments, displacements, storey drifts for all the seismic zones and presented for hard, medium and soft soil. The tank was then optimized by using N Pandian method of optimization. The theoretical values and the optimum values are compared and presented. After comparing the results it can be conclude that the displacement was more in soft soils and the least in hard soils. The displacement value was maximum when the tank located in zone V in case of soil types. Base shear values are the same for both medium and soft soils. It was maximum for these soils and was least for hard soil. The percentage of steel values was optimum and less when N Pandian method was used and the design can be made more economical.

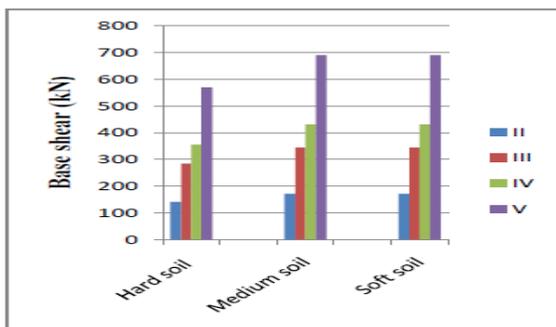


Chart 2: base shear at different soil and zone

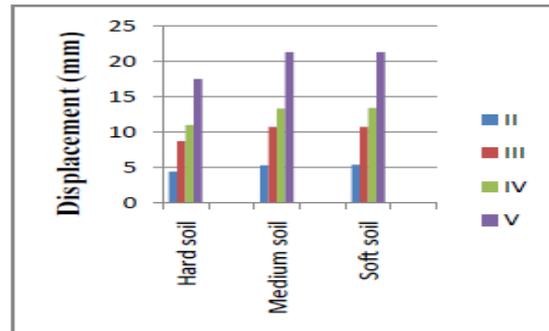


Chart 3: displacement at different soil and zone

	Normal Design			Optimum Design		
	Long wall	Short wall	Base slab	Long wall	Short wall	Base slab
A_{st}	2522.40	1650.26	1923.47	1662.50	1487.50	1662.50
$P_t\%$	1.44	0.94	1.10	0.95	0.85	0.95

Table 3: obtained values of optimum design normal design and

We conclude that N Pandian method gives best result. Showing the results N Pandian method gives optimum result so that this method is capable to optimize the structure.

Wind speed and seismic zone

Nitesh J Singh, Mohammad Ishtiyaque (2015)^[6] studied wind forces and seismic forces acting on an intze type water tank for Indian conditions were studied. The effect of wind on the elevated structures is of prime importance as Wind flows relative to the surface of ground and generates loads on the structures standing on ground. The elevated structure is designed for various Wind forces i.e. 39 m/s, 44 m/s, 47 m/s & 50 m/s and the same was cross checked with different seismic zones i.e. Zone-II, Zone-III, Zone-IV, & Zone-V by 'Response Spectrum Method' and the maximum governing condition from both the forces is further used for design & analysis. Analysis can be done in STAAD pro software. Analysing the all models they can be conclude that as the wind speed and seismic zone increases for the same bearing capacity volume of concrete and quality of steel both are increased. As the Load and moments on foundation goes on increasing in each case the size of Raft Foundation goes on increasing.

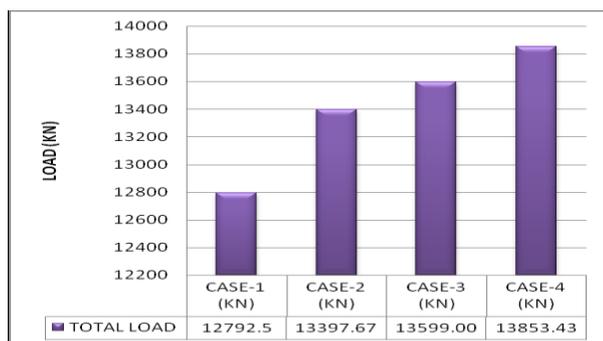


Chart 4: Total load on Foundation

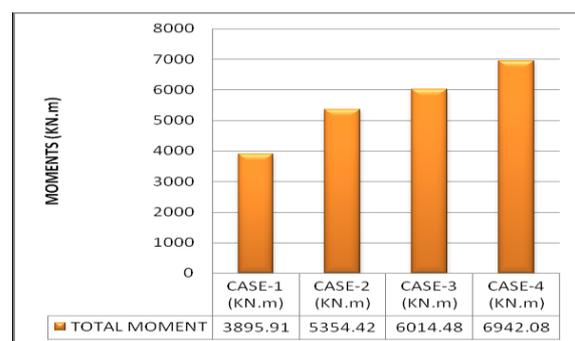


Chart 5: Total moments on Foundation

Showing above results we conclude that load and moments are increased at wind speed varying from case I to case IV. As same values are lower at seismic zone II and it increase to seismic zone V.

III. CONCLUSION

An Elevated tank on the other hand serves as an important architectural feature, and is therefore, shaped to suit the aesthetical requirement of the surroundings. IS:3370-2009, "The Code of Practice for concrete structures of liquids" has laid down the guidelines for the design and analysis of water storage structures. By all the above reviews we can conclude that optimization of elevated water tank is very tedious method. And it can be shown that displacement and base shear are the maximum in the soft soil and minimum at hard soil. Also that is maximum in the seismic zone V and also at wind speed case IV. For optimize purpose based on computer approach N Pandian method gives safe and minimum results. The result obtained from the N Pandian method is capable of the optimum solution.

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