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Analysis of Elevated Square Water Tank with Different Staging System

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***Abstract*—From the very upsetting experiences of few earthquakes, like Bhuj earthquake (2001) in India R.C.C elevated water tanks were heavily damaged or collapsed. This was might be due to the lack of knowledge regarding the behaviour of supporting system of the tank and also due to improper geometrical selection of staging. The main aim of this study is to carry out the seismic analysis of RCC square elevated tank using SAP2000. Using response spectrum analysis, compare the result of base reaction, joint displacement with different staging system. The table reveals displacement values of top node and bottom node of container of tank, though it is evident that alternate cross bracing pattern gives the minimum value of displacement, but from the construction point of view and economy of overall construction, the alternate diagonal bracing pattern can be suggested.**

Keywords*—*elevated water tank, displacement, seismic analysis, brasing pattern

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.

II. NEED OF STUDY

Elevated water tanks are commonly used for storing water in public water distribution system and it should be competent of keeping the expected performance during and after earthquake. It has large mass concentrated at the top of slender supporting structure and hence extremely vulnerable against horizontal forces due to earthquake. Elevated water tank is a structure which is constructed at a sufficient height to cover a large area for the supply of water. The performance of elevated water tanks during earthquakes is of much interest to engineers, not only because of the importance of these tanks in controlling fires, but also because the simple structure of an elevated tank is relatively easy to analyze and, hence, the study of tanks can be important.

III. MODELLING AND ANALYSIS

A. About Problem

The frame type is the most commonly used staging in practice. The main components of frame type of staging are columns and braces. In frame staging, columns are arranged on the periphery and it is connected internally by bracing at various levels. The staging is acting like a bridge between container and foundation for the transfer of loads acting on the tank. In elevated water tanks, head requirement for distribution of water is satisfied by adjusting the height of the staging portion. A reinforced elevated square water tank having different staging arrangements and staging levels has been considered for the present study.

B. Modelling

Elevated tank of tank size 6m x 6m consisting height of staging of 15 m which are located at zone III in medium type soil. Size of column is 300mm X 300 mm.

Table 1: Design data of elevated tank

Top slab		150 mm	
Bottom slab		200 mm	
Side wall		150 mm	
Height of staging		15 m	
Height of container		5 m	
Dimension of tank		6 X 6 m	
Zone factor		V (0.36)	
Importance factor		1.5 for water tank	
Reduction Factor		5 (SMRF)	
Type of soil		Medium soil	
Bracing type	Beam	Column	Bracing
Without	230 mm x 400 mm	450 mm x 450 mm	-
X bracing	230 mm x 300 mm	300 mm x 300 mm	230 mm x 230 mm
Inverted V bracing	300 mm x 300 mm	300 mm x 300 mm	230 mm x 250 mm
Diagonal bracing	250 mm x 300 mm	400 mm x 400 mm	230 mm x 250 mm

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Analysis an elevated square water tank with different bracing system like x bracing, inverted v bracing and diagonal bracing as shown in figure.

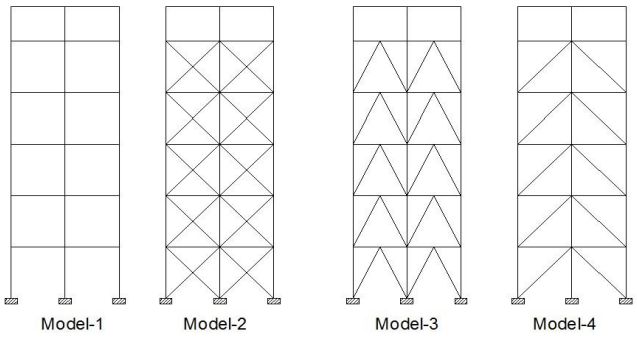

Figure 1: Different bracing pattern

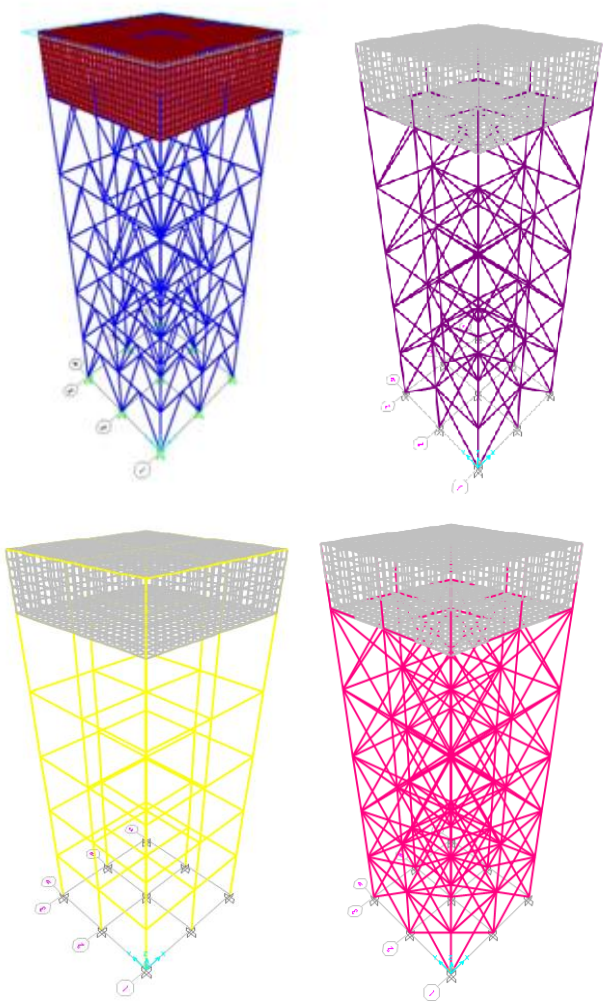

Figure 2: models in SAP 2000

C. Analysis

a. Joint displacement

Table 2: Results of nodal displacement

Maximum joint displacement (mm)				
	Node-64		Node-37	
	X	Y	X	Y
Model-1	80.52	80.53	69.61	74.80
Model-2	34.31	74.36	33.30	74.22
Model-3	81.55	77.62	72.20	77.41
Model-4	37.99	80.19	37.40	75.72

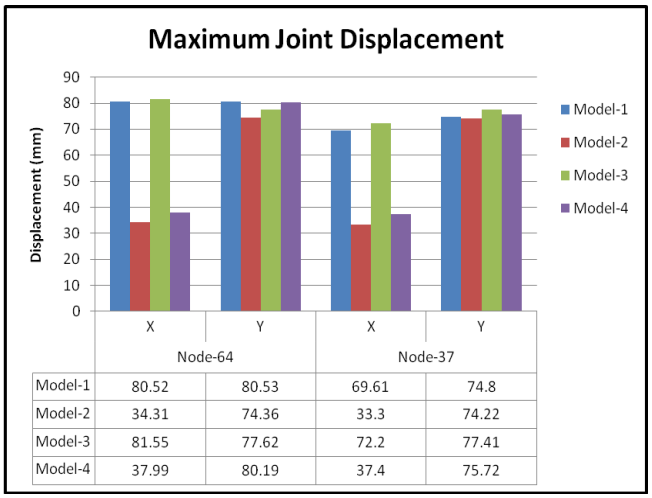

Chart 1: results of displacement of different model

This graph has shown the displacement of every model. The maximum displacement occurs in the model-1 and the minimum displacement occurs in model-02. So the graph suggests that model-2 is best between all models.

b. Base reaction

Table 3: Results of Base Reaction

	Base Reaction (KN)
Model-1	287.19
Model-2	354.84
Model-3	343.94
Model-4	355.94

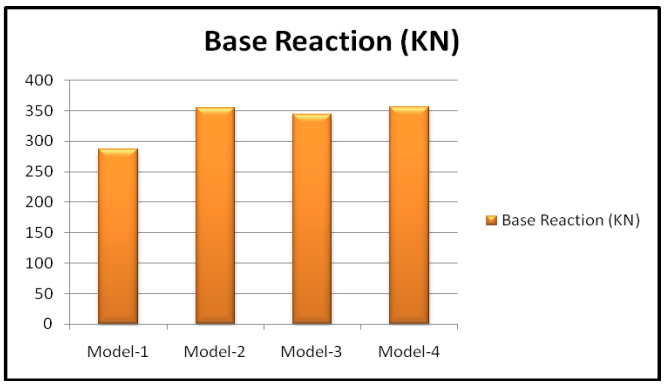

Chart 2: results of base shear of different model

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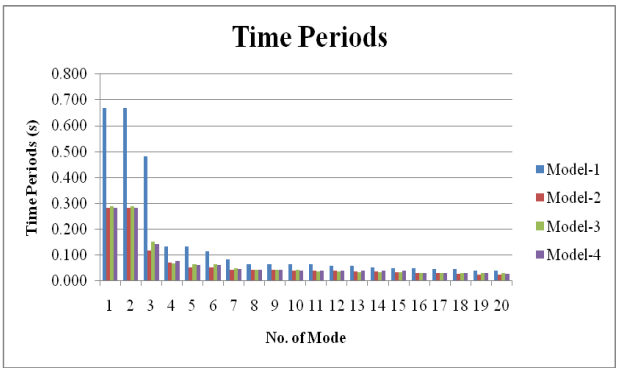
Model-1 shows the minimum value then Model-2, Model-3, Model-4. So that showing the base reaction model 1 (without bracing) is good.

c. **Time period and frequency**



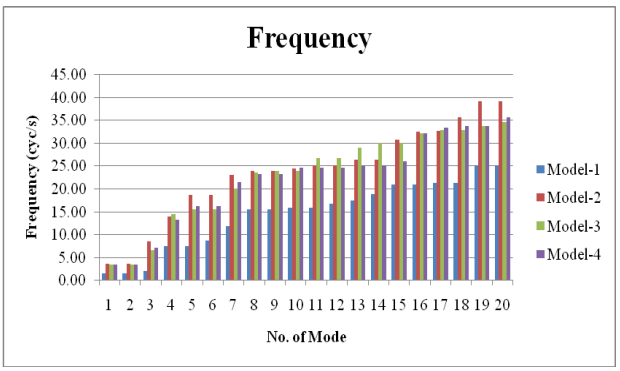


Chart 3: results of time period and frequency of different model

After showing above two results model 1 have minimum frequency and maximum time period and model 2 have maximum frequency and less time period comparing all model so based on this, time period and frequency model 2 is ideal.

IV. CONCLUSION

From the showing all above analysis results of elevated square water tank, we can conclude that

- Model-2 gives the good result for joint displacement at node-64, i.e. 34.31 mm and 74.36 mm in x and y direction respectively with respect other model, the percentage variation in joint displacement about different model configuration such as model-1, model-3 and model-4 are 57.39%, 58.08%, and 9.69% in x direction and 7.65%, 4.2%, and 7.27% in y direction respectively.
- Model-2 gives the good result for joint displacement at node-37, i.e. 33.30 mm and 74.22 mm in x and y direction respectively with respect other model, the percentage variation in joint displacement about different model configuration such as model-1, model-3 and model-4 are 52.16%, 53.88%, and 10.96% in x direction and 0.77%, 4.12%, and 1.98% in y direction respectively.
- Model-1 gives the good results for joint reaction i.e. 287.19 KN with respect to all model. The percentage variation in joint reaction about different model configuration such as model-2, model-3, and model 4 are 19.06%, 16.5%, and 19.31% respectively.
- Model-1 gives the maximum time period i.e. 0.669 second while model-2 gives minimum time period i.e. 0.026 second.
- Model-2 gives the maximum frequency i.e.39.20 cycle/sec while model-1 gives minimum frequency i.e.1.49 cycle/sec.
- From all above configuration model-2 is ideal case for all parameters such as joint displacement, time period, frequency and base shear.

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