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ANALYSIS OF ELEVATED WATER TANK WITH DIFFERENT STAGING CONFIGURATION FOR EARTHQUAKE LOAD

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ABSTRACT: Water retention is a person's basic needs in everyday life. Elevated water tanks consist of huge water mass at the top of a slender production, which most critically take into account the failure of the tank during earthquakes, elevated water tanks are critical and strategic structures, and damage to these structures during earthquakes can threaten drinking water, cause failure to prevent large fires and significant economic losses. The performance of raised water tanks during earthquakes is of great interest to engineers, not only because of the importance of these tanks for firefighting, but also because the simple structure of the elevated tank is relatively easy to analyze and therefore tank research can be informative about the behavior of buildings during earthquakes. It is observed that the lateral displacement is maximum with the value of the 20 mm in the case of model-I while it goes on decreasing with the minimum value of the model-VIII (Elevated water tank with Staging with C type Shear Wall at Peripheral Portion) having the value of 7.0 mm.

Keywords: Elevated water tank, Analysis, Comparison of forces

I. INTRODUCTION:

The Indian subcontinent is very vulnerable to natural disasters such as earthquakes, drafts, floods, cyclones and more. Most states or allied territories are prone to one or more catastrophes. These natural disasters cause many casualties and countless property losses each year. Earthquakes rank first in vulnerability. So you need to learn to live with these events. According to the seismic code IS: 1893 (part I): 2000. More than 60% of India is prone to earthquakes. After an earthquake, property losses can be restored to some extent, but the loss of life cannot. The main reason for the loss of life is the collapse of structures. It is said that the earthquake itself never kills people; these are poorly built buildings that kill. Therefore, it is important to properly analyze the structure of the earthquake. Water supply is a way of life that must remain functional after a catastrophe.

Most municipalities in India have a water supply system that depends on increased water storage tanks. The raised water tank is a large elevated water storage container built to keep the water supply at a height sufficient to put pressure on the water distribution system. These structures have a configuration that is particularly vulnerable to horizontal forces, such as an earthquake due to the large total mass concentrated at the top of the slender supporting structure. Therefore, it is important to check the seriousness of these forces for a particular region. The main goal of this project is to study the reaction of the increased water tank to dynamic forces and find the main design parameters. For seismic analysis, the effect of hydrodynamic pressure on the sides of the container, as well as the base plate of the container, must be taken into account. It is also necessary to take into account the effect of pressure due to the inertia of walls and the influence of vertical acceleration of the soil in the seismic analysis of the increased water tank.

II. REVIEW OF LITERATURE

Realizing, R.J. etc. [2] conducted an investigation, and the document clearly states the relationship between the movement of water in the tank relative to the tank and the movement of the entire structure relative to the ground. He considered the three main conditions of this analysis. He said that if the water tank is completely filled, that is. without a free board, then the effect of rubbing water is neglected, if the tank is empty, it is not cut because there is no water.

Devadanam, B. and others. [6] the studied provisions of the IS code for seismic design of raised water tanks have been revised. It was noted that due to the lack of an appropriate value of the performance factor for the tanks, a code is provided for a fairly low seismic design force for this structure. There are simple expressions that allow you to calculate the rigidity of the production, and hence the time period, including the flexibility of the beam.

Ekbot, P.S. etc. [8] studied the main plot of this document - these are changes and proposals in the IP: 1893-1984. Major changes proposed: There are no ground tanks with rigid and flexible walls above the IS code. This provision should be included in the seismic analysis. The only degree of idealization of tank freedom must be replaced by two or three degrees of idealization of freedom. A performance factor (K) of 3.0 is offered for all types of tanks.

III. METHODOLOGY

The modeling is carried out in the ETABS software; the different types of the water tank modeled are as follows.

i. Model I: Staging with Conventional Horizontal Bracings

ii. Model II: Staging with X type Bracings

iii. Model III: Staging with V type Bracings

iv. Model IV: Staging with Inverted V type Bracings

v. Model V: Staging with Single Diagonal type Bracings

vi. Model VI: Staging with Shear Wall at Central Portion

vii. Model VII: Staging with Shear Wall at Peripheral Portion

viii. Model VIII: Staging with C type Shear Wall at Peripheral Portion

The different parameters considered in the ETABS software are mentioned as follows in the table 1 in terms of the dimensions of structural member in the case of Earthquake Load case.

Table 1: Water tank data for different parameters for Earthquake load case

Parameters	**Dimension**
Size of top slab	120 mm thk.
Size of bottom slab	200 mm thk.
Size of Roof beam	250x400 mm
Size of Base Slab beam	250x900 mm
Size of column	550 mm Dia
Size of braces	250x500 mm
Size of ground beam	250x400 mm
Diameter of tank	20.2 m inner
Height of tank	5 m
Height of staging	26 m
Number of columns	24
Earthquake Zone (Z)	0.16 (III)
Response reduction factor(R)	5 (SMRF)
Importance factor	1.5
Type of soil	Soft

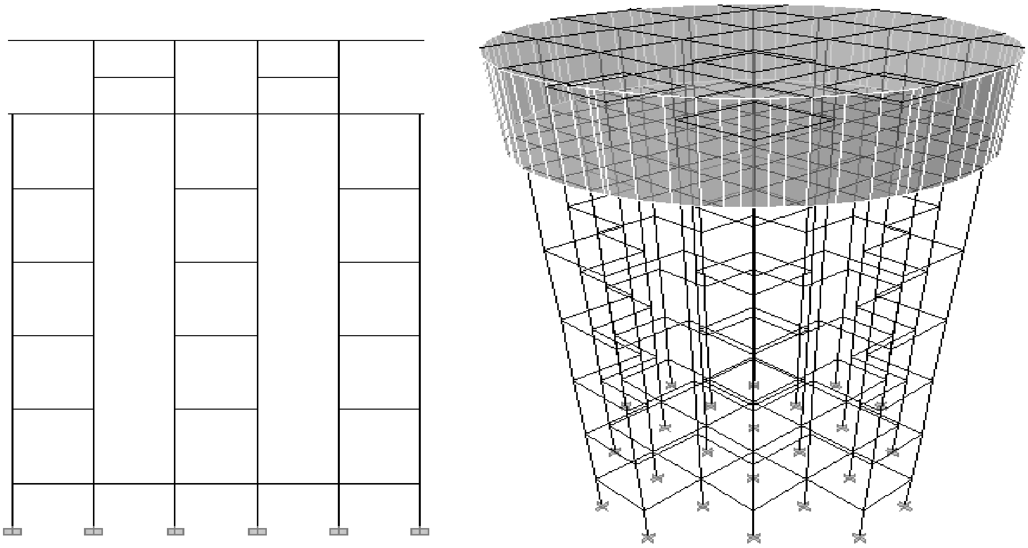

Figure 1: Elevation of the model-I

The above figure gives the elevation of the water tank with the staging configuration considered in the ETABS software for the model-I.

IV. RESULTS

The results obtained in the ETABS software are in terms of the lateral displacement, story drift, shear force, bending moment, axial load and the time period for the models which are modeled and analyzed for the case of Earthquake load case.

The table no.2 gives the lateral displacement for all the models in the tabular form as obtained in the ETABS software.

Table 2: Lateral Displacement of all models for EQ load case

All models	Lateral Displacement
Model- I	20.044
Model- II	7.47
Model- III	9.463
Model-IV	8.897
Model- V	8.646
Model-VI	10.227
Model-VII	9.942
Model-VIII	7.076

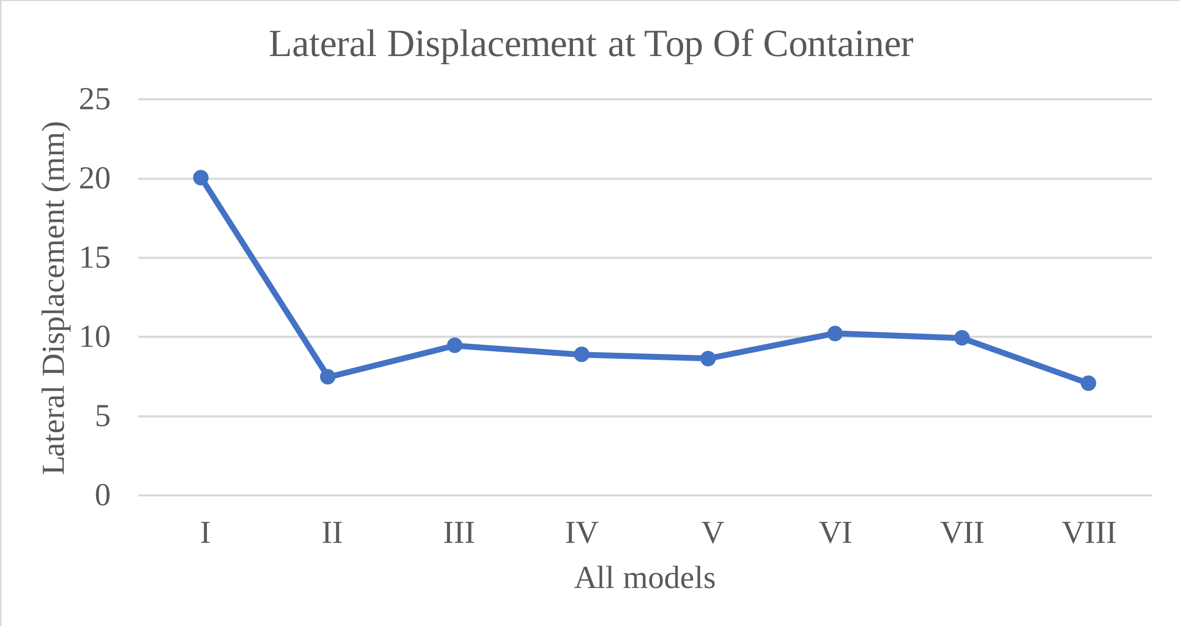

Figure 2:Lateral Displacement for all models for EQ load case

The above graph gives the lateral displacement for all the models as obtained in the ETABS software, it is observed that the model-I (Elevated water tank with staging with conventional horizontal bracings) gives the maximum displacement as compared to other models. It is observed that the lateral displacement is maximum with the value of the 20 mm in the case of model-I while it goes on decreasing with the minimum value of the model-VIII (Staging with C- type shear wall at Peripheral Portion) having the value of 7.0 mm. The other models gives the value of lateral displacement ranging from the 7 mm to 10 mm.

The table no.3 gives the First Mode time period for all models in the tabular form as obtained in the ETABS software.

Table 3: First Mode time period of all models for EQ load case

All models	Time Period
Model- I	2.00
Model- II	0.677
Model- III	0.868
Model-IV	0.818
Model- V	0.824
Model-VI	0.962
Model-VII	0.957
Model-VIII	0.586

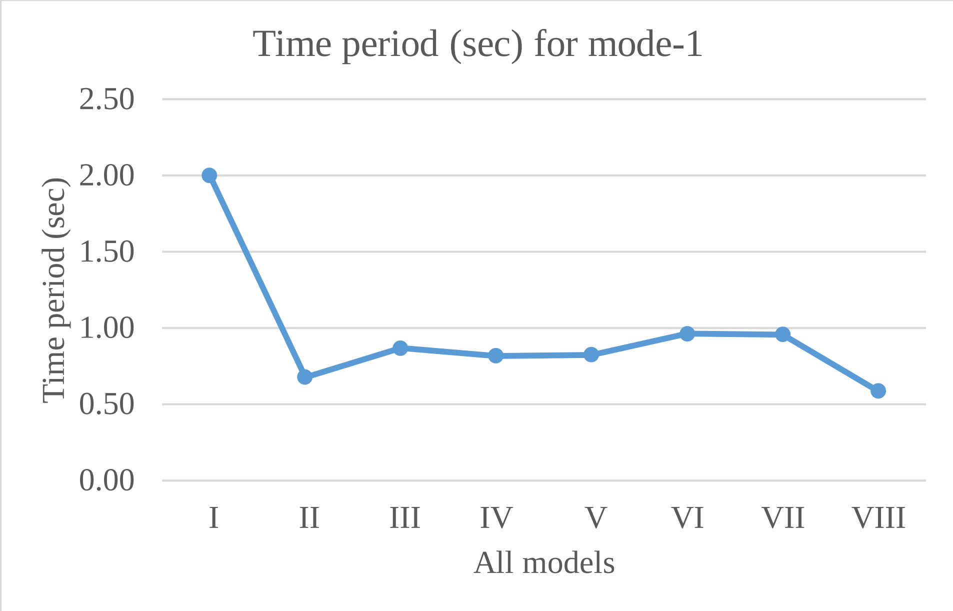

Figure 3:First Mode time period for all models for EQ load case

The above graph gives the First Mode time period for all the models as obtained in the ETABS software, it is observed that the model-I (Elevated water tank with Staging with Conventional Horizontal Bracings) gives maximum the First Mode time period as compared to other models. It is observed that the First Mode time period is maximum with the value of the 2.0 sec in the case of model-I (Elevated water tank with Staging with Conventional Horizontal Bracings) while it goes on decreasing with the minimum value of the model-VIII (Staging with C type Shear Wall at Peripheral Portion) having the value of 0.5 sec. The other models gives the value of First Mode time period ranging from the 0.5 to 1.0 sec.

Table 4: Story Drift of all models for EQ load case

All models	Story Drift
Model- I	0.2392
Model- II	0.546
Model- III	0.546
Model-IV	0.4576
Model- V	0.5044
Model-VI	0.1404
Model-VII	0.2496
Model-VIII	0.4108

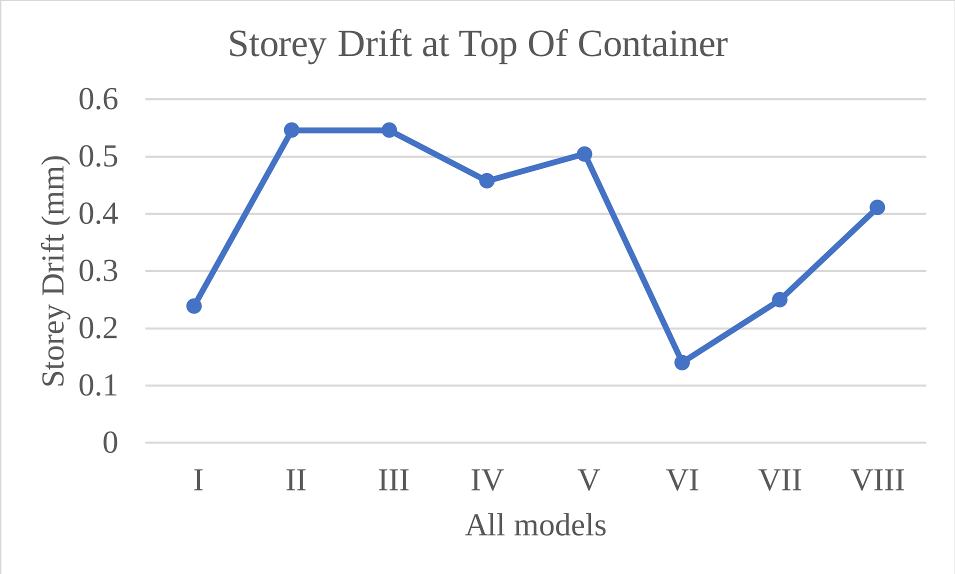

Figure 4: Story drift at top of container for all models for EQ load case

The above graph gives the story drift for all the models as obtained in the ETABS software, it is observed that the Model II: Elevated water tank with Staging with X type Bracings gives maximum the story drift as compared to other models. It is observed that the story drift at top of container is maximum with the value of the 0.5 mm in the case of Model II: Elevated water tank with Staging with X type Bracings while it goes on decreasing with the minimum value of the model- Model VI: Elevated water tank with Staging with Shear Wall at Central Portion having the value of 0.1 mm. The other models gives the value of story drift at top of container ranging from the 0.1 to 0.6 mm.

Table 5: Eq Base Shear of all models for EQ load case

All models	Eq Base Shear
Model- I	255.40
Model- II	854.00
Model- III	655.02
Model-IV	694.50
Model- V	661.22
Model-VI	594.80
Model-VII	598.29
Model-VIII	1188.09

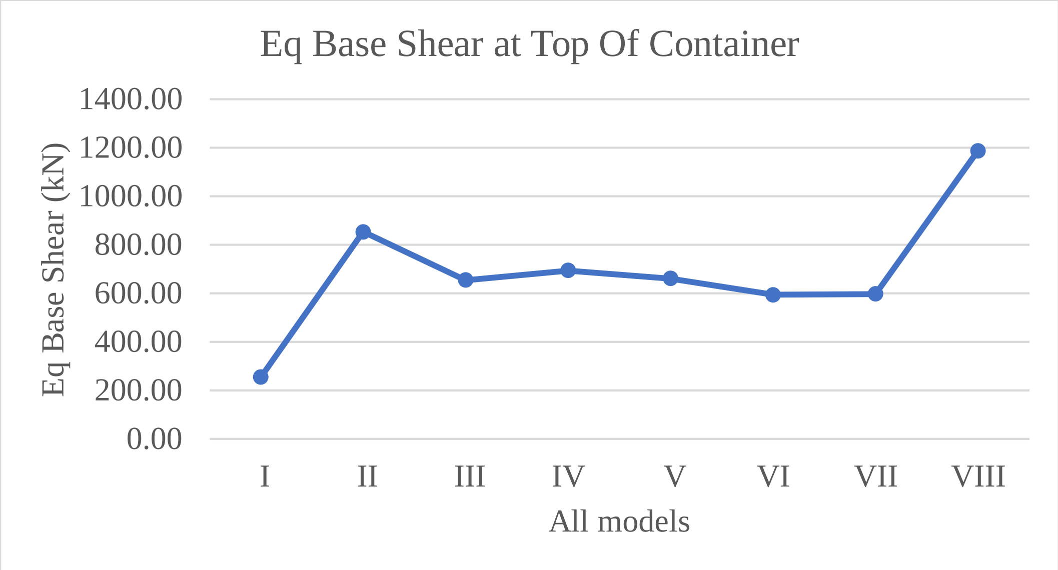

Figure 5: Eq Base shear at top of container for all models for EQ load case

The above graph gives the Eq Base Shear for all the models as obtained in the ETABS software, it is observed that the Model VIII: Elevated water tank with Staging with C type shear wall at peripheral portion gives maximum the Eq Base Shear as compared to other models. It is observed that the Eq Base Shear at top of container is maximum with the value of the 1188 kN in the case of Model VIII: Elevated water tank with staging with C type shear wall at peripheral portion while it goes on decreasing with the minimum value of the Model I: Elevated water tank with Staging with Conventional Horizontal Bracings having the value of 255 kN. The other models gives the value of Eq base shear at top of container ranging from the 594 to 854 kN.

Table 6: Max SF in column of all models for EQ load case

All models	Max SF In Column
Model- I	22.26
Model- II	201.22
Model- III	115.38
Model-IV	127.31
Model- V	93.98
Model-VI	206.84
Model-VII	52.40
Model-VIII	172.45

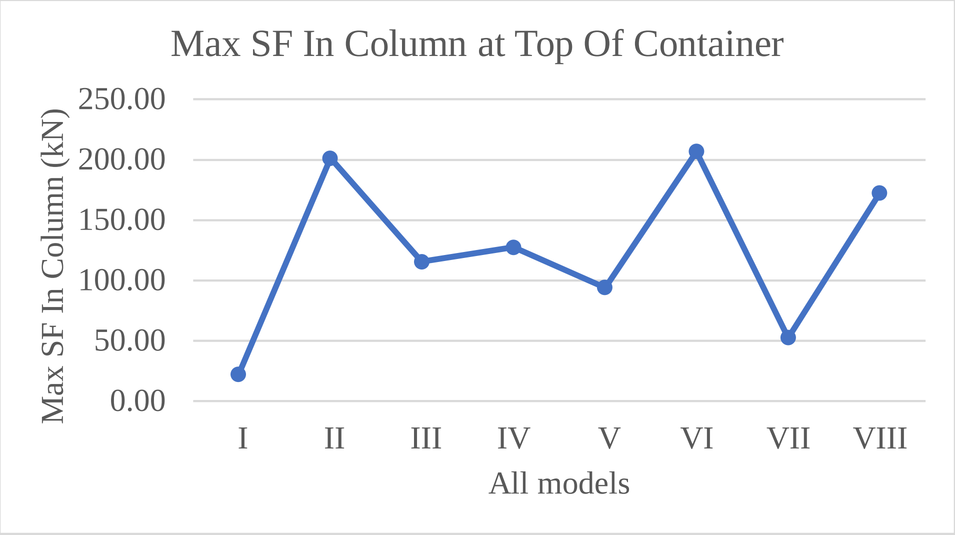

Figure 6: Max SF in column at top of container for all models for EQ load case

The above graph gives the Max SF for all the models as obtained in the ETABS software, it is observed that the Model VI: Elevated water tank with Staging with Shear Wall at Central Portion gives maximum the Max SF as compared to other models. It is observed that the Max SF in column at top of container is maximum with the value of the 207 kN in the case of Model VI: Elevated water tank with Staging with Shear Wall at Central Portion while it goes on decreasing with the minimum value of the Model I: Elevated water tank with staging with conventional horizontal bracings having the value of 22.26 kN. The other models gives the value of Max SF in column at top of container ranging from the 52-201 kN.

Table 7: Max BM In column of all models for EQ load case

All models	Max BM In Column
Model- I	59.35
Model- II	365.68
Model- III	218.79
Model-IV	237.47
Model- V	175.59
Model-VI	75.26
Model-VII	61.13
Model-VIII	100.84

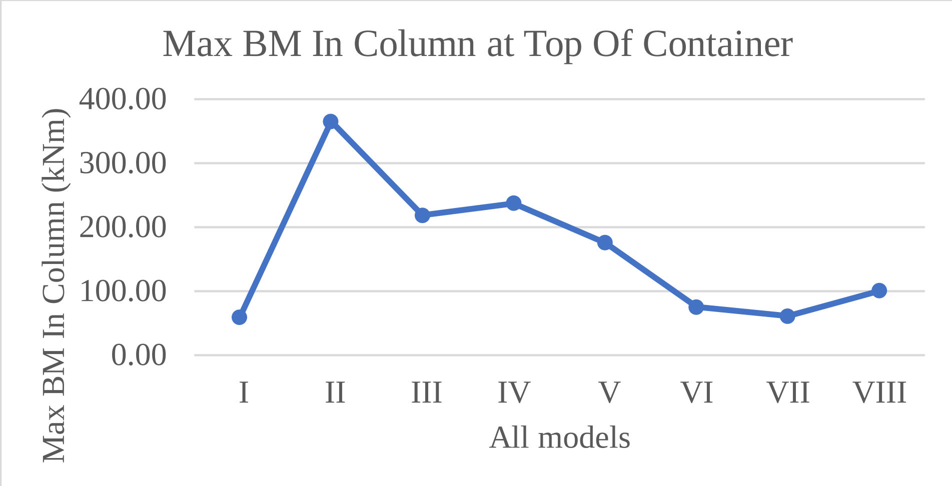

Figure 7: Max BM in column at top of container for all models for EQ load case

The above graph gives the Max BM for all the models as obtained in the ETABS software, it is observed that the Model II: Elevated water tank with Staging with X type Bracings gives maximum the Max BM as compared to other models. It is observed that the Max BM in column at top of container is maximum with the value of the 366 kNm in the case of Model II: Elevated water tank with Staging with X type Bracings while it goes on decreasing with the minimum value of the Model VII: Elevated water tank with staging with shear wall at peripheral portion having the value of 61 kNm. The other models gives the value of Max BM in column at top of container ranging from the 59 to 237 kNm.

Table 8: Max axial load in column of all models for EQ load case

All models	Max Axial Load In Column
Model- I	1986.50
Model- II	2061.12
Model- III	2061.45
Model-IV	2051.50
Model- V	2040.60
Model-VI	1832.94
Model-VII	1994.66
Model-VIII	1725.86

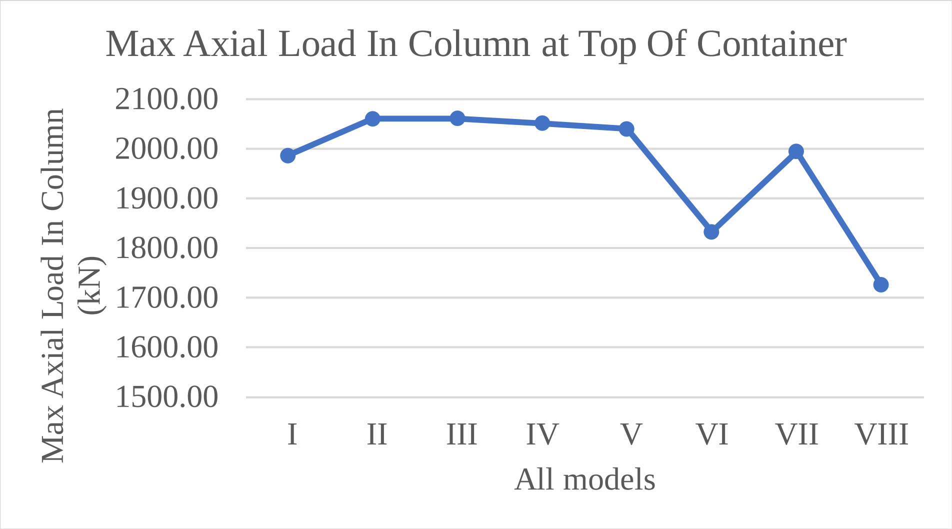

Figure 8: Max Axial load at top of container for all models for EQ load case

The above graph gives the Max Axial Load for all the models as obtained in the ETABS software, it is observed that the Model II: Elevated water tank with Staging with X type Bracings gives maximum the Max Axial Load as compared to other models. It is observed that the Max Axial Load at top of container is maximum with the value of the 2061 kN in the case of Model II: Elevated water tank with Staging with X type Bracings while it goes on decreasing with the minimum value of the Model VIII: Elevated water tank with Staging with C type Shear Wall at Peripheral Portion having the value of 1726 kN. The other models gives the value of Max Axial load at top of container ranging from the 1832 to 2051 kN.

V. CONCLUSION:

The conclusions from the above models are as follows:

i. From the results obtained in the ETABS software the different staging configurations gave the impact on the water tank analysis.

ii. As the staging configuration goes on changing the different parameters in terms of the lateral displacement, story drift, axial load, maximum shear force and bending moment also changes.

iii. It is found that the maximum value obtained for the model-I (Staging with Conventional Horizontal Bracings) in the case of lateral displacement.

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