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VARIATION OF SEISMIC FORCES WITH VOLUME OF LIQUID FOR ELEVATED TANK

Palve Gaurav A.[1], Nankar Aniket R. [2], Navale Shrikant S. [3]

[1,2,3] B. E. Student, Department of Civil Engineering, Gokhale Education Society's R. H. Sapat College of

Abstract— Seismic behavior of elevated water tank is one of the major concerns where water tanks are designed in such a way that it should remain functional even after an earthquake. Elevated water tanks are more vulnerable when earthquake hits the region thus, analysis & design of such structures against the earthquake effect is of considerable importance. Evaluation of seismic forces on circular water tank has been studied as per IS 1893-2002 (Draft) with IITK-GSDMA guidelines .Variation of seismic forces on elevated tank having different capacities ranging from 100 m^3 to 200 m^3 are presented in this paper. Seismic forces on circular water tanks are calculated for different volume and different parameters such as time period, base shear, base moment, stiffness are presented. The main aim is to evaluate influence of tank capacity on seismic forces. Finite element software ETABS has been used to calculate the stiffness of staging and forces are calculated as per IS 1893:2002.

Keywords— Seismic forces, ETABS, Tank capacity.

I. INTRODUCTION

Water tank is important part of water supply system, and extensively used for storage of liquid such as water, chemical fluid, inflammable liquid, liquefied natural gas etc. There are several types of storage tank such as underground tank, ground supported tank, elevated tank. Circular elevated water tank are used for all types of capacities and gives more economical results and performance in seismic region.

Now a day large storage capacity tanks are design to facilitate need of human being, and as such the seismic analysis and design for these large storage tanks has become more important. Elevated water tank consists of large mass of water at top of its staging that is why they are more vulnerable to earthquake .Thus elevated tanks are needs to design in such a way that they remain functional even after an earthquake.

Present study is primarily focused on understanding seismic behavior and performance characteristic of circular elevated water tank of different capacity.

II. METHODOLOGY

In the present paper different capacity of water tanks are used. Stiffness of staging is calculated with the help of ETABS analysis. Spring mass model as per IS 1893:2002 (Draft) has been used to evaluate the time period, stiffness, base shear and base moment.

2.1. Model Description

Circular elevated water tank is selected for the study. D/H ratios of the tanks are kept as 3. Considering M30 grade of concrete, five models are prepared having capacity 100m^3, 125m^3, 150m^3, 175m^3, 200m^3. As shown below.

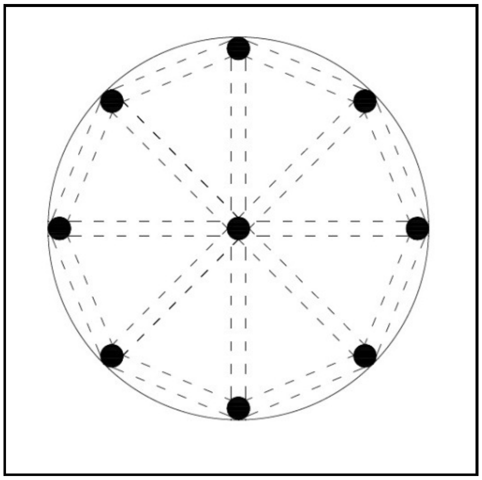

Fig -1: Circular Model (Plan)

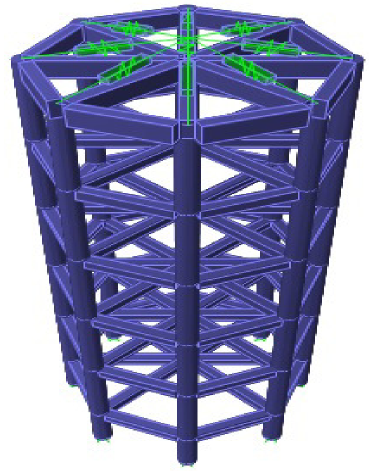

Fig -2: Finite Element Model of Staging

2.1.1. Preliminary Data

Details of sizes of various components and geometry are shown in table -3.

Table -1: Size of various components

Component Size	(mm)
Free board	300
Roof slab- thickness	120
Wall- thickness	150
Floor slab- thickness	250
Floor beams	300 X 600
Braces	300 X 300
Columns	450 a. (9 numbers)

III. ANALYSIS

3.1. Seismic data used for analysis

Table -2: Seismic data used for analysis

Zone factor (Z)	0.24
Importance factor (I)	1.5
Response reduction factor (R)	2.5
Soil type	Medium

3.2. Analysis and Calculation

Equivalent static analysis was carried out on above model. For calculating the seismic weight of tank, weight of empty container plus 1/3 weight of staging is considered. Tank staging is model in finite element software ETABS. Beams and columns are modeled as frame element. The lateral forces considering impulsive and convective masses due to earthquake is lumped at center mass of tank along both the principal directions. A rigid link is assumed from top of staging up to the CG of tank and lateral earthquake forces are lump on rigid link in both principle direction. For the present study CG of tank is taken as CG of empty container. Finally parameter such as stiffness, time period,

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base shear, base moment for the above five models are presented. The weight of different components of tank is shown in table- 2.
The parameters of spring mass model are shown in below.

Table -3: *Parameters of spring mass model along both principle directions*

Sr. No.	Parameters	M1	M2	M3	M4	M5
1	mi/m	0.38	0.38	0.38	0.38	0.38
2	mc/m	0.58	0.58	0.58	0.58	0.58
3	hi/h	0.38	0.38	0.38	0.38	0.38
4	hi*/h	1.31	1.31	1.31	1.31	1.31
5	hc/h	0.55	0.55	0.55	0.55	0.55
6	hc*/h	1.08	1.08	1.08	1.08	1.08
7	kc*h/mg	0.59	0.59	0.59	0.59	0.59

The weight of different components of tank is shown in table.

Table -4: *Weight of different components*

Sr. No.	Component	M1	M2	M3	M4	M5
1	Roof Slab (KN)	134.5	155.2	174.5	192.7	210.0
2	Wall (KN)	237.2	272.7	305.7	336.8	366.4
3	Floor Slab (KN)	280.2	323.3	363.5	401.5	437.6
4	Floor Beam (KN)	222.5	240.3	255.8	269.7	282.4
5	Columns (KN)	597.6	597.6	597.6	597.6	597.6
6	Tie Beam (KN)	556.1	600.6	639.5	674.3	705.9
7	Water (KN)	981.0	1226.3	1471.5	1716.8	1962.0
8	Staging (KN)	1153.7	1198.2	1237.2	1271.9	1303.6
9	Empty container (KN)	874.4	991.4	1099.5	1200.7	1296.4
10	Empty container + 1/3(staging) (KN)	1259.0	1390.9	1511.9	1624.7	1730.9
11	CG of Empty container (m)	0.680	0.750	0.812	0.867	0.917
12	Total Seismic weight (KN)	2240.0	2617.1	2983.4	3341.4	3692.9

IV. RESULTS AND DISCUSSION

4.1. TIME PERIOD

Time period for model M1 to M5 along both principle directions goes on increasing as volume of water changes from $100m^3$ to $200m^3$.

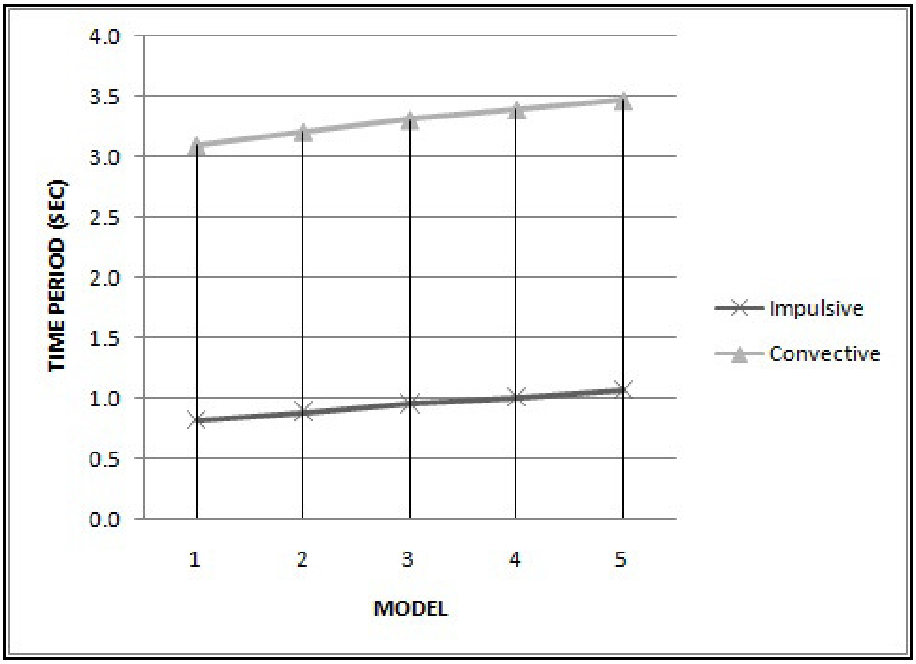

***Chart -1**: Time period*

4.2. STIFFNESS

Stiffness for model M1 to M5 along both principle directions goes on decreasing as volume of water changes from 100m^3 to 200m^3.

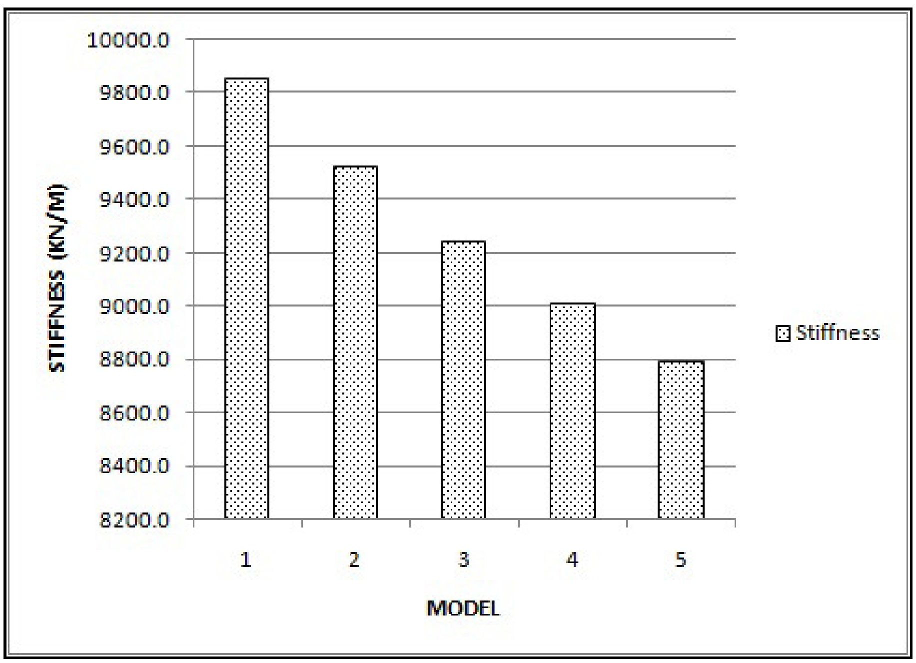

***Chart -2**: Stiffness*

4.3. BASE SHEAR

Base shear for model M1 to M5 along both principle directions goes on increasing as volume of water changes from 100m^3 to 200m^3.

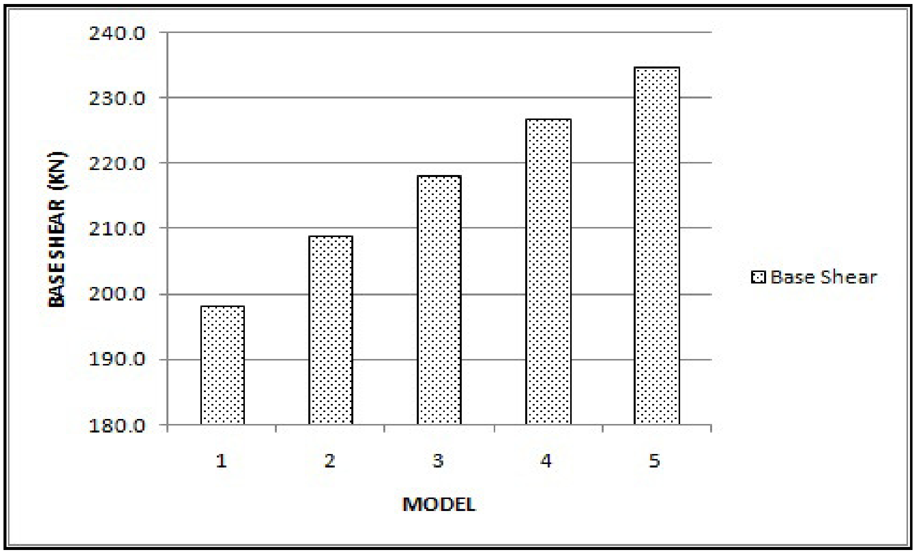

Chart -3: *Base shear*

4.4. BASE MOMENT

Base moment for model M1 to M5 along both principle directions goes on increasing as volume of water changes from $100m^3$ to $200m^3$.

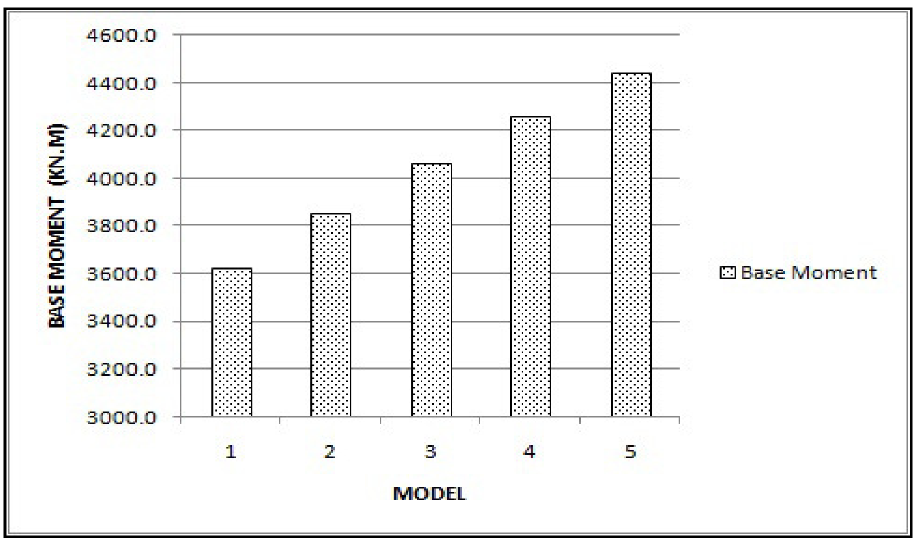

Chart -4: *Base moment*

V. CONCLUSION

Base shear for model M1 to M5 in both directions increases in the range of 3.5% to 5.31% with successive increase in capacity $100m^3$ to $200m^3$. Base moment for model M1 to M5 in both directions increases in the range of 4.2% to 6.36% with successive increase in capacity $100m^3$ to $200m^3$. There is very small change in time period was observed for change in capacity from $100m^3$ to $200m^3$. There is around 18.3 % increase in base shear for 100 m^3 rise in volume was observed.

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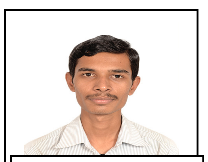
BIOGRAPHIES

Aniket Rajendra Nankar, BE Student, Gokhale Education Society’s R. H. Sapat College of Engineering, Nashik, Maharashtra, India. E- mail: aniket.nankar74@gmail.com



Shrikant Shashank Navale, BE Student, Gokhale Education Society’s R. H. Sapat College of Engineering, Nashik, Maharashtra, India. E- mail: navshris.123@gmail.com

Gaurav Ashok Palve, BE Student, Gokhale Education Society’s R. H. Sapat College of Engineering, Nashik, Maharashtra, India. E-mail: gauravpalve555@gmail.com