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EVALUATING THE PERFORMANCE OF WATER STORING STRUCTURES WHEN SUBJECTED TO SEISMIC LOADING

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Abstract - India has a track record of huge earthquake incidences in the regions like Bhuj, Kutch, Delhi, Himalayas and periphery of Nepal etc. Recent earthquakes are evident that structures designed in these seismic prone regions are severely damaged due to the seismic excitation. Therefore structures situated in this particular region have to be given more importance in their design and execution rather than structures located in other regions where earthquake is not frequent. Bhuj earthquake is an ideal example where structures were not able to resist the earthquake; especially the structures are multi-storied buildings, water storing structures, load bearing masonry structures etc. Literature is evident that ample amount of work have been carried out as far as multi-storied buildings are concerned. This particular project deals with water storing structures like overhead tank. To study the Seismic response of overhead R.C water tank subjected to heavy seismic excitation. A water tank is considered in zone V. The volume of overhead water tank is about 10,00,000 liters ≈ 2,64,172 Gallons. To understand the seismic response different F.E.M mathematical models of overhead tanks have been modeled/generated in the software SAP2000 v17. Equivalent static analysis and response spectrum method have been used to predict the seismic response. To study the influence of full tank during seismic loading a detail stress analysis has been performed (Von Mises Stress Criteria).

I INTRODUCTION

Structures positioned in seismically lively region have to resist lateral forces produced owing to tremor in accumulation to their prime reason of transporting the gravity loads. All class of water tanks and other liquid preserving structures are being built in diverse components of the country. These liquid preserving structures have experienced many hurricanes and earthquakes. Housner in the year 1963 deliberated the deeds of minute steel tanks with open roof beneath vibrant forces. He has specified terms for impetuous and convective modes of ambiance were present for few cases.
Though, no noteworthy examine was executed in the earlier period of five decades. The recital of a fluid tank structure throughout the earthquake is contingent on the quantity of the earthquake and the material goods of the structure. Trustworthiness and precision of devise of a structure basically be contingent on the fine classified structural properties like arrangements of the structural system, examination and devise method, the detailing of the structural elements and skillful construction.

CLASSIFICATION OF TANKS:
Storage tanks are used in manufacturing of depositing chemicals, petroleum goods, and for reserving water in civic water supply system. Water sharing systems use ground supported and lofty tanks of RC and steel and petrochemical plant's use earth bearing steel tanks. Concrete used has to be watertight. The damp-proof concrete is a basic obligation for water retaining structures. This is able to accomplish by proper mixing, placing and curing of concrete. The least grade of concrete used in fluid preserving structures is M25. However, higher the grade lesser is the porosity of concrete. Based on type, depositing tanks are alienated into 3 categories:
(i) Earth Supported Tanks.
(ii) Elevated Tanks.
(iii) Buried Tanks.(Underground)
Based on the shapes tanks are classified into four categories:
(i) Rectangular
(ii) Circular
(iii) Intz
(iv) Conical or funeral shape.

II METHOD OF ANALYSIS

SEISMIC ANALYSIS: The analysis procedure used to conclude the hydrodynamic force on a range of elements of the receptacle. Liquid storing structures was scrutinized for self-weight and seismic loads, hydrostatic pressure (water). Details of investigation are illustrated in this part for liquid containing lofty tanks put through to seismic loads. The software used for modeling and investigation of the water storing structure is done by SAP 2000. These practices regards as intensities stimulate owing to acceleration of tank arrangement and hydrodynamic intensity due to acceleration of fluid. While a tank occupied with fluid is vibrated, the fluid put forth impetuous and convective hydrodynamic force on the tank wall and the base in adding to the hydrostatic force. In regulate to take account, the outcome of hydrodynamic force in the investigation; tank can be romanticized by a like spring mass replica, which comprises the cause of tank-wall fluid relations. The limitation of this replica is dependent on geometry of the tank and its suppleness. While a tank restraining fluid with a liberated surface is put through to horizontal earthquake ground motion, tank wall and fluid are put through to horizontal acceleration. The liquid in bottom area of tank acts alike to a gathering that is tightly associated to tank wall. This mass is phrased as impetuous fluid mass which speed up all the length of with the wall and persuades impetuous hydrodynamic force on tank wall likewise on the base. Fluids gathering in the superior area of tank go through sloshing motion. This accumulation is phrased as convective fluid accumulation and it put forth convective hydrodynamic force on tank wall and base. Accordingly, the whole fluid accumulation gets alienated into 2 parts, i.e., impetuous accumulation and convective accumulation. In spring mass model of tank- fluid system, these two fluids ample are to be properly symbolized.

Sometimes, upright columns and shaft are there within the tank. These rudiments cause barrier to sloshing motion of fluid. In the happening of such barriers, impetuous and convective force allocations are predictable to alter. Currently, there is no study existing to enumerate effect of such obstacles on impetuous and convective forces. Though, it is logical to anticipate that owing the survival of such barriers, impetuous force will increase and convective pressure will decrease.

MODELING OF LIQUID TANKS:

Underneath motionless state, fluid is appropriate force on container. This is known as hydrostatic force. However throughout base excitation fluid Pertains supplementary force on wall and bases this is hydrodynamic force. This is a bonus to the hydrostatic force. Total fluid accumulation obtains alienated into two parts:

- Impetuous liquid mass
- Convective liquid mass

In motionless devise only hydrostatic pressure is considered, but whereas in seismic devise together hydrostatic and hydrodynamic pressure are considered. Net hydrostatic force is nil on container walls while hydrodynamic force is not zero on the container wall. Hydrostatic pressure affects only the devise of container while hydrodynamic pressures influence the devise of container, enactment and groundwork. Hydrodynamic vigor set into view by fluid on tank wall shall be measured in the examination in count to hydrostatic vigor. This hydrodynamic vigor is assessing by means of assist of spring mass model of tanks. The ample and their summit of request be contingent on feature proportion of tanks and the all limitations of motorized analogue are gained from precise terminology précised in the regulations IS 1893:2003.

III DESCRIPTIONS OF MODELS

For the present study four models have been considered with different configurations. An Intz shape water storing structure with a capacity of 250 m^3 is sustained on R.C staging of 12 columns. Details of staging configuration are shown below. Grade of concrete and rebar are M40 and Fe550 respectively. Tank is situated on tough soil in seismic zone IV density of concrete is 25kn/m^3. Thickness of top dome is 150mm; thickness of cylindrical wall is 300mm, dimensions of ring beam is 300X600mm, thickness of bottom slab is 300mm, diameter of column 450mm, thickness of shell/shear wall is 300mm, Total height of tank above ground level is 30m.

Different models considered for the present study is described as follows:

MODEL 1 Water Tank Staging with Parabolic Bottom:

Water Tank is modeled in the software as staging of Columns in circular shape with 12 columns and ring beams. Then inclined Hopper bottom is constructed, then parabolic bottom at pinnacle of columns is placed and then a circular beam on the hopper bottom is placed and after that the vertical shear/cylindrical wall is constructed and then again ring beam is positioned on pinnacle of shear/cylindrical wall then the top dome is constructed upon it.

MODEL 2 Water Tank Staging with Flat Bottom:

Water Tank is modeled in the software as staging of Columns in circular shape with 12 columns and ring beams. Then inclined Hopper bottom is constructed, then flat bottom at pinnacle of columns is placed and then a circular beam on the hopper bottom is placed and after that the vertical shear/cylindrical wall is constructed and then again ring beam is positioned on pinnacle of shear/cylindrical wall then the top dome is constructed upon it.

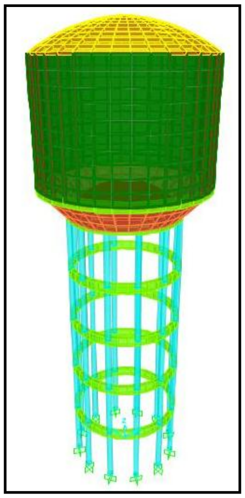
MODEL 3 Water Tank Shell Element with Parabolic Bottom:

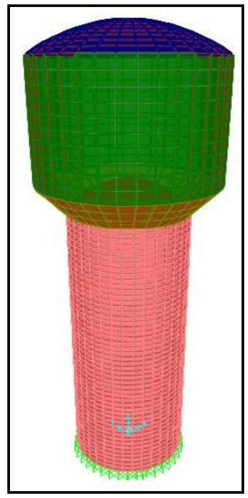
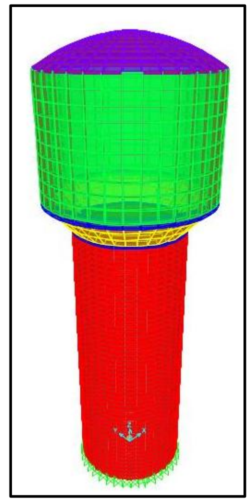
Water Tank is modeled in the software as staging of Concrete wall as shell element in circular shape and then the inclined Hopper bottom is constructed, then Parabolic bottom at pinnacle of concrete wall is placed and then a circular beam on the hopper bottom is placed and after that the vertical shear/cylindrical wall is constructed and then again ring beam is positioned on pinnacle of shear/cylindrical wall then the top dome is constructed upon it.

MODEL 4 Water Tank Shell Element with Flat Bottom:

Water Tank is modeled in the software as staging of Concrete wall as shell element in circular shape and after that the inclined Hopper bottom is constructed, then Flat bottom at pinnacle of concrete wall is placed and then a circular beam on the hopper bottom is placed and after that the vertical shear/cylindrical wall is constructed and then again ring beam is positioned on pinnacle of shear/cylindrical wall then the top dome is constructed upon it.

The following parameters considered in the study are:



JOINT DISPLACEMENT:

S.No	Joint No	EQX in mm	SPECX in mm	EQY in mm	SPECY in mm
1	39=1	17.869	15.807	17.869	15.807
2	202=2	17.564	15.555	17.556	15.549
3	210=3	17.564	15.555	17.556	15.549
4	274=4	19.349	17.015	19.352	17.017
5	428=5	19.599	17.219	19.599	17.219
6	448=6	19.599	17.219	19.599	17.22
7	622=7	17.608	15.591	17.604	15.588
8	1085=8	17.7	15.666	17.701	15.667
9	1120=9	17.833	15.774	17.825	15.768
10	1797=10	15.987	15.987	18.082	15.978
11	2030=11	19.209	16.9	19.211	16.902
12	2120=12	19.211	16.902	19.208	16.9

Table 1: Joint Displacement of Model-1

S.No	Joint No	EQX in mm	SPECX in mm	EQY in mm	SPECY in mm
1	13=1	3.883	2.526	3.885	2.527
2	39=2	2.082	1.353	2.086	1.353
3	198=3	1.816	1.178	1.852	1.201
4	202=4	1.837	1.137	1.837	1.191
5	236=5	2.228	1.447	2.221	1.441
6	278=6	3.544	2.304	3.555	2.312
7	901=7	2.046	1.327	2.046	1.337
8	1053=8	2.082	1.351	2.082	1.351
9	1457=9	0.089	0.058	0.073	0.048
10	1845=10	2.744	1.782	2.746	1.783
11	2837=11	1.787	1.159	1.769	1.480
12	2922=12	1.527	0.991	1.525	0.990

Table 2: Joint Displacements of Model

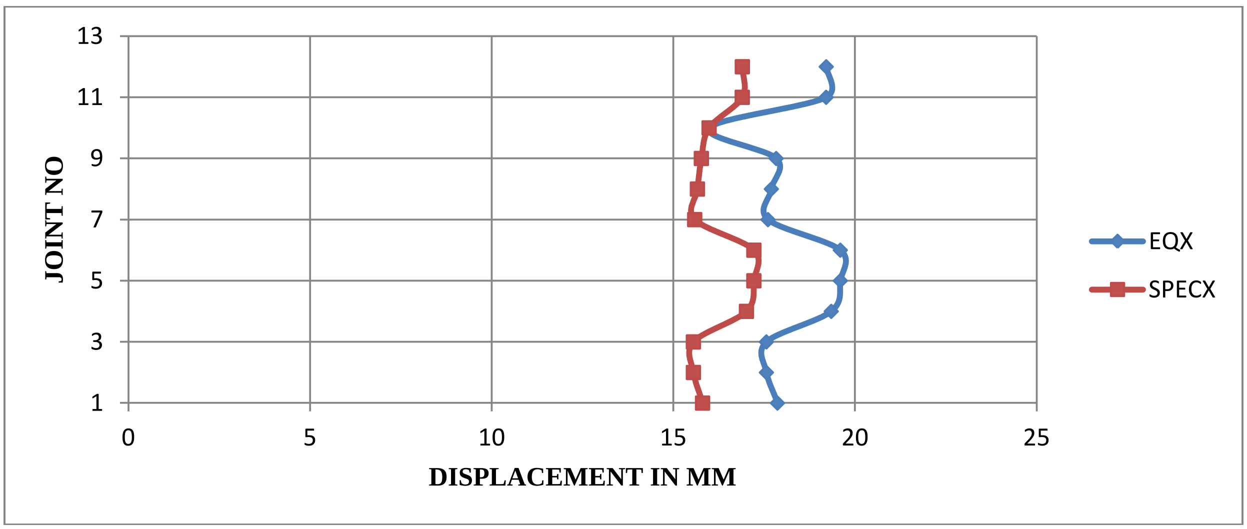


Figure 1: Displacement in X Direction for Model-1

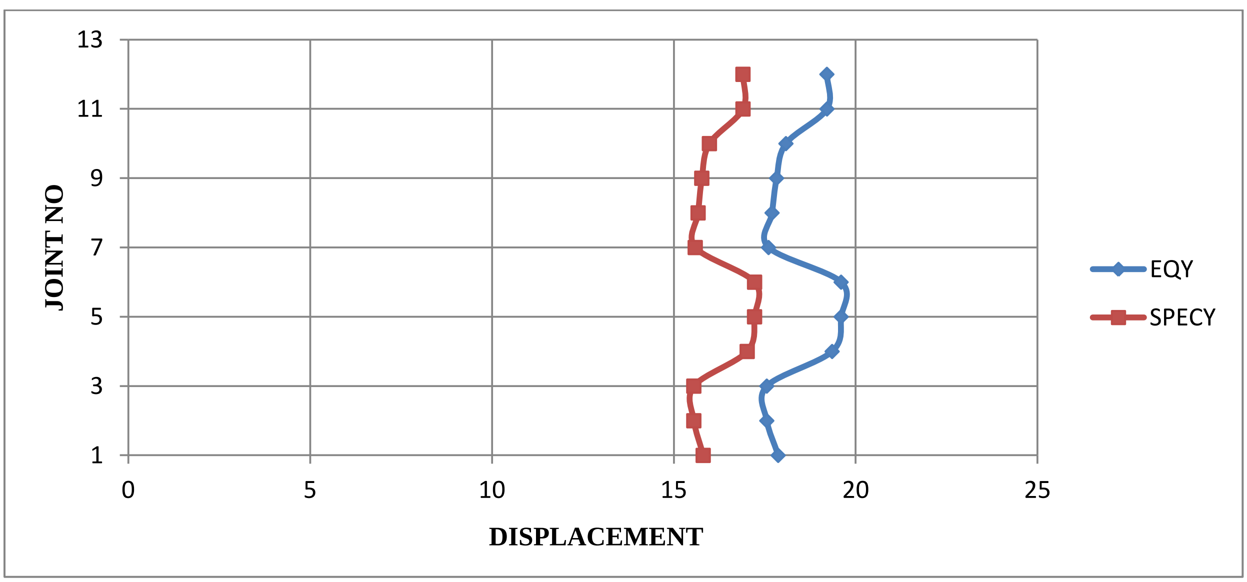


Figure 2: Displacement in Y Direction for Model-1

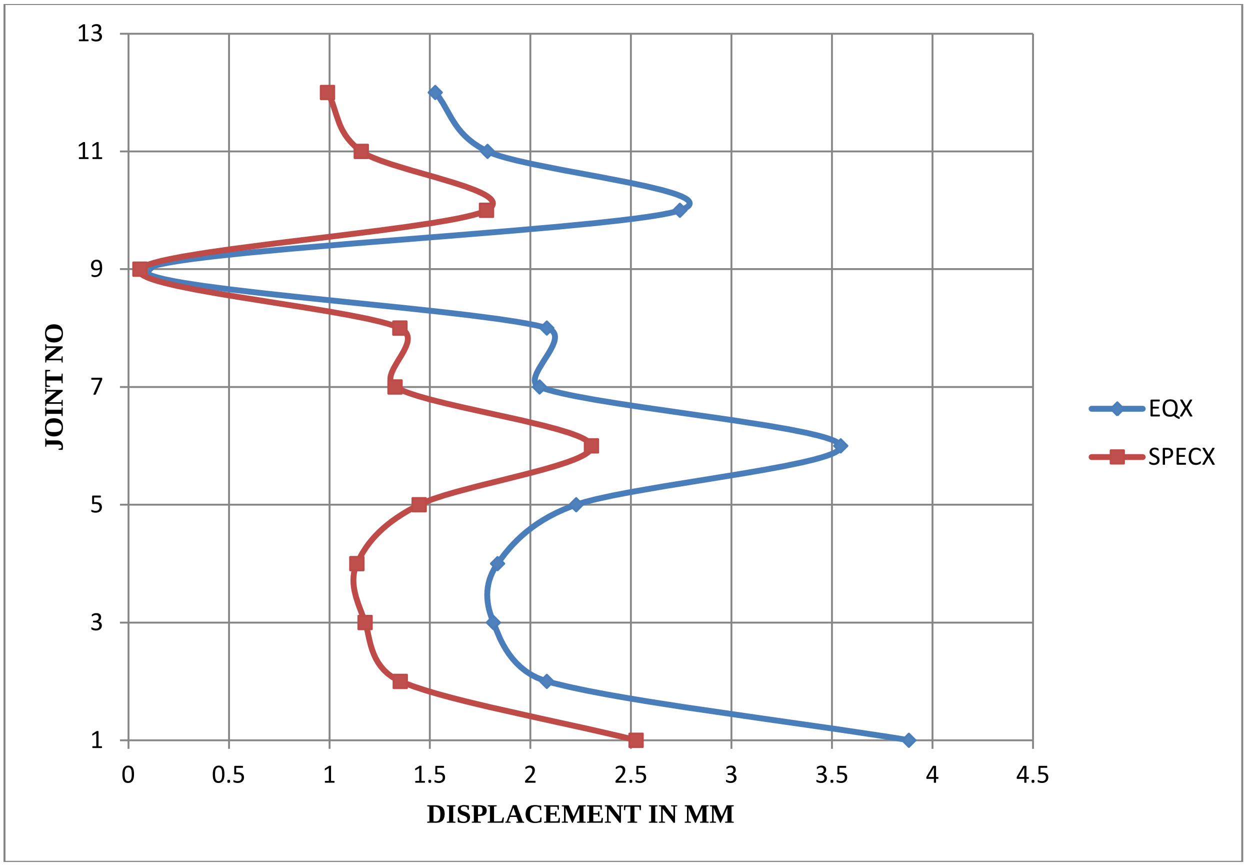


Figure 3: Displacement in X Direction for Model-3

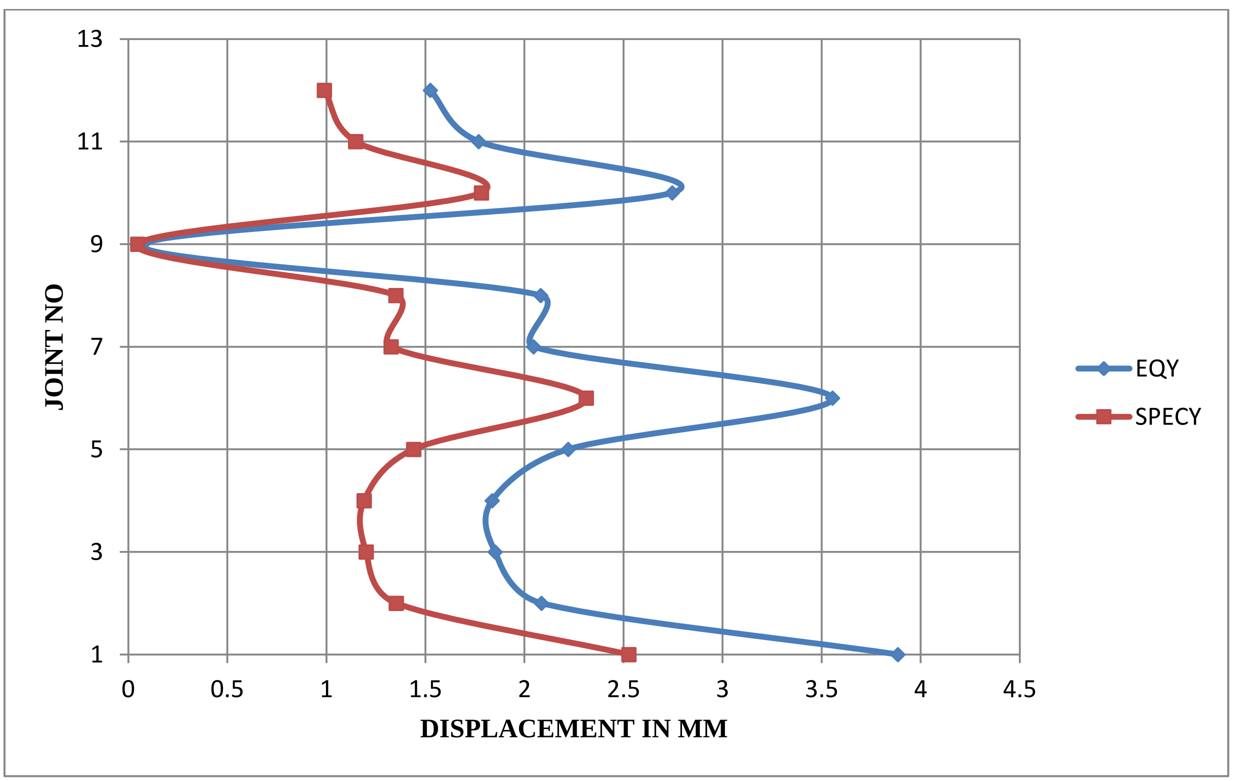


Figure 4: Displacement in Y Direction for Model-3

MODAL MASS PARTICIPATION/TIME PERIOD:

	Mode	TIME PERIOD (SEC)	Modal Mass participation in %				
			UX	UY	RX	RY	RZ
MODEL1	1	1.24	91.8	0.00	0.00	9.2	0.00
	2	1.24	0.00	91.8	9.2	0.00	0.00
	3	1.14	0.00	0.00	0.00	0.00	95.5
MODEL2	1	1.23	78.7	12.9	1.3	7.9	0.00
	2	1.23	12.9	78.7	7.9	1.3	0.00
	3	1.13	0.00	0.00	0.00	0.00	95.5
MODEL3	1	0.27	0.00	64	35.5	0.00	0.00
	2	0.27	64	0.00	0.00	35.5	0.00
	3	0.09	0.00	0.00	0.00	0.00	87.7
MODEL4	1	0.27	44.4	19.3	10.9	25	0.00
	2	0.27	19.3	44.4	25	10.9	0.00
	3	0.09	0.00	0.00	29	0.00	87.7

Table 3: Time Period/Modal Mass Participation.

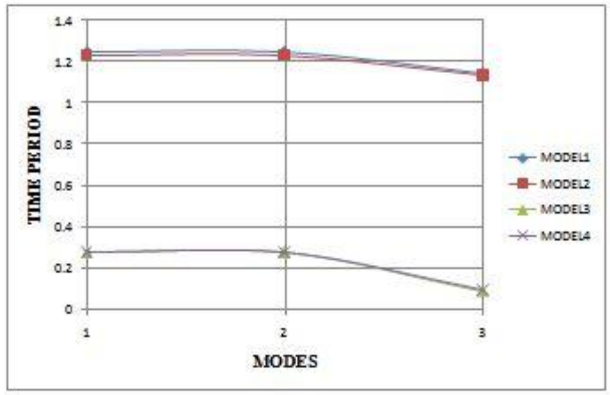


Figure 5: Time Period VS Mode

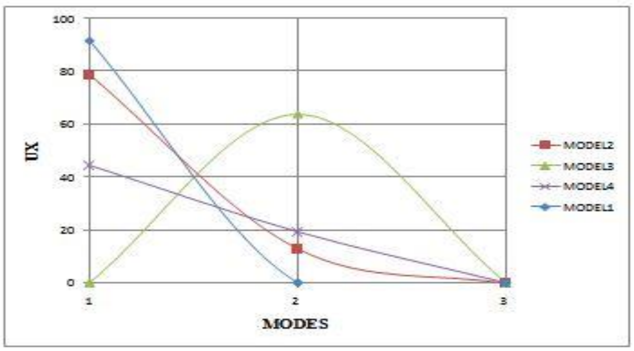


Figure 6: UX VS Mode

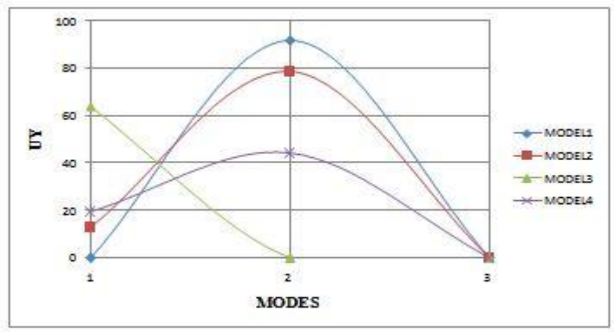


Figure 7: UY VS Mode

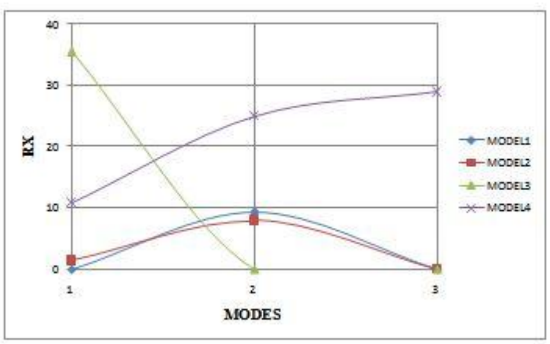


Figure 8: RX VS Mode

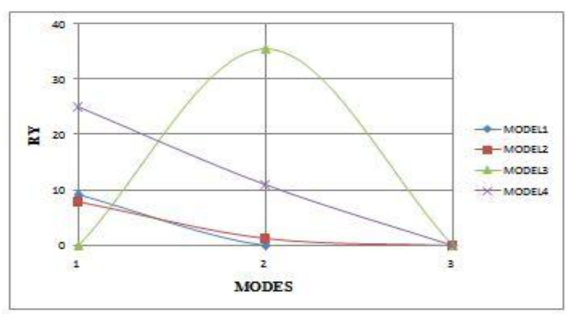


Figure 9: RY VS Mode

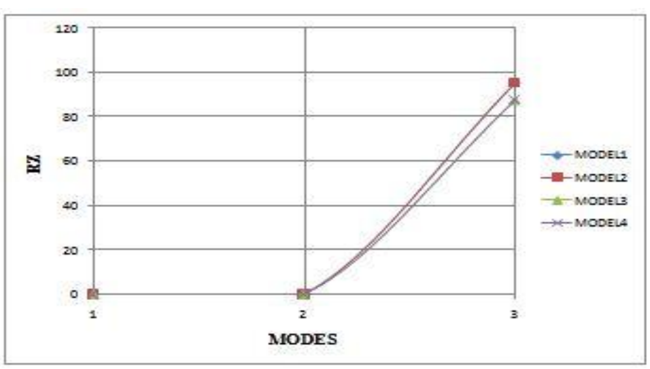


Figure 10: RZ VS Mode

BASE SHEAR:

Joint No	F1 (KN)	F2 (KN)	F3 (KN)	M1 (KN-M)	M2 (KN-M)
1	9.53	0.00	166.09	0.00	29.57
1066	8.25	10.68	143.84	22.61	25.61
1067	4.77	18.50	83.04	39.17	14.78
1068	0.00	21.36	0.00	45.23	0.00
1069	4.77	18.50	83.04	39.17	14.78
1070	8.25	10.68	143.84	22.62	25.62
1071	9.53	0.00	166.09	0.00	29.57
1072	8.25	10.68	143.84	22.62	25.62
1073	4.77	18.50	83.04	39.17	14.79
1074	0.00	21.36	0.00	45.23	0.00
1075	4.77	18.50	83.04	39.17	14.80
1076	8.25	10.70	143.84	22.62	25.62

Table 4: Base Shear for Dead Load Model-1

Joint No	F1 (KN)	F2 (KN)	F3 (KN)	M1 (KN-M)	M2 (KN-M)
1	0.00	21.35	0.00	45.23	0.00
1066	4.77	18.50	83.04	39.17	14.79
1067	8.25	10.68	143.84	22.62	25.62
1068	9.53	0.00	166.09	0.00	29.58
1069	8.25	10.68	143.84	22.62	25.62
1070	4.77	18.50	83.04	39.17	14.79
1071	0.00	21.36	0.00	45.23	0.00
1072	4.77	18.50	83.04	39.17	14.79
1073	8.25	10.68	143.84	22.62	25.62
1074	9.53	0.00	166.09	0.00	29.58
1075	8.25	10.68	143.84	22.62	25.62
1076	4.77	18.50	83.04	39.17	14.79

Table 5: Base Shear for SPECX Model-1

Joint No	F1 (KN)	F2 (KN)	F3 (KN)	M1 (KN-M)	M2 (KN-M)
1	0	0	414.95	0	0
1066	0	0	414.89	0	0
1067	0	0	414.92	0	0
1068	0	0	414.92	0	0
1069	0	0	414.95	0	0
1070	0	0	414.95	0	0
1071	0	0	414.94	0	0
1072	0	0	414.94	0	0
1073	0	0	414.9	0	0
1074	0	0	414.9	0	0
1075	0	0	414.95	0	0
1076	0	0	414.97	0	0

Table 6: Base Shear for SPECY Model- 1

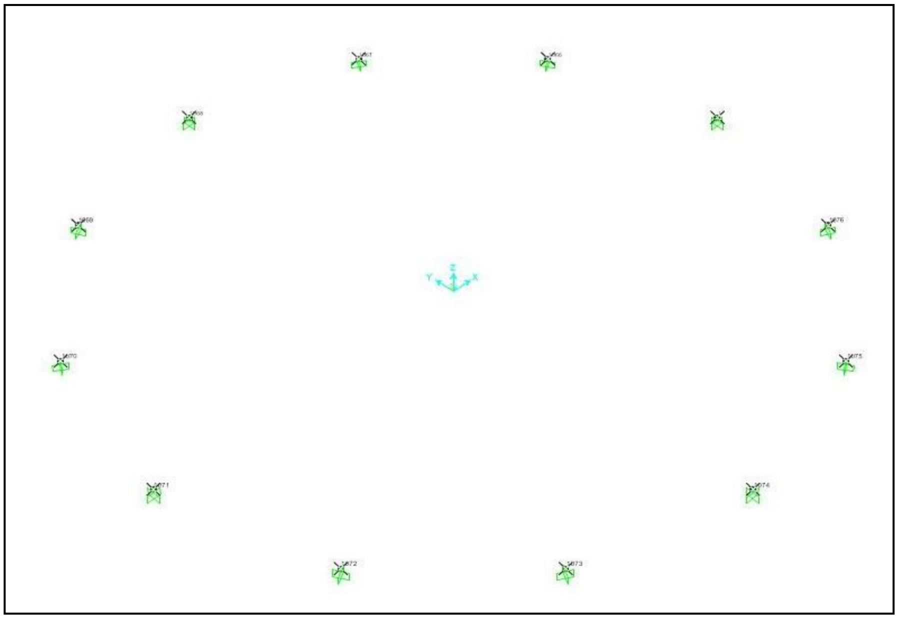


Figure 11: Joints Considered for Model - 1

Joint No	F1 (KN)	F2 (KN)	F3 (KN)	M1 (KN-M)	M2 (KN-M)
1	8.40	0.00	206.13	0.00	3.42
3	2.87	7.90	206.13	3.21	1.17
4	1.46	8.27	206.13	3.37	0.59
6	0.00	8.40	206.13	3.42	0.00
8	1.46	8.27	206.13	3.37	0.59
10	2.87	7.90	206.13	3.21	1.17
12	4.20	7.28	206.13	2.96	1.71
14	5.40	6.44	206.13	2.62	2.20
1055	6.44	5.40	206.13	2.20	2.62
1056	7.28	4.20	206.13	1.71	2.96
1057	7.90	2.87	206.13	1.17	3.21
1058	8.27	1.46	206.13	0.59	3.37
1059	8.27	1.46	206.13	0.59	3.37
1060	7.90	2.87	206.13	1.17	3.21
1061	7.28	4.20	206.13	1.71	2.96
1062	6.44	5.40	206.13	2.20	2.62
1063	5.40	6.44	206.13	2.62	2.20
1064	4.20	7.28	206.13	2.96	1.71
1065	2.87	7.90	206.13	3.21	1.17
1067	0.00	8.40	206.13	3.42	0.00
1068	1.46	8.27	206.13	3.37	0.59
1069	2.87	7.90	206.13	3.21	1.17
1070	4.20	7.28	206.13	2.96	1.71
1071	5.40	6.44	206.13	2.62	2.20
1072	6.44	5.40	206.13	2.20	2.62
1073	8.40	0.00	206.13	0.00	3.42
1074	7.28	4.20	206.13	1.71	2.96
1075	7.90	2.87	206.13	1.17	3.21
1076	8.27	1.46	206.13	0.59	3.37
1149	8.40	0.00	206.13	0.00	3.42
1150	8.27	1.46	206.13	0.59	3.37
1151	7.90	2.87	206.13	1.17	3.21
1152	7.28	4.20	206.13	1.71	2.96
1153	6.44	5.40	206.13	2.20	2.62
1154	5.40	6.44	206.13	2.62	2.20

Table 7: Base Shear for Dead Load Model - 3

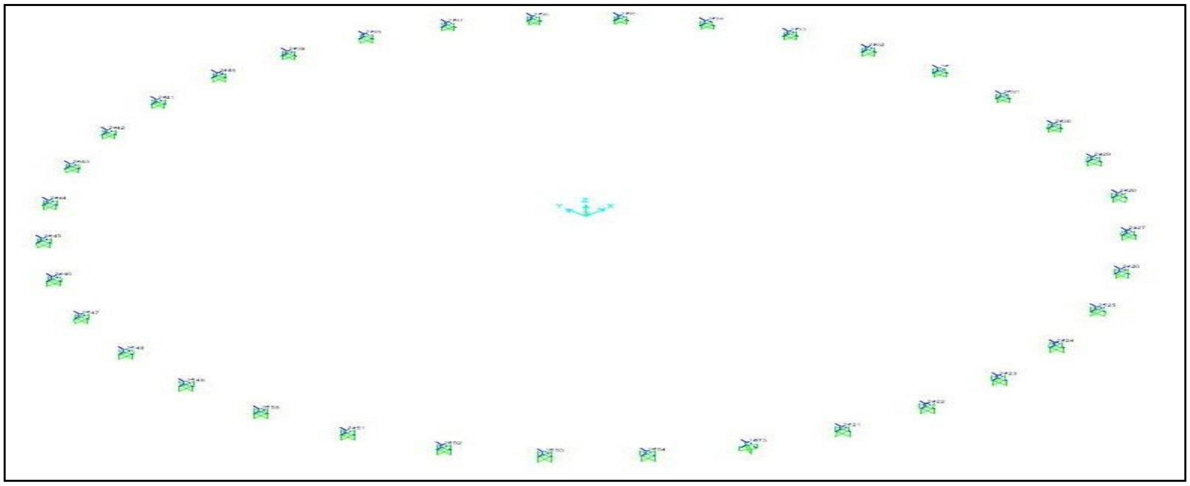


Figure 12: Joints Considered for Model - 3

Joint No	F1 (KN)	F2 (KN)	F3 (KN)	M1 (KN-M)	M2 (KN-M)
1	7.37	0.00	152.09	0.00	3.71
3	16.69	3.46	52.02	1.03	0.89
4	17.61	1.84	26.41	0.55	0.62
6	17.94	0.00	0.00	0.00	0.52
8	17.61	1.84	26.41	0.55	0.62
10	16.69	3.46	52.02	1.03	0.89
12	15.27	4.66	76.04	1.38	1.32
14	13.53	5.30	97.76	1.57	1.84
1055	11.69	5.30	116.51	1.57	2.39
1056	9.97	4.66	131.71	1.38	2.91
1057	8.58	3.46	142.91	1.03	3.34
1058	7.68	1.84	149.78	0.55	3.61
1059	7.68	1.84	149.78	0.55	3.61
1060	8.58	3.46	142.91	1.03	3.34
1061	9.97	4.66	131.71	1.38	2.91
1062	11.69	5.30	116.51	1.57	2.39
1063	13.53	5.30	97.76	1.57	1.84
1064	15.27	4.66	76.04	1.38	1.32
1065	16.69	3.46	52.02	1.03	0.89
1067	17.94	0.00	0.00	0.00	0.52
1068	17.61	1.84	26.41	0.55	0.62
1069	16.69	3.46	52.02	1.03	0.89
1070	15.27	4.66	76.04	1.38	1.32
1071	13.53	5.30	97.76	1.57	1.84
1072	11.69	5.30	116.51	1.57	2.39
1073	3.69	15.53	76.04	0.45	1.85
1074	9.97	4.66	131.71	1.38	2.91
1075	8.58	3.46	142.91	1.03	3.34
1076	7.68	1.84	149.78	0.55	3.61
1149	7.37	0.00	152.09	0.00	3.71
1150	7.68	1.84	149.78	0.55	3.61
1151	8.58	3.46	142.91	1.03	3.34
1152	9.97	4.66	131.71	1.38	2.91
1153	11.69	5.30	116.51	1.57	2.39
1154	13.53	5.30	97.76	1.57	1.84

Table 8: Base Shear for SPECX Model – 3

Joint No	F1 (KN)	F2 (KN)	F3 (KN)	M1 (KN-M)	M2 (KN-M)
1	0.00	17.94	0.00	0.52	0.00
3	3.46	8.58	142.91	3.34	1.03
4	1.84	7.68	149.78	3.61	0.55
6	0.00	7.37	152.09	3.71	0.00
8	1.84	7.68	149.78	3.61	0.55
10	3.46	8.58	142.91	3.34	1.03
12	4.66	9.97	131.71	2.91	1.38
14	5.30	11.69	116.51	2.39	1.57
1055	5.30	13.53	97.76	1.84	1.57
1056	4.66	15.27	76.04	1.32	1.38
1057	3.46	16.69	52.02	0.89	1.03
1058	1.84	17.61	26.41	0.62	0.55
1059	1.84	17.61	26.41	0.62	0.55
1060	3.46	16.69	52.02	0.89	1.03
1061	4.66	15.27	76.04	1.32	1.38
1062	5.30	13.53	97.76	1.84	1.57
1063	5.30	11.69	116.51	2.39	1.57
1064	4.66	9.97	131.71	2.91	1.38
1065	3.46	8.58	142.91	3.34	1.03
1067	0.00	7.37	152.09	3.71	0.00
1068	1.84	7.68	149.78	3.61	0.55
1069	3.46	8.58	142.91	3.34	1.03
1070	4.66	9.97	131.71	2.91	1.38
1071	5.30	11.69	116.51	2.39	1.57
1072	5.30	13.53	97.76	1.84	1.57
1073	6.39	8.97	131.71	0.26	3.21
1074	4.66	15.27	76.04	1.32	1.38
1075	3.46	16.69	52.02	0.89	1.03
1076	1.84	17.61	26.41	0.62	0.55
1149	0.00	17.94	0.00	0.52	0.00
1150	1.84	17.61	26.41	0.62	0.55
1151	3.46	16.69	52.02	0.89	1.03
1152	4.66	15.27	76.04	1.32	1.38
1153	5.30	13.53	97.76	1.84	1.57
1154	5.30	11.69	116.51	2.39	1.57

Table 9: Base Shear for SPECY Model-3

IV CONCLUSION

- When full tank condition is considered, Model-1 (Water Tank Staging with Parabolic Bottom) has got highest amount of vertical displacements when compared to other models. The % variations are 57.8%, 68.75%, 84.37% decrement in displacements of model 2, 3 & 4when compared with Model-1.
- Making flat bottom of tanks will results in higher amount of displacements but stress analysis shows, that it is not adequate to transfer water loads when compared with parabolic bottom.
- Making staging as vertical R.C walls will helps to transfer more amount of load uniformly to the ground, column and circular beam staging is not good as vertical R.C wall staging.
- Maximum displacements considered as follows 19% in Equivalent static and 17% in response spectrum in both X and Y directions correspondingly for Model-1 (Water Tank with staging as Columns with Parabolic Bottom) and Model-2 (Water Tank with staging as Columns with Flat Bottom). Then 4% in Equivalent static and 2.5% in response spectrum in both X and Y directions correspondingly for Model-3 (Water Tank with staging as Shell Element with Parabolic Bottom) and Model 4 (Water Tank with staging as Shell Element with Flat Bottom).
- Equivalent static method is giving some upper bond values when compared to response spectrum. This response spectrum is conservation method for estimated lateral strengths; therefore the values must be normalized as stated by the guide lines of the code IS 1893:2002.
- When we have comparison between Model 1, 2 and Model 3, 4 the time period decrement percentage are 77.84% for model 3 and 77.84% for model 4 when compared with model 1 and 2 respectively. This shows that modeling the water tank staging as R.C wall instead of beam and column staging will increase the strength in addition to stiffness, because time periods considerably reduces for both configuration.
- Stress Concentrations for Model-1 are 2.06 and 91.57 N/mm^2 for S11 and S22 Respectively. For Model-2 the values are 4.45 and 59.10 N/mm^2 S11 and S22 Respectively. For Model-3 the values are 1.68 and 53.54 N/mm^2 for S11 and S22 Respectively. For Model-4 the values are 2.30 and 18.37 N/mm^2 for S11 and S22 Respectively.
- Therefore stress concentrations at these locations are tremendously large enough, Therefore more concentrations must be given throughout the design and detailing of this particular zone.

V REFERENCES

[1] Pavan S. Ekbote and Dr. Jagadish G. Kori "Seismic Behavior of RC Elevated Water Tank under Different type of Staging Pattern". Journal of Engineering, Computers and applied Sciences (JEC&AS) Volume 2, No 8, August 2013.

[2] Asari Falguni and Prof. M.G. Vanza "Structural control system for Elevated water tank". International Journal of Advanced engineering research and studies, (IJAERS) Volume 1 April-June 2012.

[3] R.V.R.K. Prasad and Akshaya B. Kamdi "Effect of revision of IS 3370 on water storage tank". International Journal of Engineering Research and Application (IJERA) Volume 2, Issue 5, September-October 2012.

[4] Ayazhussain M.Jabar & H.S.Patel "Seismic behavior of RC elevated water tank under different staging pattern and earthquake characteristics". International journal of advanced engineering research and studies, (IJAERS) Volume 1, April-June 2012.

[5] Sudhir K. Jain and O.R. Jaiswal "IITK-GSDMA Guidelines for seismic design of liquid storage Tanks". In the year 2007.

[6] Durgesh C. Rai and Bhumika Singh "Seismic Design of Concrete Pedestal supported Tanks". 13th World Conference on Earthquake Engineering Vancouver, B.C, Canada, August 2004.

[7] Manish N. Gandhi and Prof. A. Rajan "Necessity of Dynamic Analysis of Elevated Water Storage structure using different Bracing in staging". International Journal of Research in Advent Technology Volume 2, Number 2, February 2014.

[8] IS 456: 2000 Code of Practice for plain and Reinforced Concrete.

[9] IS 1893 (PartI): 2002 Criteria for Earthquake Resistant Design of Structures, IS: 1893-1984 "Criteria for Earthquake Resistant Design of Structures".

[10] IS 3370: 1967 (PartI,II,III,IV) Code of Practice for Concrete Structures for the Storage of Liquids.

[11] IS 4326: 1993 Code of practice for Earthquake Resistant Design and Construction of Buildings.

[12] IS 11682: 1985 Criteria for Design of RCC Staging for Overhead Water Tanks.

[13] IS 13920: 1993 Code of practice - Ductile detailing of reinforced concrete structures subjected to seismic forces.