

Analysis of elevated water storage structure using 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 proper behavior of supporting system of the tank due to the dynamic effect and also due to improper geometrical selection of staging. The main aim of this study is to understand the behaviour of different staging, under different loading conditions and strengthening the conventional type of staging, to give better performance during earthquake. Equivalent Static Analysis, for five different types of bracing systems, applied to the staging of elevated circular water tank in zone IV, is carried out using STAAD Pro. Comparison of base storey shear and nodal displacements of the container of circular water tank for empty, half filled and full condition is done.

Eleven models are used for calculating base shear and nodal displacements After calculating base shear and nodal displacements of eleven models for empty, half filled & full condition of container applying with different types of bracing system in staging then economy point of view project study suggest such type of bracing which gives minimum base shear as well as considerable displacement for measure earthquake zones.

Keywords: Water Tank, Staging System, Staad Pro

1. Introduction:

Water is human basic needs for daily life. Sufficient water distribution depends on design of a water tank in certain area. An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to pressurization the water distribution system. The liquid storage tanks are particularly subjected to the risk of damage due to earthquake-induced vibrations. A large number of overhead water tanks damaged during past earthquake. Majority of them were shaft staging while a few were on frame staging type Elevated water tanks consist of huge water mass at the top of a slender staging which are most critical consideration for the failure of the tank during earthquakes. Elevated water tanks are critical and strategic structures and damage of these structures during earthquakes may endanger drinking water supply, cause to fail in preventing large fires and substantial economical loss. Since, the elevated tanks are frequently used in seismic active regions also hence, seismic behavior of them has to be investigated in details. Due to the lack of knowledge of supporting system some of the water tank were collapsed or heavily damages. So there is need to focus on seismic safety of lifeline structure using with respect to alternate supporting system which are Safe during earthquake and also take more design forces. Hydrodynamic pressures on tanks under earthquake forces play an important role in the design of the tank. When the tank is in full condition, earthquake forces almost govern the design of these structures in zones of high seismic activity. The failure of these structures may cause some hazards for the health of the citizens due to the shortage of

water or difficulty in putting out fire during the earthquake golden time. 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 analyse and, hence, the study of tanks can be informative as to the behaviour of structures during earthquakes.

1.2. Damage Observed to Elevated Water Tanks in Bhuj Earthquake (2001):

Most of the elevated water tanks undergo damage to their staging. Due to the lack of knowledge of supporting system some of the water tank were collapsed or heavily damages. So there is need to focus on seismic safety of lifeline structure using with respect to alternate supporting system which are safe during earthquake and also take more design forces. Bhuj earthquake (2001) [2] is the recent example, as shown in figure 1.1,1.2,&1.3 It is observed from the past earthquake; Most of the elevated water tanks undergo damage to their staging.

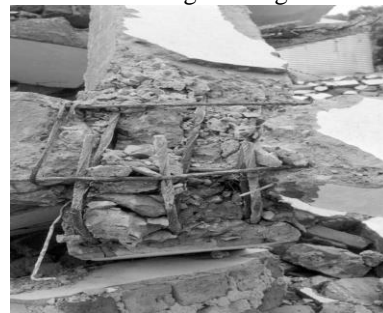


Figure-1: Poor detailing of column-brace joints for Manfera tank.



Figure-2: Collapse of water tank in Bhuj

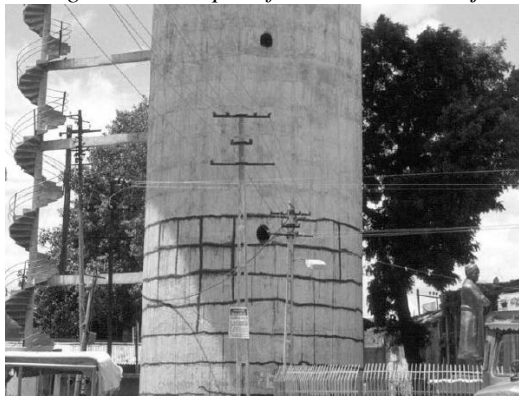


Figure-3: Flexure cracks in staging

2. Types of bracing system used

Models are used for calculating base shear and nodal displacements for staging with cross bracing , staging with chevron bracing , staging with diagonal bracing , staging with k-type bracing , staging with v-type bracing and alternate cross bracing in staging , alternate chevron bracing in staging , alternate k-type bracing in staging , alternate v-type bracing in staging., alternate diagonal bracing in staging .

3. Method used calculating base shear:

STAAD.Pro.v8i is the most popular structural engineering software product for 3D model generation, analysis and multi-material design. It has an intuitive, user-friendly GUI, visualization tools, powerful analysis and design facilities and seamless integration to several other modeling and design software products. For static or dynamic analysis of bridges, containment structures, embedded structures (tunnels and culverts), pipe racks, steel, concrete, aluminum or timber buildings, transmission towers, stadiums or any other simple or complex structure, STAAD.Pro has been the choice of design professionals around the world for their specific analysis needs

Table-1: Parameters of elevated water tank

S.N	Parameters	Values
(1)	(2)	(3)
1	size of top slab	100 mm thick
2	size of bottom slab	150 mm
3	size of top ring beam	250x350 mm
4	size of bottom ring beam	250x500 mm
5	size of column	500x250 mm
6	size of braces	500x250 mm
7	density of concrete	25 kN/sq.m
8	Diameter of tank	10 m
9	Height of tank	5 m
10	Height of staging	15 m
11	Number of columns	10
12	Zone	IV(0.24)
13	Response reduction factor	5 (SMRF)
14	Importance factor	1.5 for water tank
15	Type of soil	hard soil

4. 3D Models(few system)

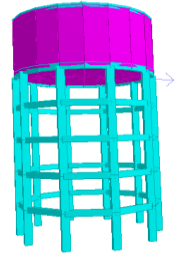


Figure-4 Staging without inclined bracing

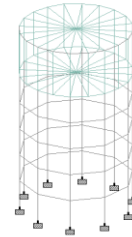


Figure-5 STAAD Pro model of staging without bracing



Figure-6 Staging with crossbracing staging

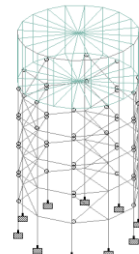


Figure-7 STAAD Pro model of with cross bracing

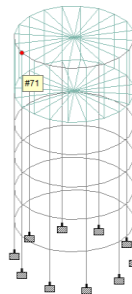


Figure-8 Position of node no. 71

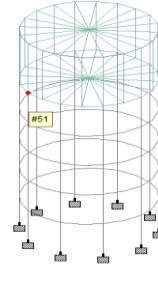


Figure-9 Position of node no. 51

5. Results :

Table-2: Results of base shear and nodal displacement of without inclined bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	12.5	12.1	99.9	
2	Half	15.0	14.6	119.94	
3	Full	17.5	17.1	139.89	

Table-3: Results of base shear and nodal displacement of cross bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	2.63	2.21	141.92	
2	Half	2.97	2.51	161.87	
3	Full	3.31	2.81	181.82	

Table-4: Results of base shear and nodal displacement of chevron bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	2.68	2.32	132.93	
2	Half	3.06	2.65	152.88	
3	Full	3.48	2.99	172.83	

Table-5: Results of base shear and nodal displacement of diagonal bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	3.10	2.67	120.96	
2	Half	3.58	3.10	140.41	
3	Full	4.06	3.53	160.86	

Table-6: Results of base shear and nodal displacement of k-type bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	3.01	2.55	133.43	
2	Half	3.43	2.92	152.38	
3	Full	3.84	3.29	172.33	

Table-7: Results of base shear and nodal displacement of v-type bracing in Staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	3.02	2.57	132.93	
2	Half	3.44	2.94	152.88	
3	Full	3.86	3.32	172.83	

Table-8: Results of base shear and nodal displacement of alternate cross bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	3.78	3.38	120.96	
2	Half	4.38	3.98	140.91	
3	Full	4.97	4.48	160.86	

Table-9: Results of base shear and nodal displacement of alternate chevron bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)	
		(2)			(3)
		Node no:71	Node no:51		
1	Empty	4.57	4.01	99.99	
2	Half	5.48	5.0	119.94	
3	Full	6.89	6.4	156.36	

Table-10: Results of base shear and nodal displacement of alternate diagonal bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)
		(2)		
	(1)	Node no:71	Node no:51	
1	Empty	5.52	4.83	108.37
2	Half	6.22	5.75	128.33
3	Full	7.18	8.66	148.28

Table-11: Results of base shear and nodal displacement of alternate k-type bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)
		(2)		
	(1)	Node no:71	Node no:51	
1	Empty	4.18	3.75	116.71
2	Half	4.86	4.39	136.66
3	Full	5.55	5.03	156.61

Table-12: Results of base shear and nodal displacement of alternate v-type bracing in staging

SN	Tank condition	Displcement (mm)		Base shear (kN)
		(2)		
	(1)	Node no:71	Node no:51	
1	Empty	4.04	3.61	116.46
2	Half	4.7	4.22	136.41
3	Full	5.36	4.83	156.36

6. Conclusion:

In this project, emphasis is given on the study of the in-built feature of solving seismic coefficient method in STAAD.pro V8i. This method provide the values of time period and base shear, which are very much in agreement with the values of the manually calculated results.

Parametric study is carried out by using different patterns of bracings in staging of an elevated water tank. From the table it is clear that the base shear value, reduces for alternate bracing pattern in staging. This is apparent because of the reduction of overall stiffness of the structure.

The table reveals displacement values of top node(71) and bottom node(51) 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.

References:

- [1] Ayazhussain m. Jabar and H. S. Patel, (2012) "Seismic Behavior of RC Elevated Water Tank under Different Staging Pattern and Earthquake Characteristics". International journal of advanced engineering research and studies e-issn2249-8974, IJAERS/Vol. I/ Issue III/April-June, 2012/293-296
- [2] Durgesh C Rai, (2003) "Performance of Elevated Tanks in Mw 7.7 Bhuj Earthquake of January 26th, 2001" International journal of advanced engineering research Proc. Indian Acad. Sci. (Earth Planet. Sci.), 112, No. 3, September 2003, pp. 421-429
- [3] Asari Falguni, Prof. M.G.Vanza, (2012) "Structural Control System for Elevated Water Tank" International journal of advanced engineering research and studies e-issn2249-8974, IJAERS/Vol. I/ Issue III/April-June, 2012/325-328.
- [4] Hasan Jasim Mohammed,(2011) "Economical Design of Water Concrete Tanks" European journal of scientific research ISSN 1450-216x vol.49 no.4 (2011), pp. 510-520 Euro journals publishing, inc. 2011
- [5] Arun Kumar, (2006) "Ductility Analysis of R.C.C.(O.H.T) Design as Per IS:3370(Part-II)" M-Tech Thesis.
- [6] Durgesh C. Rai and Bhumika Singh, (2004) "Seismic Design of Concrete Pedestal Supported Tanks"13th World Conference on Earthquake Engineering Vancouver, B.C, Canada August 1-6, 2004

Web Sites:

www.sefi.in