Analysis and Design of Intze water tank as Per IS: 3370 & IS: 456 -2000 using STAAD Pro Software

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ABSTRACT

Water tanks are important public utility and industrial structure. The design and construction methods in reinforced concrete are influenced by the prevailing construction practices, the physical property of the material and the climatic conditions. The analysis is conducted as per the specifications of IS 3370, IS 800:2002, IS 875, IS 1893 Design of tank by the dome, Ring beam supporting the dome, Cylindrical walls, Ring beam at the junction of the cylindrical walls and the conical wall , Conical slab, Floor of the tank, The ring girder, Columns, Tower with bracings, Foundations as per IS 3370 -Part III will be done by using 2-Dimensional STAAD model for 3,00,000 Litres capacity tank .Different loads such as Dead Load, Live Load, Wind load, Earthquake Load will be applied on STAAD model at appropriate location as per codes used for Loading. These elevated water tanks are especially vulnerable to horizontal forces such as wind and earthquakes.

Keyword : - *Water, Intze Water Tank, STAAD Pro, analysis, Design as per IS code*

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1. INTRODUCTION

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. In developing countries like India, the safe supplying of portable water and enough water are most significant needs. India has been able to cover about 84% of its urban population with safe drinking water supplies. For an adequate water supply scheme various system are required for collecting, transporting and treating the water

1.1 Concept of Intze Water Tank

In the cases of large diameter tanks an economical alternative would be to reduce its diameter at its bottom by conical dome. Such a tank is known as Intze tank and it is commonly used. The main advantage of such a tank is that the outward thrust from the top of the conical part is resisted by the ring beam at the bottom of cylindrical wall while the difference between the inward thrust from the bottom of conical dome and the outward thrust from the bottom dome are resisted by ring beam at the bottom of conical dome. The proportions of the conical dome and bottom dome are so arranged that the outward thrust from bottom dome balances the inward thrust due to the conical dome.

1.2 Introduction

A. **General**

A water tank is generally a storage unit for water While designing water tank some parameters are required such as:
i) Position of water tank with the head required.
ii) Volume required to serve till its design period..
iii) Purpose of which the water tank will be used.
(iv) Distribution system, as it can be gravity or can be gravity with pump

B. Classifications of water tanks-

In general water tanks can be classified under three heads:

- Tank resting on the ground.
- Elevated water tank supported on staging.
- Underground tanks.

The walls are subjected to water pressure only. The base has to carry load of Water and Tank load. The staging has to carry load of water and Tank, and is also designed for wind Forces. From the shape point of view, water tanks may be of several types, such as-

(i) Circular tanks
(ii) Rectangular tanks
(iii) Spherical tanks
(iv) Intze tanks
(v) Circular tanks
(vi) Circular tanks with conical bottoms.

1.3 Components of INTZE water tanks-

Top dome-
Top cover of the tank is given by a domical shaped member. This structure having meridional stress & Hoop stress.

Top ring beam-
To resist the horizontal thrust by top dome a ring beam is provided at just below the top dome.

Cylindrical wall-
The cylindrical wall contents water which gives maximum hoop tension at the base of the wall.

Middle ring beam-
Middle ring beam is given at just below the cylindrical wall to sustain the stresses & thrust by the above structure.

Conical dome-
Lies just above the bottom ring beam and is conical in shape and hence the name. This is the most important part of Intze tank which makes it different from other overhead tanks.

Bottom dome-
Bottom dome balances the thrust from conical dome & transfers the effects of above structure to the bottom ring beam.

Bottom ring beam-
This ring beam must be strong enough to sustain the outward thrust of dead load as well as load of water.

Bracing-
Bracing is required to prevent the buckling of whole structure which connects the supporting columns of overhead tank.

Supporting columns-
The horizontal thrust is resisted by the ring beams but the vertical component of thrust is transferred to columns of tank.

Foundation-
The whole vertical loads are transmitted to the foundation of the water tank which having a Raft or Pile type foundation. It distributes the whole load of super structure to the ground uniformly.

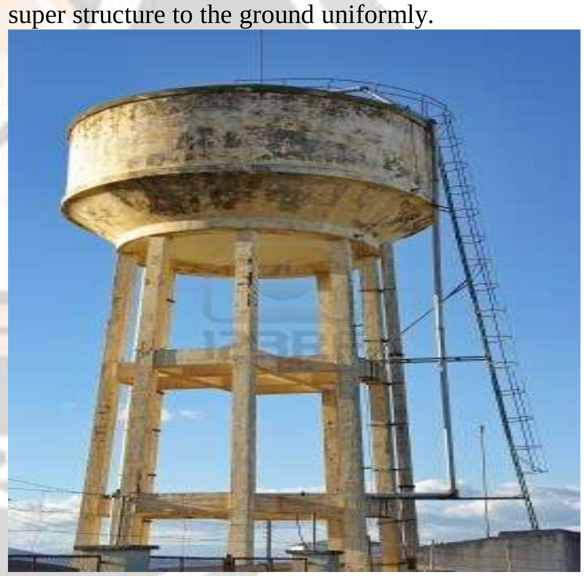


Fig -1: Elevated water tank supported on staging

2. LITERATURE REVIEW

- Pavan S Ekboteand Dr. Jagadish G. Kori(2013),Elevated water tank were profoundly smashed or collapsed during earthquake. This was might be owing to the lack of familiarity regarding the performance of supporting system of the water tanks against dynamic action and also due to improper geometrical selection of staging patterns of tank. Due to fluid structure interaction , the seismic behavior of elevated water tank has the characteristics of intricate phenomenon. The main aim of this study is to understand the behavior of supporting system.(or staging) which is more effective under different response spectrum method with SAP software.
- R.V.R.K. Prasad and Akshaya B. Kamdi(2012) , storage elevated water tank are used to store water .BIS has brought out the revised version of IS 370(Part I & II) after a long time from its 1965 previous version in the year 2009. This is the revised code mainly drafted for the liquid storage tank.In this revision important is that Limit state method is incorporated in water tank design.

- Thalapathy.M, Vijaisarathi.R.P, Sudhakar.P, Sridharan.V, Satheesh.V.S, "Analysis and Economical Design of Water Tanks ", IJISET - International Journal of Innovative Science, Engineering & Technology, A water tank is a container for storing liquid. The need for a water tank is as old as civilization, to provide storage of water for use in many applications, drinking water, irrigation, agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses. Water tank parameters include the general design of the tank, and choice of construction materials, linings. Reinforced Concrete Water tank design is based on IS 3370: 2009 (Parts I – IV).
- Nitesh J Singh, Mohammad Ishtiyaque , has "DESIGN ANALYSIS & COMPARSION OF INTZE TYPE WATER TANK FOR DIFFERENT WIND SPEED AND SEISMIC ZONES AS PER INDIAN CODES." Any design of Water Tanks is subjected to Dead Load + Live Load and Wind Load or Seismic Load as per IS codes of Practices. Most of the times tanks are designed for Wind Forces and not even checked for Earthquake Load assuming that the tanks will be safe under seismic forces once designed for wind forces. In this study Wind Forces and Seismic Forces acting on an Intze Type Water tank for Indian conditions are studied. The effect of wind on the elevated structures is of prime importance as Wind flows relative to the surface of ground and generates loads on the structures standing on ground.
- Issar Kapadia,PuravPatel, Nilesh Dholiya, Nikunj Patel "Analysis and Design of INTZE Type Overhead Water Tank under the Hydrostatic Pressure as Per IS: 3370 & IS: 456 -2000 by Using STAAD Pro Software", Water tanks are important public utility and industrial structure. The design and construction methods in reinforced concrete are influenced by the prevailing construction practices, the physical property of the material and the climatic conditions. Before taking up the design, the designer should first decide the most suitable type of staging of tanks and correct estimation of loads including statically equilibrium of structure particularly in regards to overturning of overhanging members shall be made.

3.DESIGN CRITERIA AS PER IS CODES

The design of the tank will involve the following:

1) The dome: at top, usually 100 mm to 150 mm thick with reinforcement along the meridians and latitudes. The rise is usually l/5th of the span.

2) Ring beam supporting the dome: The ring beam is necessary to resist the horizontal component of the thrust of the dome. The ring beam will be designed for the hoop tension induced.

3) Cylindrical walls: This should be designed for hoop tension caused due to horizontal water pressure.

4) Ring beam at the junction of the cylindrical walls and the conical wall: This ring beam is provided to resist the horizontal component of the reaction of the conical wall on the cylindrical wall. The ring beam will be designed for the induced hoop tension.

5) Conical slab: This will be designed for hoop tension due to water pressure. The slab will also be designed as a slab spanning between the ring beam at top and the ring girder at bottom.

6) Floor of the tank: The floor may be circular or domed. This slab is supported on the ring girder.

7) The ring girder: This will be designed to support the tank and its contents. The girder will be supported on columns and should be designed for resulting bending moment and Torsion.

8) Columns: These are to be designed for the total load transferred to them. The columns will be braced at intervals and have to be designed for wind pressure or seismic loads whichever govern.

9) Foundations: A combined footing is usually provided for all supporting columns. When this is done, it is usual to make the foundation consisting of a ring girder and a circular slab.

4. MODELLING AND ANALYSIS

For the analysis of Intze type elevated water tank following dimensions are considered which are described below. From the study of the Inzte elevated type water tank, main objective is to know deflected shape, stresses and B.M. for the same.

Parameters and Description of the Elevated Tank

Height of the tank – 26m
Staging height (linear) – 20m
Top Diameter of tank 16.00m
Height of Cylindrical Wall 4m
Thickness of Cylindrical Wall 200mm
Thickness of dome 200mm
Height of staging 20m
Number of columns 6 nos.
Column type Rectangular
Bracings 400mmx400mm

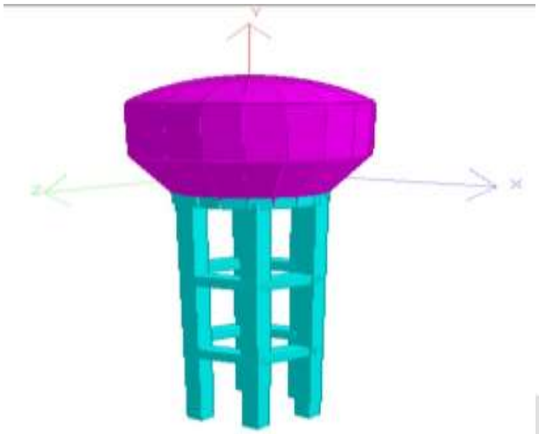


Fig.1 3D view of water tank

Parameters Dimensions/ Description

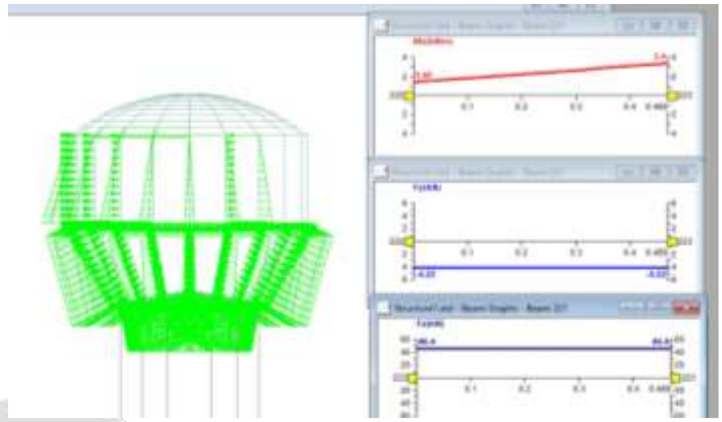


Fig. 2 Hydrostatic Load acting on Water Tank

Hydrostatic pressure on: The top plates of tank, Middle plates of tank, Bottom plates of tank respectively

(ii) Final Result

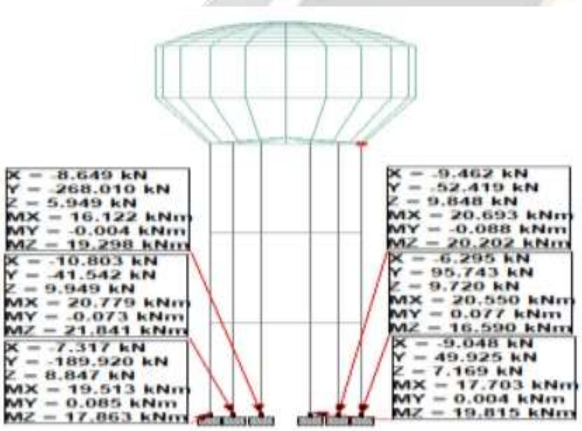
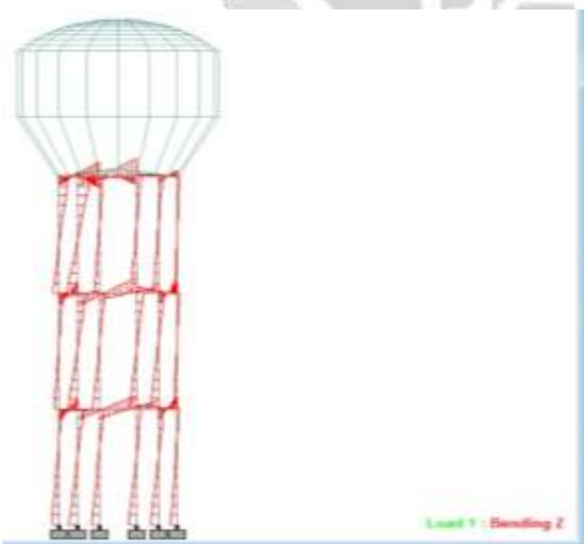


Table1:Summary of Reactions

All / Summary / Envelope

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	295	1 LOAD CAS	252	95.743	6.295	-9.720	0.077	13.471	5.441
Min Fx	283	1 LOAD CAS	244	-268.010	8.649	-5.949	-0.004	4.699	10.972
Max Fy	234	1 LOAD CAS	235	-51.513	64.468	-5.265	4.483	-0.289	-4.738
Min Fy	225	1 LOAD CAS	226	17.399	-48.778	-7.373	0.635	2.089	-23.011
Max Fz	235	1 LOAD CAS	236	-28.711	-17.316	8.516	-5.321	-3.951	-5.365
Min Fz	306	1 LOAD CAS	258	-39.206	12.952	-11.732	-0.036	19.751	21.529
Max Mx	234	1 LOAD CAS	235	-51.513	64.468	-5.265	4.483	-0.289	-4.738
Min Mx	235	1 LOAD CAS	236	-28.711	-17.316	8.516	-5.321	-3.951	-5.365
Max My	293	1 LOAD CAS	250	24.155	3.233	-11.332	-0.104	20.822	5.604
Min My	306	1 LOAD CAS	259	-39.206	12.952	-11.732	-0.036	-21.311	-23.803
Max Mz	302	1 LOAD CAS	226	-24.830	56.559	5.240	-1.918	-3.845	54.757
Min Mz	303	1 LOAD CAS	258	3.499	58.421	1.748	2.263	0.981	-41.702

Table-2: Summary of stresses



Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
221	1 LOAD CAS	222	46.399	-4.215	-0.127	0.175	0.000	1.42
		223	-46.399	4.215	0.127	-0.175	-0.020	-3.40
222	1 LOAD CAS	223	46.222	-5.820	0.296	0.694	0.157	1.95
		224	-46.222	5.820	-0.296	-0.694	-0.297	-4.68
223	1 LOAD CAS	224	46.149	-8.559	0.586	0.677	0.224	2.88
		225	-46.149	8.559	-0.586	-0.677	-0.489	[illegible]
224	1 LOAD CAS	225	39.332	-8.429	[illegible]	[illegible]	[illegible]	4.68
		226	-39.332	8.429	[illegible]	[illegible]	-0.156	[illegible]
225	1 LOAD CAS	226	17.399	-48.778	-7.373	0.635	2.089	-23.01
		227	-17.399	48.778	7.373	-0.635	1.372	8.12
226	1 LOAD CAS	227	37.403	-12.358	-2.439	0.458	0.286	-2.47
		228	-37.403	12.358	2.439	-0.458	0.879	-3.32

All / Max Axial Forces / Max Bending Moments / Max Shear Forces

Beam	L/C	Dist m	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
221	1 LOAD CAS	0.000	46.399	-4.215	-0.127	0.175	0.000	1.42
		0.117	46.399	-4.215	-0.127	0.175	[illegible]	1.91
		0.235	46.399	-4.215	-0.127	0.175	[illegible]	2.41
		0.352	46.399	-4.215	-0.127	0.175	[illegible]	2.90
		0.469	46.399	-4.215	-0.127	0.175	0.020	3.40
222	1 LOAD CAS	0.000	46.222	-5.820	0.296	0.694	0.157	1.95
		0.117	46.222	-5.820	0.296	0.694	0.192	[illegible]
		0.235	46.222	-5.820	0.296	0.694	0.227	3.31
		0.352	46.222	-5.820	0.296	0.694	0.262	4.00
		0.469	46.222	-5.820	0.296	0.694	0.297	4.68
223	1 LOAD CAS	0.000	46.149	-8.559	0.586	0.677	0.224	2.88
		0.117	46.149	-8.559	0.586	0.677	[illegible]	[illegible]

Table-3: Summary of beam Stresses

			Max Compressive			Max Tensile		
Beam	L/C	Length m	Stress N/mm2	Dist m	Corner	Stress N/mm2	Dist m	Corner
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table-4: Summary of Max. Stresses

Beam	L/C	Length m	Max x mm	Dist m	Max y mm	Dist m	Max z mm	Dist m	Max mm	Dist m	Span/Max
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table-5: Max. Relative Displacements summary

		Shear		Membrane			Bending Moment		
Plate	L/C	SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
248	1 LOAD CAS	-0.001	-0.003	-0.106	-0.053	-0.042	-0.029	-0.248	-0.044
249	1 LOAD CAS	0.003	-0.004	-0.101	-0.069	-0.004	0.014	-0.247	0.009
250	1 LOAD CAS	0.008	-0.005	-0.091	-0.078	0.037	0.136	-0.204	0.054
251	1 LOAD CAS	0.007	-0.006	-0.074	-0.036	0.084	0.312	-0.179	0.119
252	1 LOAD CAS	-0.005	-0.007	-0.076	0.141	0.137	0.093	-0.317	0.179
253	1 LOAD CAS	0.011	-0.020	-0.128	0.252	-0.011	-0.589	-0.672	0.145
254	1 LOAD CAS	0.011	-0.013	-0.082	0.126	-0.058	-0.158	-0.507	-0.026
255	1 LOAD CAS	0.003	-0.010	-0.081	0.009	-0.028	0.033	-0.344	-0.024
256	1 LOAD CAS	0.002	-0.008	-0.097	-0.051	0.017	0.035	-0.260	0.024
257	1 LOAD CAS	0.004	-0.008	-0.109	-0.077	0.055	0.062	-0.206	0.075
258	1 LOAD CAS	0.007	-0.009	-0.115	-0.080	0.084	0.091	-0.144	0.123
259	1 LOAD CAS	0.009	-0.010	-0.112	-0.051	0.116	0.123	-0.081	0.182
260	1 LOAD CAS	0.007	-0.012	-0.103	0.034	0.147	0.121	-0.058	0.247
261	1 LOAD CAS	-0.034	0.183	0.333	0.018	0.191	-1.310	-4.151	-0.216
262	1 LOAD CAS	-0.032	0.064	0.399	-0.081	-0.119	-1.110	-0.261	0.284
263	1 LOAD CAS	-0.024	0.018	0.233	0.028	-0.069	-0.740	0.415	0.161
264	1 LOAD CAS	-0.020	0.005	0.129	-0.002	-0.001	-0.506	0.449	0.242
265	1 LOAD CAS	-0.017	-0.005	0.093	-0.057	0.049	-0.244	0.423	0.290
266	1 LOAD CAS	-0.016	-0.015	0.104	-0.110	0.072	0.030	0.449	0.277
267	1 LOAD CAS	-0.017	-0.026	0.132	-0.147	0.070	0.277	0.514	0.225
268	1 LOAD CAS	-0.018	-0.036	0.157	-0.157	0.058	0.473	0.603	0.159
269	1 LOAD CAS	-0.020	-0.042	0.176	-0.143	0.060	0.628	0.778	0.101
270	1 LOAD CAS	-0.023	-0.044	0.196	-0.108	0.064	0.771	1.100	0.078
271	1 LOAD CAS	-0.026	-0.051	0.232	-0.059	0.072	0.933	1.504	0.131
272	1 LOAD CAS	-0.025	0.037	0.268	-0.140	0.077	0.484	-2.066	0.445
273	1 LOAD CAS	-0.024	-0.004	0.269	-0.156	0.033	0.692	0.157	-0.100
274	1 LOAD CAS	-0.022	-0.016	0.231	-0.154	0.010	0.616	0.613	-0.224
275	1 LOAD CAS	-0.021	-0.020	0.181	-0.145	-0.001	0.627	0.546	-0.258
276	1 LOAD CAS	-0.020	-0.024	0.135	-0.124	-0.006	0.417	0.408	-0.299
277	1 LOAD CAS	-0.020	-0.030	0.103	-0.084	0.000	0.197	0.329	-0.347
278	1 LOAD CAS	-0.021	-0.040	0.099	-0.026	0.028	-0.025	0.318	-0.364
279	1 LOAD CAS	-0.023	-0.057	0.137	0.032	0.064	-0.245	0.229	-0.326
280	1 LOAD CAS	-0.027	-0.096	0.224	0.060	0.154	-0.542	-0.567	-0.240

Table:6 Summary of Shear and Bending Moment

5. CONCLUSIONS

By carried out the study with help of the STAAD Pro Software, We made the conclusion as pointed below:

1. As the height of the water retaining structure increases the Bending moment increases
2. A remarkable reduction in base settlement occurs by using fix joint at the base
3. Compare to the circular tank intze type tank is simplest form
4. We have given the straight inclination to the staging of water tank because as respected inclination the tank performs better than that type of straight one

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