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Etabs-Based Inze Tank and Deflation Shape Analysis for Hydrostatic Pressure and Stresses

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Abstract: *Public and industrial water storage tanks play a crucial role. Weather, material physical properties, and standard building techniques all have a role in how reinforced concrete is designed and built. The designer must first determine the best method of tank staging and accurately estimate the weights, taking into account the structural balance of the building and the risk of overturning any overhanging parts, before beginning the design process. While the tank is full or empty, the design should take into account the worst-case scenario for loads, moments, and shears caused by vertical and horizontal forces acting in either direction. This study examines the shape of deflection as a result of hydrostatic pressure and strains, among other things, by analysing an Intze tank.*

Key Words: Water, hydrostatic pressure, types of tank, Intze water tank, reviews, analysis, design criteria as per IS code..

1. INTRODUCTION

Now days, water is most essential needs to save as possible because as population increases the demand of waters are increases. And as we know Water is an important element of a life. The need of water is for drinking, irrigation, industrial manufacturing, fire suppression, etc. so it is necessary to deal with the storage of water as properly as possible. Water tank is the container for storing water in large quantity. The water tanks are constructed to store water at a ground level for the daily use, treatment of water, product manufacturing, emergency storage, rainwater storage tanks, etc. The water tank is a very important structure for the civil engineering for the human society. The development of the human civilization is introduced many different types of water storage tank.

In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential. The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio. The increase in water cement ratio results in increase in the permeability. The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. Cracks can be prevented by avoiding the use of thick timber shuttering which prevent the easy escape of heat of hydration from the concrete mass. The risk of cracking can also be minimized by reducing the restraints on free expansion or contraction of the structure. The main reason for life loss is collapse of structures It is said that natural calamities itself never kills people; it is badly constructed structure that kill. Hence it is important to analyse the structure properly for different natural calamities like earthquake, cyclones, floods and typhoons etc.

2. WATER TANK IN GENERAL AND TYPES OF WATER TANK

In recent years, there has been much emphasis on water supply projects all over the world, which are very essential for the social and industrial development of the country. Water tanks can be of different capacity depending upon the requirement of consumption. Based on the location the water tanks are classified into three ways:

1. Underground water tanks
2. Tank resting on grounds
3. Elevated or overhead water tanks.

Also, the water tanks are classified based on shape:

1. Circular tanks
2. Rectangular tanks
3. Intze tanks

4. Circular tank with conical bottom
5. Spherical tanks.

2.1 Usage of water tanks:

A reinforcement concrete tank is a very useful structure which is meant for the storage of water, for swimming bath, sewage sedimentation and for such similar purposes.
Reinforced concrete overhead water tanks are used to store and supply safe drinking water.

2.2 Overhead water tank or E.S.R (Elevated Storage Reservoir)

"A Water Storage structure which is constructed above the ground"

Overhead water tanks of various shapes can be used as service reservoirs, as a balancing tank in water supply schemes and for replenishing the tanks for various purposes. For an efficient water distribution system, overhead water tanks or elevated storage reservoirs are one of the most important components. The basic purpose of elevated water tanks is to secure constant water supply with sufficient flow to wide area by gravity. The height of the elevated tank depends on the area to be covered for the water supply. Wider the area to be served higher will be the required elevation of the tank.

2.3 Intze Water Tank

Intze water tanks are constructed to minimize the project cost because lower dome in this construction resists the horizontal thrust. This type tank is simplest form as compare to the circular tank.

A water tower built in accordance with the Intze principle has a brick shaft on which the water tank sits. The base of tank is fixed with a ring anchor made of iron or steel, so that only vertical, not horizontal forces are transmitted to the tower. Due to the lack of horizontal forces the tower shaft doesn't need to be quite as solidly built. An Intze tank is characterized by its diameter. The main advantages of such tank are that the outward thrust from top of conical part is resisted by ring beamB3 (as above said).
It can be divided into two types based on support.

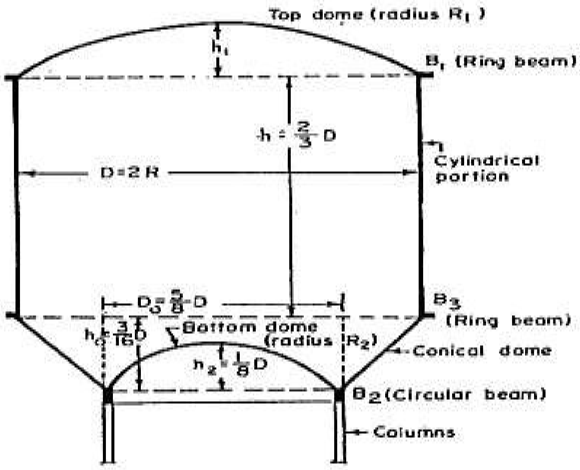
a. Column rested water tank
b. Shaft rested water tank

2.4 Structural elements of Intze tank

The various structural elements of an Intze type tank comprises of the following:

1. Top spherical dome
2.Top ring beam
3. Circular side walls
4. Bottom ring beam
5. Conical dome
6.Bottomphericaldome
7. Bottom circular girder
8. Foundations
9. Tower with columns and braces

Figure-1: Typical section and Components of Intze type Water Tower



3. LITERATURE REVIEW

This chapter gives the background to the need of tank for possible used by the study; elevated water tank with different criteria and conditions. The available published literature on analysis of elevated water tank is also briefly reviewed.

- Durgesh C. Rai and Bhumika Singh (2004), studied Reinforced concrete pedestal (circular, hollow shaft type supports) are popular choice for elevated tanks for the ease of Construction and the more solid form it provides compared to framed construction. In the recent past Indian earthquakes, Gujarat (2001) and Jabalpur (1997), thin shells (150 to 200 mm) of concrete pedestals have performed unsatisfactorily when great many developed circumferential tension exural cracks in the pedestal near the base and a few collapsed.

- IITK-GSDMA Guidelines (For Seismic Design of Liquid Storage Tanks) says that, most elevated tanks are never filled completely with liquid. Hence a two- mass idealization of the tank is more appropriate as compared to a one-mass idealization, which was used in IS 1893: 1984. Two mass models for elevated tank were proposed by Housner (1963b) and are being commonly used in most of the international codes.

- Livaoglur. R. and Dogangun A. (2006) investigated the effects of foundation embedment on the seismic behaviour of fluid-elevated tank-foundation-soil system with a structural frame supporting the fluid containing tank. Six different soil types defined in the seismic codes were considered. Both the sloshing effects of the fluid and soil-structure interaction of the elevated tanks resting on these six different soils were included in the analyses.

4. 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.

5. 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.

Height of the tank – 26m
Staging height (linear) – 20m
Number of columns -6

i. Parameters of the elevated tank

Table-1: parameters and description

Parameters	Dimensions/ Description
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

3D view of water tank

Table-2: Hydrostatic pressure On: The top plates of tank, Middle plats of tank, Bottom plates of tank respectively

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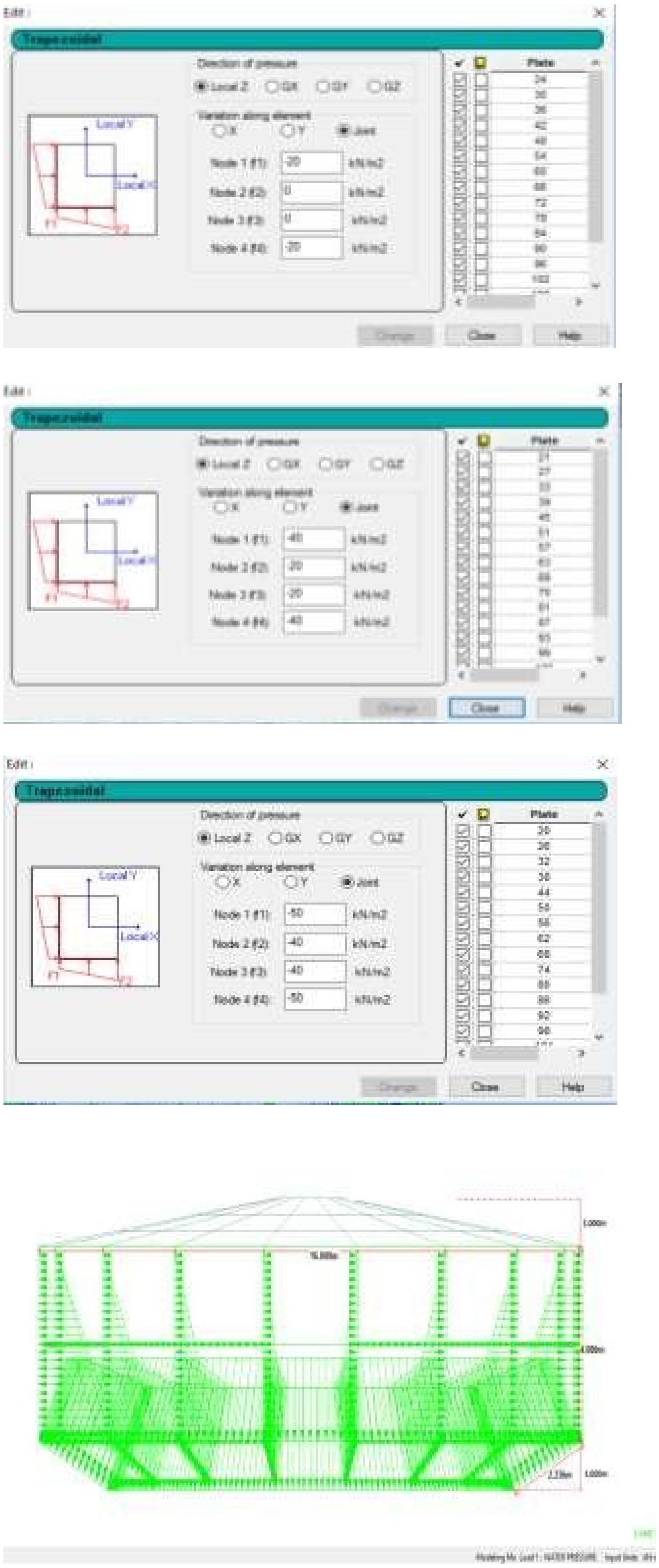
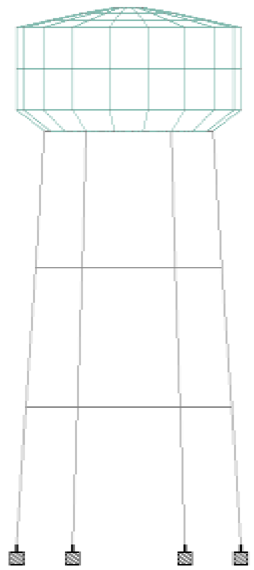


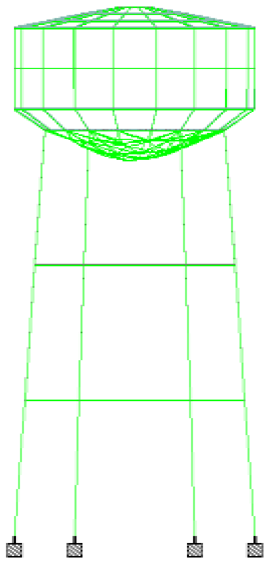
Figure-2: Hydrostatic load acted on Water Tank

ii. Final Result

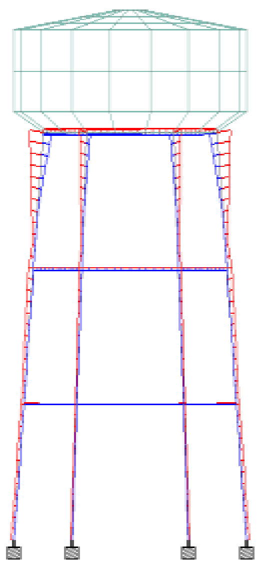
Actual view



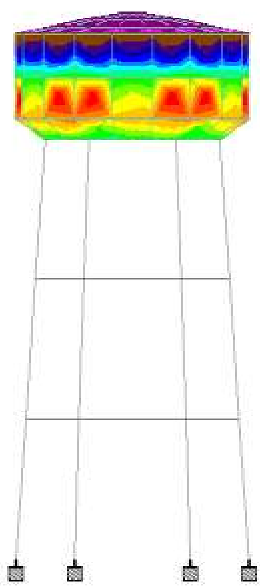
Deflected shape



Beam stresses



Shear, Bending due to Hydrostatic pressure



Pressure on Plates

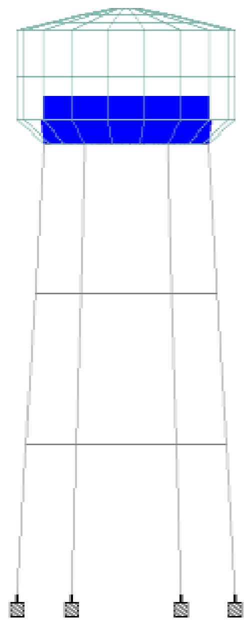
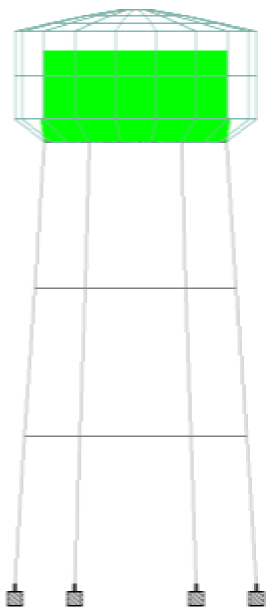


Plate Load



Hydrostatic Pressure

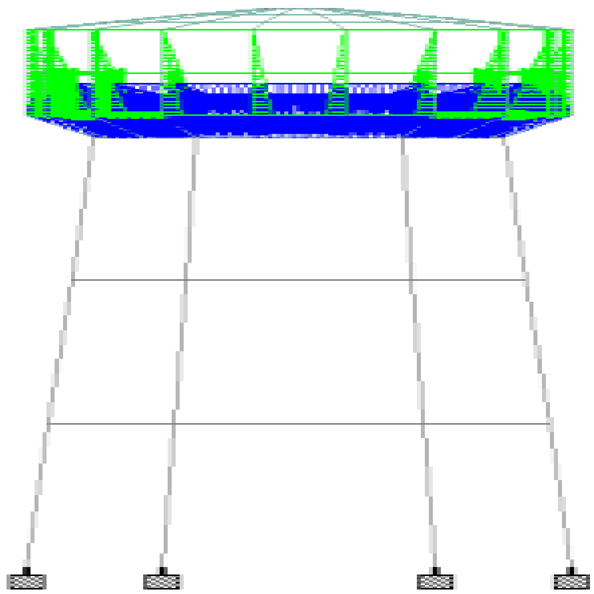


Table-2: Max stress due the loads

All | Max Stresses | Profile Stress Points

Beam	L/C	Length m	Max Compressive Stress psi	Dist m	Corner
	2 LOAD CAS	6.700	30.363	6.700	3
	3 LOAD CAS	6.700	42.508	6.700	3
217	1 WATER PR	6.700	214.065	6.700	3
	2 LOAD CAS	6.700	51.258	6.700	1
	3 LOAD CAS	6.700	71.762	6.700	1
218	1 WATER PR	6.700	279.857	6.700	2
	2 LOAD CAS	6.700	134.370	6.700	3
	3 LOAD CAS	6.700	188.118	6.700	3
219	1 WATER PR	6.000	87.600	6.000	3

Shear, Membrane and Bending | Sun

	Plate	L/C	Principal Top psi	Principal Bottom psi
Max Pri	163	3 LOAD CAS	231.410	-214.533
Min Prin	146	3 LOAD CAS	-261.384	4.920
Max Pri	21	1 WATER PR	226.522	270.126
Min Prin	163	3 LOAD CAS	229.101	-215.354
Max Vo	122	1 WATER PR	207.109	122.358
Min Vo	107	2 LOAD CAS	-0.030	0.021
Max Vo	92	1 WATER PR	155.346	168.255
Min Vo	101	2 LOAD CAS	-0.033	0.025
Max Tr	122	1 WATER PR	207.109	122.358
Min Tre	107	2 LOAD CAS	-0.030	0.021
Max Tr	92	1 WATER PR	155.346	168.255
Min Tre	101	2 LOAD CAS	-0.033	0.025

6. CONCLUSION:

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

1. There is an increase in moment when theheight of the structure increases.
2. When using fix joint at the base its remarkable reduction in base settlement.
3. This type tank is simplest form as compare to the circular tank.
4. We have given the 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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