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DESIGN AND ANALYSIS OF AN OVERHEAD WATER TANK FOR A RESIDENTIAL COMPLEX

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Abstract: *In India more than 68% of its total population lives in rural area. Domestic water is major problem in this area, so as to solve this problem innovative design and solutions to existing problem is essential hence for that study of Over Head Tank (OHT) is undertaking. There are so many case studies and report on failure during and post construction of OHT. The purpose of study of the OHT is to design and analysis safe OHT, where in the damage to the structure and its structural components even by natural hazard such as earthquake can be minimized. Indian standard for the design of liquid retaining structures have been revised in 2009. This revised edition Incorporated limits state design method. Limit state design method for water retaining structure was not adopted so far as liquid retaining structure should be crack free. Thestudy incorporates considerations for water demand, population growth, water source availability, and safety regulations to design a tank with adequate storage capacity. The designprocess begins with a thorough assessment of the complex's water consumption patterns, accounting for peak demand periods and water usage variations. Subsequently, engineering principles are applied to calculate the required storage volume to meet the complex's daily water demands. To ensure structural integrity and longevity, detailed analysis and simulationsare conducted using computer-aided design (CAD) software and design is to be executed in STAAD.Pro software. Factors such as tank material, thickness, and reinforcement mechanisms are analysed to withstand external forces, including wind, seismic activity, and water pressure.The developed water tank model offers a reliable and sustainable solution to optimize water storage and distribution, ensuring uninterrupted water supply while promoting environmental responsibility.*

Index Terms - ***Overhead water tank, residential complex, sustainable design, structural analysis, water demand, AutoCAD, STAAD.Pro.***

I. INTRODUCTION

The primary purpose of an overhead tank is to store water for domestic, commercial, or industrial use. It ensures a continuous and reliable water supply even during fluctuations in water pressure or interruptions in the water supply system. An overhead water tank is a crucial component of a residential complex's water supply system,providing a reliable and sufficient source of water for various domestic and sanitation needs. Proper design and analysis of such a water tank are essential to ensure its structural integrity, functionality, and safety. This study focuses on the design and analysis of an overhead water tank for a residential complex, taking into consideration factors such as capacity requirements, structural considerations, hydraulic performance, and environmental sustainability. In denselypopulated urban areas, residential complexes often face challenges related to water supply anddistribution. An overhead water tank addresses these challenges by storing water at an elevatedheight, allowing for gravity-driven distribution to individual units within the complex. This eliminates the need for complex pumping systems and ensures a steady and reliable supply ofwater. The primary purpose of an overhead water tank in a residential complex is to store and distribute water under the influence of gravity. This eliminates the need for complex pumpingsystems, reducing operational complexities and energy consumption. The design process begins with a thorough assessment of the water requirements of the complex, considering factors such as the number of occupants, water usage patterns, and potential future expansion.This assessment forms the foundation for determining the appropriate storage capacity of the overhead water tank, ensuring an uninterrupted water supply to the residents.

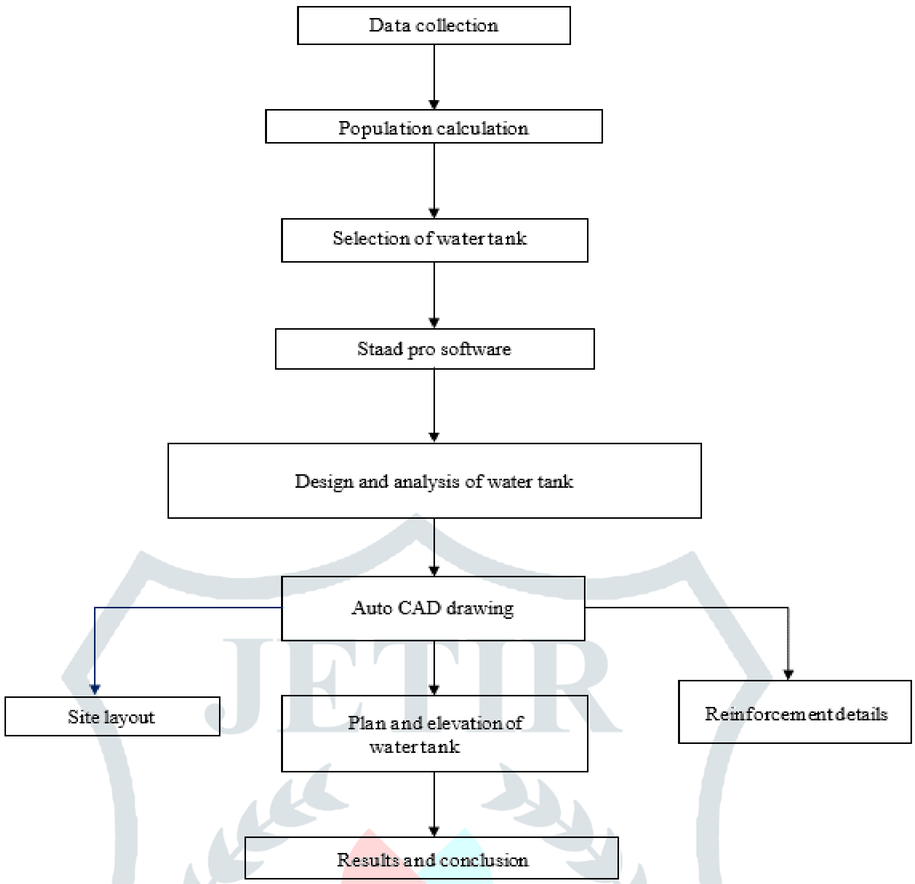
II. LITERATURE REVIEW

R. Bhaskar Reddy, V. Jyotsna Kalpana et al (2023) design an automatic cleaning mechanism for domestic overhead water tank. To achieve this, the tank is designed in such a way that the cleaning can be done both in manual and automatic ways. By keeping this view, that the fabricated material of the present overhead tank also shoots a vital effect to the people'slives in their habitual things. In order to eliminate those adverse effects, the material is alteredalong with the design alteration. Thus gives the healthy aspects for an overhead water tank to use in all daily chores. To assure the properties of polyethylene and S2 glass fibres are taken, then it undergoes a series of analysis like static, modal and dynamic. So, that S2 glass fibre is a useful material for the tank when compared with polyethylene in the storage of water.

Ugwuoke, Ikechukwu Celestine et al (2023) focused on mechanical services design of an estate with a single overhead water supply. The residential development has twenty dwelling units and consists of two housing prototypes of a four-unit five-bedroom detached house withone room servant's quarter and sixteen units four-bedroom semi-detached house with one roomservant's quarters. The estate shall be provided with a swimming pool, a gymnasium room, store, shops, car park, and children playing ground. The total floor area of the estate is 8512m2. The mechanical services covered in this work include, air-conditioning, ventilation and extraction system, hot and cold-water distribution, water storage tanks, water transfer pump set, borehole and water treatment plant, sanitary plumbing, soil and waste disposal, sewage treatment plant and firefighting. The total cooling load estimated for the estate is 35.7kW and water storage requirement was 44928litres and the estimated BOD (Biochemical Oxygen Demand) and flow rate for the sewage treatment plants are 14.1kg/BOD/day and 112.3m3/day.

Anas Ali, Mahfuzur Rahman (2023) introduced a novel design and development of an automated water tank filling system. The system effectively regulates the operation of a waterpump by monitoring the water level in a roof-top tank. Key considerations in the design includeaddressing power outages during pump operation, accommodating different tank dimensions, recording water consumption and implementing preventive measures against dry running of the pump. The installation and maintenance of the system are straightforward. The implemented system demonstrates successful control over the pump' s operation, meeting the demands of household water usage. The experimental trial validates the practicality and effectiveness of the proposed design in efficient water resource management.

III. METHODOLOGY



IV. DESIGN OF INTAZE TANK

Design data

The design data considered

Population calculation

Table: The table presents the projection of population

year	Population decadal		Incremental	Rate of growth
	(souls)	(Increment)		
1980	383	-	-	-
1990	869	486	-	1.26
2000	1254	385	(-) 99	0.44
2010	1968	714	(+) 329	0.57
2020	2836	868	(+) 154	0.44
Total		2453	384	
Average		x = 614	128	rg = 0.67

4.1 dimensions of tank

Steel = Fe 415 Concrete grade = M30

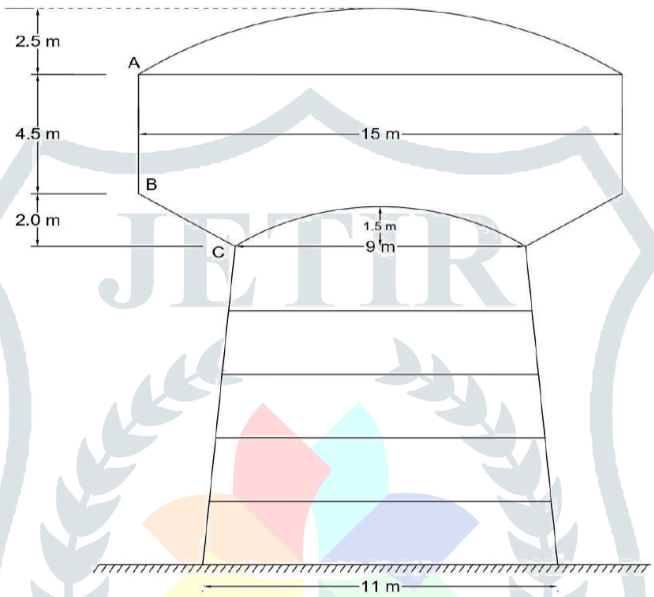
Diameter of tank (D) = 15 m

Diameter of lower Ring Beam (D_0) = 15 × 0.6 = 9m Rise of top dome (h_1) = 2.5m

Rise of bottom dome (h_2) = 1.5m

Height of conical dome (h_0) = 2m

h = 4.5 m



4.2 Design of top dome

Provide a thickness of 150 mm for the roof dome

Let 2θ be the angle subtended by the dome of its centre

These stresses are very small . Provide nominal reinforcement

∴ Provide nominal reinforcement (0.3%)

$$\therefore \quad Ast = \frac{0.30}{100} \times 1000 \times 150 = 450\ mm^2$$

∴ Provide 8 mm ϕ @ 110 mm c/c

4.3 Ring beam at top

Horizontal component of $T_1 = T_1 \cos\theta$

Provide 6 bars 18 mm diameter (1526 mm^2)

Provide 350 mm × 400 mm section.

∴ Provide 8 φ– 2 legged vertical stirrups @ 250 mm $^{c}/_{c}$

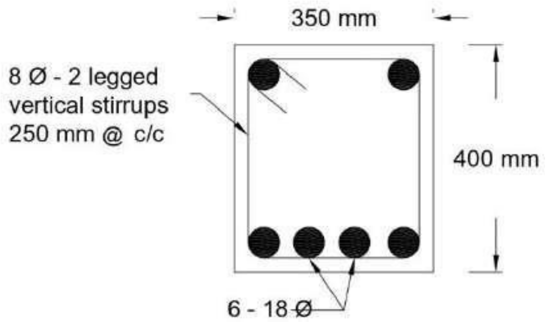
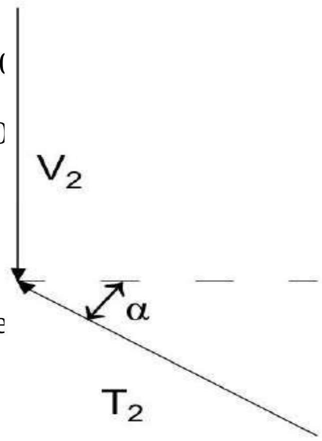


Fig: Ring beam at top

4.4 Cylindrical wall



Pressure intensity at the bottom of cylindrical wall = 4 × 1(

= 40000

Provide 12 mm φ bars @ 110 mm centers near each face

Thickness of wall = 300mm

Provide 8 mm φ bars @ 100 mm centers near each face

This stress being low profile nominal vertical stress at 0.3 % gross area

Provide of 8 mm φ bars @ 100 mm c/c near each face.

4.5 Ring beam bottom

Let T_2 be the thrust per meter run exerted by the conical slab at the junction B.

Let the ring beam be 1000mm deep.

Provide 14 bars of 24 mm diameter.

A= 696840 mm^2

Provide,750 mm × 950 mm section

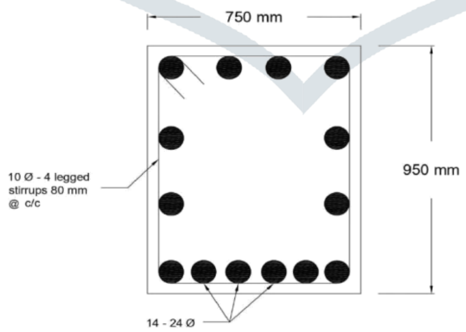


Fig. Ring beam at bottom dome

4.6 Design of conical slab

The Conical slab should be designed for

a) Hoop tension
b) Bending as it spans on a sloping slab from the ring beam at ̔B̓ at the ring girder at ̔C̓.

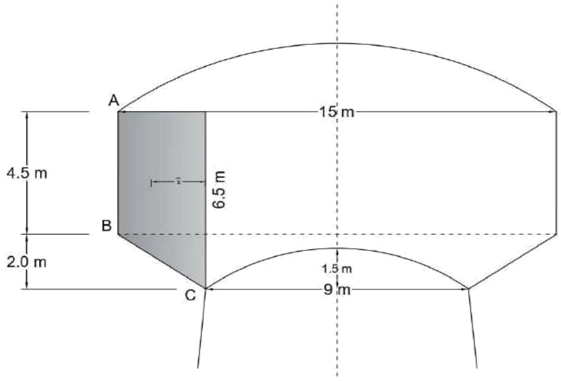


Fig : Design of the dome section

Thickness of sloping slab = 300 mm.

Provide 35 bars of 20 mm diameter

These bars may be distributed near both the faces of conical slab

4.7 The bottom dome

Span of the dome = 9 m

Rise of the dome = 1.5 m

Thickness of dome = 300 mm

These stresses are low and hence provide nominal 0.3% steel.

∴ Provide 8 mm bars @ 100 mm spacing

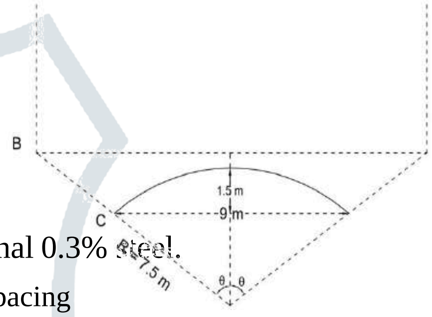


Fig: details of bottom dome

4.8 Circuler girder

Total load = 14108730 N

Maximum shear stress $\tau_{max} > \tau_v$

$\tau_{max} = 2.2\ N/mm^2$ (for M30 concrete)

∴ Hence safe.

Longitudinal reinforcement

$M_e = M + M_1$

∴ Provide 12 bars of 20 mm Ø (3770 mm^2)

Transverse reinforcement

Provide 80mm steel for sagging moment

Provide 6 bars of 18 mm diameter

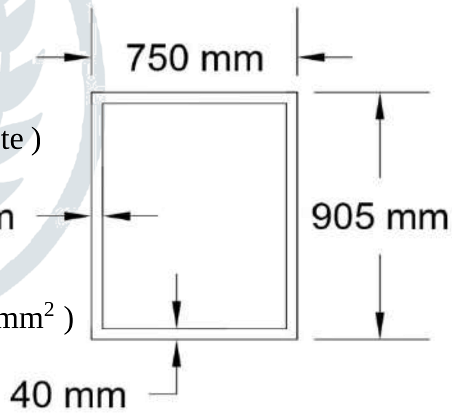


Fig: circular girder

A_{st}= 1527 mm^2

4.9 Columns

Columns should be designed for direct loads coming upon them and for Bending moments caused by wind load.

$$\text{Vertical load on one column at top} = \frac{14108730}{8} = 1763592\ N.$$

Let α be the inclination of the column with the vertical.

Provide 7 bars of 20mm diameter = 2199 mm^2

(More steel has been subjected since the column is subjected to bending moment caused bywind load)

Provide 9 bars of 20 mm diameter at an effective cover of 50 mm.

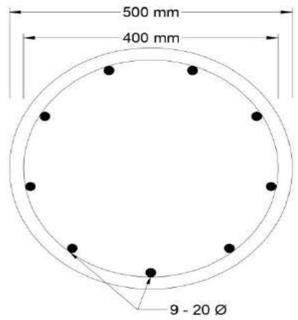


Fig: Details of column section

4.10 Design of foundation

Total load on the columns when the tank is full = 14640112

Approximate weight of foundation (10% of column load) = 1464011.2 N

Total loads = 16104123 N

Safe bearing capacity = 112.815 KN/m^2

Let us provide 16m outer dia. and 8m inner dia. for raft foundation.

Design at support section

Moment of resistance = Maximum bending moment at support0.913 bd^2 = 668321.5

bd^2 = 732006 × 1000

So, b = 750 mm and d = 1000 mm.

Effective depth = 1000 – 60 = 940 mm.

For M30 concrete, t_c max = 2.2 N/m^2

Longitudinal reinforcement

provide 14 bars of 20 mm Ø (4400 mm^2)

Transverse Reinforcement

Distance between centers of corner bars parallel to the width = b_1 = 750 – (2×40) = 670 mm.

Distance between centers of corner bars parallel to the depth = d_1 = 1000 – (2×40) = 920 mm.

Provide 6 bars of 20 mm Ø (1885 mm^2).

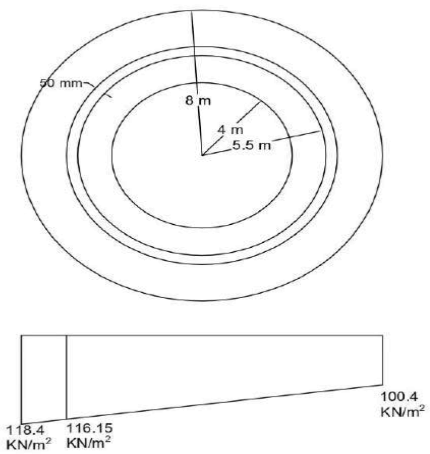


Fig: BM acting at the support section

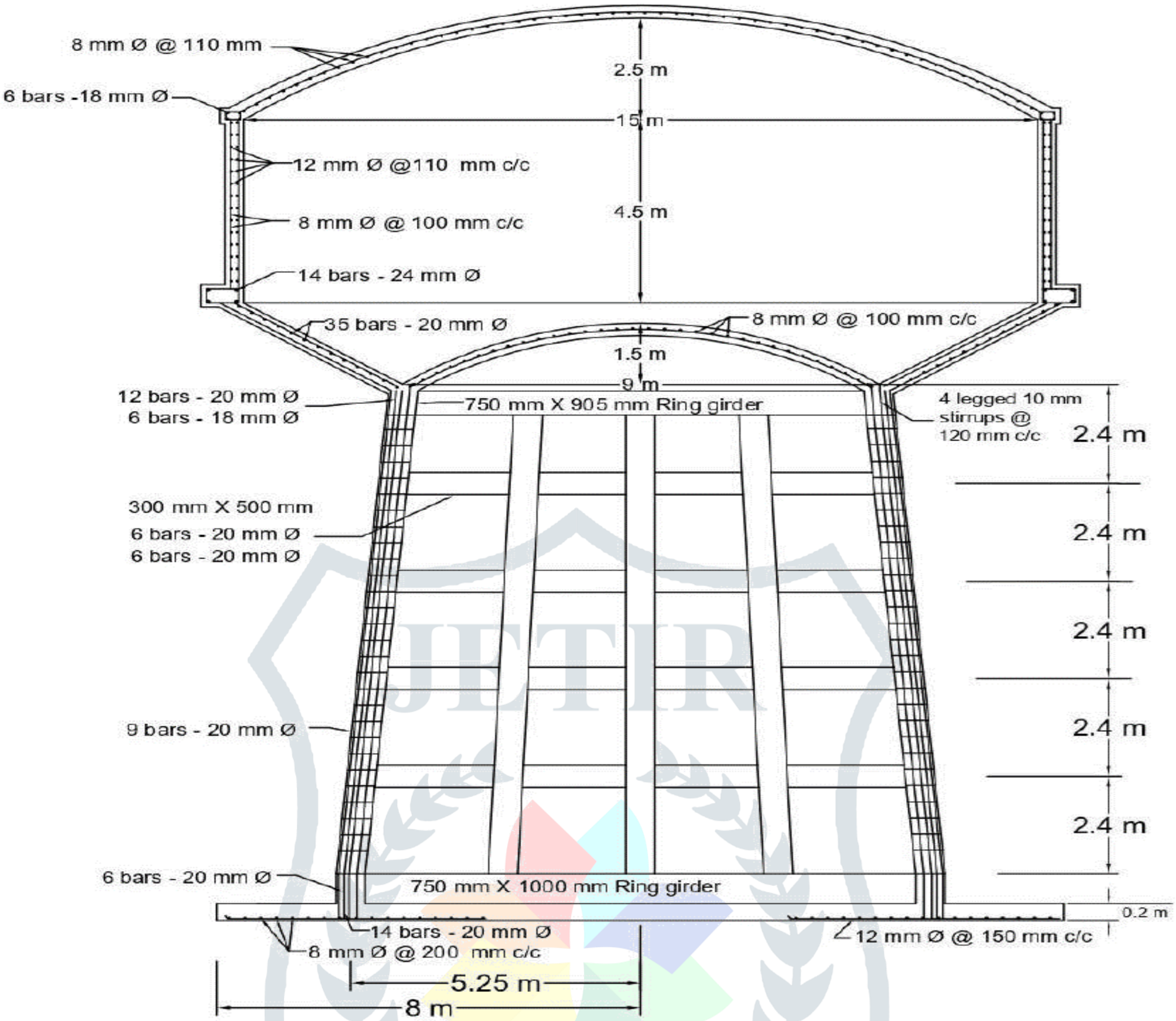


Fig: Details of reinforcement in intze tank

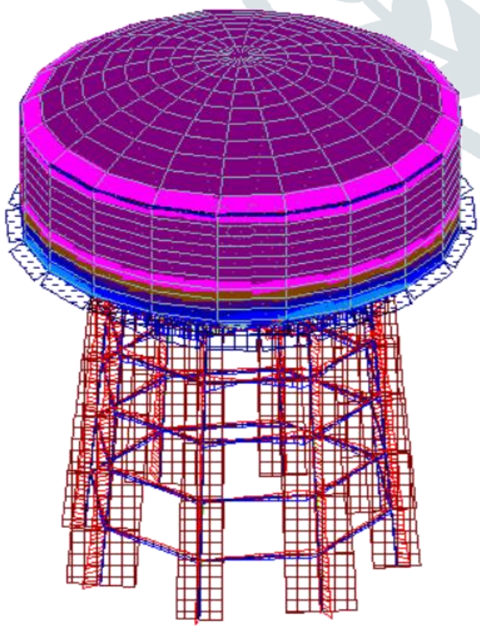


Fig: loading diagram

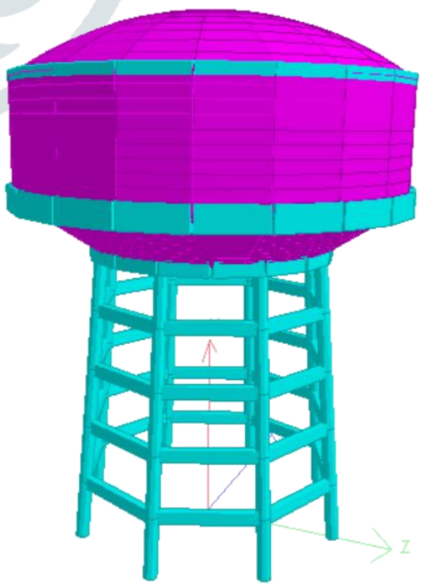


Fig: 3D rendering view

V. CONCLUSION

Storage of water in the form of tanks for drinking and washing purposes, swimming pools for exercise and enjoyment, and sewage sedimentation tanks are gaining increasing importance in the present-day life. For small capacities we go for rectangular water tanks, while for bigger capacities we provide circular water tanks. Intze tank is a modified circular tank. Intze tank is constructed to minimize the project cost because lower dome in this construction resists the horizontal thrust. Design of Intze water tank is a very tedious method. The whole structure is designed manually considering M30 grade concrete. Detailed drawings have been prepared in the AutoCAD software, which are shown in necessarily. The staging has been designed with maximum safety and effects due to seismicforce and wind force are also taken into account.

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