DESIGN AND ANALYSIS OF OVERHEAD WATER TANK

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ABSTRACT

The design and analysis of an above water container for households are critical to providing appropriate water supply and distribution. The research examines the structural and hydraulic aspects of building such tanks to meet home water supply demands while maintaining structural integrity and safety. The structural design comprises establishing the tank's measurements, materials, and reinforcement to handle different loads such as live and dead loads, and earthquake forces. FEA (Finite Element Analysis) methods are used to evaluate the performance of structures and enhance designs for efficiency and durability. On the hydraulics side, the research involves evaluating a tank's needed volume depending on the need for water, population serviced, and service frequency. Hydraulic modelling methods are applied to Adapt the storage tank's inlet and outlet layouts to ensure that water is filled and distributed efficiently to the residences. In addition, ecological considerations like collecting rainwater as well as sustainability are incorporated into the process of design to optimize resource use while minimizing the environmental impact. This study seeks to give a thorough knowledge of the design and analysis procedure for above water tanks, allowing engineers and designers to create efficient and environmentally friendly water storage solutions for residential structures.

KEY WORDS: *FEA (FINETE ELEMENT ANALYSIS), LIMITE STATE METHOD, HYDRAULIC MODELING.*

1. Introduction

Water tanks are liquid storage containers. These containers are commonly used to store water for human use, irrigation, fire, agricultural cultivation, chemical manufacture, food preparation, rainfall gathering, and a variety of other applications. Water is an important part of everyday living; hence water storage is vital. The primary goals of water tank design are to offer safe drinkable water after extended periods of storage while also optimizing cost strength, service life, and performance during exceptional situations such as earthquakes. The other objectives are to keep the water's pH stable and to inhibit microbial growth. Water is vulnerable to a variety of environmental unfavorable affects, including bacteria, viruses, algae, pH changes, and mineral accumulated gas. A design. Water tank specifications include the tank's overall design as well as the construction materials and linings used. The design of reinforced concrete water tanks is based on the IS code. The design is determined by the tank's placement, such as above, ground, or underground water tanks. Tanks can be manufactured from RCC or steel. Overhead tanks are typically lifted from ground level using a series of columns and beams. The underground tanks, on the other hand, are located below ground level.

2. Related Works and Literature Survey

1.Sagar Mhamunkar, Mayur Satkar, Dipesh Pulaskar, Nikhil Khairnar, Reetika Sharan, Reshma Shaikh ‘’ Design and Analysis of Overhead Water Tank at Phule Nagar, Ambernath’’

In India, about 68% of the total population lives in rural areas. Domestic water is a big issue in this area. To address this, novel design and solutions are needed. Research of Elevated Storage Reservoirs (ESR) is in underway. In this publication, an elevated circular water tank with a flat bottom requires significant reinforcement at the ring beam. Providing a conical and spherical bottom minimizes strains in the ring beams.

3. OBJECTIVES

1. Analysing the need for water and consumption patterns to estimate an overhead tank capacity.
2. To Ensure that the tank's structure can handle weight from water, winds, earthquakes.
3. Select elements for building according to strength, affordability, and ability to withstand corrode.
4. Performing hydrological computations to guarantee appropriate supply of water at a sufficient pressure as well as flow rate.

3.1 KEY COMPONENTS AND TASKS

The second step of our project is literature survey which is an essential component of study design, offering an in-depth analysis of existing information and research findings on an overhead water tank. A literature survey allows researchers to identify the demerits and merits in current knowledge and situate their work within the larger academic landscape. Furthermore, it assists researchers in avoiding duplication of efforts by identifying what has previously been investigated and what regions require further investigation. Overall, doing a thorough literature review is important for research activities, as well as increasing the credibility and significance of scholarly contributions. Some major key points taken from doing literature survey are:

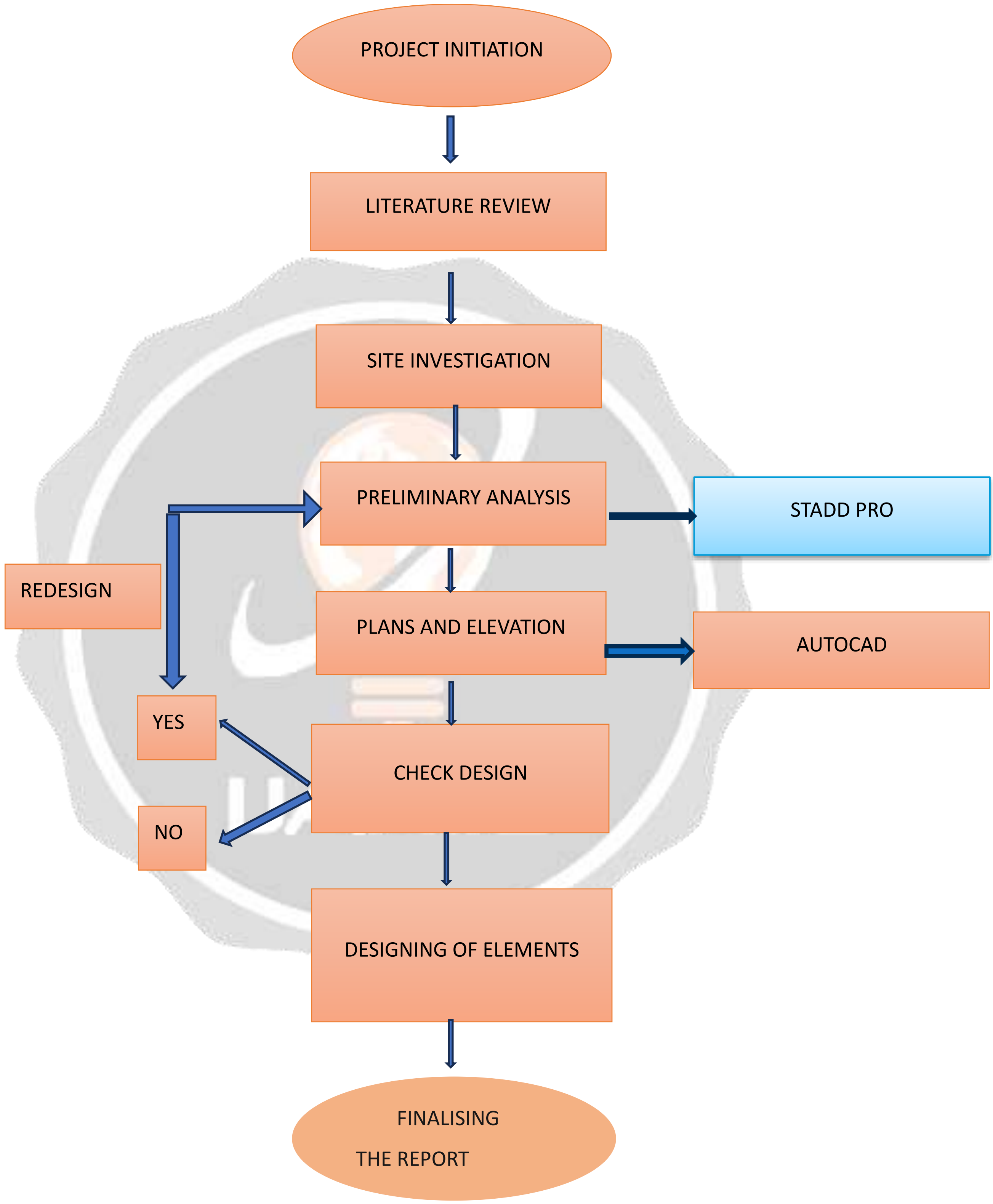
In India more than 68% of its total population lives in rural area. Domestic water is major problem in this area, so as to solve this problem innovative design and solutions to existing problem is essential hence for that study of Elevated Storage Reservoir (ESR) is undertaking. The Elevated circular water tank with large capacity and flat bottom needs large reinforcement at the ring beam, to overcome this in intze tank, by providing a conical bottom and another spherical bottom reduces the stresses in ring beams. Water is the most essential component of all life on Earth. It accounts for around 71.4 percent of the earth's surface. It is the most prevalent chemical in the human body. In a city of 20,000 inhabitants, the average daily water use is 200 liters.

This work comprises the documentation of comparative analysis of different design models of overhead storage steel tanks (30,000 liters) capacity and 6m height.

This research study comparative analysis of different design models of overhead storage steel tank (30,000 liter’s) capacity was carried with the aim to further improve in the design for structural steel works. Circular overhead water tank used for larger storage capacities up to 750000 litres and the height of tank will be provided up to 3 to 4.5m and diameter will be up to 5 to 15m. The study is carried out for finding circular and rectangular overhead water tank difference for the different parameters.

3.2 METHODOLOGY

3.2: METHODOLOGY:



3.2.1: Project Initiation:

The start of a project is a critical phase that lays the groundwork for its effective conclusion, involving designing the project. It includes the defining of the task's subject matter, objectives, dimension, participants, and preliminary planning. This article gives an in-depth account of the process of starting a project for field deployment. Studying the benefits and drawbacks for an overhead water tank could help enhance the tanks's quality. Effective preparation at the start of the project is critical to minimizing both financial and time loss. Proper planning in the design and analysis of overhead tanks promotes structural integrity, optimal capacity, efficient water distribution, and economical efficiency. This also contributes to increased safety and durability.

3.2.2: Literature and Survey:

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3.2.3: Site investigation:

An important stage in the design and analysis of an overhead water tank is site study. It includes getting data identifying the site's characteristics that may have an impact on the stability of the structure and functionality of the tank. The following are some crucial elements of an overhead water tank site investigation. At first to know the geography the site and slope and elevation which can affect the design of the tank's support structure and the choice of building materials. After that Soil qualities are being investigated to determine the soil's load bearing capability, settling features, including susceptibility to the liquefaction which are essential for building a base that will hold the total weight in the tank. Seismic activity needs to be evaluated when constructing the tank's supporting structure, and seismic stresses in regions susceptible to earthquakes must be considered.

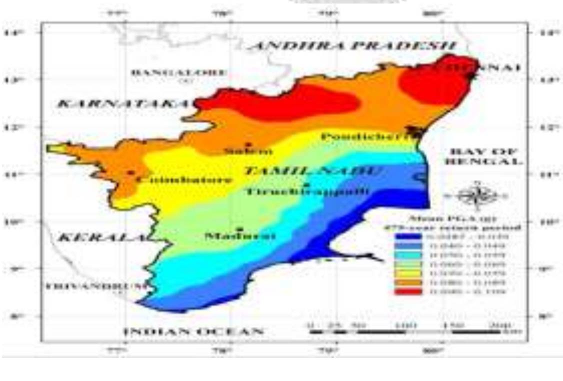

Figure 3.1: Earthquake zones in India

Soil evaluation needs to be performed by collecting samples of soil from various levels on-site and analysing them in a laboratory in order to identify soil properties like load bearing capacity, compression, permeability, and settle potential.

Table 3.1: Soil bearing capacity

Soil Type	Allowable Bearing Capacity
Rock	3240
Soft Rock	440
Course Sand	440
Medium Sand	245
Fine Sand	440
Stiff Sand	100
Soft Clay	100
Very Soft Clay	50

3.2.3: Preliminary analysis:

STAAD Pro is a helpful software for conducting preliminary research as well as planning for overhead water tanks. It allows you to simulate the tank's structure, includes the tank supports columns, and the basis and investigate how it behaves under different loads like dead load,

weight on its own, hydrostatic pressure induced by fluid, and wind load. The study confirms that the container can safely handle these loads. satisfies the design requirements. A preliminary analysis using STAAD Pro for the design and evaluation of an overhead water tank comprises many essential steps. To get started, input the container's structural data, including its dimensions, material attributes, and load conditions, which involve dead loads from the building itself, live loads from water, and any additional loads like as wind or earthquake forces. STAAD Pro then applies the technique of finite element analysis to calculate stresses, deformations, and stability under various loading scenarios. Utilizing these understandings, continuously change the layout to ensure sure the tank meets safety, functionality, and regulatory requirements. STAAD Pro also offers visualization features for analyzing the behavior of structures as well as recognizing possible design improvements. This full program enables speedy and exact design variations, resulting in an affordable overhead water storage structure.

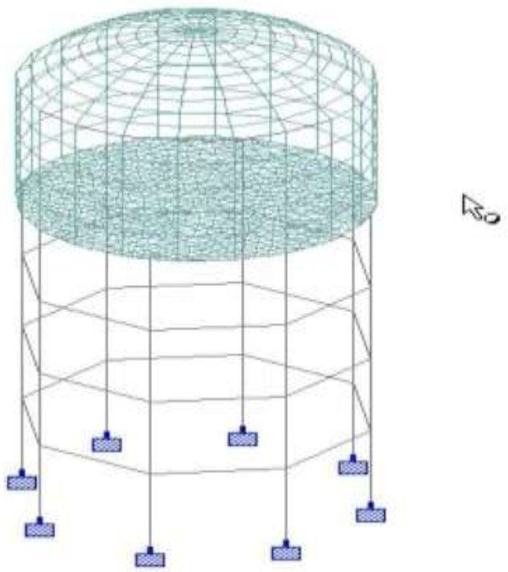

Figure 3.2: Overhead water tank

3.2.4: Plans and elevation:

For the purpose to ensure sure the tank's strength, performance, and effectiveness, a variety of processes must be followed in the design and research for an overhead water tank utilizing AutoCAD.Strong features of AutoCAD facilitate the generation of complicated drawings and elevations, hence streamlining the entire process from conception to construction. The first step is to create a design in accordance with the requirements of the site, the required capacity, and any applicable rules. Utilizing AutoCAD, designers can create preliminary plans and sketches that help them visualize the shape, size, and elevation of the tank in relation to the surrounding landscape. Once the fundamental plan is finished, detailed plans and elevations are produced using AutoCAD's modeling tools. Designs often comprise floor drawings, sections, and elevations; these provide comprehensive documentation of the geometry, dimensions, and structural components of the tank. Floor plans display the tank's size which includes the walls, columns and and other interior components like baffles, walls, & inlet/outlet pipes as well as places of entry. Elevations show off the construction details and final touches while giving a comprehensive view of the tank's outside. The method of design needs to include structural evaluation to ensure both the safety and stability of the tank.Because AutoCAD integrates with analytical tools, engineers may simulate a variety of load scenarios, including water pressure, wind, and seismic activity. Through the examination of the tank's structural reaction to these loads, engineers may maximize it enhance the tank's design for withstanding external forces while reducing use of materials and building expenses.

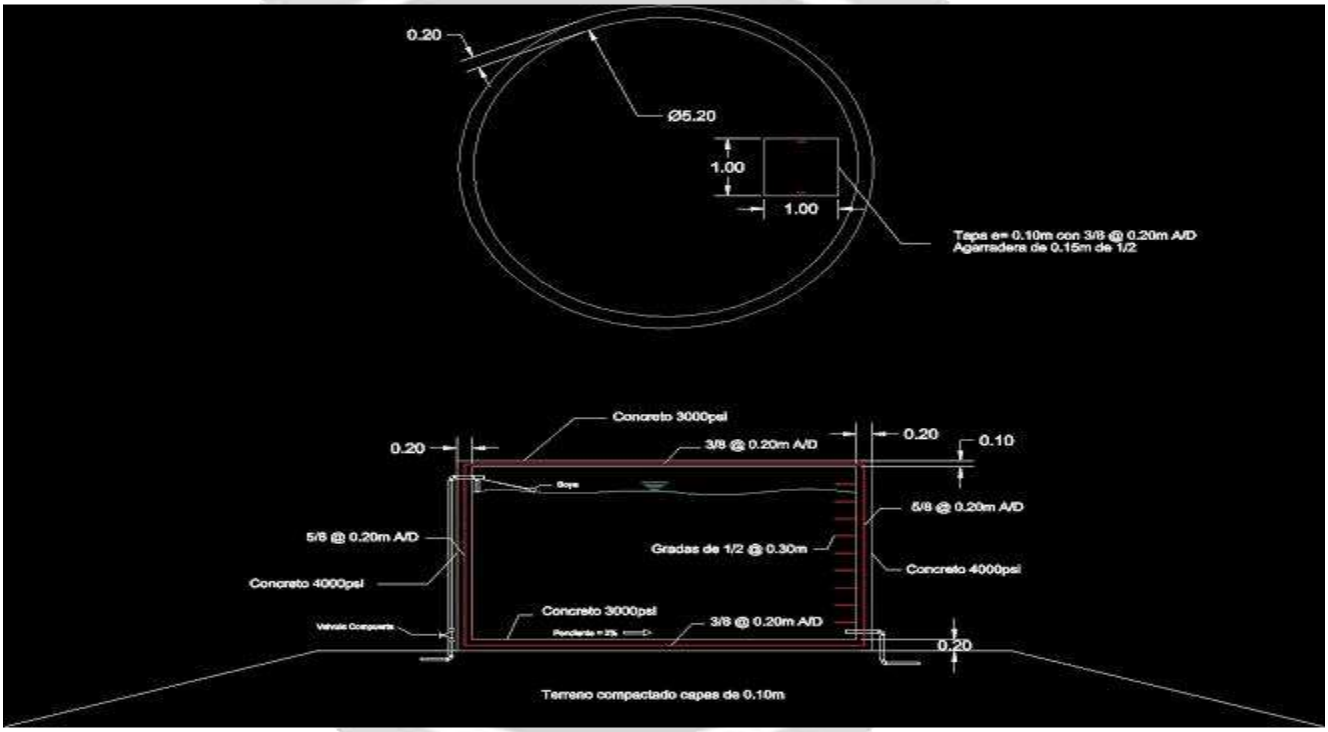

Figure 3.3: planning and elevation in CAD

3.2.5: Check design:

After completing the preliminary analysis using stadd pro software and plans and elevation using Auto cad then the next step is to check whether the structure can withstand the load acting on the tank, if it passes then we can design the other elements of the water tank but if the design doesn't withstand the load, then we should again start to redesign the structure using stadd pro.

As per code book IS3370/2009 part 1&2 some key points to check design are;

- The tank should be made of steel grade Fe 410 conforming to IS 226 or an equivalent standard.
- The design wind speed for the tank should be determined as per IS 875
- The tank must be designed to withstand seismic loads as per IS 1893
- The fire resistance rating of the tank should comply with relevant building codes.
- The steel plates used in the tank construction must have a minimum thickness of 5 mm.
- An opening large enough for inspection and cleaning purposes is required.

- The tank design should incorporate ventilation openings to prevent moisture accumulation.
- An overflow system must be included to prevent the tank from overtopping.
- To make thorough draining and cleaning simpler, the tank must to include a drain connection. For safe entry to the tank, ladders—both external and internal—are required.

Table 3.2: Permissible concrete stresses in calculations relating to resistance to cracking

Table 1 Permissible Concrete Stresses in Calculations Relating to Resistance to Cracking
[*Clauses* 4.5.1(c), 4.5.2.1 *and* 6.3(b)]

Sl No.	Grade of Concrete	Permissible Concrete Stresses, N/mm²	
		Direct Tension	Tension Due to Bending
(1)	(2)	(3)	(4)
i)	M25	1.3	1.8
ii)	M30	1.5	2.0
iii)	M35	1.6	2.2
iv)	M40	1.8	2.4
v)	M45	2.0	2.6
vi)	M50	2.1	2.8

NOTE — The maximum values of shear stress in concrete shall be as given in IS 456.

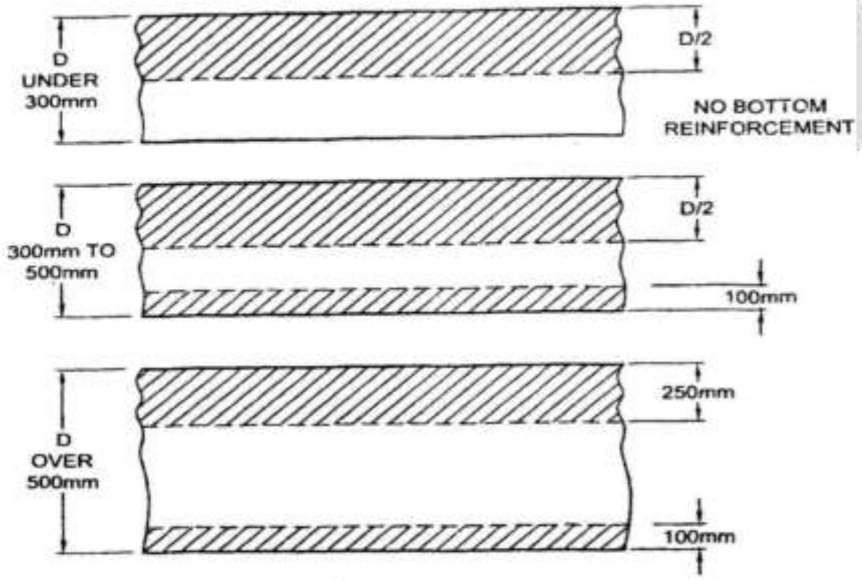

FIG. 2 SURFACE ZONES: GROUNDED SLABS

Figure 3.4: Surface zone; Grounded slabs

3.2.6: Designing of Elements:

6.1 Staircase:

- Determine the required dimensions and location of the staircase based on accessibility requirements and tank design.
- Design the staircase with appropriate rise and run dimensions according to building codes and safety standards.
- Select suitable materials for construction, considering factors such as durability, corrosion resistance,

and cost-effectiveness.
- Ensure proper reinforcement and anchorage to the tank structure to withstand loads and ensure stability.

3.2.6.2: Dome:

- Identify the dome's dimensions and shape based on load-bearing capacity and internal pressure.
- Select acceptable dome materials based on strength, weight, and resistance to weathering.
- Plan reinforcing methods to appropriately distribute loads and prevent structural failures.
- Provide access points and openings for repair and inspection while retaining structure integrity.

3.2.6.3: Tank wall:

- Establish the tank's wall's thickness & height according to pressure of water, ability, & the state of the soil.
- Choose appropriate construction materials, such as reinforced concrete or steel, based on durability, cost, and construction feasibility.
- Design reinforcing plans that can withstand bending, shear, and lateral stresses.
- Use weather proof to avoid leaks and provide long-lasting durability.

3.2.6.4: Floor slab:

- Find carrying load capacity and bending limitations to evaluate slab thickness and reinforcement required.
- Design the floor slab with appropriate reinforcing patterns to distribute loads evenly and prevent cracks.
- Provide expansion joints to prevent cracking during thermal motions.
- Ensure adequate curing and surface finishing to increase durability and reduce water permeability.

3.2.6.5: Base slab:

- Determine foundation slab size and thickness depending on the capacity of the soil and tank loading.
- Ensure the base slab has adequate reinforcement to distribute loads evenly and prevent settlement.
- Include soil type, groundwater level, and seismic activity in the design process.
- Implement proper drain and waterproof to avoid soil eroding and base slab corrosion.

3.2.6.6: Column footing:

- Choose the column footing depth and size based on foundation loads and soil bearing capabilities.
- Ensure column footings are reinforced to withstand bending and shear stresses.
- Consider settlement, uplift, and lateral stability while designing footings.
- Ensure correct drainage and backfilling around column footings to avoid water accumulation and soil erosion.

3.2.6.7: Brace beam:

- Determine the necessary stiffness as well as durability of brace beams according to lateral stresses and tank stability requirements.
- Design brace beams with proper cross-sectional dimensions and reinforcing to withstand bending and shear pressures.
- Ensure adequate anchorage and connection details for optimum load transmission between brace beams and tank construction.

4. PROPOSED WORK MODULES

As per code book IS3370/2009 part 1&2 some key points to check design are;

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5. RESULTS AND DISCUSSION

To summarize, designing and analyzing an overhead water tank is critical for assuring structural integrity, water safety, and effective distribution. Engineers can build a strong design that meets both functional and safety standards by taking into account material selection, load calculations, seismic concerns, and hydraulic analysis. Continuous monitoring and maintenance are required to ensure long-term functioning and to address any possible issues swiftly. Finally, a well-designed and thoroughly evaluated above water tank helps to promote sustainable water management and community well-being. The case study design of elevated overhead water reservoir is undeniably the most common type of steel structure in South East Nigeria.

The structural design of elevated steel water reservoir structure for safety and economic should be well understood by students of Civil Engineering. This will help them to become expert to meet the demand challenges for most economical design and use of steel section at their ultimate state. Also, the overhead storage tank is a very important structure in the communities of which its failure in service can create unnecessary inconveniences to the people. It is therefore imperative for storage tanks to be designed and strictly checked by only registered and competent engineers who have the relevant experience needed for the design and construction of such structures. It is also recommended that other methods of analysis could also be employed to facilitate comparison and appraisal to the one adopted in this study.

6.2 Suggestion For Future Work:

Future work in the design and analysis of overhead water tanks opens up exciting avenues for research and development, which is critical for improving efficiency, sustainability, and resilience in water supply systems.

• Utilizing innovative materials and building techniques can enhance tank performance and lifetime. For example, studying the use of innovative composites or reinforced concrete formulations could lead to tanks that are more durable and require less maintenance. Incorporating sensors and IoT technology into tank design allows for continuous monitoring of water levels, structural strength, and environmental conditions, facilitating preventative maintenance and risk-control measures. Furthermore, climate change and urbanization present severe hazards to water infrastructure. Future study should concentrate on developing studies to create resilient tank designs that can endure extreme weather events such as flooding, storms, and seismic activity.

• Using green infrastructures like as rainwater collecting systems or vegetated roofs Incorporating tank structures not only enhances sustainability, but also aids stormwater management and urban greening efforts.

• Advanced computer modelling and simulation techniques have significant promise to enhance tank design and performance. Computational fluid dynamics (CFD) models, for example, can provide helpful insights into circulation patterns, mixing productivity, and the water's condition within the tank, enabling for the creation of improved distribution systems and wastewater treatment procedures. Similarly, finite element analysis (FEA) can be utilized to evaluate structural integrity under different loading circumstances, which aids in the optimization of tank shape and reinforcement strategies In along with developments in technology, future study should consider factors like socioeconomic status and community demands when constructing and managing water tanks.

• Collaborating with groups of people from diverse backgrounds can lead to more inclusive and context-sensitive solutions to region water challenges, while also promoting community engagement and ownership. Furthermore, researching various finance models and governance structures for water infrastructure projects may aid in overcoming economic barriers while assuring long-term viability and efficiency.

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