Minor Project - Report on

Design of a rectangular RCC underground water tank using MS Excel

In Partial Fulfilment of the requirements for the degree of

Bachelor of Technology

In

Civil Engineering

Submitted by:

Divyansh Shivhare	211111019
Anushka Thakur	211111027
Riya Katiyar	211111048
Divyansh Tiwari	211111228

Under the Guidance of

Dr. P.K. Jain Sir

Professor

Department of Civil Engineering
Maulana Azad National Institute of Technology, Bhopal

April 2024

MAULANA AZAD

NATIONAL INSTITUTE OF TECHNOLOGY - BHOPAL

INDIA 462003

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE

This is to certify that the project report entitled **“Design of a rectangular RCC underground water tank using MS Excel”** was carried out by the following students:

Divyansh Shivhare	211111019
Anushka Thakur	211111027
Riya Katiyar	211111048
Divyansh Tiwari	211111228

They have successfully completed their project in partial fulfillment of their Degree in Bachelor of Technology in Civil Engineering under my guidance and supervision.

Dr. P.K. Jain
(Project Mentor)

DECLARATION

We, hereby declare that the following report which is being presented in the Minor - Project documentation entitled as “Design of a rectangular RCC underground water tank using MS Excel” is an authentic documentation of our own original work, to the best of our knowledge. The following project and its report, in part or whole, has not been submitted by us or anybody else, for any purpose, in any institute or organization. Any contribution made to the research by others, with whom we have worked at Maulana Azad National Institute of Technology, Bhopal or elsewhere, is explicitly acknowledged in the report.

Divyansh Shivhare	211111019
Anushka Thakur	211111027
Riya Katiyar	211111048
Divyansh Tiwari	211111228

ACKNOWLEDGEMENTS

We extend our deepest gratitude to Maulana Azad National Institute of Technology for their unwavering support throughout the duration of this project. Their provision of resources, facilities, and expertise has been instrumental in the successful completion of this endeavor.

We would like to express our sincere appreciation to Dr. P.K Jain sir for their guidance and encouragement, which has significantly contributed to the accomplishment of our goals.

Furthermore, we are grateful to Dr. S.K Dubey sir for their invaluable assistance and cooperation at every stage of this project. Their professionalism and dedication have been indispensable in overcoming challenges and achieving milestone

ABSTRACT

This project focuses on designing a rectangular underground RCC water tank using Excel to ensure water safety, durability, and space utilization. By comparing theoretical and program values, it emphasizes safety margins in design. The project begins with comprehensive research into design considerations, material properties, and construction requirements. Leveraging Excel, it develops a user-friendly program to automate calculations, incorporating key design parameters and standards from IS and ASTM. Validation of the Excel program involves comparing theoretical and program-generated values, emphasizing safety margins. This project contributes to enhancing the efficiency and reliability of underground RCC water tank design by facilitating accurate and systematic design processes through Excel utilization.

यह परियोजना जल सुरक्षा, स्थायित्व और स्थान के उपयोग को सुनिश्चित करने के लिए एक्सेल का उपयोग करके एक आयताकार भूमिगत आरसीसी पानी की टंकी को डिजाइन करने पर केंद्रित है। सैद्धांतिक और कार्यक्रम मूल्यों की तुलना करके, यह डिजाइन में सुरक्षा मार्जिन पर जोर देता है। यह परियोजना डिज़ाइन संबंधी विचारों, भौतिक गुणों और निर्माण आवश्यकताओं पर व्यापक शोध के साथ शुरू होती है। एक्सेल का लाभ उठाते हुए, यह आईएस और एएसटीएम से प्रमुख डिजाइन मापदंडों और मानकों को शामिल करते हुए, गणनाओं को स्वचालित करने के लिए एक उपयोगकर्ता-अनुकूल कार्यक्रम विकसित करता है। एक्सेल प्रोग्राम के सत्यापन में सुरक्षा मार्जिन पर जोर देते हुए सैद्धांतिक और प्रोग्राम-जनित मूल्यों की तुलना करना शामिल है। यह परियोजना एक्सेल उपयोग के माध्यम से सटीक और व्यवस्थित डिजाइन प्रक्रियाओं को सुविधाजनक बनाकर भूमिगत आरसीसी जल टैंक डिजाइन की दक्षता और विश्वसनीयता बढ़ाने में योगदान देती है।

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background:

Water is one of the most vital resources for sustaining life on Earth. It is essential for various purposes, including drinking, agriculture, and industrial use. Adequate storage of water is crucial to ensure a consistent supply, especially in areas where water scarcity is a significant concern. One of the efficient methods for water storage is through the construction of underground water tanks. These tanks not only provide the necessary storage but also save space, making them suitable for both urban and rural areas.

1.2 Purpose of the Project:

The design of an underground water tank requires careful planning, especially in terms of strength, durability, and longevity. This project focuses on the design of a rectangular underground Reinforced Cement Concrete (RCC) water tank. The primary purpose is to create a robust and reliable structure that can withstand various loads and environmental factors. The tank is designed to ensure the safety and security of the stored water and to prevent any contamination.

1.3 Importance of the Project:

The design of a rectangular underground RCC water tank is crucial for several reasons:

- **Optimal Space Utilization:** Underground water tanks save surface space, making them ideal for both residential and commercial areas, especially in urban settings where space is limited.

- **Protection from Environmental Factors:** Being underground, the tank is protected from environmental factors such as sunlight, reducing the possibility of algae growth and ensuring the water remains clean.
- **Prevention of Contamination:** A properly designed underground water tank helps prevent contamination, ensuring the stored water is safe for consumption.
- **Longevity and Durability:** A well-designed RCC water tank can last for several years with minimal maintenance, providing a long-term solution for water storage needs.
- **Sustainability:** Efficient water storage promotes sustainable water management practices, which are becoming increasingly important in the face of climate change and population growth.

1.4 Objectives of the Project:

The primary objectives of this project are as follows:

- To develop excel program for the design of underground water tank to avoid the tedious calculations.

- To ensure the structural integrity and stability of the tank under various loads.

- To provide detailed construction drawings and guidelines for building the water tank.

2. LITERATURE REVIEW

2.1 Introduction

Underground Reinforced Concrete Cement (RCC) water tanks are essential infrastructural elements widely employed for water storage in residential, commercial, and industrial settings. Designing these tanks requires a comprehensive understanding of structural engineering principles and material behaviors under varying conditions. Recent advancements in computational tools, particularly Excel spreadsheets, have revolutionized the design process, rendering it more efficient and accurate. This literature review aims to explore existing knowledge and methodologies related to the design of underground RCC water tanks.

2.2 Design Considerations for Underground RCC Water Tanks

Designing underground RCC water tanks involves critical considerations to ensure durability, stability, and efficiency. The primary design factors include structural analysis, material properties, environmental conditions, and construction requirements.

2.3 Structural Analysis:

Structural analysis forms the cornerstone of underground RCC water tank design. The Finite Element Method (FEM) and Limit State Design (LSD) are widely used for this purpose. P.C. Varghese's "Limit State Design of Reinforced Concrete" offers a comprehensive explanation of LSD, providing a fundamental understanding of the method. Additionally, "Reinforced Concrete Structures" by N. Subramanian is a valuable resource, providing in-depth knowledge of various aspects, including analysis, design, and construction.

2.4 Material Properties:

Understanding the properties of materials used in RCC water tanks is crucial. A standard reference for concrete properties is "Properties of Concrete" by A.M. Neville. These resources serve as essential references for understanding the materials used in RCC water tank construction.

2.5 Environmental Conditions:

Environmental conditions, including soil properties and groundwater levels, significantly impact the design of underground water tanks. "Geotechnical Engineering" by C. Venkatramaiah provides a detailed explanation of soil mechanics, which is essential for understanding the interaction between the tank structure and the surrounding soil.

2.6 Construction Requirements:

The construction process plays a vital role in ensuring the structural integrity and longevity of the RCC water tank. "Reinforced Concrete: Mechanics and Design" by J. Wight and "Construction of Prestressed Concrete Structures" by Ben C. Gerwick Jr. are valuable resources that cover the construction aspects of RCC structures.

2.7 Integration of Excel in Underground RCC Water Tank Design

The integration of Excel spreadsheets in the design process has significantly enhanced the efficiency and accuracy of underground RCC water tank design. Various researchers and engineers have developed Excel-based tools, offering simplified design methodologies and allowing for a more streamlined and error-free design process.

2.8 Excel Spreadsheets for Material Properties:

Excel spreadsheets are also utilized for calculating material properties. "Concrete Mix Design Spreadsheet" by ACI Committee 211 simplifies the concrete mix design process, enabling engineers to optimize the mix for the specific requirements of the underground RCC water tank.

2.9 Advantages of Excel-Aided Design

The integration of Excel spreadsheets in the design of underground RCC water tanks offers several advantages:

2.9.1 **Efficiency:** Excel-based tools streamline the design process, reducing the time and effort required for calculations and analysis.

2.9.2 **Accuracy:** By eliminating manual calculations, Excel-based tools minimize the risk of errors, ensuring the accuracy of the design.

2.9.3 **Accessibility:** Excel spreadsheets are widely available and easy to use, making structural analysis and design accessible to a broader range of engineers.

2.9.4 **Flexibility:** Excel-based tools can be customized to suit specific design requirements, offering flexibility in the design process.

2.9.5 **Cost-Effectiveness:** Utilizing Excel spreadsheets reduces the need for expensive software, making it a cost-effective solution for engineers and design firms.

3. DESIGN REQUIREMENTS

3.1 Design Criteria for Rectangular Underground RCC Water Tank:

3.1.1 **Volume of Water (V):**

- Determine the required volume of water to be stored.

3.1.2 **Dimensions:**

Determine the length, width, and height (depth) of the tank.
The dimensions of the tank should be such that it accommodates the required volume of water.

3.1.3 **Depth (D):**

The depth of the tank is essential. A typical range is between 2 meters to 4 meters.

3.1.3 **Length (L):**

The length of the tank can be calculated using the formula:
$L=VW\times DL=W\times DV$ Where:
VV = Volume of water (m³)
WW = Width of the tank (m)
DD = Depth of the tank (m)

3.1.4 **Width (W):**

The width of the tank can be calculated using the formula:
$W=VL\times DW=L\times DV$ Where:
VV = Volume of water (m³)
LL = Length of the tank (m)
DD = Depth of the tank (m)

3.1.5 **Wall Thickness:**

The minimum thickness of the wall can be determined according to the structural requirements and the conditions of the soil. It's typically between 15cm to 30cm.

3.1.6 **Base Slab Thickness:**

The thickness of the base slab should be calculated based on soil bearing capacity and the tank's dimensions.

3.2 Material Properties:

3.2.1 **Reinforced Concrete:**

Concrete Grade: M25 to M40
Reinforcement Steel: Fe415 or Fe500

3.2.2 **Waterproofing:**

Use appropriate waterproofing materials to prevent water leakage.

3.3 Standards:

3.3.1 **Concrete:**

IS 456:2000: Code of practice for plain and reinforced concrete

IS 3370: 2009 (Part 1 & Part 2): Code of practice for concrete structures for the storage of liquids - Part 1: General requirements, Part 2: Reinforced concrete structures**.**

3.3.2 **Reinforcement:**

IS 1786: High strength deformed steel bars and wires for concrete reinforcement.

ASTM A615/A615M: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

3.4 Safety Considerations:

3.4.1 **Structural Integrity:**

Ensure the structural integrity of the tank to withstand the load it will bear. The structure should be designed to resist various loads, including the weight of water, soil, and any external loads.

3.4.2 **Waterproofing:**

Implement effective waterproofing measures to prevent leakage. Any leakages can weaken the structure and contaminate the surrounding soil.

3.4.3 **Soil Conditions:**

Conduct a thorough soil investigation to determine its bearing capacity and to prevent settlement issues.

3.4.4 **Reinforcement:**

Ensure that the reinforcement is properly placed and adequately covers all portions of the tank. This will provide the necessary strength to withstand internal and external forces.

3.4.5 **Quality Control:**

Implement strict quality control measures during construction to ensure that the materials used meet the required standards and specifications.

3.4.6 **Construction Supervision:**

Have the construction supervised by qualified engineers and follow the approved design drawings meticulously.

3.4.7 **Seismic Considerations:**

In seismic areas, the tank design should consider seismic forces and appropriate reinforcement detailing.

4. DESIGN METHODOLOGY

Tank size		**10.00**	**x**	**3.33**	**x**	**3.00**	m	
Tank capacity						**100000**	ltr	
Saturated unit weight of soil		17.00 kN/m^3				17000	N/m^3	
Concrete	**M**	**25.00**		**Unit weight of concrete**	=	25000	N/m^3	
Steel	f_y	**415** N/mm^2		**Tensile stess of steel**	=	150.00	N/mm^2	
	s_{cbc}	**7** N/mm^2		**m**	=	11.20		
Nominal cover		50 mm		**Unit weight of water**	=	9.80	N/mm^3	9800

Design Constants

For HYSD Bars — Concrete M = 25

s_{st} = 150 N/mm^2 — Weight of concrete = 25000 N/mm^2

s_{cbc} = 7 N/mm^2 — m = 11.20

$$k = \frac{m*\sigma_{cbc}}{m*\sigma_{cbc}+\sigma_{st}} = \frac{11.20 \times 7}{11.20 \times 7 + 150} = \mathbf{0.343}$$

$$j = 1 - \frac{k}{3} = 1 - 0.343 / 3 = \mathbf{0.886}$$

$$R = 0.5 \times 7 \times 0.886 \times 0.343 = \mathbf{1.064}$$

Determination of Bending Moment for horizontal bending

L / B = 10.00 / 3.33 = 3.00 > 2

The long wall will be designed as cantilever.

Here h = H/4 or 1 m whichever is greater \ **h = 1.00** m

Thus top 2.00 m height of walls will be bend horizontally while the bottom 1.00 m will bend as vertical cantilever . The bending moments for horizontal bending may be determined by moment distribution by considering tank as continuos frame of unit height at level of D.

Water pressure p at point D is given by =p= w (H - h) = 9800 (3.00 - 1.00)= **19600** N-m

The Fixed end moments for long wall $= \frac{PL^2}{12} = \frac{P \times 10.00^2}{12} =$ 8.33 P N-m

Fixed end moments for short wall $= \frac{PB^2}{12} = \frac{P \times 3.33^2}{12} =$ 0.93 P N-m

Refer fig 1. Consider quarter frame *FAE* with joint A rigid. Taking clock wise moment as positive and anticlock wise moment as negative, the fixed end moment M_{AF} for long wall will be + 8.33 P while the fixed end end moments M_{AF} for short wall will be - 0.93 P Considreing Area *A* and moment of inertia *I* for both the walls to be the same, the stiffness of walls will be inversely proportional to these length.

Thus, we have the following table

Member	Stiffness	Relative stiffness	Sum	Distribution factor
AE	$\frac{1}{3}$	$\frac{1}{3} \times 10.00 = 3.333$	8.333333333	$\frac{3.3333}{8.3333} = 0.4$
AF	$\frac{1}{2}$	$\frac{1}{2} \times 10.00 = 5$		$\frac{5}{8.3333} = 0.6$

The moment distribution is carried out in the table below.

Joint	A	
Member	*AE*	*AF*
Distribution factor	0.4	0.6
Fixed end moments	+ 8.33 p	- 0.93 p
Balancing moments	- 0.6666667 p	- 1 p
Final moments	+ 7.67 p	- 1.93 p

Hence moment at supports, Mf= 7.67 x 19600 = 150267 N-m/m

This support moment will cause tension at the water force.

B.M. at the center long span $= \frac{p L^2}{8} - Mf = \frac{19600 \times 10.00^2}{8} - 150267 = 94733$ N-m/m

This bending moment cause tension at outer face.

B.M. at the center short span $= \frac{p B^2}{8} - Mf = \frac{19600 \times 3.33^2}{8} - 150267 = -123045$ N-m/m

This will cause tension at the water face. \ Max. design B.M. = **94733** N-m/m

DESIGN OF SECTION Considering bending effect alone,

Required depth $= \sqrt{\dfrac{94733 \times 1000}{1.064 \times 1000}} = 298$ mm

Provide total depth T= 298 + 50 = **350** mm   So,that available depth = **300** mm

DETERMINATION OF PULLING FORCE

Direct tension on Long wall = $P_L = P \times B/2 =$ 19600 x 3.33 / 2 = **32666.66667** N

Direct tension on short wall = $P_L = P \times B/2 =$ 19600 x 10.00 / 2 = **98000** N

CANTILEVER MOMENT Cantilever moment at the base, per unit length .

$= wH \times \dfrac{h2}{6} = \dfrac{9800 \times 3.33 \times 1.00^2}{6}$ **5444** N-m

This will cause tension at water face.

REINFORCEMENT AT CORNERS OF LONG WALLS

The upper portion of long walls is subjected to both bending in horizontal direction as well as pull. The reinforcement for both will be in horizontal direction. Hence , reinforcement has to be provided for a net moment (M_F - Px), where M_f is the moment at ends (causing tension on water face). Similarly vertical section of unit height (1 m) of long wall, at its end, at the level of 1.00 m above the base , where reinforcement is provided at the water face.

$x = d - \dfrac{T}{2} = 298 - \dfrac{350}{2} = 123$ mm

A_{st} for B.M. $= \dfrac{Mf - Pl\,x}{s_{st}.j.d} = \dfrac{150267 \times 1000 - 32667 \times 123}{150 \times 0.886 \times 300} = 3668$ mm^2

A_{st} for pull $= \dfrac{PL}{s_s} = \dfrac{32666.667}{150} = 218$ mm^2

Total A_{st} = 3668 + 218 = **3886** mm^2 per meter height.

using 20 mm bars $A = \dfrac{3.14xdia^2}{4\,x100} = \dfrac{3.14 \times 20 \times 20}{4 \times 100} =$ **314** mm^2

Spacing of Bars = 1000 x 314 / 3886 = 81 say = 80 mm

Hence Provided **20** mm F bar, @ **80** mm c/c. The above reinforcement is to be provided at inner face, near the corners, and at a height **1.00** m above the base. For other height the above spacing may be varied, since bending moment will reduce.

REINFORCEMENT AT MIDDLE OF LONG WALL

Tension occurs at the outer face. However, since distance of corner of steel from water face will be less than 225 mm, permissible stress will be 150 N/mm^2 only. Design constants will be **k =** **0.34326** **j =** **0.8855809** **R =** **1.0639**

Design B.M. = 94733 N-m per meter height. Also P_L = 32666.66667 N

A_{st} for B.M. $= \dfrac{M - Pl\,x}{sst.j.d} = \dfrac{94733 \times 1000 - 32667 \times 123}{150 \times 0.886 \times 300} = 2276$ mm^2

A_{st} for pull $= \dfrac{PL}{s_s} = \dfrac{32666.667}{150} = 218$ mm^2

Total A_{st} = 2276 + 218 = **2494** mm^2 per meter height.

using 20 mm bars $A = \dfrac{3.14xdia^2}{4\,x100} = \dfrac{3.14 \times 20 \times 20}{4 \times 100} =$ **314** mm^2

Spacing of Bars = 1000 x 314 / 2494 = 126 say = 120 mm

This is very near to the reinforcement provided at ends.Hence provided **20** mm f bars **80** mm c/c. Bend half the bars provided at ends, outwards.at distance L/4 = **2.50** m form ends. This reinforcement is to be provided at outer face. The additional 20 mm f bars provided @ **160** mm c/c. are continued upto the end.

REINFORCEMENT FOR SHORT WALLS

Bending moment at the ends=M_f = 150267 N-m   Direct pull P_u= 98000 N

A_{st} for B.M. $= \dfrac{M - P_B\,x}{sst.j.d} = \dfrac{150267 \times 1000) - 98000 \times 123}{150 \times 0.886 \times 300} = 3468$ mm^2

A_{st} for pull $= \dfrac{PL}{s_s} = \dfrac{98000.00}{150} = 653$ mm^2

Total A_{st} = 3468 + 653 = **4121** mm^2 per meter height.

using 20 mm bars $A = \dfrac{3.14 \times diameter^2}{4\,x100} = \dfrac{3.14 \times 20 \times 20}{4 \times 100} =$ **314** mm^2

Spacing of Bars = 1000 x 314 / 4121 = 76 say = 70 mm

Hence, provide **20** mm f bars @ **70** mm c/c at inner face near the ends of short span. The B.M. at the center of short walls cause tension at water face (unlikethat in the center of long walls where tension is produced at outer face).since this B.M. is small, only nominal reinforcement is required. Similarlly, we have to provide nominal reinforcement at outer face,. Hence bend half bars outward at distance B/4 = 0.83 meter from each end, and continue remaning half throughout . Thus at the center of span, the reinforcement on each face will consist of 20 mm f bars @ **140** mm c/c.

REINFORCEMENT FOR CANTILEVER MOMENT AND DISTRIBUTION REINFORCEMENT

max. cantilever moment= **5444** N-m

$$A_{st} = \frac{5444 \times 1000}{150 \times 0.886 \times 300} = 137 \text{ mm}^2$$

But minimum reinforcement in vertical direction $= \frac{0.3}{100} \times (350 \times 1000) = 1050 \text{ mm}^2$

Since half of this area of steel can reist cantilever moment, we will provide = 525 mm^2 steel area vertically on the inner face and remaining area i.e.= 525 mm^2 vertically at outer face to serve as distribution reinforcement. \ Area of steel on each face = 525 mm^2.

using 12 mm bars $A = \frac{3.14\text{x diameter}^2}{4 \times 100} = \frac{3.14 \times 12 \times 12}{4 \times 100} =$ **113.0** mm^2

Spacing of Bars = 1000 x 113.0 / 525 = 215 say = 210 mm

Hence Provided **12** mm Ø bar, @ **210** mm c/c on out side face, at bottom of long wall

DESIGN OF BASE SLAB

Since tank rests underground on soil , provide a 250 mm thick base slab.
Taking 1m length for calculation and 0.20 % of nominal reinforcement

$$\text{area of steel} = \frac{0.20 \times 1000 \times 250}{100} = \mathbf{500} \text{ mm}^2$$

using 8 mm bars $A = \frac{3.14\text{xdia}^2}{4 \text{ x}100} = \frac{3.14 \times 8 \times 8}{4 \times 100} =$ **50.2** mm^2

Spacing of Bars = 1000 x 50.2 / 500 = 100 say = 100 mm

Hence Provided **8** mm Ø bar, @ **100** mm c/c in both direction , at top and bottom of base slab.

DESIGN OF ROOF SLAB

Since, L/B = 3.00 > 2 , top slab will be designed as one way slab.
Let live load on top slab be 2000 N/m^2 . Assuming a thickness of 20 cm including finishes etc, t = 200 mm
Self weight of slab = 0.2*1*25000 = 5000 N/m^2 . Total = 2000 + 5000 = 7000 N/m^2

$$\text{Bending moment} = \frac{wB^2}{8} = \frac{7000 * (3.33 + 0.35)^2}{8.00} = \mathbf{11871} \text{ N-m}$$

$$d = \sqrt{\frac{M}{R}} = \sqrt{\frac{11871.08}{1.064}} = 105.62683 \text{ mm} = \mathbf{105.63} \text{ mm}$$

Provide a total thickness of 120 mm. Keeping a clear cover of 25 mm and using 12 mm Ø bars, d= **89** mm.

$$A_{st} = \frac{11871.08 * 1000}{120 * 0.886 * 89} = 1254.54 \text{ mm}^2$$

using 12 mm bars $A = \frac{3.14 \text{ x dia}^2}{4 \text{ x } 100} = \frac{3.14 \times 12 \times 12}{4 \times 100} =$ **113.0** mm^2

Spacing between 12 mm Ø bars = 1000 * 113.0 / 1255 = 90.1046 mm = 100 mm

So, Provide **12** mm Ø bars @ **100** mm c/c spacing in the roof slab.

FACTOR OF SAFETY

Weight of water above base slab = 9800.00 * 100.00 = 980 * 10^3 N
Self weight of tank = Weight of walls + Weight of roof + Weight of slab

Weight of long wall = 52.50 * 10^3 N Weight of short wall = 17.5 * 10^3 N
Weight of roof = 16.6667 * 10^3 N Weight of Base Slab = 20.8 * 103 N

Self weight of tank = 107.50 * 10^3 N
Total weight of tank + water = **1088 * 10^3 N**

Force applied by water = 29400 N/m^2 Total uplift force = 29400 * (11.00 + 4.33) = **451 * 10^3 N**

Factor of Safety = 1088 / 451
= **2.412417**

Factor of Safety about **3** or greater should be adopted during the final design of water tank.

Considering Factor of safety is needed because, (1)Concrete may weigh less than 25000 N/m^2.
(2) Earth may weigh less than what it is in the given conditions.
(3) Groundwater may turn saline and may weight more than 9810 N/m^3

5. DESIGN AND ANALYSIS

The image depicts a cross-section of a structural element, showcasing various design parameters and reinforcement details. The section design indicates a required depth of 298 mm, within an available depth of 300 mm, and a total depth of 350 mm for a water tank of capacity 1,20,000 litres.

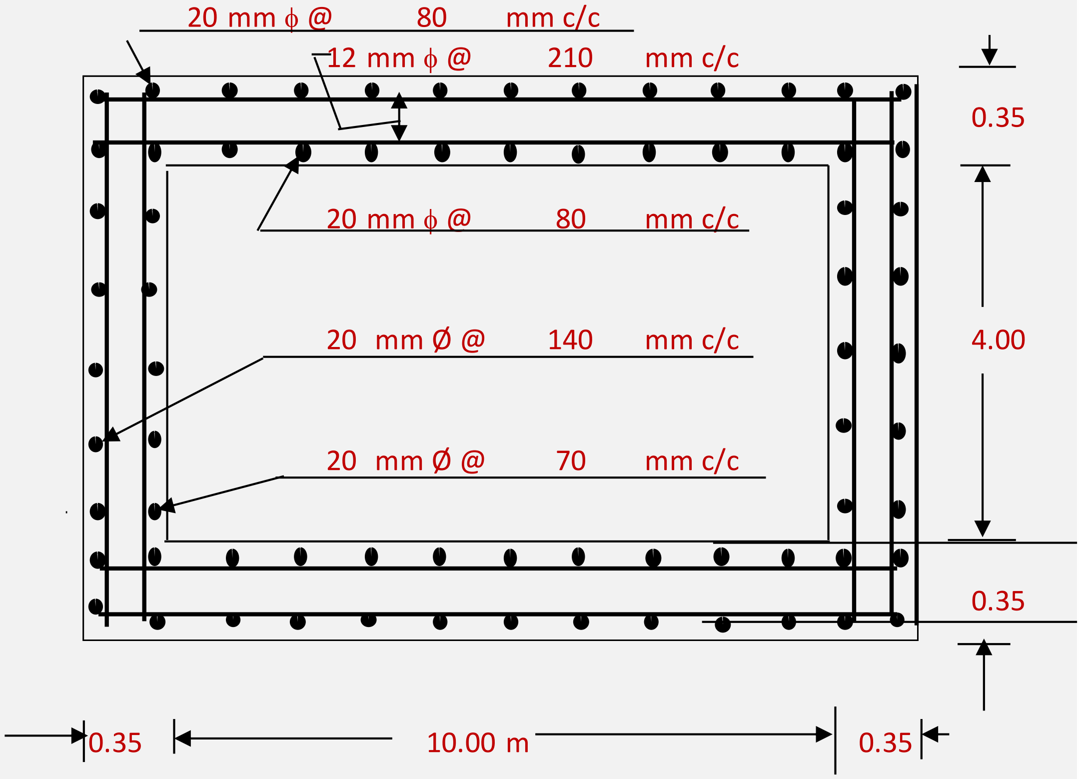
Arrows or labels illustrate the pulling forces acting on the structure, including direct tension on both long and short walls. Additionally, a cantilever moment at the base per unit length is represented to visualize the structural loadings.

5.1 Reinforcement details are delineated for different sections of the structure:

At the corners of long walls, reinforcement bars are depicted with labels indicating Ast for bending moment and Ast for pull.
Similarly, reinforcement bars at the middle of long walls are shown with corresponding Ast values.
Short walls display reinforcement bars at the ends, along with Ast for bending moment and Ast for pull.
Reinforcement for the maximum cantilever moment is illustrated, with labels indicating Ast and spacing of bars.

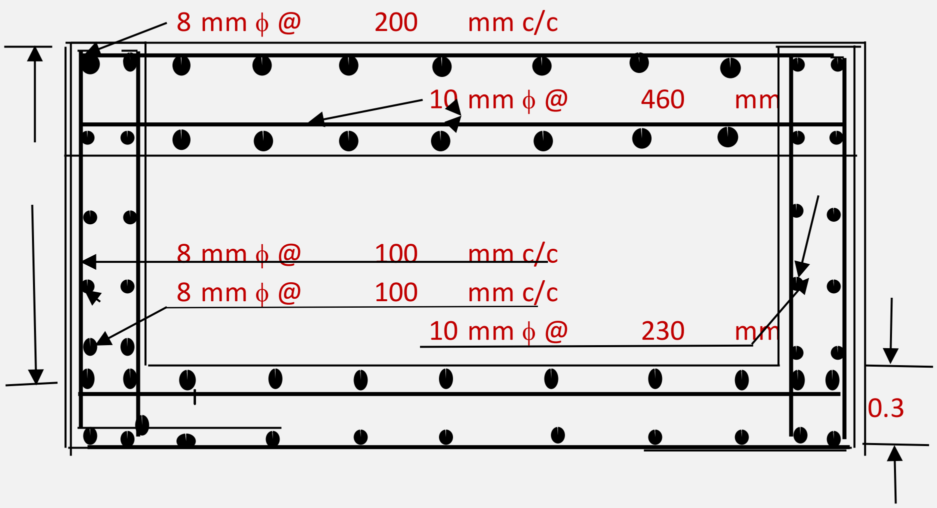
5.2 Moreover, the design of the base slab and roof slab is included:

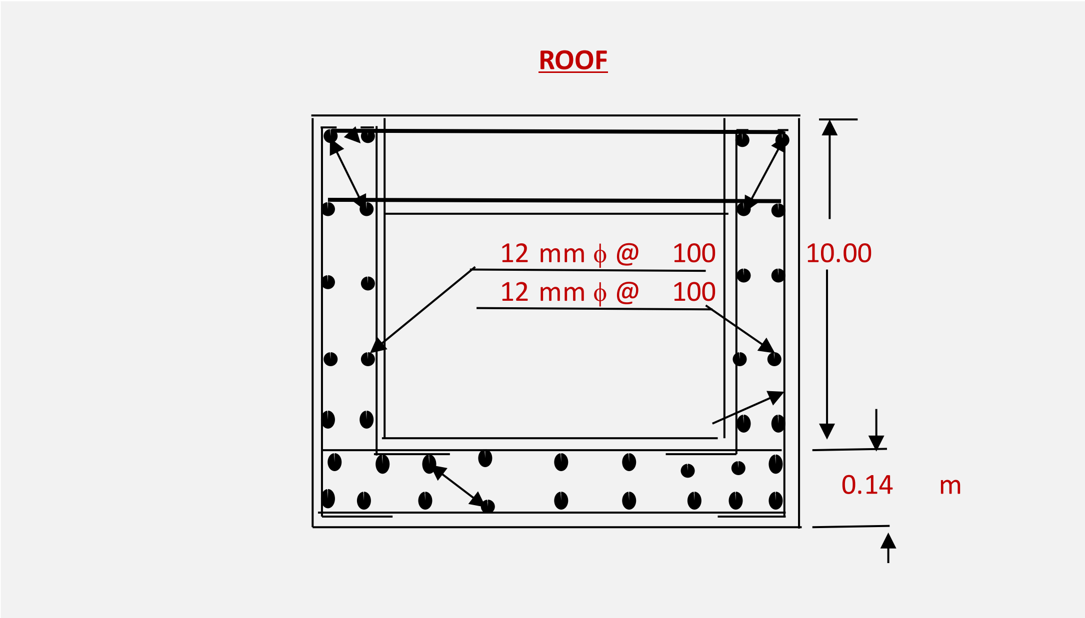
The base slab shows the area of steel and spacing of bars.
Similarly, the roof slab indicates the area of steel and spacing of bars required for reinforcement.
The visualization provides a comprehensive understanding of the structural design and reinforcement distribution, essential for ensuring the stability and strength of the construction.



Reinforcement details for short wall and long wall

BASE SLAB




ROOF
12 mm ϕ @ 100
12 mm ϕ @ 100
10.00
0.14 m

6. RESULTS AND DISCUSSION

Capacity of tank = 1,20,000 liters

Depth of tank = 3 m

Angle of repose of soil = 30 degree

Unit weight of soil = 17 kg/m^3

Unit weight of water = 10 kg/m^3

Characteristic compressive strength of concrete (f_{ck}) = 25 N/mm^2

DESCRIPTION	THEORETICAL VALUE	PROGRAM VALUE
DESIGN OF SECTION		
Required Depth	300 mm	298 mm
Available Depth	300 mm	300 mm
Total Depth	350 mm	350 mm
DETERMINATION OF PULLING FORCE		
Direct Tension on Long Wall	39240 N	39200 N
Direct Tension on Short Wall	98540 N	98000 N
CANTILEVER MOMENT		
Cantilever moment at the base, per unit	6856 N-m	6533 N-m
REINFORCEMENT AT CORNERS OF LONG WALLS		
x	129 m	123 m
Ast for B.M.	3876 mm^2	3648 mm^2
Ast for Pull	261.6 mm^2	261 mm^2
Total Ast	mm^2	3909 mm^2
REINFORCEMENT AT MIDDLE OF LONG WALLS		
Design B.M.	101235 N-m	94733 N-m
Ast for B.M.	2565 mm^2	2256 mm^2
Ast for Pull	261.6 mm^2	261 mm^2
Total Ast	2853 mm^2	2517 mm^2
REINFORCEMENT FOR SHORT WALLS		
Bending moment at the ends (Mf)	167473 N-m	150267 N-m
Direct Pull (Pu)	98540 N	98000 N
Ast for B.M.	3759 mm^2	3468 mm^2
Ast for Pull	702 mm^2	653 mm^2
Total Ast	4332 mm^2	4121 mm^2
REINFORCEMENT FOR CANTILEVER MOMENT AND DISTRIBUTION REINFORCEMENT		
Max. cantilever moment	6997 N-m	6533 N-m
Ast	182 mm^2	164 mm^2
Spacing of Bars	236 mm	210 mm
DESIGN OF BASE SLAB		
Ast	729 mm^2	500 mm^2
Spacing of bars	250 mm	100 mm
DESIGN OF ROOF		
Ast	1328 mm^2	1225 mm^2
Spacing of bars	100 mm	100 mm

7. CONCLUSIONS AND FUTURE WORK

Conclusion:

Underground water tanks, with their space-saving advantages, emerge as indispensable solutions for both urban and rural areas. This project's core objective is the design of a rectangular underground Reinforced Cement Concrete (RCC) water tank using MS Excel, aimed at ensuring not only water safety and durability but also optimal space utilization.

Throughout the project, a comprehensive exploration of design considerations, material properties, and the utilization of MS Excel has been undertaken. A critical aspect of the project involves comparing theoretical calculations with program-generated values, emphasizing the necessity of incorporating safety margins into the design process. This ensures that the resulting structure can withstand various loads and environmental factors, thereby guaranteeing long-term functionality and reliability.

A program provides a solution to these problems, but there is a slight difference between program and manual design values. The program provides the least value for the design, so designers should not provide less than the program's values. In theoretical calculations, designers should add extra values to ensure safety.

In essence, by leveraging modern techniques and materials, engineers can develop water storage solutions that not only fulfill diverse application demands but also minimize their environmental impact. This project underscores the importance of such an approach, paving the way for the creation of sustainable water infrastructure that meets the challenges of the future.

Future scope:

For the future design of rectangular underground RCC water tanks, circular tanks, and overhead tanks, it's crucial to account for various forces that these structures may encounter in future. These forces include:

- **Hydrostatic Pressure**: Water and soil exert hydrostatic pressure on the tank walls and base. Understanding and properly considering hydrostatic pressure are essential for ensuring structural integrity and stability.
- **Soil Pressure**: Underground tanks experience lateral soil pressure from the surrounding soil. Analyzing soil properties and interactions is necessary to design tanks that withstand soil pressure without failure.
- **Dead Loads**: These include the weight of the tank structure and permanent fixtures. Accurate calculation of dead loads ensures the tank can support its weight and additional permanent loads.
- **Live Loads**: Transient loads during operation or maintenance, such as personnel and equipment, must be considered. Designing for live loads is crucial, especially for overhead tanks, to ensure safety and load distribution.
- **Seismic Forces**: Earthquake-prone regions require special consideration for seismic forces, which can cause dynamic loading and structural damage. Proper seismic analysis and reinforcement enhance the tank's resilience.
- **Wind Loads**: Overhead tanks are exposed to wind forces, necessitating analysis of wind speed, direction, and exposure. Wind load mitigation measures like bracing and shaping improve structural stability.
- **Temperature and Thermal Expansion**: Temperature fluctuations induce thermal stresses, requiring insulation and expansion joints to prevent damage. Considering thermal expansion ensures structural integrity and prevents leakage.

By integrating these forces into the design process, engineers can create resilient water tank structures capable of withstanding environmental and operational challenges, ensuring long-term performance and safety.

References

IS Codes :

1. IS 8112**:** 1989 for the quality of cement.

2. IS 383**:** 1970 for the aggregates used.

3. IS 1786**:** 2008 conforming the High Yield Strength Deformed (HYSD) bars.

4. IS 456: 2000 for permissible stresses in concrete.

5. IS: 3370-2009 provides guidelines for the design and construction of concrete water tanks.

Books :

1. RCC DESIGNS by Dr. B.C. Punmia, Er. Ashok Kumar Jain and Dr. Arun K. Jain.

2. RCC Design and Drawings by S.S. Bhavikatti.

3. Varghese, P.C. (2011). Limit State Design of Reinforced Concrete. Prentice-Hall of India.

4. Subramanian, N. (2008). Reinforced Concrete Structures. Oxford University Press.

5. Neville, A.M. (2011). Properties of Concrete. Pearson.

6. Venkatramaiah, C. (2008). Geotechnical Engineering. New Age International.

7. Wight, J., & MacGregor, J. (2018). Reinforced Concrete: Mechanics and Design. Pearson.

8. Gerwick Jr., B.C. (2018). Construction of Prestressed Concrete Structures. John Wiley & Sons.

9. ACI Committee 211. (2012). Concrete Mix Design Spreadsheet. American Concrete Institute.

Websites :

1. www.researchgate.net

2. www.academia.edu

3. www.studocu.com

4. www.wikipedia.org