

Aci water tank design example

aci water tank design example Designing an ACI (American Concrete Institute) water tank involves careful planning, precise calculations, and adherence to industry standards to ensure safety, durability, and functionality. This comprehensive guide provides a detailed ACI water tank design example, illustrating the process from initial considerations to final specifications. Whether you're an engineer, architect, or student, this example aims to clarify the essential steps involved in designing a reinforced concrete water tank based on ACI guidelines.

Understanding the Basics of ACI Water Tank Design

Before diving into the detailed example, it's important to understand the fundamental aspects that influence design decisions.

Key Principles and Standards

ACI Code References: The primary standard is ACI 370R-05, which provides guidelines for the design and construction of concrete water tanks.

Material Specifications: Use of high-quality concrete and reinforcement steel conforming to specified strength grades.

Structural Considerations: Ensuring the tank withstands hydrostatic pressure, seismic loads, wind loads, and other environmental factors.

Design Philosophy: Typically, reinforced concrete is used for its durability, strength, and ability to form various shapes.

Types of Water Tanks

Elevated Tanks: Supported on columns or towers.

Ground Storage Tanks: Usually underground or at ground level with reinforced walls.

Standpipe Tanks: Tall, cylindrical tanks with a slender profile.

In this example, we focus on a ground-supported, circular reinforced concrete water tank, which is a common configuration.

Design Example Parameters

To illustrate, let's consider the following scenario:

- Tank Capacity:** 5000 cubic meters
- Shape:** Circular
- Location:** Seismic zone (moderate to high seismic activity)
- Design Water Level:** 10 meters
- Tank Height:** 12 meters (including freeboard)
- Wall Thickness:** To be determined
- Base Thickness:** To be determined
- Material Strengths:** Concrete: M30 (compressive strength of 30 MPa)
- Reinforcement Steel:** Fe500 (yield strength of 500 MPa)

Step-by-Step Design Process

Designing a water tank involves a sequence of calculations to determine dimensions, reinforcement, and structural details.

1. Determining the Tank Dimensions

Given the volume (V) and shape, the tank radius (r) and height (H) are calculated to match the capacity.

Calculate the radius: $V = \pi r^2 H$

Assuming a height of 12 m, compute radius: $r = \sqrt{\frac{V}{\pi \times H}}$

$r = \sqrt{\frac{5000}{\pi \times 12}} \approx 11.52$ meters

Result: Radius ≈ 11.52 meters, Diameter ≈ 23.04 meters

Note: Final dimensions may be adjusted for site constraints and structural considerations.

2. Structural Analysis of the Tank

The main structural components include:

- Walls:** Subjected to hydrostatic pressure
- Base Slab:** To distribute loads
- Roof (if applicable):** Usually flat or domed

Hydrostatic Pressure Calculation: The maximum pressure at the bottom of the tank: $P_{\max} = \gamma \times h$

Where: γ = unit weight of water (~ 9.81 kN/m³)
 h = height of water column (10 m)

$P_{\max} = 9.81 \times 10 = 98.1$ kPa

3. Wall Thickness Design

Using ACI guidelines, the wall thickness (t) is designed to resist the internal pressure and bending moments.

Design considerations: Minimum thickness based on stability, Reinforcement to handle hoop tension and axial forces

Estimate wall thickness: $t \approx \frac{P_{\max} \times r}{(0.8) \times f_{ct} \times \phi}$

Where: f_{ct} = concrete tensile strength (~ 2.2 MPa for M30)
 ϕ = strength reduction factor (typically 0.9 for tension-controlled sections)

A simplified approach: $t \approx$

$\frac{98.1}{1760} \times 11.52 \times 0.8 \times 2.2 \times 1000 \approx 0.64$ This indicates a very conservative estimate; in practice, the wall thickness can be around 0.3 to 0.5 meters, depending on reinforcement detailing and safety factors.

Final Wall Thickness: Typically, 0.4 meters (400 mm) is selected, with reinforcement designed accordingly.

4. Reinforcement Detailing Designing reinforcement involves:

- Hoop reinforcement:** To resist circumferential tension
- Radial reinforcement:** To resist axial loads

Reinforcement Calculation: Use ACI 318 and ACI 350 guidelines. Calculate the required steel area based on bending moments and axial forces. Provide reinforcement with sufficient cover (usually 50-75 mm).

Example: Assume a hoop reinforcement of 16 bars at 200 mm spacing. Radial reinforcement of 20 bars at suitable spacing.

5. Base Slab Design The base must support the entire water load plus tank weight and resist uplift and settlement.

Calculations: Total load: $V = \text{area} \times \text{water density}$. Check for overturning, sliding, and settlement.

Design slab thickness based on bending and shear. Typical base slab thickness: Around 0.5 meters, with reinforcement designed per ACI standards.

Seismic and Wind Load Considerations Designing for seismic activity involves:

- Seismic forces calculation:** Using seismic design spectra
- Reinforcement detailing:** To resist lateral forces
- Foundation design:** To accommodate seismic displacements

Wind loads are less significant but must be considered, especially for elevated tanks.

Final Structural and Material Specifications

Component	Material/Details	Notes
Concrete	M30 ($f'_c = 30$ MPa)	High durability for water contact
Reinforcement Steel	Fe500 ($f_y = 500$ MPa)	Adequate ductility and strength
Wall Thickness	0.4 meters	Based on hydrostatic and structural analysis
Cover to Reinforcement	50-75 mm	Ensures durability and corrosion protection
Foundation	Reinforced concrete mat or strip footing	Designed per load and seismic considerations

Construction and Quality Control

- Formwork:** Precise forming for circular shape
- Reinforcement Placement:** Correct positioning and tying
- Concrete Pouring:** Adequate compaction and curing
- Inspection:** Regular checks for compliance with design specifications
- Waterproofing:** Application of suitable coatings or membranes

Conclusion Designing an ACI water tank involves integrating structural analysis, material selection, reinforcement detailing, and adherence to safety standards. The example provided offers a clear illustration of the step-by-step process from initial capacity requirements to detailed reinforcement design. Proper planning and rigorous quality control are vital to ensure the tank's longevity, safety, and performance. Always tailor the design to site-specific conditions, local codes, and environmental factors for optimal results.

Note: This example is simplified for illustrative purposes. Actual tank design should involve detailed structural analysis, finite element modeling, and consultation with qualified structural engineers to meet all safety and code requirements.

ACI Water Tank Design Example: A Comprehensive Guide to Engineering, Planning, and Implementation

Designing a water tank is a critical aspect of civil and mechanical engineering,

ensuring reliable water storage and distribution for residential, commercial, or industrial applications. Among the many standards that govern water tank design, the American Concrete Institute (ACI) provides comprehensive guidelines, especially for concrete water tanks. This article explores an exemplar ACI water tank design, offering detailed insights into the engineering principles, calculations, and considerations involved in creating a safe, durable, and efficient water storage system.

Introduction to ACI Water Tank Design

Understanding the foundations of ACI standards is essential before delving into a design example. The American Concrete Institute develops and publishes guidelines primarily focused on concrete structures, including water tanks, through documents such as ACI 350 and ACI 318. These guidelines emphasize structural integrity, durability, safety, and serviceability. Designing a water tank involves multiple stages: Conceptual planning, Structural analysis, Material selection, Structural detailing, and Construction considerations. This example aims to elucidate these stages with practical calculations and reasoning, offering a clear pathway from initial concept to final design.

Project Overview and Design Parameters

To ground the discussion, consider a typical scenario:

- Tank Type:** Reinforced concrete circular above-ground water tank
- Capacity:** 500,000 liters (approx. 132,000 gallons)
- Shape:** Circular with a cylindrical shell and a domed roof
- Location:** Moderate seismic and wind zones
- Material:** Reinforced concrete with a compressive strength (f'_c) of 25 MPa (3,625 psi)
- Design Standards:** ACI 350 for reinforced concrete structures, ACI 318 for structural design

Key parameters derived from the capacity:

- Tank diameter (D):** To be determined based on volume and height
- Tank height (H):** To be optimized for structural stability and functional capacity
- Wall thickness (t):** To be calculated considering hydrostatic pressure and reinforcement

Determining Tank Dimensions and Geometry

Volume and Geometry Calculations

The volume (V) of a cylindrical tank:

$$V = \pi \times \left(\frac{D}{2}\right)^2 \times H$$

Given: $V = 500,000$ liters = 500 m³

Choosing a practical height-to-diameter ratio (H/D) is common; for concrete tanks, H is typically between 0.75 and 1.2 times D for stability and construction ease. Suppose we select:

- $D = 15$ meters
- $H = 10$ meters

Check the volume:

$$V = \pi \times (7.5)^2 \times 10 \approx 3.1416 \times 56.25 \times 10 \approx 1770 \text{ m}^3$$

This exceeds the target volume; thus, adjusting D or H is necessary. Alternatively, choosing $D = 12$ meters and $H = 8.8$ meters:

$$V = \pi \times 6^2 \times 8.8 \approx 3.1416 \times 36 \times 8.8 \approx 996 \text{ m}^3$$

Still below the target. Fine-tuning: $D = 14$ meters and $H = 8.5$ meters

Calculating volume:

$$V = \pi \times 7^2 \times 8.5 \approx 3.1416 \times 49 \times 8.5 \approx 1309 \text{ m}^3$$

Close to the target; thus, $D = 14$ meters and $H = 8.5$ meters are suitable.

Structural Analysis and Reinforcement Design

Hydrostatic Pressure and Wall Thickness

Hydrostatic pressure at the bottom of the tank due to water height:

$$p = \rho \times g \times h$$

Where: ($\rho = 1000$ kg/m³) (density of water) ($g = 9.81$ m/s²) ($h = 8.5$ m)

Calculating:

$$p = 1000 \times 9.81 \times 8.5 \approx 83,385 \text{ Pa} \approx 0.083 \text{ MPa}$$

Design of the wall thickness (t):

Using ACI's simplified approach, the hoop (circumferential) and radial stresses are considered. The maximum hoop stress at the base:

$$\sigma_h = \frac{p \times R}{t}$$

Where ($R = D/2 = 7$ m). Rearranged for thickness:

$$t = \frac{p \times R}{\sigma_{allow}}$$

Assuming an allowable tensile stress of concrete plus reinforcement: For concrete, tensile strength is low; reinforcement handles tension. Design the reinforcement to handle hoop stresses with a safety margin. As a practical approach: For typical reinforced concrete tanks, wall thickness varies between 150mm and 300mm depending on height.

and pressure. A conservative initial estimate: $t = 200\text{mm}$ (0.2m). Reinforcement Details Design reinforcement: Main reinforcement: To resist hoop stresses Distribution reinforcement: To control cracking and handle lateral loads Anchorage and lap lengths: As per ACI 318 Calculate the reinforcement ratio (ρ) : $\rho = \frac{A_s}{b \times t}$ Where: (A_s) = area of steel reinforcement (b) = width of the wall (perimeter segment) Assuming: Steel yield strength $(f_y = 420\text{ MPa})$ Concrete $(f_c = 25\text{ MPa})$ Foundation and Base Design Load Transfer and Settlement The foundation must support the entire weight of the tank and water: $W_{\text{tank}} = \text{volume} \times \text{density} = 1309\text{ m}^3 \times 9800\text{ N/m}^3 \approx 12.8\text{ MN}$ Adding the weight of the tank shell and roof, plus surcharge loads, the foundation design ensures: Uniform load distribution Adequate bearing capacity Resistance to settlement and overturning Foundation Type Mat foundation: Suitable for moderate loads Pile foundation: For poor soil conditions Design involves soil investigation data, which guides the choice of foundation and reinforcement. Roof and Dome Design Dome Structural Considerations The tank's roof, often domed to minimize material use and resist internal pressure, must: Support dead load (self-weight) Handle internal water pressure Resist environmental loads (wind, snow) Using ACI 350 guidelines, the dome's thickness, reinforcement, and shape are optimized for load transfer and durability. Material and Reinforcement Reinforced concrete with appropriate steel ratios Incorporation of prestressed elements if necessary Seismic and Wind Load Considerations Seismic Loads In seismic zones, the design incorporates load combinations as per ACI 318, with: Seismic force calculations based on site hazard level Reinforcement detailing to prevent brittle failure Wind Loads The tank is designed to withstand wind pressures, especially on the roof and exposed surfaces. Wind load calculations follow ASCE 7 or local standards, with ACI guidelines ensuring the structure's stability. Durability and Material Selection Durability Aspects Use of high-quality concrete with low permeability Adequate cover to reinforcement Proper curing and construction practices Material Choices Concrete grade: C25/30 or higher Reinforcing steel: Deformed bars meeting ASTM A615 or equivalent Construction Considerations and Quality Control Formwork design and stability Reinforcement placement and coverage Concrete pouring and curing procedures Inspection and testing protocols Ensuring quality control aligns with ACI standards, guaranteeing the tank's long-term performance. Conclusion: Key Takeaways from the ACI Water Tank Design Example Designing a water tank per ACI standards involves a meticulous process that balances structural safety, durability, economic efficiency, and environmental considerations. The example outlined demonstrates the importance of: Precise geometric calculations to meet volume requirements Structural analysis considering hydrostatic and environmental loads Appropriate reinforcement detailing to withstand stresses Foundation design tailored to site conditions Incorporation of seismic and wind load considerations for safety Adherence to ACI guidelines ensures the water tank will serve its purpose reliably over decades, withstanding the forces of nature and operational demands. Whether for municipal water supply, industrial use, or emergency reserves, the principles demonstrated in this example serve as a foundational reference for engineers engaged in water storage projects. In summary, the ACI water tank design exemplifies an integrated approach that combines theoretical calculations, practical engineering judgment, and adherence to standards, culminating

QuestionAnswer

What are the key considerations in designing an ACI water tank example?

Key considerations include tank capacity requirements, material selection, structural stability, seismic and wind load considerations, foundation design, and compliance with ACI standards such as ACI 350 for water tank stability and durability.

How does ACI 350 influence the design of water tanks?

ACI 350 provides guidelines for designing reinforced concrete structures exposed to water, emphasizing durability, corrosion protection, and structural safety, which directly influence thickness, reinforcement details, and material choices in water tank design.

Can you provide a step-by-step example of designing a cylindrical water tank following ACI standards?

Yes, the process involves determining the tank capacity, selecting dimensions, calculating wall thickness based on hydrostatic pressure, designing reinforcement details according to ACI 318, checking stability against overturning and sliding, and detailing foundation requirements, all aligned with ACI guidelines.

What are common challenges faced in ACI water tank design examples?

Common challenges include ensuring structural stability under variable loads, preventing corrosion through proper detailing, accommodating seismic forces, optimizing reinforcement to reduce cost, and complying with local code requirements alongside ACI standards.

How does seismic design influence ACI water tank examples?

Seismic design requires incorporating additional reinforcement, flexible joints, and foundation considerations to withstand earthquake forces, as guided by ACI 318 and ACI 350, ensuring the tank remains stable and leak-proof during seismic events.

Where can I find detailed ACI water tank design examples and templates?

Detailed examples and templates can be found in ACI publications such as ACI 350 and ACI 318, as well as in civil engineering textbooks, online technical forums, and software tutorials dedicated to reinforced concrete water tank design.

Related keywords: ACI water tank design, water tank structural analysis, reinforced concrete water tank, water tank load calculations, water tank design standards, cylindrical water tank design, water tank foundation design, concrete water tank detailing, water tank seismic design, water tank capacity calculation

Circular steel water tank design example

circular steel water tank design example provides a comprehensive understanding of how to plan, engineer, and construct a durable and efficient water storage solution using steel materials. Steel water tanks are widely favored for their strength, longevity, and ease of maintenance, making them an ideal choice for municipal, industrial, and residential applications. In this article, we will explore a detailed example of designing a circular steel water tank, covering key considerations, calculations, and best practices to ensure a successful project.

Introduction to Circular Steel Water Tanks

Circular steel water tanks are cylindrical structures constructed primarily from steel panels, often bolted or welded, designed to store large volumes of water securely. They are commonly used in various settings, including:

- Municipal water supply systems
- Industrial process water storage
- Fire protection systems
- Emergency water reserves

The circular shape offers inherent structural advantages, such as evenly distributed stresses and minimal material usage for a given volume, making it a cost-effective and robust design choice.

Key Design Considerations

Before delving into the example, it's essential to understand the primary factors influencing the design of a circular steel water tank.

- Capacity and Dimensions** Determine the required volume based on demand. For example, a 500 cubic meter (m^3) tank is a common size for small municipalities or industrial facilities.
- Material Selection** Steel grades vary based on corrosion resistance, strength, and cost. Commonly used materials include:
 - Carbon steel with protective coatings
 - Stainless steel for enhanced corrosion resistance
- Structural Design** Considerations include tank wall thickness, foundation design, and roof structure, all of which should withstand internal hydrostatic pressure and external environmental loads.
- Loading and Stress Analysis** Calculate internal pressure, dead loads, and live loads, ensuring the structure can handle maximum water height and external forces like wind or seismic activity.
- Codes and Standards** Design must comply with relevant standards such as AWWA D100, BS EN 14651, or local building codes.

Design Example: 500 m^3 Circular Steel Water Tank

Let's walk through a practical example of designing a 500 m^3 capacity circular steel water tank.

Step 1: Determining Tank Dimensions

Assuming a cylindrical shape, the volume (V) is given by: $V = \pi r^2 h$ Where: (V) = 500 m^3 (r) = radius of the tank (h) = height of the water column

Select a height-to-diameter ratio for practical reasons; a common ratio for steel tanks is approximately 1:1 or 1:1.5. Suppose we choose: ($h = 6$, meters)

Calculate radius: $r = \sqrt{\frac{V}{\pi h}} = \sqrt{\frac{500}{\pi \times 6}} \approx \sqrt{\frac{500}{18.85}} \approx \sqrt{26.52} \approx 5.15$, meters

Thus, the tank

dimensions are approximately: Diameter $(D = 2r \approx 10.3, \text{meters})$ Height $(h = 6, \text{meters})$

Step 2: Material and Wall Thickness Selection Designing the tank wall involves calculating the required thickness to withstand hydrostatic pressure. The maximum internal pressure at the tank bottom: $[P = \rho g h]$ Where: $(\rho = 1000, \text{kg/m}^3)$ (density of water) $(g = 9.81, \text{m/s}^2)$ $(h = 6, \text{m})$ Calculating: $[P = 1000 \times 9.81 \times 6 = 58,860, \text{Pa}] \approx 59, \text{kPa}]$ Using thin-walled pressure vessel theory, the hoop stress (σ_h) : $[\sigma_h = \frac{P r}{t}]$ Where: (t) = wall thickness Choosing a steel with a allowable stress (σ_{allow}) of about 150 MPa, include a safety factor of 2: $[\sigma_{allow} = \frac{150, \text{MPa}}{2} = 75, \text{MPa}]$ Rearranged to find (t) : $[t = \frac{P r}{\sigma_{allow}} = \frac{58,860, \text{Pa} \times 5.15, \text{m}}{75 \times 10^6, \text{Pa}} \approx 0.004, \text{m} = 4, \text{mm}]$ Adding a standard safety margin, a wall thickness of 6 mm is recommended.

Step 3: Foundation Design The foundation must support the tank's weight and resist settlement. It typically involves: Concrete base with reinforcement Proper compaction and leveling Design to handle load distribution and environmental factors Calculate the tank's weight: $[W_{\text{tank}} = \text{Volume} \times \text{Steel density} + \text{water weight}]$ Assuming steel density of 7850 kg/m^3 and tank walls: $[W_{\text{steel}} = \text{Surface area} \times t \times \text{density}]$ Surface area of the cylindrical wall: $[A_{\text{wall}} = 2 \pi r h \approx 2 \pi \times 5.15, \text{m} \times 6, \text{m} \approx 194, \text{m}^2]$ Wall volume: $[V_{\text{wall}} = A_{\text{wall}} \times t = 194, \text{m}^2 \times 0.006, \text{m} \approx 1.16, \text{m}^3]$ Steel weight: $[W_{\text{steel}} = 1.16, \text{m}^3 \times 7850, \text{kg/m}^3 \approx 9,106, \text{kg}]$ Water weight: $[W_{\text{water}} = 500, \text{m}^3 \times 1000, \text{kg/m}^3 = 500,000, \text{kg}]$ Total weight: $[W_{\text{total}} \approx 509,106, \text{kg}]$ The foundation must be designed to support this load with appropriate safety margins.

Structural Components of the Steel Water Tank A typical steel water tank comprises several key components:

1. Shell The cylindrical wall that holds water and withstands internal pressure.
2. Roof A domed or flat roof that covers the tank, providing protection from the environment.
3. Nozzles and Inlets For filling, draining, and maintenance access.
4. Foundation Supports the tank's weight and prevents settlement or tilting.
5. Support Structures Bracing and stiffeners to maintain structural integrity.

Assembly and Construction Tips Proper construction practices are vital to ensure tank longevity and safety: Use high-quality steel with corrosion-resistant coatings or linings. Ensure precise fabrication and welding according to standards. Implement leak-proof sealing at joints and penetrations. Install inspection and maintenance access points. Conduct hydrostatic testing to verify strength and leak tightness.

Maintenance and Longevity Steel tanks require regular inspection and maintenance to prevent corrosion and structural deterioration: Apply protective coatings and repaint as needed. Inspect welds, joints, and interior surfaces periodically. Ensure proper drainage and water quality management. Replace or repair damaged components promptly.

Conclusion A well-designed circular steel water tank, like the 500 m^3 example presented, combines engineering precision, material selection, and construction best practices to ensure a durable and efficient water storage solution. By carefully considering factors such as capacity, structural stresses, foundation requirements, and maintenance, engineers can develop safe and cost-effective tanks suited to diverse needs. This example provides a foundational understanding of the design process, which can be adapted and scaled for larger or smaller applications. Proper planning and adherence to

standards are essential to achieving a successful and long-lasting water storage infrastructure.

Circular Steel Water Tank Design Example: An In-Depth Guide

Designing a circular steel water tank involves a complex interplay of structural integrity, material selection, hydrodynamic considerations, and adherence to standards. This comprehensive review aims to provide a detailed walkthrough of a typical circular steel water tank design example, highlighting essential aspects, calculations, and best practices.

Introduction to Circular Steel Water Tanks

Circular steel water tanks are widely used in various industries, municipal water supply systems, fire protection, and irrigation due to their durability, ease of construction, and effective use of materials. Their inherent geometry provides excellent strength against internal pressure and external loads, making them ideal for storing large volumes of water.

Advantages:

- Uniform distribution of stress
- Reduced material wastage
- Ease of fabrication and installation
- Good resistance to seismic and wind loads

Applications:

- Municipal water storage
- Industrial process water
- Fire protection systems
- Agricultural water reservoirs

Fundamental Design Principles

Designing a circular steel water tank must consider several primary factors:

- Hydrostatic pressure:** The water exerts pressure on the tank walls, increasing with depth.
- Material strength:** The steel must withstand hoop stresses, axial stresses, and potential buckling.
- Foundation stability:** The base must support the tank's weight and resist settlement.
- Corrosion protection:** Appropriate coatings or lining to prevent steel deterioration.
- Operational considerations:** Filling and emptying rates, seismic and wind loads, and thermal expansion.

Design Example Overview

Suppose we are tasked with designing a circular steel water tank with the following specifications:

- Capacity:** 500 m³
- Location:** Moderate seismic zone
- Design head (maximum water height):** 10 meters
- Material:** Carbon steel (Grade A36)
- Design standards:** API 650 / AWWA D100 / BS EN 14015 (as applicable)

This example will walk through the steps for sizing, structural analysis, detailing, and safety considerations.

Step 1: Determining Tank Dimensions

The initial step involves defining the geometric parameters based on capacity and practical considerations.

a) Volume and Dimensions:

Given: Volume, $V = 500 \text{ m}^3$

Water height (h) = 10 m (maximum water level)

Assuming a cylindrical tank with a uniform cross-section:

$$V = \pi r^2 h$$

Solving for radius (r):

$$r = \sqrt{\frac{V}{\pi h}} = \sqrt{\frac{500}{\pi \times 10}} \approx \sqrt{\frac{500}{31.416}} \approx \sqrt{15.9} \approx 3.99 \text{ m}$$

Tank dimensions:

- Diameter (D):** approximately 8.0 meters
- Radius (r):** approximately 4.0 meters
- Height (H):** 10 meters (water level), with additional height for tank roof and foundation considerations

Step 2: Structural Analysis of the Tank Shell

a) Hoop Stress Calculation:

The primary stress in the tank wall is hoop stress (σ_h), caused by internal water pressure.

Hydrostatic pressure at bottom:

$$p = \rho g h$$

where: ($\rho = 1000 \text{ kg/m}^3$) ($g = 9.81 \text{ m/s}^2$) ($h = 10 \text{ m}$)

$$p = 1000 \times 9.81 \times 10 = 98,100 \text{ Pa} \approx 0.098 \text{ MPa}$$

Hoop stress in thin-walled cylinder:

$$\sigma_h = \frac{p \times r}{t}$$

where: (t) = wall thickness

Rearranged for design:

$$t = \frac{p \times r}{\sigma_{\text{allow}}}$$

Assuming a permissible stress (σ_{allow}) of steel: For carbon steel Grade A36, yield strength ($\approx 250 \text{ MPa}$)

Applying a safety factor of 1.5:

$$\sigma_{\text{allow}} = \frac{250}{1.5} \approx 167 \text{ MPa}$$

Calculating thickness:

$$t = \frac{0.098 \times 4.0}{167} \approx 0.0023 \text{ m} \approx 2.3 \text{ mm}$$

$\times 4 \approx \frac{0.392}{167} \approx 0.00235$, $t \approx 2.35$, $t \text{ (mm)}$

Design consideration: Even though the theoretical thickness is very small, practical design requires thicker shells for corrosion allowance, fabrication tolerances, and load considerations. Typically, a minimum thickness of 6-8 mm is used for steel tanks.

b) Additional Loads and Considerations: Wind and seismic loads, Live loads, dead loads, External soil pressure if underground, Internal liquid dynamics during filling/emptying.

c) Reinforcements: Use of stiffeners or rings to prevent buckling, Reinforced bottom plates for uniform load distribution.

Step 3: Material Selection and Corrosion Protection

a) Material choice: Carbon steel (A36) is economical; for corrosive environments, consider lining or coating.

b) Corrosion protection: Coatings: Epoxy paints, asphalt coatings; Linings: Glass-fiber reinforced plastic (GRP), rubber linings; Cathodic protection in underground tanks.

c) Welding and fabrication: Use qualified welders following standards such as AWS D1.1. Ensure proper weld design, inspection, and testing.

Step 4: Foundation and Support Design

a) Foundation considerations: Uniformly distribute tank load, Designed for soil bearing capacity, Incorporate expansion joints if necessary.

b) Calculations: Total weight of water: $W_{\text{water}} = V \times \rho \times g = 500 \times 1000 \times 9.81 = 4,905,000$, N . Add self-weight of tank components, foundation, and safety margins.

c) Foundation design: Concrete footing or raft foundation, Geotechnical analysis to determine bearing capacity, Incorporate drainage and seepage control.

Step 5: Detailing of Tank Components

a) Shell plates: Plate thickness based on stress calculations with additional allowances, Stiffeners at strategic locations.

b) Roof design: Fixed or floating, Wind load considerations, Ventilation and access openings.

c) Nozzles and outlets: Inlet/outlet pipe connections, Overflow and venting provisions, Manholes and inspection openings.

d) Accessories: Level gauges, Drainage valves, Access ladders and safety rails.

Step 6: Seismic and Wind Load Considerations

a) Seismic design: Adherence to local seismic codes, Use of seismic supports and bracings, Damping systems if necessary.

b) Wind load: Calculated using ASCE 7 or relevant standards, Structural reinforcement for high wind zones.

Step 7: Structural Safety and Compliance

Ensure tank design meets API 650, AWWA D100, or local standards. Conduct finite element analysis for complex load cases. Perform stability checks against buckling and overturning. Implement quality assurance during fabrication and erection.

Step 8: Construction and Maintenance Aspects

Fabrication in controlled environments, Transport and erection procedures, Inspection and testing (hydrostatic, non-destructive testing), Routine maintenance: coating inspection, corrosion monitoring, leak detection.

Conclusion and Best Practices

Designing a circular steel water tank is a multidisciplinary process that requires balancing structural safety, economic viability, operational efficiency, and environmental considerations. The example outlined above demonstrates a systematic approach, from dimensioning to detailed structural analysis and fabrication planning.

Key takeaways: Always start with clear specifications and capacity requirements. Use conservative estimates for thickness and reinforcement to ensure safety. Incorporate corrosion protection and maintenance planning. Comply with relevant standards and codes. Consider seismic and wind loads for site-specific safety. Engage experienced structural engineers and fabricators throughout the process. By following these comprehensive steps and considerations, engineers can ensure the successful design and long-term operation of circular steel water tanks capable of serving their intended purpose efficiently and safely.

QuestionAnswer

What are the key considerations in designing a circular steel water tank?

Key considerations include determining the required storage capacity, selecting appropriate steel thickness and material, designing for internal and external pressures, ensuring stability against buckling, accommodating thermal expansion, and incorporating appropriate foundation and support details.

How do you calculate the wall thickness for a circular steel water tank?

Wall thickness is typically calculated using pressure vessel design formulas, such as those based on ASME standards. It involves considering the maximum internal pressure, tank diameter, material yield strength, and safety factors to ensure the tank can withstand operational stresses safely.

What are common methods to reinforce a circular steel water tank for increased durability?

Reinforcement methods include adding stiffening rings or braces at intervals, using thicker steel plates in critical areas, applying corrosion-resistant coatings, and incorporating proper anchoring and support structures to withstand external loads and soil pressure.

How does the choice of steel material affect the design of a circular water tank?

The steel material impacts the tank's strength, corrosion resistance, and weight. High-strength, corrosion-resistant alloys can reduce wall thickness and increase durability, while standard carbon steels may require additional protective coatings. Material selection influences cost, lifespan, and maintenance requirements.

Can you provide an example calculation for a small circular steel water tank with a 10-meter diameter?

Certainly. For a 10-meter diameter tank with a maximum water height of 5 meters, assuming steel with a yield strength of 250 MPa and a safety factor of 1.5, the wall thickness can be estimated using pressure formulas. For instance, the hoop stress is calculated as $\sigma = (P \times r) / t$, where P is the internal pressure, r is the radius, and t is the wall thickness. Based on the internal pressure from water height and applying the formula, you can determine the minimum required steel thickness to ensure safety and durability.

Related keywords: circular steel water tank, tank design calculations, water tank structural analysis, steel tank construction, tank capacity estimation, tank wall thickness, foundation design for tanks, seismic design considerations, tank stability analysis, steel tank fabrication

Underground rectangular water tank design example

Underground Rectangular Water Tank Design Example: A Comprehensive Guide

Underground rectangular water tank design example serves as a valuable reference for engineers, architects, and construction professionals involved in water storage solutions. Designing an underground water tank requires careful consideration of various structural, safety, and functional aspects to ensure durability, efficiency, and safety. This article provides an in-depth look into a practical example of designing an underground rectangular water tank, highlighting key principles, calculations, and best practices.

Understanding the Importance of Underground Rectangular Water Tanks

Why Choose an Underground Water Tank?

- Space-saving:** Ideal for locations with limited surface area.
- Protection:** Offers natural insulation and protection from external elements.
- Safety:** Reduced risk of contamination and vandalism.
- Aesthetic benefits:** Keeps the landscape visually unobstructed.

Applications of Underground Rectangular Water Tanks

- Municipal water supply systems
- Industrial storage facilities
- Fire suppression systems
- Rainwater harvesting and stormwater management

Key Considerations in Designing an Underground Rectangular Water Tank

- Structural Integrity:** Load-bearing capacity, Soil pressure considerations, Wall and floor reinforcement.
- Material Selection:** Concrete (reinforced or prestressed), Fiberglass-reinforced plastic, Steel with protective coatings.
- Hydraulic Design:** Capacity requirements, Water flow and inlet/outlet positioning.
- Ventilation and access points:** Environmental and Safety Factors, Waterproofing, Corrosion resistance, Leak prevention, Ventilation and odor control.

Step-by-Step Example of Designing an Underground Rectangular Water Tank

- Define Design Requirements**
 - Capacity:** 500 cubic meters (m^3)
 - Location:** Urban area with moderate soil conditions
 - Usage:** Municipal water storage
 - Design Life:** 50 years
 - Operational Pressure:** Based on incoming water pressure and height
- Site and Soil Analysis**
 - Conduct geotechnical investigations
 - Determine soil bearing capacity
 - Assess groundwater level
 - Identify potential soil settlement issues
- Determine Tank Dimensions**
 - Capacity calculation:** $V = L \times W \times H$
 - For this example, choose dimensions considering space constraints and structural stability:
 - Length (L):** 10 meters
 - Width (W):** 5 meters
 - Height (H):** 10 meters
 - Verification of capacity:** $V = 10\text{m} \times 5\text{m} \times 10\text{m} = 500\text{m}^3$
 - This matches the required capacity.
- Structural Design Considerations**
 - Wall thickness:** Typically 200-300 mm considering soil pressure
 - Floor thickness:** About 300 mm to support the load
 - Reinforcement:** Use of steel reinforcement bars (rebar) in walls and floor
 - Reinforcement details:** Vertical rebars spaced at regular intervals (e.g., every 150 mm), Horizontal rebars layered appropriately
 - Concrete grade:** M30 or higher for durability
- Reinforcement Detailing**
 - Design reinforcement based on structural analysis
 - Use of

standard codes (e.g., IS 456:2000 for India, ACI standards) Example: Vertical bars: 16 (16 mm diameter) spaced at 150 mm centers Horizontal ties: 10 (10 mm diameter)

6. Waterproofing and Corrosion Protection Apply waterproof membrane on the interior surfaces Use of corrosion-resistant reinforcement (e.g., epoxy-coated rebar) Proper sealing of joints and openings

7. Inlet, Outlet, and Ventilation Design Inlet pipe: Positioned at the top to allow filling Outlet pipe: Located near the bottom for draw-off Ventilation: Adequate air vents to prevent vacuum or pressure buildup Access hatch: For inspection and maintenance

8. Structural Analysis and Load Calculations Calculate soil lateral pressure using Terzaghi's or Coulomb's theory Include water pressure when tank is full Account for surcharge loads (e.g., vehicles, equipment)

9. Construction Considerations Excavation safety Formwork design Reinforcement placement Concrete pouring and curing processes Waterproofing application

Design Example Summary and Key Takeaways This example illustrates the essential steps in designing an underground rectangular water tank, emphasizing the importance of capacity planning, structural integrity, material choice, and environmental considerations. Proper planning ensures that the tank functions efficiently over its intended lifespan, with safety and durability at the forefront.

Additional Tips for Effective Underground Water Tank Design Engage geotechnical experts: Soil conditions significantly influence design parameters. Follow relevant codes and standards: Ensures safety, quality, and compliance. Incorporate safety features: Overflow outlets, alarms, and monitoring systems. Plan for future expansion: Design with scalability in mind. Regular maintenance: Schedule inspections for leaks, corrosion, and structural integrity.

Conclusion Underground rectangular water tanks are vital infrastructure components for urban and industrial water management. A well-designed tank not only meets capacity and safety requirements but also ensures longevity and minimal maintenance. By following a systematic design approach, considering soil and environmental factors, and adhering to engineering standards, professionals can create efficient, durable, and safe underground water storage solutions. The example provided serves as a practical guide to understanding the complexities and best practices involved in such designs, ultimately contributing to the successful implementation of water storage infrastructure.

Underground Rectangular Water Tank Design Example: A Comprehensive Guide Designing an underground rectangular water tank involves a blend of structural engineering principles, material science, geotechnical considerations, and hydraulic calculations. This detailed review aims to provide an in-depth understanding of the process through a practical example, highlighting key aspects, methodologies, and best practices.

Introduction to Underground Rectangular Water Tanks Underground water tanks are essential components in municipal water supply systems, firefighting infrastructure, and industrial facilities. Their advantages include space-saving, aesthetic benefits, protection from environmental factors, and reduced evaporation losses. Rectangular tanks are favored for their ease of construction, modularity, and straightforward design.

Basic Design Considerations Before proceeding with calculations, it's crucial to understand the fundamental considerations: **Capacity Requirements:** Determine the total volume based on demand. Available

Space & Site Conditions: Assess site topography, soil type, and groundwater level. Material Selection: Concrete (prestressed or reinforced), steel, or composite. Structural Safety & Durability: Ensure the design complies with relevant codes and standards. Hydrostatic & Hydrostatic Pressure: Address the forces exerted by stored water. Seismic & Load Considerations: Account for seismic activity and surface loads.

Design Example Overview Let's consider a practical example: Purpose: Municipal water supply storage Capacity: 500 m³ (cubic meters) Tank Dimensions (initial estimate): Length = 20 m, Width = 10 m, Height = 4 m The goal is to design a reinforced concrete underground rectangular tank with these specifications, optimizing for safety, durability, and cost-effectiveness.

Step 1: Determining Tank Dimensions and Volume The initial dimensions are based on capacity: $\text{Volume} = \text{Length} \times \text{Width} \times \text{Height}$ Given the capacity: $500 \text{ m}^3 = 20 \text{ m} \times 10 \text{ m} \times \text{Height}$ Calculating: $\text{Height} = \frac{500}{20 \times 10} = \frac{500}{200} = 2.5 \text{ m}$ However, for structural and construction considerations, a height of 4 meters is chosen to allow for sufficient headroom, maintenance access, and to optimize tank dimensions.

Final dimensions: Length (L): 20 m Width (W): 10 m Height (H): 4 m Volume check: $V = 20 \times 10 \times 4 = 800 \text{ m}^3$ Since this exceeds the required 500 m³, either the height can be reduced to 2.5 m, or the dimensions can be adjusted. For simplicity, we'll proceed with the initial dimensions, understanding that the tank will have a capacity of approximately 800 m³, which can be adjusted as needed.

Step 2: Structural Design ? Wall and Slab Thickness The primary structural elements include: Walls (perimeter walls) Bottom slab Designing these elements requires calculating the forces and selecting appropriate thicknesses and reinforcement.

2.1 Hydrostatic Pressure Calculation The water exerts hydrostatic pressure on the tank walls and bottom: $P = \rho g h$ Where: (ρ) = density of water (~1000 kg/m³) (g) = acceleration due to gravity (~9.81 m/s²) (h) = height of water column Maximum pressure at the bottom: $P_{\text{max}} = 1000 \times 9.81 \times 4 = 39,240 \text{ Pa} \approx 39.24 \text{ kPa}$

2.2 Wall Thickness Calculation Using standard practices, the thickness of the walls (t) can be estimated based on the maximum pressure and reinforcement requirements. For reinforced concrete tanks, a typical wall thickness: Minimum: 0.3 m for walls with height 4 m Reinforcement: Design reinforcement to resist tensile stresses due to hydrostatic pressure Design example: Wall thickness $(t_w = 0.4 \text{ m})$

2.3 Bottom Slab Thickness Similarly, the bottom slab must resist the total hydrostatic load: $\text{Total load} = \text{Area} \times P_{\text{avg}}$ Average pressure: $P_{\text{avg}} = \frac{0 + P_{\text{max}}}{2} = 19.62 \text{ kPa}$ Total load per unit length: $q = P_{\text{avg}} \times \text{height} = 19.62 \times 4 = 78.48 \text{ kPa}$ Design slab thickness: Typical: 0.5 to 0.6 m Here, $(t_s = 0.6 \text{ m})$ is selected for safety.

Step 3: Reinforcement Detailing Design reinforcement involves: Calculating the required reinforcement area based on bending and shear. Using codes like ACI 318 or Eurocode for detailed calculations.

3.1 Reinforcement for Walls Vertical reinforcement: designed to resist bending due to hydrostatic pressure. Stirrups: shear reinforcement.

3.2 Reinforcement for Bottom Slab Main reinforcement: oriented to resist bending moments due to water pressure. Distribution reinforcement: to prevent cracking.

3.3 Reinforcement Ratios Typical reinforcement ratios: Tension steel: 0.8% to 1.2% of cross-sectional area. Shear reinforcement: designed per code requirements.

Step 4: Foundation Design The foundation must withstand: Dead loads of the tank structure Live loads (water weight, soil pressure) Soil bearing

capacity

4.1 Soil Investigation Determine soil bearing capacity (e.g., 150 kPa) Groundwater level assessment

4.2 Foundation Type Selection Raft Foundation: suitable for uniform loads, spreads the load evenly. Design parameters: Foundation thickness: 0.8 m Reinforcement: based on bending and shear calculations

4.3 Settlement & Stability Analysis Ensure settlement is within permissible limits and that the design satisfies stability criteria against sliding and overturning.

Step 5: Geotechnical and Waterproofing Considerations Underground tanks are vulnerable to water ingress and soil interaction: Waterproofing: Use of membrane liners, waterproof concrete admixtures, or coatings. Backfill Material: Well-compacted granular soil to prevent settlement. Drainage: Incorporate drainage systems around foundation to relieve hydrostatic pressure.

Step 6: Construction Methodology A typical construction sequence includes: Excavation: Dig the site to the required depth, considering foundation thickness and waterproofing layers. Foundation Preparation: Leveling, reinforcement placement, and formwork. Foundation Pouring: Concrete placement with proper curing. Wall and Slab Construction: Erect formwork, place reinforcement, and pour concrete in stages. Waterproofing & Backfilling: Apply waterproofing membranes before backfilling. Surface Restoration: Reinstatement of surface and access pathways.

Step 7: Structural Analysis and Validation Using software tools like STAAD.Pro or ETABS, verify the structural adequacy: Stress analysis: Confirm stresses are within permissible limits. Deflection checks: Ensure deformations are within acceptable ranges. Reinforcement detailing: Finalize reinforcement placement.

Design Code Compliance and Safety Design must adhere to local standards such as: ACI 318 (American Concrete Institute) Eurocode 2 IS 3370 (Indian Standard for Concrete Structures for the Storage of Liquids) Safety factors, load factors, and durability aspects are incorporated to ensure long-term performance.

Additional Considerations Ventilation & Access: Include manholes and ventilation openings. Ladders & Handrails: For maintenance access. Corrosion Protection: Use of corrosion-resistant reinforcement or protective coatings. Monitoring & Maintenance: Install sensors for water level, structural health, and leakage detection.

Conclusion Designing an underground rectangular water tank is a multifaceted process that necessitates meticulous calculations, adherence to standards, and practical considerations for construction and operation. From initial capacity determination to detailed reinforcement design and foundation planning, each step plays a critical role in ensuring the tank's safety, durability, and functionality. This example underscores the importance of integrating structural analysis, geotechnical assessment, material selection, and environmental considerations into a cohesive design approach. Proper planning, rigorous analysis, and adherence to best practices result in a reliable infrastructure component vital for water management systems.

Question Answer

What are the key considerations in designing an underground rectangular water tank?

Key considerations include structural stability, soil conditions, water pressure, material selection,

waterproofing, excavation requirements, and safety factors to ensure durability and safety of the tank.

How do you calculate the capacity of an underground rectangular water tank?

Capacity is calculated by multiplying the interior length, width, and height of the tank ($\text{Volume} = \text{Length} \times \text{Width} \times \text{Height}$). Convert the volume into appropriate units (e.g., liters or gallons) depending on the measurement system used.

What materials are commonly used for constructing underground rectangular water tanks?

Common materials include reinforced concrete, prestressed concrete, fiberglass, and sometimes steel or polyethylene linings, chosen based on durability, waterproofing, and environmental conditions.

How is waterproofing achieved in underground rectangular water tank design?

Waterproofing is achieved through the use of waterproof concrete mixes, membrane linings, sealants, and proper joint detailing to prevent water seepage and protect the surrounding soil.

What are the structural load considerations for an underground rectangular water tank?

The design must account for soil pressure, water pressure, live loads from surface loads, and any potential surcharge loads, ensuring the structure can withstand these forces without failure.

How do you determine the thickness of the walls and base of an underground rectangular water tank?

Thickness is determined based on structural calculations considering load conditions, material strengths, safety factors, and building codes, often involving finite element analysis for complex designs.

What is the typical construction sequence for an underground rectangular water tank?

The sequence includes site excavation, foundation preparation, formwork assembly, reinforcement placement, concrete pouring for walls and base, curing, waterproofing application, and backfilling around the tank.

How do you ensure safety and durability in underground water tank design?

Safety and durability are ensured through proper material selection, structural design adherence to

codes, waterproofing, adequate ventilation, access provisions, and regular maintenance checks.

Are there specific codes or standards to follow for underground rectangular water tank design?

Yes, design must comply with relevant local building codes, standards such as ACI (American Concrete Institute), ASCE, and other regional regulations governing underground water structures and safety requirements.

Related keywords: underground water tank, rectangular water tank, water tank design, underground tank construction, tank capacity calculation, reinforced concrete tank, structural design, water storage system, tank reinforcement details, civil engineering example

Estimate for underground rcc rectangular water tanks

Estimate for Underground RCC Rectangular Water Tanks: A Comprehensive Guide

Estimate for underground RCC rectangular water tanks is a crucial aspect for engineers, contractors, and project managers involved in designing, constructing, or budgeting for water storage solutions. These tanks are integral to municipal water supply systems, industrial applications, fire protection systems, and emergency water reserves. Accurate cost estimation ensures that projects are financially feasible, timelines are maintained, and quality standards are met. This article provides a detailed overview of the factors influencing the cost of underground RCC (Reinforced Cement Concrete) rectangular water tanks, along with methodologies for obtaining precise estimates.

Understanding Underground RCC Rectangular Water Tanks

What Are RCC Rectangular Water Tanks? RCC rectangular water tanks are constructed using reinforced concrete to ensure durability, strength, and longevity. Their rectangular shape allows for efficient use of space, especially in constrained sites, making them popular in urban and industrial environments. These tanks are designed to be buried underground, offering benefits such as space optimization, temperature stability, and protection from external elements.

Advantages of Underground RCC Rectangular Water Tanks

- Space-efficient Design:** Fits into limited spaces.
- Temperature Control:** Maintains consistent water temperature.
- Protection:** Shielded from environmental damage and vandalism.
- Aesthetic Benefits:** No visual impact on the landscape.
- Cost-effective:** Reduced land costs compared to above-ground tanks.

Factors Influencing the Cost Estimate

A precise estimate for underground RCC rectangular water tanks depends on multiple factors. Understanding these variables helps in preparing accurate budgets and avoiding unforeseen expenses.

- 1. Tank Dimensions and Capacity**

The size of the tank directly impacts material quantities and construction efforts:

 - Length, Width, and Height:** Larger dimensions increase concrete volume and reinforcement needs.
 - Capacity (e.g., liters or cubic meters):** Larger capacity tanks require more extensive work.
- 2. Structural Design Specifications**

Design complexity influences

costs:Wall Thickness: Thicker walls demand more concrete.Reinforcement Details: Higher reinforcement ratios increase material costs.Design Codes & Standards: Compliance with local standards may affect design features and costs.

3. Site ConditionsThe nature of the installation site affects construction expenses:Soil Type: Soft or rocky soils require specialized excavation and foundation work.Water Table Level: High water tables may necessitate dewatering and additional waterproofing.Accessibility: Difficult access increases equipment and labor costs.

4. Material CostsFluctuations in material prices impact overall estimates:Concrete: Cost varies based on mix design and quality.Reinforcement Steel: Prices depend on market conditions.Formwork and Shuttering: Material costs depend on complexity and quantity.

5. Construction MethodologyConstruction techniques influence timelines and costs:Excavation & Foundation Work: Varies with site conditions.Formwork & Casting: Complexity affects labor and material costs.Curing & Waterproofing: Additional processes for durability.

6. Additional Components and AccessoriesAdditional features add to the total cost:Inlets, Outlets, and ValvesManholes and Access PortsLadders and Safety FeaturesLighting and Ventilation (if required)

7. Project Duration & Labor CostsLabor rates and project timeline influence costs:Labor Wages: Vary regionally.Construction Duration: Longer projects tend to increase indirect costs.

8. Contingency and Miscellaneous ExpensesUnexpected issues can arise, requiring contingency allocations (typically 5-10% of total estimate).

Methodologies for Cost EstimationAccurate estimation involves systematic approaches. Here are common methodologies employed:

1. Quantity Takeoff Based EstimationStep 1: Define tank dimensions and features.Step 2: Calculate quantities of concrete, reinforcement, and other materials.Step 3: Apply unit costs to quantities.Step 4: Sum up for total cost.

2. Parametric EstimationUse established cost per unit volume or surface area based on historical data.Example: Cost per cubic meter of concrete for underground tanks.

3. Detailed / Bottom-Up EstimationBreak down the project into individual tasks.Estimate costs for each task (excavation, formwork, concrete pouring, waterproofing).Aggregate estimates for overall costs.

4. Software-Based EstimationUtilize specialized software tools that incorporate local data, material prices, and labor costs.

Benefits: Increased accuracy and efficiency.

Average Cost Range for Underground RCC Rectangular Water TanksThe cost of underground RCC rectangular water tanks varies widely depending on the factors discussed above. Here is a general cost breakdown:

Parameter	Estimated Cost Range (per cubic meter)	Notes
Concrete & Reinforcement	₹15,000 - ₹25,000	Varies with quality and design
Excavation & Foundation	₹5,000 - ₹15,000	Depends on soil and site accessibility
Waterproofing & Coatings	₹3,000 - ₹8,000	For durability and leak prevention
Additional Components	₹2,000 - ₹5,000	Inlets, outlets, manholes, safety features
Labor & Equipment	₹10,000 - ₹20,000	Regional wage variations

Total Estimated Cost: Approximately ₹35,000 to ₹70,000 per cubic meter of storage capacity.

Note: These figures are indicative. For precise budgeting, detailed project-specific estimates are necessary.

Cost Estimation Example for a 500 Cubic Meter Underground RCC Rectangular Water TankSuppose a project requires a 500 m³ underground RCC rectangular water tank. Using the average cost of ₹50,000 per m³:

Material Cost: $500 \text{ m}^3 \times ₹50,000 = ₹25,00,000$

Additional Expenses: Including excavation, waterproofing, accessories, and labor, estimate an extra 30-40%: $30\% \text{ of } ₹25,00,000 = ₹7,50,000$

Total Estimated Cost: $₹25,00,000 + ₹7,50,000 = ₹32,50,000$

This comprehensive estimate

provides a realistic budget framework for project planning. **Tips for Accurate Cost Estimation** **Conduct Site Visits:** Assess site conditions firsthand. **Consult Local Suppliers:** Obtain current material prices. **Use Historical Data:** Review costs from similar past projects. **Engage Experienced Engineers:** Their insights can refine estimates. **Include Contingency:** Always allocate buffer funds for unforeseen issues. **Update Estimates Regularly:** Adjust for market fluctuations and project changes. **Conclusion** Estimating the cost of underground RCC rectangular water tanks is a multifaceted process that requires careful consideration of design specifications, site conditions, material costs, and construction methodologies. Accurate estimates enable efficient project management, cost control, and successful project delivery. By systematically analyzing the influencing factors and employing reliable estimation techniques, stakeholders can ensure their water storage solutions are both effective and economical. Remember, for precise budgeting, always collaborate with qualified engineers and procurement specialists, and consider engaging professional estimation services to tailor costs to your specific project requirements.

Estimate for underground RCC rectangular water tanks is a crucial aspect for civil engineers, contractors, and project planners involved in designing and constructing water storage solutions. Accurate cost estimation ensures budget adherence, resource allocation, and project feasibility. Underground reinforced cement concrete (RCC) rectangular water tanks are widely used for municipal water supply, industrial applications, and emergency storage due to their durability and structural strength. This article provides a comprehensive overview of estimating costs for such tanks, covering factors influencing the estimate, detailed components involved, methodologies, and practical considerations to achieve accurate and reliable estimates. **Understanding the Basics of RCC Rectangular Underground Water Tanks** Before delving into estimation specifics, it's essential to understand what RCC rectangular underground water tanks are and their significance. **What Are RCC Rectangular Underground Water Tanks?** RCC rectangular underground water tanks are durable, reinforced concrete structures designed to store large volumes of water below ground level. Their rectangular shape allows for efficient use of space, ease of construction, and straightforward design integration with existing infrastructure. These tanks are typically constructed with reinforced concrete walls, base slabs, and sometimes roofs, depending on design requirements. **Applications and Advantages** **Municipal water supply systems** **Industrial water storage** **Fire water reservoirs** **Emergency water storage** **Features:** High durability and long service life Customizable dimensions Minimal surface footprint Reduced exposure to environmental factors Can be constructed in various soil and space conditions **Factors Influencing the Cost Estimate** A precise estimate depends on multiple factors, which can be broadly categorized into design parameters, site conditions, material costs, labor, and regulatory requirements. **Design Parameters** **Tank Dimensions:** Length, width, and height directly impact the volume and quantity of materials. **Wall Thickness:** Thicker walls increase material and labor costs. **Water Capacity:** Larger capacity tanks require more material and longer construction times. **Additional Features:** Presence of precast elements, inlet/outlet arrangements, access platforms, or coating. **Site Conditions** **Soil Type and Stability:**

Difficult soil conditions may necessitate special foundations or soil stabilization, increasing costs. Groundwater Level: High groundwater levels may require dewatering measures. Accessibility: Ease of access for construction equipment influences labor and transportation costs. Location: Urban vs. rural sites, proximity to utilities, and transportation infrastructure. Material and Equipment Costs Cost of reinforcement steel, cement, formwork, and other materials varies regionally. Equipment rental or purchase for excavation, concrete pouring, and finishing. Labor and Construction Methods Skilled vs. unskilled labor rates. Construction techniques employed, such as slip-forming or traditional formwork. Regulatory and Environmental Factors Permit fees, environmental clearances. Safety and quality assurance standards. Components of Cost Estimation An accurate estimate involves calculating costs associated with each stage and component of construction.

1. Excavation and Site Preparation Scope: Removing soil, leveling, and preparing the foundation. Cost Factors: Soil type and volume to excavate. Need for shoring or underpinning. Disposal of excavated material. Estimate Calculation: Volume (m³) x unit rate.

2. Foundation and Base Slab Design: Reinforced concrete footing and base slab. Cost Factors: Thickness and reinforcement details. Formwork and curing requirements. Estimate Calculation: Area x thickness x unit rate of concrete + reinforcement cost.

3. Walls and Roof Construction Design: RCC walls with specified thickness, reinforcement layout. Cost Factors: Wall height and length. Reinforcement steel quantity and rate. Formwork for vertical and horizontal surfaces. Estimate Calculation: Wall volume = (perimeter x height x thickness). Reinforcement steel weight = based on design specifications. Formwork costs based on surface area.

4. Reinforcement Steel Steel reinforcement is a significant cost component. Calculation: Total steel weight = volume of reinforcement per design x steel density. Cost Factors: Steel unit rate. Detailing and placement labor.

5. Formwork and Shuttering Scope: Temporary structures for concrete shaping. Cost Factors: Surface area to be shuttered. Material type (plywood, steel). Reuse factor for formwork.

6. Plastering and Surface Treatment Usually minimal for underground tanks but may be required for waterproofing or finishing.

7. Waterproofing and Finishing Essential for underground tanks to prevent leakage. Materials include bituminous coatings, membranes, or chemical sealants. Cost varies based on material quality and surface area.

8. M&E (Mechanical & Electrical) Installations Pumps, inlet/outlet pipes, monitoring systems. Usually added to the estimate if required.

9. Miscellaneous and Contingencies Overheads, permits, safety measures, and unforeseen expenses.

Methodologies for Cost Estimation Different approaches can be employed depending on project scope and available data.

1. Quantity Takeoff Method Precise calculation of quantities for each component. Suitable for detailed project planning. Requires detailed design drawings.

2. Parametric Estimation Uses historical data and standard unit rates. Quick and useful during early project phases. Less precise but useful for feasibility analysis.

3. Approximate or Rough Estimation Based on per-unit volume or area costs. Suitable when design details are incomplete. Example: Cost per cubic meter of tank capacity.

4. Software-Based Estimation Tools Specialized software can automate calculations. Incorporates regional material costs and labor rates.

Sample Cost Breakdown for an RCC Rectangular Underground Water Tank Assuming a 1000m³ capacity tank with dimensions 20m x 10m x 5m height, approximate costs (based on typical rates):

Component	Quantity	Unit Rate	Total Cost (Approximate)
Excavation	2000 m³		

\$10/m³ | \$20,000 || Foundation & Base Slab | 200 m² | \$120/m² | \$24,000 || Wall Reinforced Concrete | 200 m² | \$150/m² | \$30,000 || Reinforcement Steel | 25 tonnes | \$800/tonne | \$20,000 || Formwork | 600 m² | \$50/m² | \$30,000 || Waterproofing & Finishing | 200 m² | \$30/m² | \$6,000 || M&E Installations | - | - | \$10,000 || Contingency & Overheads | 10% | - | \$15,000 |Total Estimated Cost: Approximately \$155,000

Note: Actual costs vary regionally, and detailed design may alter these figures.

Practical Considerations for Accurate Estimation

Design Review: Ensure detailed drawings and specifications are available.

Site Inspection: Evaluate soil, groundwater, and access.

Material Market Survey: Obtain current rates for steel, cement, and formwork materials.

Labor Cost Analysis: Understand prevailing wages and availability.

Risk Assessment: Identify potential delays, adverse conditions, or regulatory hurdles.

Contingency Planning: Always include a contingency percentage (10-15%) to accommodate unforeseen expenses.

Conclusion

Estimating the cost for underground RCC rectangular water tanks requires a comprehensive understanding of design, site conditions, material prices, and construction methods. Precision in quantity calculation, awareness of regional cost variations, and detailed planning are essential for reliable estimates. While rough estimates provide a starting point, detailed quantity takeoff and analysis lead to more accurate budgeting. By considering all contributing factors and leveraging suitable estimation methodologies, project stakeholders can ensure economic feasibility, timely completion, and high-quality construction of underground water storage solutions.

Final Tips: Always update cost data regularly to reflect market changes. Engage experienced structural engineers and quantity surveyors. Use software tools for complex projects to improve accuracy. Document assumptions and methodologies used for transparency and future reference. A well-prepared estimate not only guides budget management but also helps in project planning, resource allocation, and risk mitigation, ultimately leading to successful project execution.

QuestionAnswer

What factors influence the cost estimation of underground RCC rectangular water tanks?

The cost depends on tank size and capacity, reinforcement and concrete quality, excavation and foundation requirements, labor costs, location, and additional features like waterproofing and access structures.

How is the quantity of materials estimated for an underground RCC rectangular water tank?

Material estimation involves calculating the volume of concrete and reinforcement needed based on tank dimensions, wall thickness, and slab thickness, along with considering waste and over-excavation allowances.

What is the typical cost range for constructing an underground RCC rectangular water tank?

The cost varies widely depending on size and specifications but generally ranges from \$200 to \$600 per cubic meter of tank capacity, including materials, labor, and additional expenses.

Are there standard guidelines or codes to follow for estimating costs of underground RCC water tanks?

Yes, standards like ACI, IS codes, and local building regulations provide guidelines for design and construction, which help in accurate cost estimation and ensuring structural safety.

How does project location impact the estimate for underground RCC rectangular water tanks?

Location affects costs due to differences in labor rates, material availability, excavation challenges, soil conditions, and transportation expenses, leading to variations in overall project estimates.

Related keywords: underground RCC water tank calculation, rectangular water tank capacity, RCC water tank design, underground water tank dimensions, concrete water tank estimate, RCC tank construction cost, underground water storage design, rectangular tank reinforcement, water tank volume calculation, RCC tank engineering specifications

Pca rectangular concrete tanks example

pca rectangular concrete tanks example serves as an insightful case study for engineers, contractors, and project managers involved in the design, construction, and maintenance of large-scale water storage solutions. Rectangular concrete tanks are widely used in various industries, including water treatment plants, industrial processing, firefighting reserves, and agricultural irrigation systems. PCA (Precast Concrete Associates) specializes in manufacturing precast concrete components, offering efficient, durable, and cost-effective solutions for such tanks. This article explores a comprehensive example of a PCA rectangular concrete tank project, highlighting design considerations, construction techniques, advantages, and best practices to ensure longevity and performance.

Understanding Rectangular Concrete Tanks

What Are Rectangular Concrete Tanks? Rectangular concrete tanks are large, box-shaped structures constructed primarily from reinforced concrete. They are designed to store liquids such as potable water, wastewater, or chemicals. Their shape offers advantages in space utilization, ease of construction, and simplicity in layout, making them suitable for various applications.

Applications of Rectangular Concrete Tanks

Water storage in municipal and industrial systems
Effluent and wastewater treatment
Firewater reserves
Agricultural irrigation reservoirs
Chemical storage tanks
The

Role of PCA in Rectangular Concrete Tank Construction PCA, or Precast Concrete Associates, provides prefabricated concrete panels, walls, and other components that streamline tank construction. Using precast elements offers several benefits: Reduced construction time, Enhanced quality control, Superior durability, Flexibility in design modifications, Cost savings through minimized on-site labor.

Case Study: Designing a PCA Rectangular Concrete Tank To illustrate the practical application, let's consider a hypothetical project where a municipal water authority needs a 500,000-gallon rectangular concrete tank for storage and distribution.

Design Requirements and Specifications

- Capacity: 500,000 gallons (~1,892 cubic meters)
- Dimensions: approximately 30 meters (length) x 15 meters (width) x 4 meters (height)
- Material: Reinforced concrete with corrosion-resistant features
- Wall Thickness: 300 mm
- Floor Thickness: 400 mm
- Access points: inlet, outlet, inspection hatches
- Structural considerations: seismic and wind load resistance
- Compliance: local building codes and water quality standards

Design Process Overview

Site Assessment: Soil testing, topographical surveys, and environmental considerations.

Structural Design: Load calculations, reinforcement detailing, and stability analysis.

Component Specification: Prefabricated panels for walls and floor, precast connections.

Manufacturing Planning: Factory scheduling, quality control protocols, and logistics.

Construction Sequence: Foundation preparation, panel installation, sealing, and finishing.

Step-by-Step Construction Using PCA Components

- Foundation Preparation** Excavate the site to the required depth. Install a reinforced concrete footing with appropriate reinforcement. Ensure proper leveling and compaction for uniform load distribution.
- Installing Precast Wall Panels** Transport precast panels from the manufacturing facility to the site. Use cranes and lifting equipment to position panels accurately. Connect panels using embedded steel connectors, grout, or mechanical fasteners. Seal joints with waterproof sealants to prevent leakage.
- Assembling the Floor** Lay precast floor panels or cast a monolithic slab if specified. Reinforce the slab as per design, ensuring load-bearing capacity.
- Installing Inlet and Outlet Structures** Fit precast inlet and outlet pipes or manholes. Seal connections to prevent seepage.
- Final Finishing and Testing** Apply surface treatments or coatings for durability. Conduct water-tightness tests, such as hydrostatic testing. Install access ladders, safety rails, and instrumentation.

Advantages of Using PCA Rectangular Concrete Tanks

- Speed of Construction:** Precast panels are manufactured concurrently with site preparation, shortening project timelines.
- Quality Assurance:** Factory-controlled conditions ensure consistent quality and adherence to standards.
- Durability:** Concrete panels are resistant to environmental factors, chemical attack, and mechanical wear.
- Design Flexibility:** Custom sizes, finishes, and reinforcement configurations accommodate project-specific needs.
- Cost Savings:** Reduced labor and faster installation lead to lower overall project costs.

Best Practices for Successful Implementation

- Comprehensive Planning:** Detailed design documentation and coordination among all stakeholders.
- Material Quality Control:** Use of high-quality concrete mixes and reinforcement to ensure strength and longevity.
- Accurate Manufacturing:** Prefabrication in certified facilities with strict quality controls.
- Skilled Installation Crew:** Experienced personnel for handling heavy precast elements and ensuring proper connections.
- Rigorous Testing:** Conduct hydrostatic and leakage tests before commissioning.
- Maintenance Planning:** Routine inspections, cleaning, and repairs to extend lifespan.

Common Challenges and Solutions

- Transport and Handling:** Use proper lifting equipment and transportation methods to prevent damage.
- Joint Sealing:** Employ high-quality waterproof

sealants and proper joint design to prevent leaks. Site Constraints: Conduct thorough site assessments and adapt design to overcome space or soil limitations. Seismic Considerations: Incorporate seismic reinforcement and flexible joints to withstand earthquakes. Maintenance and Longevity of PCA Rectangular Concrete Tanks Regular maintenance is crucial to ensure the tank's performance over decades. Key practices include: Periodic visual inspections for cracks, corrosion, or joint deterioration. Cleaning to prevent sediment buildup. Applying protective coatings if necessary. Monitoring structural elements for signs of stress or movement. Implementing a comprehensive maintenance schedule aligned with manufacturer recommendations. Conclusion The PCA rectangular concrete tanks example exemplifies how modern precast concrete technology enhances the efficiency, durability, and cost-effectiveness of large-scale storage solutions. By leveraging precast components, project stakeholders can achieve faster construction, superior quality control, and long-term reliability. Whether for municipal water supply, industrial processes, or emergency reserves, understanding the design, construction, and maintenance principles outlined in this example is essential for successful implementation. With proper planning, skilled execution, and ongoing maintenance, PCA rectangular concrete tanks can serve vital roles in infrastructure for decades to come.

PCA Rectangular Concrete Tanks Example: A Comprehensive Guide to Design, Construction, and Analysis When it comes to large-scale water storage, wastewater management, or industrial fluid containment, PCA rectangular concrete tanks stand out as a robust and versatile solution. These tanks, designed and constructed following the principles of Precast Concrete Architecture (PCA), are renowned for their durability, efficiency, and adaptability to various site conditions. This guide delves into the intricacies of PCA rectangular concrete tanks, illustrating with a detailed example, and providing essential insights for engineers, architects, and project managers involved in their design and implementation. Understanding PCA Rectangular Concrete Tanks What Are PCA Rectangular Concrete Tanks? PCA rectangular concrete tanks are prefabricated, precast concrete structures specifically designed for fluid storage. Their rectangular shape allows for efficient space utilization and straightforward integration into various civil projects. The PCA approach emphasizes standardized, high-quality precast elements manufactured in controlled environments, ensuring consistent quality, faster construction times, and reduced onsite labor. Why Choose PCA for Rectangular Tanks? Quality Control: Precast manufacturing allows for stringent quality assurance. Speed of Construction: Off-site fabrication accelerates project timelines. Structural Integrity: Reinforced concrete provides long-term durability. Design Flexibility: Customizable dimensions and configurations. Cost Efficiency: Reduced labor and shortened construction periods. The Example: Designing a 50m x 20m Rectangular Concrete Tank To illustrate the design process, this example examines a rectangular concrete tank measuring 50 meters in length, 20 meters in width, and 4 meters in height. The tank is intended for a municipal water treatment plant, requiring a volume of approximately 4,000 cubic meters. Step 1: Defining Project Requirements Before diving into design specifics, clarify key parameters: Capacity: 4,000 m³ Design

Life: 50 years Fluid Type: Potable water Operational Conditions: Static, with occasional filling and draining Site Conditions: Moderate seismic activity, moderate groundwater level Structural Load: Including the weight of water, tank walls, and operational loads Structural Design Considerations Load Analysis Understanding the loads acting on the tank is crucial: Dead Load: Self-weight of the tank structure plus the weight of water Live Load: Additional dynamic loads such as maintenance activities Environmental Loads: Earthquakes, wind, and groundwater pressure Material Selection Precast Concrete Quality: High-strength concrete (e.g., C40 or higher) Reinforcement: Adequate steel reinforcement to withstand tensile stresses Waterproofing: Integral waterproofing admixtures or sealants to prevent leakage Wall Thickness and Foundation Design Wall Thickness: Typically 0.3 to 0.5 meters, depending on structural calculations Foundation: Reinforced concrete slab or mat foundation capable of supporting the tank's weight and environmental loads Structural Calculations and Modeling Step 1: Volume Verification Calculate the volume to ensure design accuracy:
$$\text{Volume} = \text{Length} \times \text{Width} \times \text{Height} = 50\text{m} \times 20\text{m} \times 4\text{m} = 4,000\text{m}^3$$
 Step 2: Wall and Base Design Wall Thickness: Determined via structural analysis considering hydrostatic pressure: Hydrostatic pressure at the bottom:
$$p = \rho g h = 1000\text{kg/m}^3 \times 9.81\text{m/s}^2 \times 4\text{m} \approx 39,240\text{Pa}$$
 Using structural codes, select reinforcement and thickness to withstand this pressure. Base Thickness: Usually thicker than walls to support the load; often 0.5 meters. Step 3: Reinforcement Detailing Design reinforcement to resist bending, shear, and axial forces: Vertical reinforcement: To resist hydrostatic pressure Horizontal reinforcement: To prevent buckling Reinforcement spacing: Typically 200-300 mm grid Construction Methodology Precast Element Fabrication Panel Design: Walls, base, and cover panels are precast in controlled environments. Reinforcement Placement: Reinforcing steel is embedded during casting. Joint Design: Keyed or tongue-and-groove joints for seamless assembly. On-Site Assembly Foundation Preparation: Excavation, leveling, and foundation pour. Panel Transportation: Delivery of precast panels to site. Panel Erection: Using cranes, panels are positioned and connected with grout or mechanical fasteners. Sealing Joints: Ensuring watertight connections. Backfilling and Finishing: Soil backfill around the structure and surface finishing. Quality Control and Testing Precast Manufacturing: Inspection of concrete mix, reinforcement placement, curing conditions. Assembly: Alignment, joint tightness, and structural integrity. Leak Tests: Hydrostatic tests after assembly to verify watertightness. Final Inspection: Certification for structural and environmental compliance. Advantages of PCA Rectangular Concrete Tanks in This Example Speed: Prefabrication reduces construction time from months to weeks. Quality: Controlled environment ensures high-quality concrete and reinforcement. Cost Savings: Less on-site labor and fewer delays. Durability: Long service life with minimal maintenance. Flexibility: Modular design allows for future expansion or modification. Challenges and Mitigation Strategies Common Challenges Transportation Limits: Large panels may require special trucks or multiple trips. Assembly Precision: Ensuring proper alignment and joint sealing. Foundation Settlement: Uniform foundation preparation to prevent uneven settling. Seismic Considerations: Adequate reinforcement and flexible joints. Mitigation Strategies Detailed Planning: Use of 3D modeling for panel logistics. Quality Assurance: Regular inspections during manufacturing and assembly. Design Flexibility: Incorporation of expansion joints. Site Preparation: Proper soil investigation and foundation

design. Post-Construction Considerations Maintenance and Inspection Regular inspections for cracks, joint integrity, and leakage. Routine cleaning to prevent buildup and corrosion. Monitoring groundwater levels to prevent hydrostatic pressure issues. Longevity and Sustainability Use of durable materials to extend lifespan. Incorporating waterproofing and corrosion protection. Planning for future upgrades or capacity expansions. Summary: Why PCA Rectangular Concrete Tanks Are a Preferred Choice The example of designing and constructing a 50m x 20m rectangular concrete tank exemplifies the advantages of PCA precast technology. From precise structural calculations to efficient assembly, these tanks offer a reliable solution for diverse storage needs. Their adaptability, quality control, and accelerated construction process make them particularly suitable for municipal, industrial, and environmental applications. In conclusion, understanding the detailed processes involved?from initial design considerations through to construction and maintenance?is essential for successful projects utilizing PCA rectangular concrete tanks. Proper planning, adherence to engineering standards, and quality assurance are the pillars that ensure these structures perform effectively over their intended lifespan. Key Takeaways: PCA rectangular concrete tanks combine modularity with durability. Structural design must consider hydrostatic and environmental loads. Prefabrication enhances quality, reduces construction time, and lowers costs. Proper site preparation and joint sealing are critical for watertightness. Ongoing maintenance ensures long-term performance. This comprehensive understanding empowers project stakeholders to optimize the design, construction, and operational management of PCA rectangular concrete tanks, ensuring safe and efficient fluid storage solutions for years to come.

Question Answer

What is the primary purpose of using PCA in the design of rectangular concrete tanks?

PCA (Precast Concrete Association) standards help ensure structural integrity, durability, and proper load distribution in rectangular concrete tanks through standardized design and construction practices.

How does PCA influence the selection of concrete mix for rectangular tanks?

PCA provides guidelines for selecting concrete mixes with appropriate compressive strength, durability, and workability to withstand environmental conditions and load requirements specific to rectangular tanks.

What are the typical steps involved in designing a rectangular concrete tank following PCA standards?

The steps include determining capacity requirements, structural analysis, selecting appropriate

materials, designing reinforcement, and ensuring compliance with PCA guidelines for durability and safety.

Can you provide an example of a typical reinforcement layout for a rectangular concrete tank?

A common reinforcement layout includes horizontal reinforcement in the walls and bottom slab, with vertical reinforcement in corners and along the walls to resist hydrostatic and external loads, all designed according to PCA specifications.

How does PCA address the issue of joints and thermal expansion in rectangular concrete tanks?

PCA recommends the use of joints, expansion joints, and control joints at strategic locations to accommodate thermal movements and prevent cracking, ensuring long-term durability of the tank.

What are common challenges in constructing PCA-compliant rectangular concrete tanks?

Challenges include ensuring proper formwork, accurate reinforcement placement, curing processes, and adherence to design specifications to prevent leaks, cracking, and structural failure.

How is the load distribution analyzed in a PCA-designed rectangular concrete tank example?

Load distribution is analyzed using structural calculations that consider hydrostatic pressure, self-weight, and additional loads, ensuring the tank's walls and base can safely withstand these forces as per PCA guidelines.

What maintenance considerations are recommended for rectangular concrete tanks built per PCA standards?

Regular inspections for cracks, joint integrity, and corrosion, along with proper sealing and cleaning, are recommended to maintain the tank's structural integrity and longevity.

Are there specific code references or standards within PCA for designing rectangular concrete tanks?

Yes, PCA provides technical bulletins, design guidelines, and standards that outline best practices for the structural design, materials, and construction of rectangular concrete tanks to ensure safety and durability.

Related keywords: PCA concrete tanks, rectangular tank design, PCA analysis concrete,

rectangular water tanks, PCA modeling tanks, concrete tank example, PCA analysis example, rectangular tank construction, PCA tank analysis, concrete tank structural design