# Design Parameters for Circular Water Tanks: A Comprehensive Review

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**Abstract:** *Water tanks are pivotal infrastructural components vital for numerous applications, from domestic use to industrial and firefighting needs. Circular water tanks, characterized by their cylindrical shape, offer structural advantages, ensuring stability and efficiency. This review paper explores the structural considerations and design parameters essential for circular water tanks. The study delves into material selection, foundation design, hydraulic loadings, seismic resilience, wind loads, stress distribution, adherence to design codes, waterproofing methods, and integration of accessories. Understanding these aspects is crucial for ensuring the durability, safety, and operational efficiency of circular water tanks.*

**Keywords:** *Circular Water Tanks, Structural Considerations, Material Selection, Foundation Design, Hydraulic Loadings, Wind Loads, Stress Distribution, Design Codes.*

## I. INTRODUCTION

Water is the primary source of life for mankind and one of the most basic necessities for rural development. The rural demand for water for crop irrigation and domestic water supplies is increasing. At the same time, rainfall is decreasing in many arid countries, so surface water is becoming scarce. A water tank is a vessel like structure that is used to store water for all house-hold chores like drinking, cooking, washing, bathing etc., the evolution of tanks from stone tanks to contemporary water tanks occurred with time. Elevated storage tanks are built where the landscape does not suit and contains sufficient ground water to supply. These can be installed by small families and also large communities. It should be built so strong in order to store water safely and distribute necessity volume of water like ground water can be done. It requires a tower-like structure to hold large capacity of water for large communities. Depending on different applications there are different types of tanks [1].

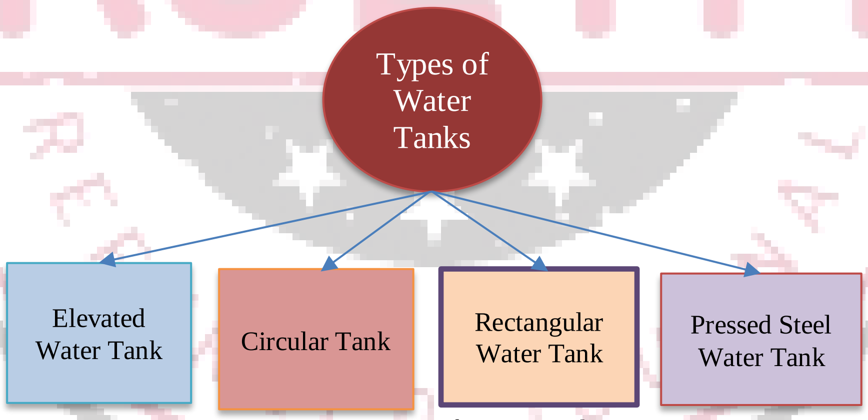


Figure 1 Types of Water Tank

Exploring RCC Circular Underground Water Tanks offers a holistic insight into these pivotal structures, crucial within water storage and distribution systems. Crafted to reside beneath the earth's surface, these tanks optimize spatial utilization, assuring a dependable water reservoir catering to diverse applications such as residential, industrial, and firefighting demands. RCC Circular Underground Water Tanks are characterized by their cylindrical shape, which offers several advantages. The circular design allows for efficient distribution of stresses and pressures, making them well-suited to withstand external forces, including soil pressure and potential seismic loads. This shape also minimizes the potential for corners or edges, reducing stress concentration points that could lead to structural vulnerabilities.

Figure 2 Circular Water Tank

Water is necessary for life on our planet. Seventy-one percent of the earth's surface is covered with water. this quantity is much smaller compared with the total earth volume. The oceans contain around 97% of the total water on earth]. Unfortunately, ocean water also has very heavy salt content and thus cannot be used directly for many household needs such as drinking, cooking. The rest of the total water is available as freshwater [2]. The evolution of the use and major achievements of water cisterns is presented and discussed here with emphasis placed on the most significant technologies applied throughout the centuries. Valuable insights into ancient water cistern technologies and management are provided, highlighting their characteristics of durability, environmental adaptability, and sustainability. A comparison of the water technological developments in several civilizations is undertaken [3]. Storage tanks are used to store water, liquid oil, petroleum products, etc. The strength analysis of tanks or containers is approximately the same regardless of the chemical nature of the product. All tanks are designed with a slotless construction to eliminate leaks. The slab and walls holding water or oil can be reinforced concrete with adequate reinforcement cover. A Water container is a container for storing liquid. The need for a water reservoir is as old as civilization to provide water storage for many applications, drinking water, irrigation, agriculture, firefighting, agriculture, for both plants and livestock, chemical production, food preparation and many other purposes. Water tank parameters include general tank design, choice of construction materials, coatings. The design depends on the location of the tank. above, underground or in underground water tanks, partly underground. Ground-based tanks include clean water tanks, sediment tanks, air tanks, etc., which rest directly on the ground. Pressure is exerted on the walls of these tanks and the weight of the water sinks to the bottom [4].

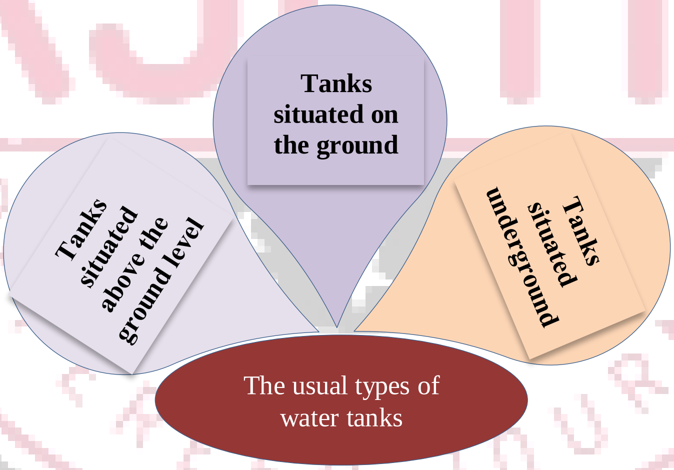


Figure 3 The Usual Types of Water Tanks

Underground water tanks are structures which act as a reservoir for small domestic or commercial buildings. Basic components of underground water tanks are Base slab, Side walls, and Roof slab. Tanks are very ductile, enabling to withstand seismic forces and varying water backfill. Tanks utilize material efficiently – steel in tension, concrete in compression. Underground water tanks have Low maintenance throughout the life as these are built with concrete, durable material that never corrodes and does not require coatings when in contact with water or the environment. The main advantage of underground water tank is that the temperature is lower than the overhead tanks, which will reduce evaporation inside water tank. Underground water tank faces different type of loads compared to other structures, they mainly face horizontal or lateral loads due to earth pressure and water pressure or any liquid pressure which is been stored in the tank. The side walls of the underground water tank will face greater load at the bottom and the load linearly decreases towards the top. The underground water tank not only faces loads inside the tank it also has to bear the surcharge above the ground level. So the roof slab of the underground tank should have enough strength to with stand the surcharge [5].

Importance of Underground Water Tank

- Seepage
  It is very important to store water and not to lose it. The tank should have a durable, watertight, opaque exterior and a clean, smooth interior. Below ground tanks must also be plastered well and correctly installed, otherwise they can collapse.
- Evaporation All storage tanks should have a roof made from locally available materials. A tight fitting top cover prevents evaporation.
- C) Safety
  We should prevent mosquito breeding and keeps insects, rodents, birds and children out of the tank. A suitable overflow outlet(s) and access for cleaning are also important.
- Storage of water
  It is very imperative for all tanks to store water because the main process of the tank is to store water due to lack of running fresh water in all areas.
- Emergency
  Underground tanks are used as reservoirs where water is pumped to overhead tanks. When water is not available it will help us store and use water.

## II. LITERATURE REVIEW

**J.G. Teng, et.al. [6]** Fibre-reinforced polymer (FRP) jackets have been widely used to confine reinforced concrete (RC) columns for enhancement in both strength and ductility. This article discusses the findings of a recent study that investigated at the advantages of confining hollow steel tubes in FRP. The first description is of axial compression testing on steel tubes contained in FRP. The next topic is finite element modeling of these tests. The test and numerical results demonstrate that FRP jacketing is a very promising method for retrofitting and bolstering spherical hollow steel tubes. Further evidence that FRP jacketing is a successful strengthening technique for such shells failing by elephant's foot collapse towards the base is provided by finite element findings for thin cylindrical shells with FRP jacketing under combined axial compression and internal pressure.

**Saaed TE et. al. [7]** Although there are still many research avenues to take in order to improve the efficacy of these methodologies, the use of structural control systems to reduce the responses of civil engineering structures under the effects of various kinds of dynamics loadings has become a standard technology. This article's objective is to review the most innovative structural control system technologies available today. To do this, the aouthors introduce a comprehensive literature study of all existing vibration control systems. Based on their operating processes, these systems can be divided into four major groups: (a) passive; (b) semi-active; (c) active; and (d) hybrid systems. Each of these primary classes and their subgroups are briefly described, along with their accompanying benefits and drawbacks. In order to highlight the potential and potential future direction of structural control systems in civil engineering, this article will provide an overview of various novel practical implementations of devices.

**Hashash, et. al. [8]** Water tanks are used as storage containers for storing water. For the social and industrial development of the country, water supply projects are essential. Earthquakes are one of the major natural calamities which have a potential to stop the normal going life of human by causing damage to infrastructure and lifeline facilities. Elevated water tanks should remain intact even after the earthquake since they are crucial for providing drinking water and putting out flames. RCC elevated water tanks were severely damaged, and some of them even collapsed, according to historical experience with a few earthquakes, such as the Bhuj earthquake (2001) in India. Examining how a reinforced concrete elevated water tank performs when subjected to dynamic load is the primary goal of this work. Additionally, the variation of dynamic responses—including base shear, overturning moment, displacement with change in staging height, water tank capacity, seismic zone, and soil conditions—was also investigated.

**Q Shi et. al. [9]** Water wave energy remains a largely untapped resource due to technological limitations and challenging environments. Triboelectric nanogenerators (TENGs) offer a promising alternative for harvesting water wave energy. Unlike traditional methods, TENGs are lightweight, cost-effective, and can harness energy from various sources. This study introduces a 3D spherical-shaped water-based TENG (SWTENG) that incorporates a double-layer water-based TENG on both its inner and outer surfaces. The symmetrical structure enhances energy harvesting from random directions, and the design's resilience to water leakage is beneficial for water wave energy harvesting. The SWTENG can also be applied to various energy sources and sensors, making it a versatile solution for energy harvesting and environmental monitoring on water surfaces.

**C Vashistha et. al. [10]** The efficiency of convectional heat exchangers plays a crucial role in transferring energy efficiently. Inserts have emerged as a viable method to enhance heat transfer coefficients while allowing for manageable frictional losses. This study investigates the heat transfer and fluid flow characteristics of circular tubes fitted with multiple inserts arranged in co-swirl and counter-swirl orientations. Experimental data is collected for various configurations and parameters. Notably, the use of multiple twisted tape inserts significantly enhances heat transfer, albeit with a proportional increase in friction losses. The study provides insights into the trade-offs between enhanced heat transfer and increased friction and presents correlations for Nusselt number and friction factor as functions of Reynolds number and twist ratio for different twisted tape configurations.

**TH New et. al. [11]** investigates the flow dynamics resulting from a laminar circular jet impinging upon a convex cylinder. Employing laser-induced fluorescence and digital particle image velocimetry techniques, the research examines cylinder-to-jet diameter ratios of 1, 2, and 4. The flow visualization and analysis reveal the behavior of ring-vortices generated by the impingement, their movement around the cylindrical surface, and the effects of cylinder diameter on boundary layer separation, vortex dipole formation, and wake size. The research quantifies wall shear stress distribution and presents a three-dimensional flow dynamics model to explain the observed phenomena.

**DR Plew et. al. [12]** explores the influence of juvenile Atlantic salmon on flow and turbulence within a circular tank. Different fish sizes and stocking densities were considered, and their impact on water velocity, turbulent kinetic energy, turbulence intensity, and turbulence dissipation rates were measured. Additionally, dissolved oxygen levels were assessed, and turbulent transport of oxygen was calculated. The presence of fish led to alterations in flow patterns, turbulence characteristics, and oxygen distribution within the tank. The research provides insights into the interplay between fish behavior and flow dynamics, shedding light on the interactions between aquatic life and fluid motion.

**T Arunkumar et. al. [13]** introduces an innovative compound parabolic concentrator (CPC)-concentric circular tubular solar still (CCTSS) that incorporates phase change material (PCM). The study involved experimental tests with the CCTSS, both with and without PCM. In the experiments, a circular trough within the tubular solar still was filled with 450 grams of paraffin wax per tube, serving as the PCM. Key parameters such as the water temperature (Tw), air temperature (Tair), outer cover temperature (Toc), and the production of fresh water were monitored at regular intervals. The findings of the study highlight the performance of the CPC-CCTSS system when integrated with PCM exhibited a fresh water production of 5779 ml/m2/day, whereas the system without PCM yielded 5330 ml/m2/day. Consequently, PCM integration led to an 8% enhancement in fresh water productivity.

## III. WATER TANKS MATERIALS USED

Water tanks are vital structures used for storing and distributing water for various purposes, and the choice of materials is crucial to ensure durability, safety, and suitability for specific applications. Different materials are used in the construction of water tanks, each offering unique advantages based on factors such as cost, strength, and resistance to corrosion. Here are the commonly used materials for water tanks:

### A. Concrete Tanks:

Concrete is a popular choice for constructing large water tanks due to its strength and durability. Concrete tanks can withstand harsh weather conditions, making them suitable for outdoor installations. They are often used in municipal water storage, agricultural irrigation, and industrial applications. Concrete tanks can be precast and transported to the site or cast in place, allowing flexibility in design and size.

### B. Steel Tanks:

Steel water tanks are widely used in commercial and industrial settings. They are sturdy, resistant to rust, and can be customized to fit specific requirements. Steel tanks are favored for their long lifespan and are often used for fire protection, municipal water storage, and wastewater treatment. They can be coated with specialized materials to prevent corrosion and ensure water quality.

### C. Fiberglass Reinforced Plastic (FRP) Tanks:

FRP tanks are lightweight, corrosion-resistant, and suitable for both above-ground and underground installations. They are commonly used in residential, commercial, and industrial applications. FRP tanks are easy to transport and install, making them a popular choice for areas with limited accessibility. They are resistant to chemicals and can withstand varying temperatures, making them ideal for storing diverse liquids, including water, chemicals, and oils.

### D. Polyethylene Tanks:

Polyethylene tanks, also known as plastic tanks, are lightweight, cost-effective, and easy to transport and install. They come in various shapes and sizes, making them suitable for residential water storage, rainwater harvesting, and agricultural use. Polyethylene tanks are resistant to rust and corrosion, making them low-maintenance and ideal for outdoor installations. They are UV-resistant, ensuring longevity even when exposed to sunlight.

### E. Stainless Steel Tanks:

Stainless steel tanks are known for their excellent corrosion resistance and hygienic properties, making them suitable for storing potable water and other liquids in sensitive applications, such as hospitals and food processing industries. They are durable, easy to clean, and maintain water quality. Stainless steel tanks are often used in situations where maintaining water purity is of utmost importance.

## IV. CIRCULAR WATER TANKS AND THEIR STRUCTURAL CONSIDERATIONS

Circular water tanks are cylindrical structures designed to store and distribute water for various purposes, such as domestic, industrial, and firefighting needs. Their distinct shape provides several structural advantages, making them a popular choice in water storage systems. Here's an overview of circular water tanks and the key structural considerations associated with their design:

### A. Shape and Properties

Circular water tanks are characterized by their cylindrical shape, which offers inherent structural stability. The symmetrical design ensures uniform distribution of forces and stresses, contributing to enhanced load-bearing capacity and resilience against external pressures.

### B. Structural Considerations

Designing circular water tanks involves several critical considerations to ensure their structural integrity, durability, and operational efficiency:

Material Selection: The choice of construction material, such as reinforced concrete or steel, is essential in determining the tank's strength and durability. Engineers consider factors like corrosion resistance, cost-effectiveness, and the tank's intended service life.

Foundation Design: Proper foundation design is crucial to distribute the tank's weight evenly and prevent settlement. Soil characteristics, bearing capacity, and potential for settlement under varying loads are assessed to ensure stable support.

Hydraulic Loadings: Circular tanks experience hydraulic loads due to the weight of stored water, which can be substantial. Engineers must calculate the hydrostatic pressure and ensure that the tank walls, base, and foundation can withstand these loads without deformation or failure.

Seismic Resilience: Circular water tanks located in earthquake-prone regions must be designed to withstand seismic forces. Engineers analyze the tank's response to ground motion, considering factors like the seismic zone, soil conditions, and potential ground acceleration.

Wind Loads: Circular tanks are exposed to wind forces, especially when located in open areas. Engineers evaluate wind speed, local topography, and building height to calculate wind loads and ensure structural stability.

Stress Distribution: The cylindrical shape of these tanks results in consistent stress distribution along the wall and base. Engineers analyze hoop stress (circumferential stress), axial stress (parallel to the tank's axis), and radial stress (perpendicular to the symmetry axis) to ensure they remain within safe limits.

Design Codes and Standards: Circular water tanks must adhere to relevant design codes and standards that govern construction practices, material specifications, and safety factors. Codes like IS 3370 (Part II) and IS 456 provide guidelines for designing water-retaining structures.

Waterproofing: To prevent leakage and maintain water quality, proper waterproofing methods are crucial. Engineers must ensure that the tank's walls and base are effectively sealed to prevent water infiltration and potential structural damage.

Accessories and Appurtenances: Design considerations also extend to tank accessories and appurtenances, such as inlets, outlets, valves, and overflow provisions, which must be integrated into the tank's design without compromising its structural integrity.

## V. CONCLUSION

Circular water tanks, with their cylindrical configuration, present an array of structural challenges and opportunities. Proper material selection, adherence to design codes, and meticulous attention to factors like foundation design, seismic resilience, and waterproofing are paramount. Addressing hydraulic and wind loads, along with stress distribution considerations, ensures the tank's durability and operational efficiency. Integrating essential accessories and appurtenances while maintaining structural integrity completes the comprehensive design process. Engineers and stakeholders must collaborate, understanding these intricacies to construct resilient and reliable circular water tanks tailored to specific needs and locations.

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