IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 3, March 2016.
www.ijiset.com
ISSN 2348 – 7968

Analysis and Economical Design of Water Tanks

Thalapathy.M[1], Vijaisarathi.R.P[1], Sudhakar.P[1], Sridharan.V[1], Satheesh.V.S[2]

[1]UG student, Department of Civil Engineering, Adhiyamaan College of Engineering, Hosur, Tamilnadu, India.
thalapathy1595@gmail.com

[2]Assistant professor, Department of Civil Engineering, Adhiyamaan College of Engineering, Hosur, Tamilnadu, India.

Abstract

Storage reservoirs and water tanks are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage.

This project gives the detailed analysis of the design of liquid retaining structure using working stress method. The project takes into consideration the design of reservoir for the following cases: 1) Underground Tank, 2) Tank Resting on ground and 3) Overhead water tank. The analytical design has been made with Microsoft Excel sheet. The paper gives idea for safe design with minimum cost of the tank and give the designer relationship curve between design variable. Thus design of tank can be more economical, reliable and simple. The paper helps in understanding the design philosophy for the safe and economical design of water tank.

Keywords: *Microsoft Excel, minimum total cost, tank capacity, design, details, graph comparison.*

1. Introduction

A water tank is a container for storing liquid. The need for a water tank is as old as civilization, to provide storage of water for use in many applications, drinking water, irrigation, agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses. Water tank parameters include the general design of the tank, and choice of construction materials, linings. Reinforced Concrete Water tank design is based on IS 3370: 2009 (Parts I – IV). The design depends on the location of tanks, i.e. overhead, on ground or underground water tanks. The tanks can be made of RCC or even of steel. The overhead tanks are usually elevated from the ground level using number of columns and beams. In the other hand the underground tanks rest below the ground level.

2. Types of Water Tanks

In this section, the types of water tanks are discussed in detail. There are different type of water tank depending upon the shape, position with respect to ground level etc. From the position point of view, water tanks are classified into three categories. Those are,

a) Underground tanks
b) Tanks resting on ground
c) Overhead water tanks

In most cases the underground and on ground tank are circular or rectangular in shape but the shape of the overhead tanks are influenced by the aesthetical view of the surroundings and as well as the design.

2.1 Underground water tank

An Underground storage tank (UST) is a storage tank that is placed below the ground level. Underground storage tanks fall into three different types:

1. Steel/aluminum tank, made by manufacturers in most states and conforming to standards set by the Steel Tank Institute.
2. Composite overwrapped a metal tank (aluminum/steel) with filament windings like glass fiber/aramid or carbon fiber or a plastic compound around the metal

ISSN 2348 – 7968

cylinder for corrosion protection and to form an interstitial space.

3. Tanks made from composite material, fiberglass/aramid or carbon fiber with a metal liner (aluminum or steel).

Underground water storage tanks are used for underground storage of potable drinking water, wastewater & rainwater collection. So whether you call it a water tank or water cistern, as long as you are storing water underground these are the storage tanks for you. Plastic underground water tanks (cistern) is a great alternative to concrete cisterns.

2.2 Tanks resting on ground

In this section, we are studying only the tanks resting on ground like clear water reservoirs, settling tanks, aeration tanks etc. are supported on ground directly. The wall of these tanks are subjected to pressure and the base is subjected to weight of water. These tanks are rectangular or circular in their shape.

2.3 Overhead water tanks

Overhead water tanks of various shapes can be used as service reservoirs, as a balancing tank in water supply schemes and for replenishing the tanks for various purposes. Reinforced concrete water towers have distinct advantages as they are not affected by climatic changes, are leak proof, provide greater rigidity and are adoptable for all shapes.

From the shape point of view, water tanks may be of several types. These are,

a) Circular tanks
b) Conical or funnel shaped tanks
c) Rectangular tanks

2.3.1 Circular tanks

Circular tanks are usually good for very larger storage capacities the side walls are designed for circumferential hoop tension and bending moment, since the walls are fixed to the floor slab at the junction. The co-efficient recommended in IS 3370 part 4 is used to determine the design forces. The bottom slab is usually flat because it's quite economical.

2.3.2 Conical or funnel shaped tanks

This tank is best in architectural feature and aesthetic this tank has another important advantage that its suitable for high staging the tank's hollow shaft can be easily built. It can be economical and rapidly constructed using slip from processing of casting. They can also be built using pre-cast concrete elements.

2.3.3 Rectangular tanks

The walls of Rectangular tank are subjected to bending moments both in horizontal as well as in vertical direction. The analysis of moment in the wall is difficult since water pressure results in a triangular load on them. The magnitude of the moment will depend upon the several factors such as length, breadth and height of tank, and conditions of the support of the wall at the top and bottom edge. If the length of the wall is more in compression to its height the moment will be mainly in vertical direction i.e. the panel will bend as a cantilever. If, however, height is larger in comparison to length, the moments will be in horizontal direction, and the panel will bend as a thin slab supported on the edges. The wall of the tank will thus be subjected to both bending moment as well as direct tension.

3. Objective and Scope of the Project

- To make the study about the analysis and design of water tank.
- To make the guidelines for the design of liquid retaining structure according to IS code.
- To know about design philosophy for safe design of water tank.
- To develop program for water tank to avoid tedious calculations.
- To know economical design of water tank.

ISSN 2348 – 7968

- This report is to provide guidance in the design and construction for various types of water tanks.

4. Sources of Water Supply

The various sources of water can be classified into two categories:
Surface sources such as

1. Ponds and lakes
2. Streams and rivers
3. Storage reservoirs and
4. Oceans, generally not used for water supplies, at present.

Sub-surface sources or underground sources, such as

1. Springs
2. Infiltration wells and
3. Wells and Tube-wells.

5. Water Quantity Estimation

The quantity of water required for municipal uses for which the water supply scheme has to be designed requires following data:
Water consumption rate (Per Capita Demand in litres per day per head)
Population to be served
Quantity = per capita demand × Population

Factors affecting per capita demand

- Size of the city: Per capita demand for big cities is generally large as compared to that for smaller towns as big cities have sewered houses.
- Presence of industries
- Climatic conditions
- Habits of economic status
- Quality of water
- Pressure in the distribution system
- Efficiency of water works administration: Leaks in water mains and services; and unauthorized use of water can be kept to a minimum by surveys.
- Cost of water
- Policy of metering and charging method: Water tax is charged in two different ways: on the basis of meter reading and on the basis of certain fixed monthly rate.

6. Design steps:

6.1 Underground rectangular tank

Design constants,

$$k = \frac{mc}{mc + \sigma_{st}}$$

Design of long wall,

$$P_a = K_a \gamma' H + \gamma_w H$$

Design of long wall,

$$P_a = K_a \gamma' (H - h) + \gamma_w (H - h)$$

Design of bottom slab,

$$P_u = wH_1$$

Where, m = modular ratio
C = compressive force.
σ_{st} = permissible stress in steel in tension.
K_a = coefficient of active earth pressure.
H = Height.
γ_w = Unit weight of water
W = Total load

6.2 Tanks resting on ground

Design constants,

$$k = \frac{mc}{mc + \sigma_{st}}$$

Water pressure,

$$P = w\,(H - h)$$

ISSN 2348 – 7968

Cantilever moment,

$$= wH \times \frac{h^2}{6}$$

Reinforcement at corners of long walls,

$$X = d - \frac{T}{2}$$

Where, m = modular ratio
C = compressive force.
σ_{st} = permissible stress in steel in tension.
H = Height.
W = Total load
d = Effective depth
T = Torsional moment

6.3 Overhead tank

Dimensions of tank,

$$= \frac{\pi \times D^2}{4} \times rD$$

Max. Hoop tension at base of wall

$$F_1 = \frac{whD}{2}$$

Design of bottom spherical dome

$$R = \frac{\frac{D^2}{2} + r^2}{2r}$$

Total design load on the ring girder

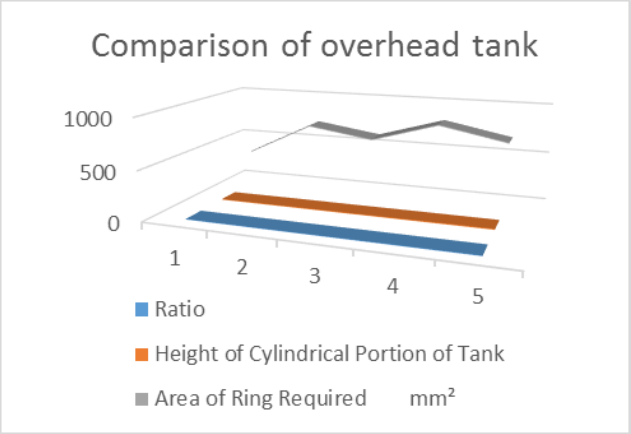
$$W = \pi Dw$$

Where, D = Diameter at base
R = Radius of the dome
r = central rise
w = density of water
h = depth of water
W = Design load

7. Tables and Figures

Table 1: Overhead water tank

Depth/Diameter Ratio	*Height of Cylindrical Portion of Tank in metres*	*Spacing 12mm dia bars (m)*
0.1	1	1.09
0.45	3	2.59
0.6	3	3.35
0.75	4	1.24
0.85	4	4.99

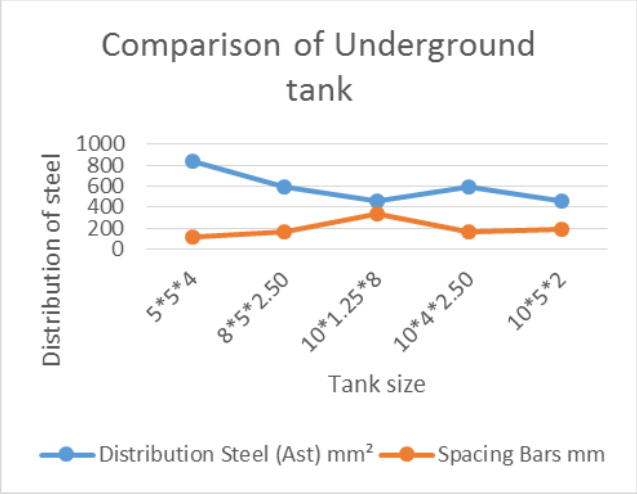


Graph 1: 3-Dimensional diagram for the values of Ratio, Height of cylindrical portion of tank and Area of ring req.

Table 2: Underground water tank

Tank size	*Distribution steel (Ast)*	*Area of ring required*
5×5×4	837	367
8×5×2.5	597	700
10×1.25×8	457	600
10×4×2.5	591	800
10×5×2	457	667

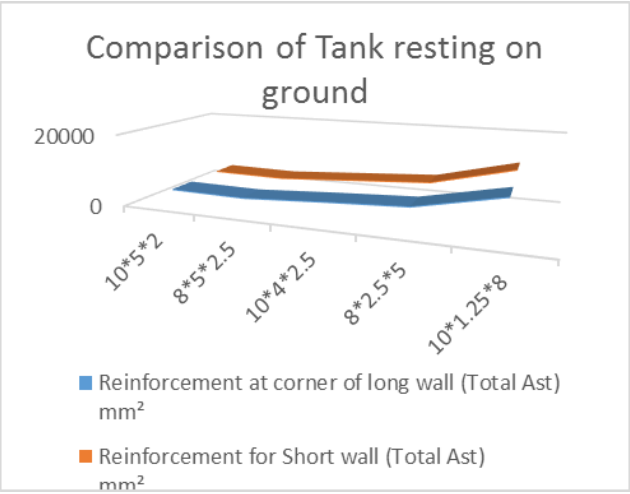
ISSN 2348 – 7968



Graph 2: Detailing of reinforcement

Table 3: Tank resting on ground

Tank size	*Reinforcement at corner of long wall (Total Ast) mm²*	*Reinforcement for Short wall (Total Ast) mm²*
10×5×2	4046	4165
8×5×2.5	3756	3858
10×4×2.5	5021	5220
8×2.5×5	6124	6574
10×1.25×8	10790	12003



Graph 3: Detailing of Reinforcement of walls

8. Conclusion

- From the results, the height to diameter ratio 0.45 is safest economical design.
- In the results of rectangular tank (resting on ground) 8×5×2.5 having a moderate shear, deflection, bending moment, etc.
- 8×5×2.5 / 10×1.25×6 sections are given a moderate results for underground water tank.
- Cost wise 8×5×2.5 section is more economical in tank resting on ground.
- Increase in shear force & bending moment becomes milder as one goes towards downwards side of slope.
- The thickness of cylindrical wall, conical dome and bottom dome of intze water tank are increased due to the considerations of new IS code:3370-2009 and earth quake forces.
- It can be clearly seen from the results that the formwork required for the constructions of water tanks is minimum for circular shaped tank as compared to square shaped and rectangular shaped tanks.
- It is possible to formulate and obtain solution for the minimum cost design for underground rectangular tank.
- Limit state method was found to be most economical for design of water tanks as the quantity of steel and concrete needed is less as compared to working stress method.

References

[1] KavitiHarsha, K.S.K.Karthik Reddy, Kondepudi Sai Kala, “Seismic Analysis and Design of INTZE Type Water Tank”, International Journal of Science Technology & Engineering, Volume 2, Issue 03, Sept-2015.

[2] Smt. Dhotre, Chandrakala and Jawalkar G.C, “Analysis on Overhead Circular water tank for various bearing capacity with sloping ground”, International Journal of Scientific & Engineering Research, Volume 6, Issue 5, ISSN: 2229-5518, May-2015.

ISSN 2348 – 7968

[3] Bhandari.M , Karan Deep Singh, “Economic Design of Water Tank of Different Shapes With Reference To IS: 3370-2009”, International Journal of Modern Engineering Research (IJMER), Volume 4, Issue 12, ISSN: 2249-6645, Dec-2014.

[4] Bhandari .M , Karan Deep Singh, “Comparative Study of Design of Water Tank With Reference to IS 3370”, International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 11, ISSN: 2250-2459, Nov-2014.

[5] Ranjit Singh Lodhi, Dr.Abhay Sharma, Dr.Vivek Garg, “Design of Intze Tank in Perspective of Revision of IS :3370”, International Journal of Scientific Engineering and Technology, Volume No.3, Issue No.9, pp:1193-1197, ISSN :2277-1581, Sep-2014.

[6] Neeta .K Meshram, Dr. P. S. Pajgade, “Comparative Study of Water Tank Using Limit State Method and Working Stress Method”, International Journal of Research in Advent Technology, Volume 2, Issue 8, ISSN: 2321-9637, Aug-2014.

[7] Aditya Wad, Gore N. G, Salunke P. J, Sayagavi V. G, “Cost Optimization of Rectangular RCC Underground Tank”, International Journal of Recent Technology and Engineering (IJRTE), Volume 3, Issue 3, ISSN: 2277-3878, July-2014.

[8] Manish N. Gandhi, Rajan .A, “Necessity of Dynamic Analysis of Elevated Water Storage Structure Using Different Bracing in Staging”, International Journal of Research in Advent Technology, Volume 2, Issue 2, ISSN:2321-9637, Feb-2014.

[9] Riyaz Sameer, Mundhada A.R, Snehal Metkar, “Comparison of RCC and Pre-stressed Concrete Circular Water Tanks”, International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 12, ISSN: 2250-2459, Dec 2012.

[10] Chirag N. Patel , H. S. Patel, “Optimum Diameter of Tapered Elevated RC Water Tank Staging”, International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 12, ISSN 2250-2459, Dec-2012.