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Comparative Analysis and Design of RCC Circular and Rectangular Shape Water Tank Resting on Ground

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***Abstract*: The need for a water tank is as old as a civilization, to provide storage of water for use in many applications. Design and quantity estimation of water tanks is a time consuming task, which requires a great deal of expertise. This project therefore studies the efficiency of rectangular or circular tanks of different capacities were used in order to draw reasonable inferences on tank shape design effectiveness, relative cost implications of tank types and structural capacities. In this project, we have discussed about the design of rectangular and circular shape of water tank, Estimation of water tank and analysis by using STAAD-PRO software. From the analysis results concluding about the influence of shape factor in design loads and how shapes of the tanks play predominant role in the design and in stress distribution and overall economy. The result of design and estimation revealed that circular tank consumed lesser materials as compared to rectangular tank. Hence circular tank is more economical than the rectangular tank for large quantity.**

***Keywords*: water tank, economic design, reinforced concrete, steel reinforcement, formwork, STAAD-PRO.**

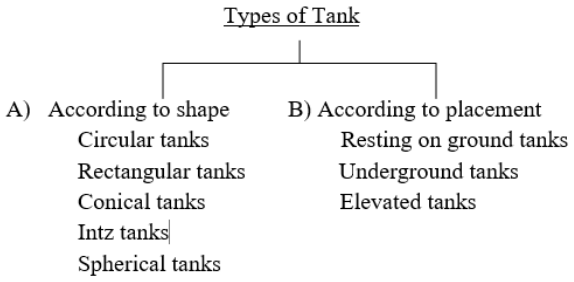
1. Introduction

A. General

Water is considered as the source living for every creation as it as a crucial element for healthy living. Safe drinking water is one of the basic elements for human to sustain a healthy life. High demand for safe and clean water is rising day by day, as one cannot live without water. Thus it becomes necessary to store the water with clean and effectively. Generally, storage reservoirs and water tanks are used to store the water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoir or tank is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. Water or raw petroleum retaining slab and walls can be of reinforced. concrete with adequate cover to the reinforcement. Water and petroleum are reacting with concrete and hence, no special treatment is required. The need for a water tank is as old as civilization, to provide storage of water for use in many applications. Water tanks can be generally classified as circular, rectangular and conical, depending upon their quantity and location. The tanks can be made of steel or concrete. Tanks resting on ground are normally circular or rectangular in shape and are used where large quantity of water need to stored. Water tank parameters include the general design of the tank, and choice of construction materials and linings. . In design of water tanks, design aspects is to be followed as per books and loads is to be applied carefully.

B. Types of tank

Water tank can be classified in two types are as follows,



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C. Significance of the study

This research is concern with the comparison between circular and rectangular reinforce concrete tanks. It attempted to achieve some measure of the best practical solutions, that is, the optimum design of reinforced concrete water tanks for a specified performance.

D. Aim

The major aim is to reveal the degree of effectiveness of geometric shapes for the functional requirement, with the view to achieving adequate strength and economy..

E. Objectives

- To make the analysis and design of water tank in accordance with IS3370 code.
- To estimate the quantities of PCC and steel of both the

circular and rectangular tanks and hence to access possible cost implications of each choice.

- To compare the economical design of circular and rectangular RCC tank.
- To know about the design philosophy for the safe and economical design of water tank.
- To provide guidelines for the design of liquid retaining structure according to IS code.
- To compare the manually and analytical results of Circular and Rectangular shape water tank by using STAD-PRO software.

2. Methodology

Design of circular and rectangular tank for various capacities are done by working stress method in accordance IS 3370 (2009) of rigid based and design tool reinforced concrete water tanks was prompted by the manually, fully dimensioned and listed in a schedule of the reinforcement which is used on site for bending and fixing the bars. The principal features include:

- The use of factor of safety-1.0
- The grade of concrete used- M20
- The grade of steel used –Fe415
- Free board-300mm
- The use of minimum cover 25-30mm
- Maximum bar spacing of 300mm Wall thickness is exceeding 160mm

A. Design of circular water tank

Data Assume: M20 Grade of Concrete
Fe415 Grade of Steel
Free Board- 300 mm

Design steps of circular RCC water tank

Size of tank- $A = \pi/4 \times D^2$

$t = 30 H + 50$

Where, H- Height of water in tank=3.5m

Hoop Tension - $\frac{\alpha W H D}{2}$

Where, α –Coefficient for hoop tension

Maximum Bending Moment- $\alpha W H^3$

Where, α- Coefficient for Bending Moment

Design of section

Area of steel for Hoop Tension = $\frac{T \max}{6st}$

Area of steel for Bending Moment - $\frac{M}{6st.\ j.\ d}$

Table 1
Design results for circular water tank

Capacity (m^3)	Hoop Tension (KN)	Ast For Hoop Tension (mm^2)	Cantilever BM (KN.m)	Ast for BM (mm^2)
75	59.14	448.00	3.99	450
100	66.30	448.00	4.39	450
300	88.88	592.53	6.35	450

B. Design steps for rectangular

Size of the tank- A = L x B x H

Table 2
Dimesions of the rectangular tank

Capacity (m^3)	Dimensions (m)	Thick. of wall (m)	Thick. of slab (m)
75	6.25x4x3	0.17	015
100	7x4.8x3	0.17	0.15
300	7.7x6.5x4	0.17	0.15

Coefficient of Moment

Vertical Moment $= M_x \times W \times H^3$

Maximum Horizontal Moment $= M_y \times W \times H^3$

Tension in wall $= w \times h \times l / 2$

Depth of Section $= \sqrt{Mmax / q. B}$

Reinforcement in vertical direction

$Ast = M/6_{st} \times j \times d$

Distribution Steel –

Ast_{min} = Min. % of steel x b x d

Design of Horizontal Reinforcement-

Water pressure (P) = W X (H-H)

H = H/4 OR 1M

Tension in wall (T) = P X L/2

NET Bending Moment in wall = BM – T_{XX}

Design of Base Slab & Roof Slab:

Providing nominal thickness = 150 mm and Minimum % of steel is 0.3%

Using 12mm dia. bars @ 250mm c/c

Table 3
Design Results for Rectangular Water Tank.

Capacity (m^3)	Max. BM (KN.m)	Vertical Ast mm^2	Ast for Dist. steel	Net BM (KN.m)	Hori. Ast (mm^2)
75	23.22	1228	467	11.06	1002
100	29.16	1397	532	13.15	1097
300	107.5	2746	840	79.83	3289

C. Estimation of quantities of PCC and Steel of water tank

1) Analysis of water tank using STAAD-PRO

For Circular Shape Water Tank:

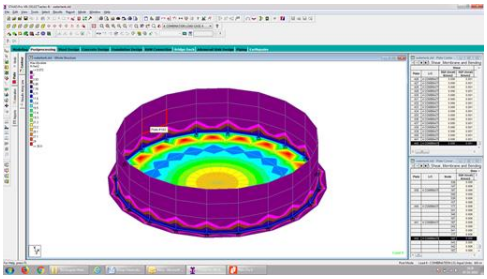

Fig. 1. Plate Stresses for Circular Water Tank.

Table 4
Analysis Results for Circular Water Tank

Capacity of Tank M^3	Software Analysis Result	
	Hoop Tension	Cantilever BM
75	55.37	3.49
100	66.30	3.51
300	86.65	4.70

For Rectangular Water Tank:

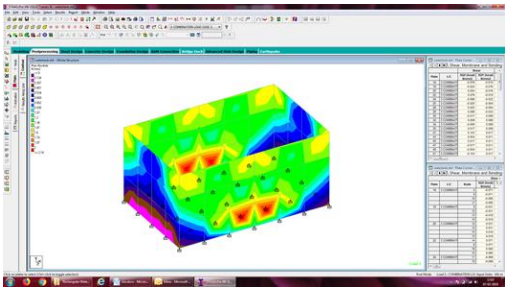

Fig. 2. Plate Stresses for Rectangular Water Tank

Table 5
Analysis Results for Rectangular Water Tank

Capacity of Tank (M^3)	Software Analysis Result	
	Moment in Short wall	Moment in Long wall
75	11.03	21.167
100	17.93	27.83
300	74.16	109.27

3. Results

Table 6
Comparison Results for Circular water tank

Capacity of Tank M^3	Manual Deign Result		Software Analysis Result	
	Hoop Tension	Cantilever BM	Hoop Tension	Cantilever BM
75	59.14	3.99	55.37	3.49
100	66.30	4.39	66.30	3.51
300	88.88	6.35	86.65	4.70

Table 7
Comparison Results for Rectangular water tank

Capacity of Tank (M^3)	Manual Deign Result		Software Analysis Result	
	Moment in Short wall	Moment in Long wall	Moment in Short wall	Moment in Long wall
75	11.09	23.22	11.03	21.167
100	13.15	29.16	17.93	27.83
300	79.83	107.50	74.16	109.27

Table 8
Comparison for Estimation of water tank

Capacity of tank M^3	Shape of Tank	Quantity of PCC in M^3	Quantity of Steel in Kg
75	Circular	21.50	1688
	Rectangular	20.81	1634
100	Circular	26.68	2095
	Rectangular	26.96	2117
300	Circular	51.97	4080
	Rectangular	78.09	6130

A. Discussion

Table 9 indicates that the quantities of PCC and Steel need for circular water tank more than those rectangular water tank up 75 m3 capacity and above 75 m3 capacity the quantities of PCC and Steel Reinforcement for circular water tank is lesser than that of rectangular water tank, hence the rectangular water tank is economical for smaller capacities and circular tank economical for larger capacity.

Therefore, it is advisable to use the rectangular tank in terms of cost but in case of resistance to all pressure exerted in the circular shape tank is better.

4. Conclusion

- There is not much difference in design of tank done by manual and software analysis.
- The area of steel reinforcement in rectangular shape tank is greater than the circular shape tank.
- It can be clearly seen that quantities of PCC and Steel Reinforcement needed for the construction of rectangular shape tank is comparatively more than those required for circular one but ease of construction, is more difficult in circular water tank compared to that of rectangular water tank.
- For smaller capacities rectangular shape tank is economical and for large capacities circular shape tank are economical.

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