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Comparative Design and Analysis of Circular and Rectangular 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 cost 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. 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.**

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 react 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-
According to shape

- Circular tanks
- Rectangular tanks
- Conical tanks
- Intz tanks
- Spherical tanks

According to placement

- Resting on ground tanks
- Underground tanks
- Elevated tanks

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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 a guideline for the design of liquid retaining structure according to IS code.

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-1.4
- 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

Table 1
Dimensions of circular tanks

Capacity (m^3)	Diameter (m)	Height (m)	Thickness of wall (m)
75	6.0	3.5	0.16
100	7.0	3.5	0.16
200	9.0	3.5	0.16

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- $\frac{M}{6st.j.d}$

B. Design steps for rectangular

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

Table 2
Dimensions of the rectangular tank

Capacity (m^3)	Dimension (m)	Thickness of wall (m)	Thickness of base and top slab (m)
75	6.25×4×3	0.170	0.150
100	7×4.8×3	0.190	0.150
200	7.7×6.5×4	0.250	0.150

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 steelAst_{min} = min.% of steel x b x d

Design of Horizontal ReinforcementWater 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 – TX XDesign of Base Slab & Roof Slab: Providing nominal thickness = 150 mm and Minimum % of steel is 0.3%

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

Table 3
Sample Estimation of Circular water tank for 75 m

SR.	Description	No	L	B	D	Quantity
1.	**PCC** **Base slab** D = 7.32, t = 0.15 $Q = \pi/4 \times 7.32^2 \times 0.15 = 6.31 m^3$					6.31 m^3
	Cylindrical wall D_1=6.0+0.16+0.16 = 6.32 D_2=6.0m, H=3.50m $Q=\pi/4 \times (6.32^2-6.0^2) \times 3.50 = 10.84 m^3$					10.84 m^3
	Top Slab D = 6.32 m, t = 0.15 m $Q = \pi/4 \times 6.32^2 \times 0.15 = 4.71 m^3$ **Deduction** D = 1.0m, t = 0.15 m $Q = \pi/4 \times 1.0^2 \times 0.15 = 0.14 m^3$					4.71 m^3 - 0.14 m^3 4.57 m^3
	Total Quantity of PCC = 21.72-0.22					**21.50 m^3**
2.	**RCC** (Assume 1% of PCC) $=1/100 \times 21.72 = 0.22 m^3$ **Steel in kg** Q=1/100x21.50x 7850 = 1687.75 kg					**0.22 m^3** **1688 kg**

Table 4
Design results for circular tank

Capacity (m^3)	Hoop Tension (KN)	Ast for Hoop Tension mm^2	BM KN.m	Ast for BM mm^2
75	57.88	448	3.76	448
100	66.30	448	4.39	448
200	79.20	528	5.47	448

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

Table 5
Design results for rectangular tank

Capacity (m^3)	Max.BM (KN.m)	Vertical Ast (mm^2)	Net BM (KN.m)	Horizontal Ast (mm^2)
75	23.22	1228	11.06	1002
100	29.16	1397	13.15	1097
200	55.04	1918	26.44	1691

Used base and top slab bar dia.12mm@170mm c/c
Used vertical bars of dia.12mm@90mm c/c
Used distribution bars of dia.8mm@90mm c/c
Used horizontal bars of dia.12mm@110mmc

Table 6
Comparative results for water tanks

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

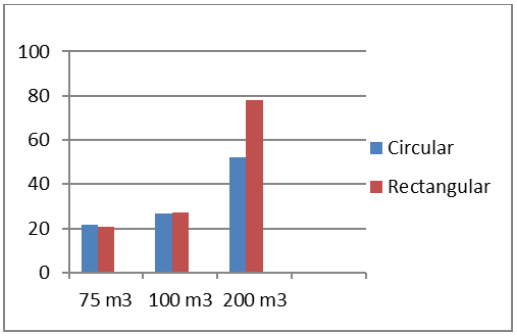

Fig. 1. Graphical Comparative result of circular and rectangular water tank basis on quantities of PCC

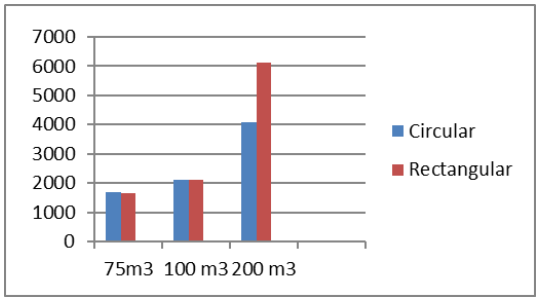

Fig. 2. Graphical comparative result for circular and rectangular water tank on basis of quantities of steel

3. Conclusion

Based on the results it can be clearly seen that area of reinforcement and pcc of rectangular water tank is comparatively more than those required for circular one but ease of construction, is more difficult in circular water tank as compared to that of rectangular water tank.

From this design it is showed that maximum bending moment are found to be less in circular tank than rectangular tank design.

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