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Optimization of Dimension and Quantity of Material for Clear Water Sump of 300 KL Capacities with Pump House

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Abstract

Water is considered as the source of life for every creation of God, it as a crucial element for sustainable and healthy living. Naturally, such an important element is always high on demand. And the demand for such safe and clean water is rising day by day, as one cannot survive without water. In today's time the main issue, in general, is to get clean, portable, regular supply of drinking water which is scarce and limited. So, the need arises for reusing and treating water, hence Water Treatment Plant is being constructed across the globe. In these WTP there is a clear water reservoir for storage and distribution of pure /treated water for a city or small town. We had designed and analyzed water reservoirs of two shapes in plan i.e. circular and rectangular shapes having 300kl capacity of treated water. A pump house is mounted on top of this sump. Both the sumps are analyzed for different conditions (tank full and empty) and comparative results are drawn, based on which we can conclude which shape is more economical for construction.

Keywords: *Optimization of Dimensions, Economical shape etc.*

1. Introduction

In today's time water is a very essential need for everyone, without which we cannot survive. Water is always available on our planet but portable drinking water is scarce and very limited in nature. For any developing country accessibility to portable drinking water is essential for its success. Keeping this in mind, today in India water sector is the fastest growing industry. In this our Indian government has also taken initiative by launching schemes like AMRUT, 24 x7 water supply scheme, etc. under these schemes many water treatment plants, sewage treatment plant, clear water sump, and pump house, ESR,distribution networks are being constructed. The aim is to provide portable drinking water to every citizen of this country.

1.2. Preamble

Clearwater sump having different shapes on the plan is considered for the design of 300kl capacity of treated water. A Pumphouse is mounted on top of the sump whose roof slab is designed as supported over beam and column frame arrangement. RCC columns are

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provided inside the sump to support the roof slab of the sump and pump house. Every other component is designed by Limit State Method of IS: 456, IS: 3370(PART-IV), and according to the latest provision in Indian Standards Codes.After size and shape are finalized. The net safe bearing capacity of soil strata is considered 115 KN/sqm for designing. 3-D Model is used for analysis (standard STAAD Pro Software) for interpretation of results and comparison.

2. Theoretical Background

Basic components of clear water reservoirs are Base slab, Sidewalls, 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. We are primarily dealing with two shapes of reservoirs one being circular and another rectangular. Both the shapes of reservoirs are briefly explained below.

2.1 Circular: It is the simplest form of a water tank. It has no corner and can be made watertight easily. It is economical for the storage of treated water. The side walls are designed for hoop tension and vertical bending moment. A circular tank is a cylinder holding the water. Water exerts pressure from inside equally in from all directions.

Merits: Structural strength, Economic, Constant heat level, Clean and hygienic.

2.2 Rectangular: Rectangular tanks are modular Large tanks of high capacity can be constructed. Multiple units of water storage can be constructed using rectangular type tanks.The walls of the Rectangular tank are subjected to bending moments both in horizontal as well as in vertical direction. The analysis of the moment in the wall is difficult since water pressure results in a triangular load on them. The magnitude of the moment will depend upon several factors such as length, breadth, and height of the 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 the horizontal direction, and the panel will bend like a thin slab supported on the edges. The wall of the tank will thus be subjected to both bending moments as well as direct tension.

2.3.Design of Tank

Two Load are applied on the wall element

a) Water load from Inside and

b) Soil Load from Outside

Water Load

Depth of water = 3.5m

Pressure on Wall = 3.5x 9.81 = 30 kN/m2

Soil Load

Height of Earth outside sump = 3.5-0.75=2.75m

Pressure on Wall = (2.75x 18.5) /3 = 16.95 say 17 kN/m2

The wall is analyzed for both Empty and Full Condition but since soil load is less in comparison the design is governed by water load.

2.4 Rectangular Wall

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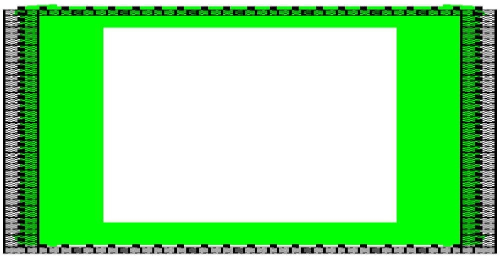

Figure 1. Water Pressure in Staad Pro Software from Inside

2.4.1Vertical Reinforcement

Wall Thickness: 230thk Cover= 45mm

For Long Wall L1-L2

For L1

Critical moment in vertical Direction=18.15 kNm(due to water)

Mu = 18.15 x 1.5 = 27.22 kNm

For L2

Critical moment in vertical Direction=18.15 kNm (due to water)

Mu = 18.15 x 1.5 = 27.22 kNm

$$As - ve = \frac{18.15 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} = 411.75\ mm^2$$

$$As + ve = \frac{10.24 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} = 232.30\ mm^2$$

As min= 0.35x 230 = 805 mm^2 = 402.5 mm^2 on EACH FACE

Provide

10 TOR @ 150 c/c STR on EACHFACE

For Short Wall L1-L2

For S1

Critical moment in vertical Direction = 20.37 kNm (due to water)

Mu = 20.37 x 1.5 = 30.555 kNm

For S2

Critical moment in vertical Direction = 20.37 kNm (due to water)

Mu = 20.37 x 1.5 = 30.555 kNm

$$As - ve = \frac{20.37 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} = 462.11\ mm^2$$

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$$As + ve = \frac{17.49 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} = 396.77\ mm^2$$

As min= 0.35x 230 = 805 mm^2 = 402.5 mm^2 on EACH FACE

Provide

10 TOR @ 150 c/c STR on EACHFACE

1.*Horizontal Reinforcement*

Wall Thickness: 230THK Cover= 45mm

For Long Wall L1-L2

Axial Load = 123x0.23 = 28.29 kN/m

For Short Wall S1-S2

Axial Load = 118x0.23 = 27.54 kN/m

Long Wall Reinforcement

FOR L1

Critical moment in vertical Direction = 10.6 kNm(Due To Water)

Mu = 10.6 x 1.5 = 27.22 kNm

FOR L2

Critical moment in vertical Direction = 10.6 kNm(Due To Water)

Mu = 10.6 x 1.5 = 27.22 kNm

$$As - ve = \frac{1.5 \times 10.6 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} + \frac{28.29 \times 1.5 \times 1000}{2 \times 0.87 \times 500} = 411.75\ mm^2$$

$$As + ve = \frac{5.02 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} + \frac{28.29 \times 1.5 \times 1000}{2 \times 0.87 \times 500} = 162\ mm^2$$

As min= 0.35x 230 = 805 mm^2 = 402.5 mm^2 on EACH FACE

Provide

10 TOR @ 150 c/c STR on EACHFACE

Short Wall Reinforcement

FOR S1

Critical moment in vertical Direction= 10.64 kNm (Due To Water)

Mu = 10.64 x 1.5 = 15.96 kNm

FOR S2

Critical moment in vertical Direction= 10.64 kNm(Due To Water)

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Mu = 10.64 x 1.5 = 15.96 kNm

$$As - ve = \frac{1.5 \times 10.64 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} + \frac{27.14 \times 1.5 \times 1000}{2 \times 0.87 \times 500} = 288.17 \text{ mm}^2$$

$$As + ve = \frac{7.88 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} + \frac{27.14 \times 1.5 \times 1000}{2 \times 0.87 \times 500} = 225.55 \text{ mm}^2$$

As min= 0.35x 230 = 805 mm^2 = 402.5 mm^2 on EACH FACE

Provide

10 TOR @ 150 c/c STR on EACHFACE

2.4.2 Design Of Base Slab

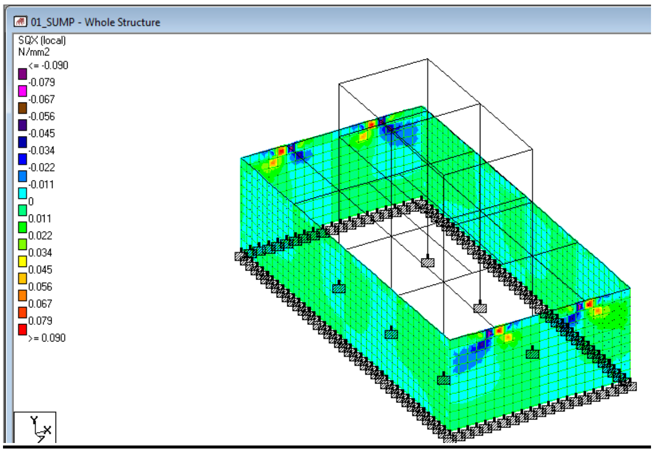

Figure 1. Design of base Slab in Staad Pro .

Base Slab: 150 The

Tension in base slab due to wall = 90 x 0.23 = 20.7 kN/m
6t = 20.7 x 1000 / 200 x1000

= 0.10N/mm^2< 1.5 N/mm^2 Hence OK

Provide

8 TOR@150 c/c

2.4.3 Design Of Circular Tank

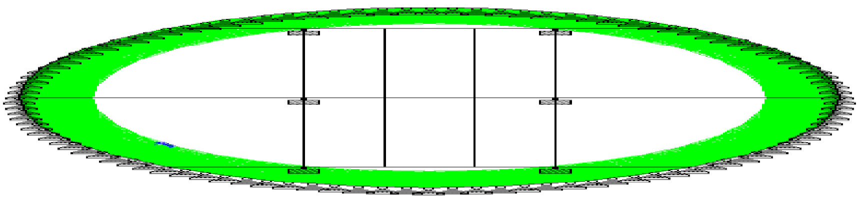

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Figure 1. Water Pressure in Staad.Pro

Vertical Reinforcement

Wall Thickness: 200 THK; Cover= 45mm

Critical moment in vertical Direction = 16.5kNm (due to water)

Mu = 16.5 x 1.5 = 24.75kNm

$$As - ve = \frac{18.15 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} = 411.75\ mm^2$$

$$As + ve = \frac{10.24 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 190} = 232.30\ mm^2$$

As min= 0.35x 230 = 805 mm^2 = 402.5 mm^2 on EACH FACE**Provide**

12 TOR @ 150 c/c STR on EACHFACE

Horizontal Reinforcement

Critical moment in horizontal Direction= 4.42kNm (Due To Water)
Mu = 4.42 x 1.5 = 6.63kNm

Axial Load = 551 x0.2 = 110.2 kN/m

$$As - ve = \frac{1.5 \times 4.42 \times 10^6}{0.8 \times 0.87 \times 500 \times 160} + \frac{110.2 \times 1.5 \times 1000}{2 \times 0.87 \times 500} = 309.07\ mm^2$$

$$As + ve = \frac{16.2 \times 1.5 \times 10^6}{0.8 \times 0.87 \times 500 \times 160} + \frac{110.2 \times 1.5 \times 1000}{2 \times 0.87 \times 500} = 233.64\ mm^2$$

Provide
10 TOR @ 150 c/c STR

Design Of Base Slab
Base Slab: 150 THK
Tension in base slab due to wall = 143 x 0.2 = 28.6 kN/m

6t= 28.6 x 1000 / 200 x1000

= 0.14N/mm^2< 1.5 N/mm^2 Hence OK

Provide

8 TOR@150 c/c

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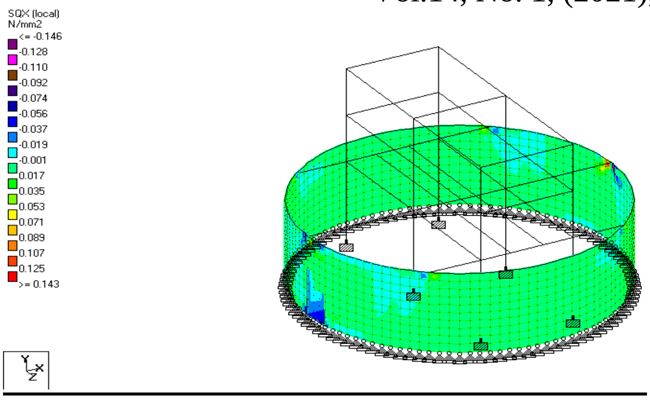

Figure 1. Design of Base Slab in Staad.Pro

3. Results

Table1. Comparision of Various Parameters

Sr. No.	Particulars	Rectangular	Circular
1.	Size Of Tank	7.1 X 14.2 X 3.5m	11.5m
2.	Thickness Of Wall	230mm	200mm
3.	Volume Of Tank	300KLit	300KLit
4.	Volume Of Concrete Required	26.11 m^3	19.29 m^3
5.	Reinforcement In Wall		
6.	Vertical Reinforcement		
	Spacing	150mmc/c	150mmc/c
	Dia Of Bar	10 mm	12mm
7.	Horizontal Reinforcement		
	Spacing	150 mm c/c	150 mm c/c
	Dia Of Bar	10 mm	10 mm
8.	Total Weight Of Steel	4544.23 KG	2514.92 KG

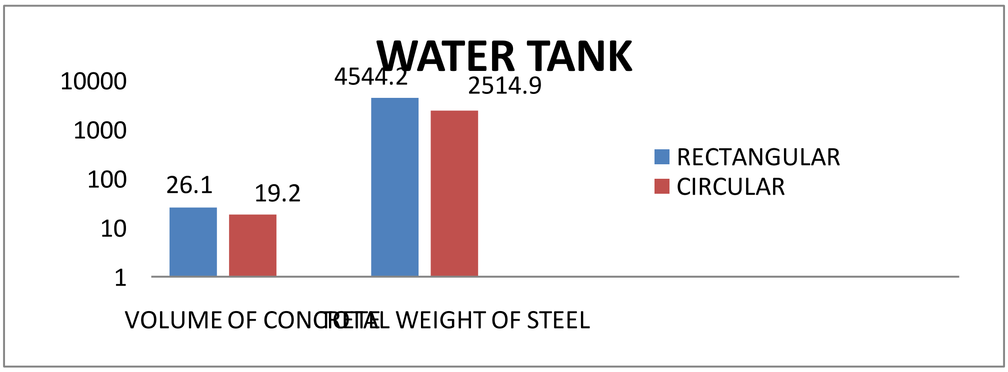

Figure 1. Comparision of volume of concrete and steel of water Tank

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Table1. Comparision of Various Parameters of Base Slab

Sr. No.	Particulars	Rectangular	Circular
1	Thickness Of Slab	150mm	150mm
2	Volume of Concrete	23.28 m^3	24 m^3
3	Reinforcement		
4	Dia of Bars	8 mm	8 mm
5	Spacing	150 mm c/c	150 mm c/c
6	Total Weight Of Steel	1065.89 KG	1178 KG

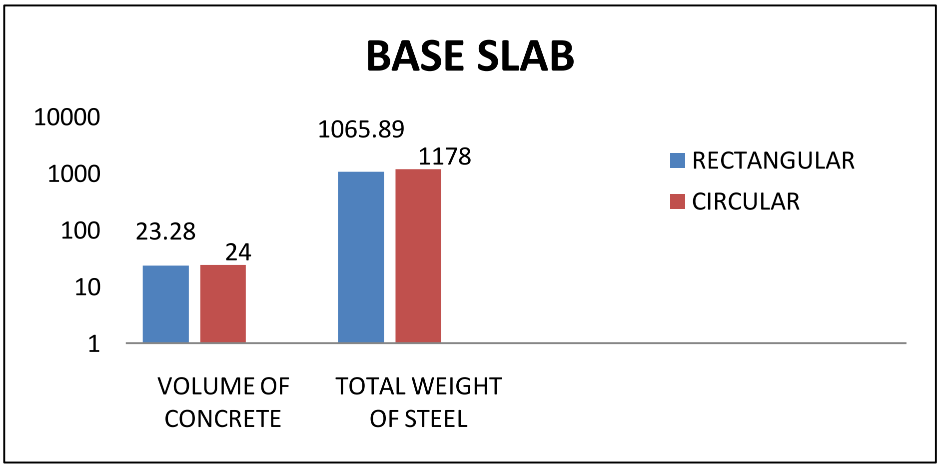

Figure 1. Comparision of volume of concrete and steel of Base Slab

5.Conclusion.

While analyzing and designing Rectangular and Circular sump we have prioritized the economic aspects. The results of each test point us towards only one conclusion that the overallmaterial required for the constructionof water sump is minimum for circular shape tanks than rectangular shape tanks, also for the same amount of storage circular water tank requires lesser area as compared to the rectangular water tank

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