Design of Overhead Water Tank And Analyze by STAAD Pro

Swapnil Bokade[1], Sneha Askar[2], Payal Gothale[3], Ashwini Morey[4], Gaurav Malewar[5], Sandip Sanghvikar[6], Prachi Khobragade[7], Vishal Sonkusare[8]
Dept of Civil Engineering
Government College of Engineering, Chandrapur Maharashtra, India
CEAD Consultancy, Maharashtra, India

Abstract- *Water is one of the crucial parts of our daily needs. It plays a very important role in serving water to the public and also for the industrial purposes and agricultural purpose. The main objective of this study is to build up a water tank for a selected area whose population is around 5000. The consumption of water by each person is taken as 200 litre per capita per day. This deals with comparative study of manual and analytical design of circular overhead water tank by STAAD Pro V8i. While designing the water tank is subjected to live load, dead load, hydrostatic load due to water. The wind speed for Nagpur region is 44m/s is considered for that particular area where the overhead water tank is to be constructed with another required factor. According to that we have calculated the wind force at various height on the columns. We have manually designed the water tank considering both limit state design and working stress method. The aim was to built up a water tank which should be economical.*

Keywords- Overhead water tank, wind load, IS 875 Part 3, IS 3370, STAAD Pro Design, grid pattern, and parabolic slab, etc

I. INTRODUCTION

An overhead water tank is a huge water storage tank that is constructed at a height so that it would certain help for pressurizing the water in the distribution system. The water tank is used to store water to meet the daily requirement of human being. The capacity of the water tank varies according to the consumption of water in that particular area. There are different types of water tank depending upon there shape, size, position with respect to ground level. According to the shape of the water tank. They are classified as circular tanks, rectangular tanks, and circular tanks with conical bottom.

Circular tanks: This tank usually proves good for very large storage. The side walls are designed for sustaining the circumferential hoop tension, bending moment.

Rectangular tanks: When the storage is very small this type of tank is used.

II. LITERATURE REVIEW

This paper**[1]**presents the designing of circular overhead water tank. The water tank is constructed for a population of 20000 and consumption of 200 litres/head/day. The main aim of the project is to mainly limits the stress in steel and limits the cracking considering limit state method.

In paper **[2]** Earlier limit state design method for water retaining structures was not adopted but now it is used extensively everywhere. This method of designing proves to be economical. The Indian Standard has recently revised the design of liquid retaining structures.

Paper**[3]** gives the design of an overhead circular water tank and then analyzing it with STAAD Pro. The loads that are considered on the water tank are self weight, hydrostatic load due to water, dead load.

The paper**[4]** study is based on the structural stability and the behaviour of different shapes of overhead water tank. It also deals with the design of the supporting system provided to the overhead water tank.

In paper [5] concerns with the designing of the elevated water tank with proper type of staging to provide good performance during the earthquake.

III. OBJECTIVE OF THE PROJECT

- Compare the result between manual design and STAAD PRO
- Preparing a water tank design which is economical and safe, providing proper steel reinforcement in concrete
- To study about the design philosophy for safe design of an overhead water tank
- To design the water tank according to IS Code and checking the design

IV. METHODOLOGY

4.1 Population forecasting methods:

There are various methods which are adopted to estimate the future population for a particular city.

The methods are mentioned below:

1. Geometrical increase method

Table-1:Calculation of geometrical increase (progression) method

Year (1)	Population (2)	Increase in population in each decades	Percentage increase in population i.e. growth rate(r) = $\frac{col(3)}{col(2)} * 100$ (4)
1981	2060	-	
1991	3229	1169	1169/2060*100=56.75%
2001	4128	899	899/3229*100=27.84%
2011	5068	940	940/4128*100=22.77%

The geometric mean of the growth rate (r) = $\sqrt[3]{(56.754*27.84*22.77)}$ = 33.01%
Now, assuming that the future population increase at this constant rate (33.01%)

We have, $P_n = P_o (1+r/100)^n$
$P_n = P_o (1+0.3301)^n$

i. The population after 1 decade i.e. for the year 2021. (n=1)
$P_{2021} = 5068(1.3301)$
= 6740.94

ii. The population after 2 decade i.e. for the year 2031, (n=2)
$P_{2031} = 5068(1.3301)^2$
= 8966.133

iii. The population after 3 decade i.e. for the year 2041, (n=3)
$P_{2041} = 5068(1.3301)^3$
=11925.85

iv. The population after 4 decade i.e. for the year 2041, (n=4)
$P_{2051} = 5068(1.3301)^4$
=15862.57 ≈ 15870

The total population after 4 decade is 15870.

2. Arithmetic increase method:
The total population after 4 decade is 10,000.
4. Incremental increase method:
The total population after 4 decade is 7950.
5. Logistic curve method:
The total population after 40 year is 4200.
6. Decreasing Rate of Growth Method:

The total population after 4 decade is 4000.

From the above population forecasting methods, Geometrical increase (progression) method gives the maximum population for Babupeth area.

4.2 Water Quantity Estimation:

Quantity of Water = Per capita demand x Population

= 200 * 15870
= 3.174 MLD
$= \frac{3.174 * 10^6}{10^3} m^3$
= **3174** m^3

Quantity of Water≈ 3200 m^3.

4.3Design of water tank Manually:

The capacity of the water tank is 3.2 MLD. The diameter of the water tank is 15 m. The height of the water tank is 5 m. The grade of steel is Fe415. The grade of concrete is M20. The various parts of the overhead water tank which are designed manually are:

- Design of Top Dome
- Design of Top Ring Beam
- Design of Cylindrical Wall
- Design of Bottom Ring Beam
- Design of Slab
- Design of Beam (Grid Pattern)
- Design of Column
- Design of Bracing
- Design of Foundation (Bottom Girder, Raft Slab)

We have calculated the required values used in the design of the water tank. The water tank is designed step by step with the help of IS 3370 and IS 875. The parts are deigned in the manner described below:

1. Deign of Top Dome: We have assumed the thick
ness of the top dome as 100mm.The meridional stress and hoop stress are in the permissible limits.

2. Design of Top Ring Beam : The top ring beam 310 × 310 mm is provided considering the hoop tension of spring level.
3.Design of Cylindrical Wall : The maximum hoop tension at the base and at various depth are calculated and the

reinforcement detailing at that particular depth. The cylindrical wall of thickness 250 mm is designed.

4. <u>Design of Bottom Ring Beam</u>: The bottom ring beam is designed by taking all the loads coming on it vertically and horizontally.

5. <u>Design of Two Way Slab</u>: We have designed the bottom slab by considering the grid pattern . therefore the designing of the slab is in square shape, parabolic shape.

The square shape two way slab is designed by considering the self weight of the slab , live load. The thickness of the slab is considered as 200 mm.

The parabolic slab is designed by considering the self weight, live load. The thickness of the slab is considered as 200 mm.

6. <u>Design of Continuous Beam</u>: The continuous beam is designed by limit state method. The width of the beam is 400mm and the depth of the slab is 950 mm.

7. <u>Design of T Beam</u>: The T-Beam is designed by limit state method where the width of beam is 400 mm and the total depth is 675 mm.

8<u>. Design of Column</u>: The supporting column comprises of 20 columns at diameter of 15 m.

The vertical load on each column is calculated according to the grid pattern.

9. <u>Design of Bracings</u> : We have considered the wind force while designing the bracings of the column following the grid pattern. The width of the bracings is 400 mm and the effective depth is 350 mm.

10. <u>Design of The Circular Girder</u> : The total load on the circular girder is calculated by considering the maximum +ve moment at support , maximum -ve moments at mid span, maximum torsional moment. The width of the girder is 600 mm and the depth is 800 mm.

11. <u>Design of Foundation</u> : A circular girder with a raft slab is provided for the tank foundation. While designing the total load on foundation and self weight of foundation is considered. The width of the raft slab is 2 m, the inner diameter is 9 m and the outer diameter is 18 m.

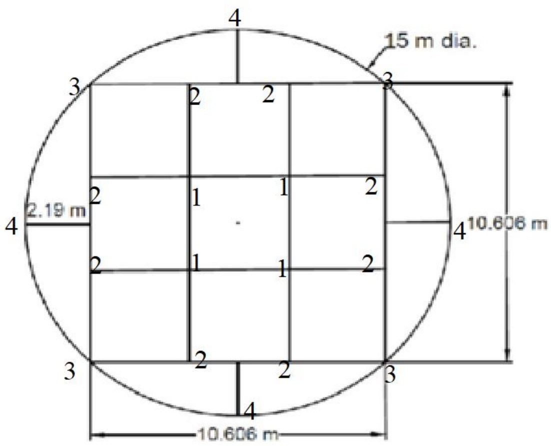


Fig : The Grid Pattern of Slab

4.4Analyze with STAAD PRO :

In this we are going to discuss the steps that we have gone through while modelling in STAAD PRO V8i. The following steps are explained below:

1. Firstly we draw the model with the dimensions which we got from the manual calculations.
2. while modelling we go through the geometry and provide properties to the components of the structure. The properties assigned to the particular component are described below:

- Top dome 100 mm thickness
- Top ring beam 310 mm × 310 mm
- Cylindrical wall 250 mm thickness
- Bottom ring beam 1800 mm × 600 mm
- Continuous beam 400 mm × 950 mm
- T Beam:

Primary beam 400 mm × 625 mm
Secondary beam 400 mm × 575 mm

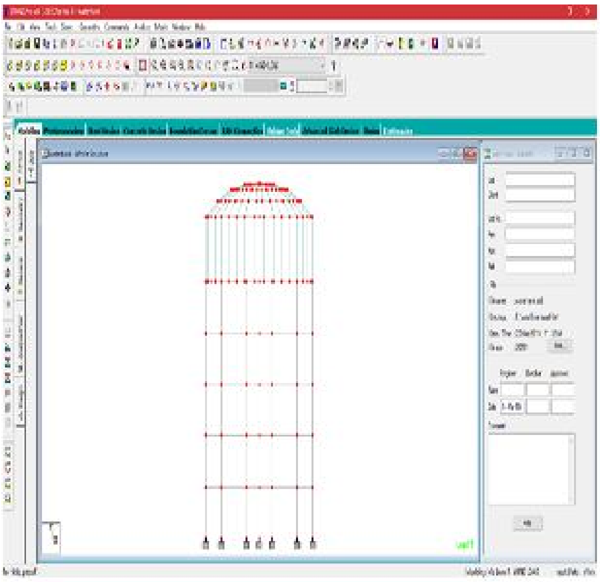
- Column 500 mm diameter
- Bracings 400 mm × 400 mm

3. The load combinations are provided to the components of the structure are as follows:
Selecting the geometry, apply definition in load & definitions where we are providing the intensity as 44 m/s and exposure of 0.7 from IS 875 part 3 clause no.6.2.3.2.
4. Apply the self weight to the structure.
5. Slab load of pressure intensity 1.5 KN/m^2 is given.
6. The water load is applied on the cylindrical wall.

The wind force is applied on various height on the column as follows:

Table-2: Calculations of wind force at various height

HEIGHT	1	2	3	4
20 m	157.59	216.582	166.086	157.59
16 m	149.19	199.782	157.686	149.19
12 m	140.79	182.982	149.286	140.79
8 m	132.39	166.182	140.886	132.39
4 m	123.99	149.382	132.486	123.99



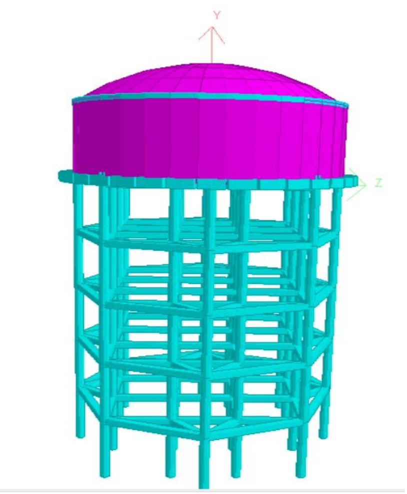


Fig: Structural Drawing 2D and 3D view

Table-3: Comparison between Manual design and STAAD Pro

SR NO	MANUAL CALCULATION	STAAD PRO ANALYSIS	CHANGE IN %
1	Top ring beam		
	Main bar 6#16 mm∅= 1206.37 mm^2	Main bar 6# 12 mm ∅= 678.5 mm^2	43.76 %
	Stirrups 2 legged 8 mm ∅ @300 mm c/c = 30159.28 mm^2	Stirrups 5 legged 8 mm ∅@130 mm c/c = 32672.56 mm^2	
2	Bottom ring beam		
	Main bar 12 # 25 mm ∅= 5890.48	Main bar 2 [27 # 10 mm∅] = 4241.15	28 %
3	Continuous beam		
	6 # 20 mm ∅ = 1884.96	20 # 10 mm ∅ = 1507.7	20.01 %
4	T Beam	Main bar	
	8 # 25 mm ∅ = 3926.99	2 [14 # 10 mm ∅] = 2199.12	44 %
5	Column		
	a) Vu_1 (4 Nos) 6 # 22 mm ∅ = 2280.79	6 # 12 mm ∅ = 678.58	70 %
	b) Vu_2 (8 Nos) 6 # 22 mm ∅ = 2280.79	6 # 12 mm ∅ = 678.58	70 %
	c) Vu_3 = (4 Nos) 6 # 22 mm ∅ = 2280.79	14 # 12 mm ∅ = 1583.36	70 %
	d) Vu_4 = (4 Nos) 6 # 22 mm ∅ = 2280.79	6 # 12 mm ∅ = 678.58	30.58 %
6	Bracings		
	4 # 25 mm ∅ = 1963.45	8 # 10 mm ∅ = 628.31	68 %

V. RESULTS AND CONCLUSION

- The past census of the particular area helps us to calculate the future population.
- Manual designing is very much time consuming and tedious.
- Design of water tank with STAAD PRO V8i is tedious but saves the time and make the accuracy level better.+9
- The Wind force plays an essential role while designing with STAAD PRO as well as in manual calculations.
- While modelling in STAAD PRO the perfect circular geometry is not possible but generally the values we get are same as manual design.

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