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Analysis and design of Elevated Storage Reservoir by using STAAD PRO

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ABSTRACT

Water is as important commodity as food and air for the existence of life. The Elevated Storage Reservoir (overhead tanks) which have been the inevitable part of water supply system are important public utility structures and industrial structure by the help of which the required water head can easily be achieved and water can be made available to all by the mere action of gravity.

In this project, we have analysed and designed an ESR (overhead circular reinforced cement concrete tank) to carter the requirements of Girls hostel which is in girls boarding school. The population of the school is estimated as 572 including all the students, teacher staff and their families. The ESR has been designed by increasing the capacity for future plans in campus. For this requirement a ESR is analysed by using premiere analysis software STAAD PRO. Based on the analysis using STAAD PRO the silent feature of the ESR is manually designed.

Keywords : ESR, STAAD PRO, Water Supply System

I. INTRODUCTION

A ESR or an overhead water tank is used to store water to overcome the daily demand of water. Elevated storage reservoir are able to supply water even during power cuts, because ESR depends on hydrostatic pressure produce by elevation of water (due to gravity) to push the water into domestic and industrial water distribution system.

The site allotted to us was in Pune. In this site a girls hostel for 500 students has been under construction along with staff quarters.

The site was started on February of 2022. The land sanction for this school is 15 acres and the budget of this project is 27 crore.

The project include construction of :-

500 seated (G+1) school building

351 seated (G+3) hostel building (3 seated rooms)

140 seated (G+3) hostel building (2 seated rooms)

And F,G,H,I named staff quarters.

II. LITERATURE REVIEW

Mr. Manoj Nallanathel , Mr.B. Ramesh , L. Jagadesh had done the “DESIGN AND ANALYSIS OF WATER USING TANKS USING STAAD PRO”. The paper includes the study of design of water tanks of both overhead and underground tanks of shapes rectangular, square and circular shapes are designed and analysed using STAAD PRO. The shape of tanks does matter in the stress distribution and overall economy. The circular water tank has less corner stresses and maximum shear and bending stresses as compared to other shapes of tanks.

For Underground tank which are surrounded by soil, Uplift pressure plays predominant role in design which was caused by surrounding soil on outside walls of tank. The shape of the tanks plays predominant role in the design of water tanks. Usage of STAAD PRO in design gives accurate results for corner stresses and maximum shear and bending stresses than convenient method.

Hemishkumar Patel, Dr. Jayeshkumar Pitroda had done the “ANALYSIS OF CIRCULAR AND RECTANGULAR OVERHEAD WATERTANK”. This paper includes the study of optimised method for analysis and design of overhead water tank. A computer program had been developed to solve numerical examples. By comparing hoops tension, axial force in column , weight between rectangular and circular water tank in SAP 2000 it was concluded that the circular water tank had water load, hoop tension and axial force in columns due to water load less than rectangular water tank

Thalapathy M, Vijaisarathi.R.P, Sudhakar.P had done “ANALYSIS AND ECONOMICAL DESIGN OF WATER TANKS”. This paper includes the detailed analysis of the design of liquid retaining structure using working stress method. This paper provides idea for safe design with minimum economy of the tank and gives the designer relationship curve between design variable. This paper helps in understanding the design philosophy for the safe and economical design of water tank.

Mainak Ghosal had done “WATER TANK ANALYSIS USING STAAD PRO” This paper includes the design and analysis of reservoir for a locality in which he has surveyed a village water 9 requirement to full fill their water demand. The population data and water requirement is collected so that capacity of tank can be obtained. The tank has analysed in STAAD PRO and was manually designed. Dead load , wind load, hydrostatic load were considered except seismic load because construction is situated at Zone II i.e low intensity as per IS 1893 Part 1.

Mareddy Arun Kumar, O.Sriramulu, N.Venkateswarlu has done “PLANNING , ANALYSIS AND DESIGN OF A OVERHEAD CIRCULAR WATER TANK IN N.B.K.I.S.T USING STAAD PRO SOFTWARE”. This paper includes planning, design and analysis of water tank for N.B.K.R. Institute of Science and Technology.The capacity of tank was 1500 kL. The tank was designed and analysed in STAAD PRO and it was safe from software design with respect to the loads applied.

Issar Kapadia, Purav Patel, Nilesh Dholiya, Nikunj Patel, had done the “DESIGN, ANALYSIS AND COMPARISON OF UNDERGROUND RECTANGULAR WATER TANK BY USING STAAD PROVI8 SOFTWARE”. This paper includes the study and discussion of Under Ground Rectangular tank that what are the actions will be produced and how the shape deflected when tank empty or full by using STAAD Pro. There were two cases were taken for the design and analysis with different wall thickness of tank and rest of the data same. If proper thickness of components was not considered the tank design would failed.

III. DATA COLLECTION AND ANALYSIS

Population Estimation

The quarters are named F,G,H,I designed for Principal, teachers staff, guards, workers etc. along with their families. There are two hostel are being constructed

1. G+3 351 seated (3-seater room) hostel building
2. G+3 140 seated (2-seater room) hostel building

Following are the data collected for population estimation at campus:-

Sr. no	Type of consumption	lit/capita/day
1	Drinking	5
2	Cooking	5
3	Bathing	55
4	Clothes and washing	20
5	Utensils washing	10
6	House Washing	10
	Total	135

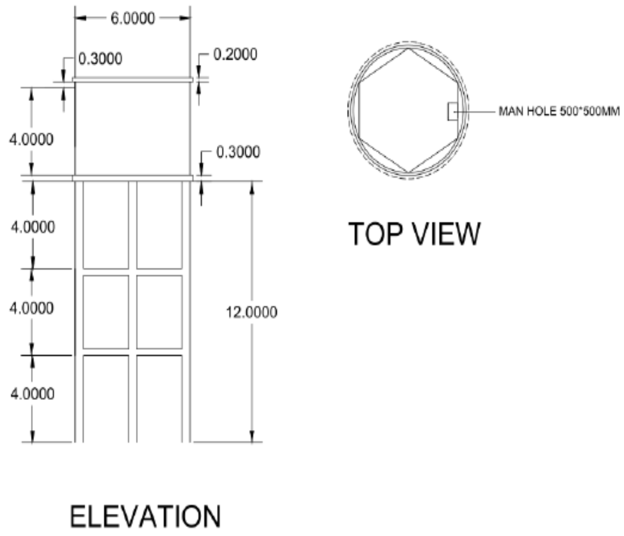
Table 3.2

As per the IS:1172 1993 water required for boarding school is **135 lit/day/capita** The quantity of water required for daily uses for which the water supply scheme has to be designed requires following data: 13 Water consumption rate (Per Capita Demand in litres per day per head) Population to be served.

Quantity= Per demand x Population
Required Quantity of ESR= 563x135
= 76005 litres

But as the campus is of 15 acres so there may future plans so, we designed ESR for 110 m3 i.e 110000 litres

Plan of ESR



Geometric details of ESR;-

· Diameter of ESR – 6m
· Height of ESR – 4m
· Height of staging – 12 m
· Free board – 300 mm

Components	Thickness/Dimensions
Top dome	100 mm
Top ring beam	200x100 mm
Circular wall of tank	125 mm
Base slab	200 mm
Bottom ring beam	300x300 mm
Column	430x430 mm
Manhole	500x500 mm

Analysis

The analysis of the structure is determination of the internal forces like bending moment, shear force, etc in the component members, for which these members have to be designed, under the action of given external loads. This process requires knowledge of structural mechanics which include mechanics of rigid bodies, mechanics of deformable bodies (i.e mechanics of deformation) and theory of structures (i.e science dealing with response of structural system of external loads). It is only after the analysis; one will be able to design the structure accordingly to carry out those loads safely during the life span of the structure

Data Required for Analysis of ESR

- Diameter of tank.
- Height of tank.
- Height of staging.
- Member properties of components of ESR i.e top dome, top ring beam, tank wall, bottom ring beam, braces, column etc.
- Grade of concrete and steel.
- Load calculations of dead load and hydrostatic load.

Analysis Results

Front View of ESR

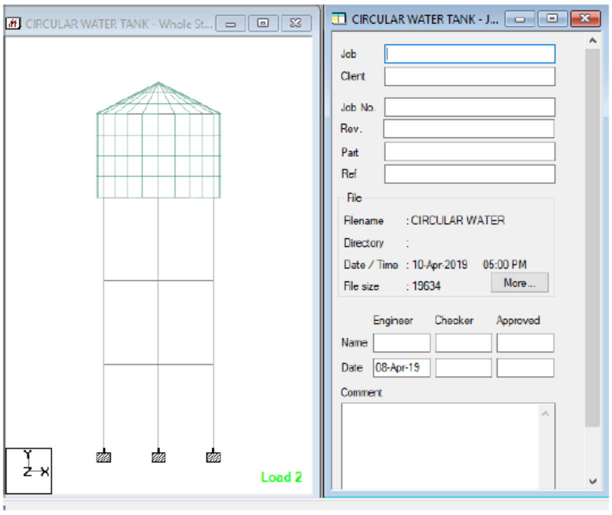


Fig.3.2 Front view of ESR

This is front view of ESR designed in STAAD PRO. The diameter of tank is 6 m with height of 4 m.

The height of staging is 12 m from ground and the braces are in distance of 4 m.

Rendered view of ESR

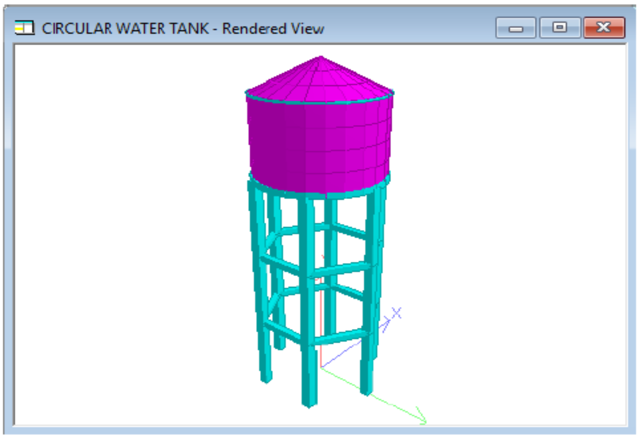


Fig.3.3 3-D view of ESR

The Rendered View in STAAD PRO shows the 3-Dimnsional image of structure. This view represents the designed structure in form that appers to be physically present with designated structure. It allows to view the structure from various dimensions which includes width, depth, and height

Plate Components of ESR

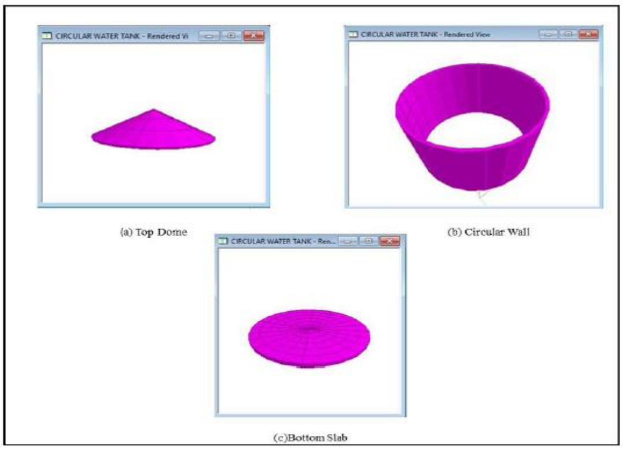


Fig.3.4 Plate components

The figure 3.4 shows all the plate components in ESR in Rendered view.

Section Properties

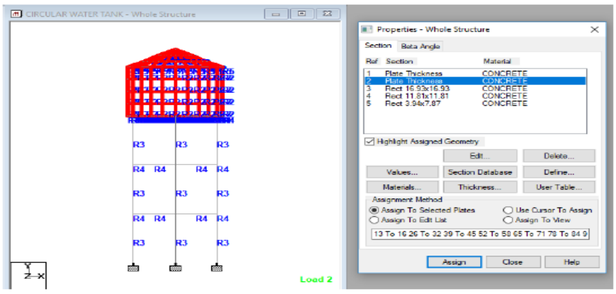


Fig. 3.5 Member Properties of Plates, Column, Ring Beams, Braces

This figure 3.5 shows the properties assigned to the components of ESR.

Following are the properties :

- Top dome thickness – 100 mm
- Top ring beam size – 200x100 mm
- Tank wall thickness – 125 mm
- Base slab thickness – 200 mm
- Bottom ring beam size - 300x300 mm
- Braces size – 300x300 mm
- Column size – 430x430 mm

Self Weight

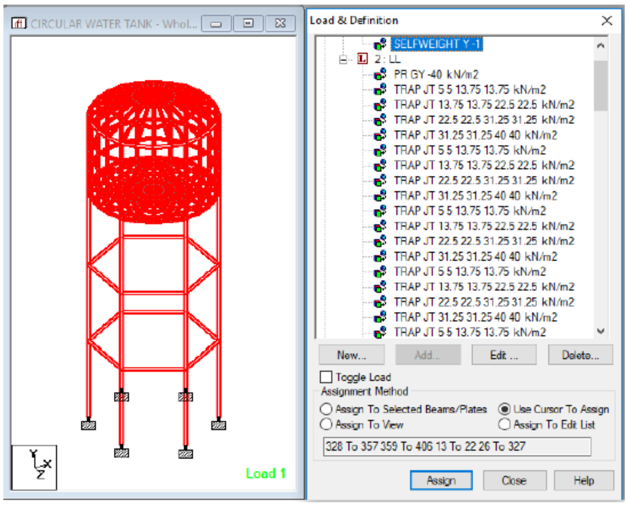


Fig. 3.6

The figure 3.6 shows Dead loading applied to the structure that is self-loading. Every component in the structure has dead load so it is applied to the whole structure. the self-weight applied is -1 KN/m2.

Live load due to hydrostatic pressure

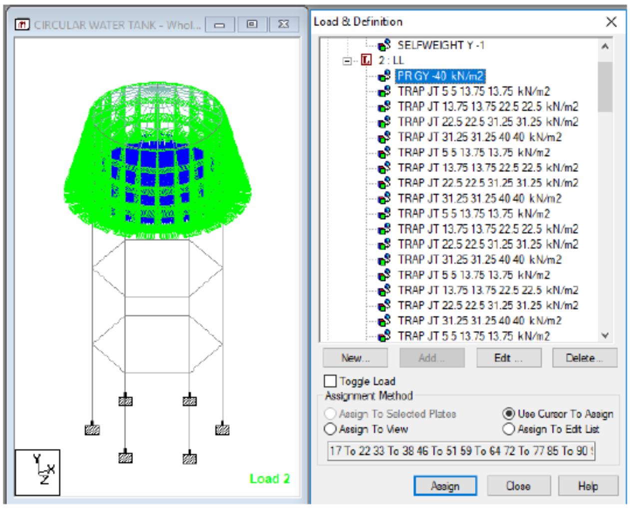


Fig. 3.7

ρ = 1000 Kg/m3

g = 10 m/s2

h = 4 m

Hydrostatic load = ρgh

= 1000x10x4

= 40KN/m2

Stresses in plates

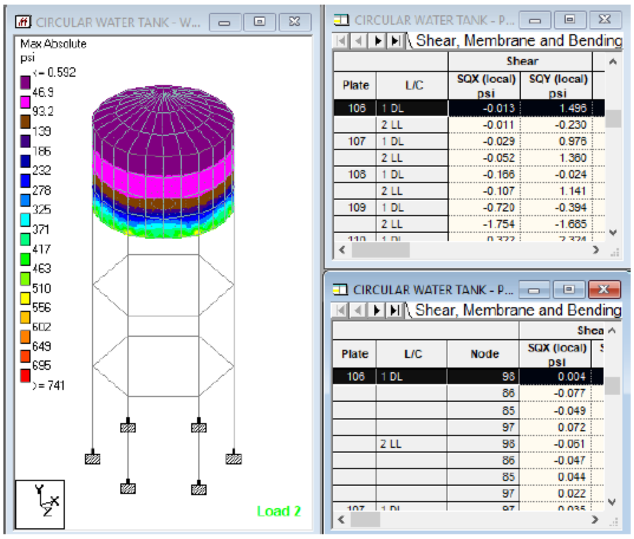


Fig. 3.8

The figure 3.8 shows the stress developed in plates of overhead water tank due to hydrostatic load created by water in the tank. By colours in figure it is clear that the upper plates of tank has less stress than the lower plates. The stress is varying from top to bottom plates of tank. This result can be concluded by matching the colour scale provided in STAAD PRO.

Stresses in bottom slab

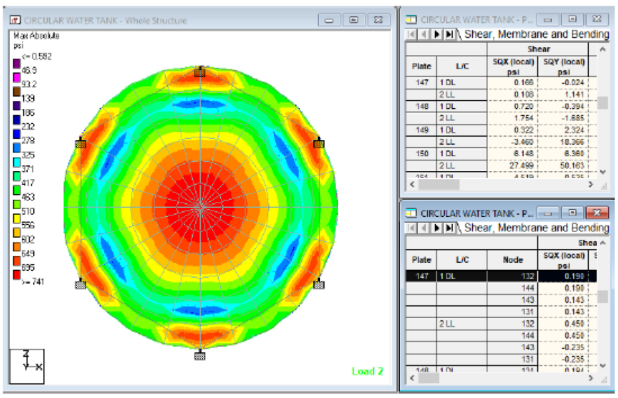


Fig. 3.9

Plate stresses refers to the bending of plates due to loads applied on plates which results in deflection. These stresses in plates can be calculated from the deflections. When the stresses are obtained, the failure theories can be applied to determine whether these plates will bear the load or not.

In this figure 3.9 the centre of the bottom plate has maximum stress due to hydrostatic load.

Analysis Result

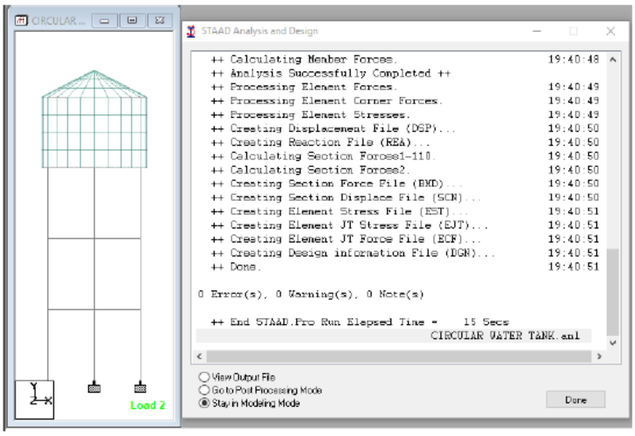


Fig. 3.10

The analysis of ESR has done successfully in STAAD PRO.

CONCLUSION

The proposed ESR in school campus designed and analysed in STAAD PRO.

- The population was estimated at campus. Based on population and water demand total capacity of ESR was calculated.
- The plan and elevation for the Elevated Storage Tank was prepared using AutoCAD software.
- The structure was analysed in STAAD PRO for self-weight, hydrostatic load, member properties etc. and the outputs were verified.
- The design would satisfy safety norms and can be used for similar population.
- For small capacities rectangular water tanks are preferred over circular water tanks but when there is required of large capacity circular shaped overhead tanks are more preferable, as the circular water tanks has water load, hoop tension and axial force in columns is less than rectangular water tank.
- The circular water tank has less corner stresses and maximum shear and bending stresses as compared to other shapes of tanks.

IV. REFERENCES

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