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Analysis of Circular Elevatd Water Tank with Slant Columns Considering Hydrostatic Load

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ABSTRACT

Water tanks are the storage units of water which are used for distribution. Water tanks are constructed at high heads to distribute the water with the effect of gravity. These are mainly used for serving drinking water for highly populated areas of metropolitan urban communities in cities and towns. Water is the basic essential requirements for all living organisms in world. Frame works, transportation of inflammable fluids and chemicals. After tanks are used for water supply, firing.

In this project work we are proposing circular elevated water tank considering slant height of 0°, 2°, 4°, 6°, 8°, 10° and 12° slope using analysis tool staad.pro. In this study we are considering hydraulic pressure as per I.S. 3370 L.S.M. and lateral forces.

Keywords : Water Tank, Elevated, Sloping Columns, Staad.Pro, Hydraulic Pressure, Lateral Force.

I. INTRODUCTION

Water is the basic need for all the living organisms to survive. Portable water is essential for good health of human beings. It is important to supply portable water to every individual and every community; hence it is very essential to store water. Water is generally stored in tanks and later the stored water is supplied to every community through pipelines.

A structure which stores the water is commonly terms as reservoir. A reservoir can built above or below the ground level. Generally underground reservoirs are built to store water in large quantities whereas overhead tanks are built to store water in small quantities and to distribute water by the effect of gravity reservoirs are used to store water tanks are used to store water. Crude oil and other liquid substances. All the tanks are made leakage free for raw petroleum crude oil.

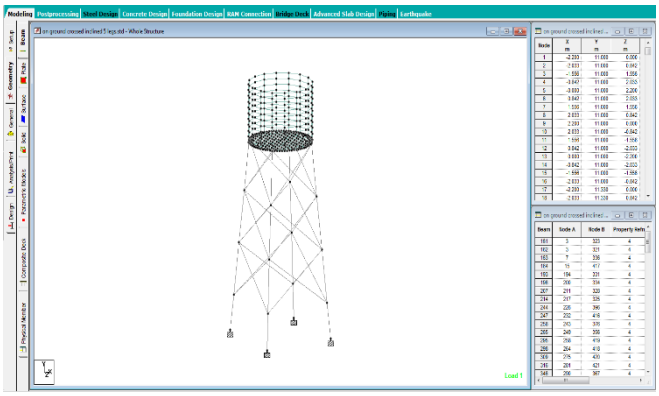

Fig 1 : Water Tank design

II. LITERATURE REVIEW

Tiruveedhula et. al. (2019) the research paper presented the performance of elevated reinforced concrete overhead water tanks to seismic and wind forces. Tanks of various shapes namely Circular, Rectangular and Intze Elevated water tank were modelled in STAAD.PRO software. Gravity analysis, Seismic analysis and wind analysis was performed on the modelled structure. From the analysis results, the seismic parameters such as displacements, base shear and over turning moments was examined deeply and compared and cost analysis was performed for all the three water tanks.

While considering the shape and geometry, the results concluded that over-turning moment was found to be greater in rectangular water tank when compared to the other two water tanks (Circular and Intze). Under seismic loading**, Circular water tank was recommended**. Under wind loading, Intze water tank was recommended. Circular water tank experiences greater displacement when compared to other two water tanks due to its support conditions. Circular water tank experienced greater base shear when compared to Rectangular and Intze water tanks. Comparing seismic analysis and wind analysis results, Intze water tank was recommended. **As per cost analysis, Circular water tank was found to be economical when compared to the other two tanks extensions.**

Ramakrishna Hegde et. al. (2018) this project presented comparison between the circular water tank and rectangular water tanks dealing with the optimum working needs of both of them. 21000 liters capacity tank was utilized for design in this project. The water tank construction of tanks was Rebars, cement, sand, aggregate and formwork.

The conclusion derived from the results stated that maximum principle stresses was found in circular tank in comparison to rectangular tank. Hoop Tension was less in rectangle tank with values as 120 Kn than circular tank with values as 180 Kn. Area of steel was 490 mm^2 for rectangular water tank and 734 mm^2 for circular water tank. Formwork was found maximum in rectangular tank than the circular water tank.

Objectives

1. To prepare a comparative study of water tank with different water proportion as per I.S. 3370 L.S.M. considering population forecasting.
2. To determine the effect of lateral forces on a elevated water reservoir.
3. To determine the effect of lateral forces water tank with slant columns.
4. To prepare the modelling and analysis of the elevated water tank using staad.pro

III. PROBLEM STATEMENTS

Bhopal is located at heart of India and north of the upper limit of the Vindhya mountain ranges located on the Malwa plateau. It is higher than north Indian plains and the land rises towards the Vindhya range to the south.

The city has uneven elevation and has small hills within its boundaries. The major hills in Bhopal comprise of Idgah hills and Shyamla hills in the northern region and Arera hills in the central region.

Average Water Demand = Avg. water demand coefficient. (gpm/Acre)*Landuse(Area (acre))

Maximum Day Demand=2.2*Average Day Demand

Peak Hour Demand=3.4*Average Day Demand

Operation storage =25% of Maximum Day Demand

Fire Storage=0.63 MG per acre

Emergency Storage=Underground (provided emergency pumping methods are available for supplying 25% Maximum Day Demand)

Table 1 : Geometrical Data

Height of the tank	3.5 m
Staging height (linear)	8 m
Base diameter of tank	4.4 m
Diameter of Sphere	4.4 m
Number of columns	4
Grade of Concrete	M30
Grade of Steel	Fe415
Size of column	500 mm²
Size of Beam	500 X 350 mm
Plate Thickness	800 mm
Wall Thinkness	450 mm
Cover Thickness	50 mm

Table 2 : Seismic Data

S.No.	Parameter	Value	Remarks
1	Seismic zone	II	0.1 intensity
2	Importance Factor	1.5	Table-6 (1893-I)
3	Response Reduction	5	Table 7
4	Soil type	II	Medium

IV. Methodology

Following steps are considered for analysis of study:

Step 1: To prepare a literature survey related to our study

Literature Survey was prepared for the past study undertaken till date and shortcomings were identified on which further research needs to be executed.

Step 2: To prepare geometrical structure of the study using analysis tool Staad.pro

Step 3 To create material for structural sections

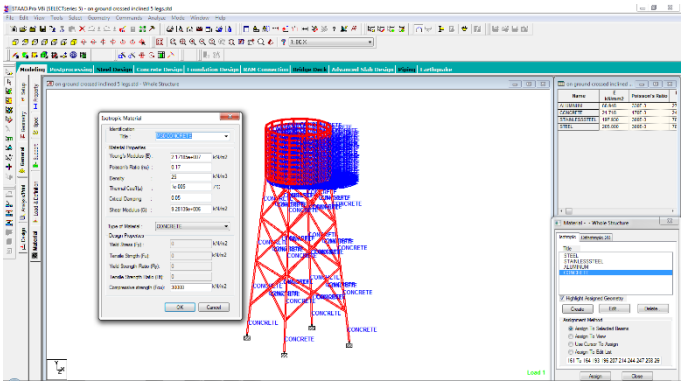

Fig 2 : Modelling and section description

Step 4 To Assign and create sectional properties

Step 5: Assign weak spring at base beams and cylindrical surface

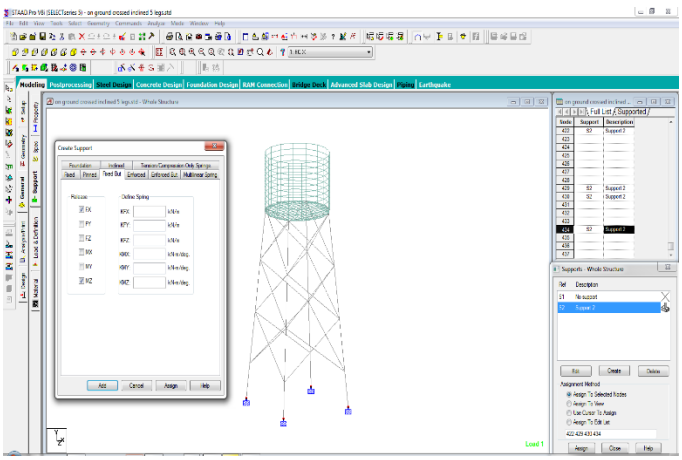

Fig 3 : Assigning support conditions

Step 6: Assigning Hydrostatic Pressure (full condition)

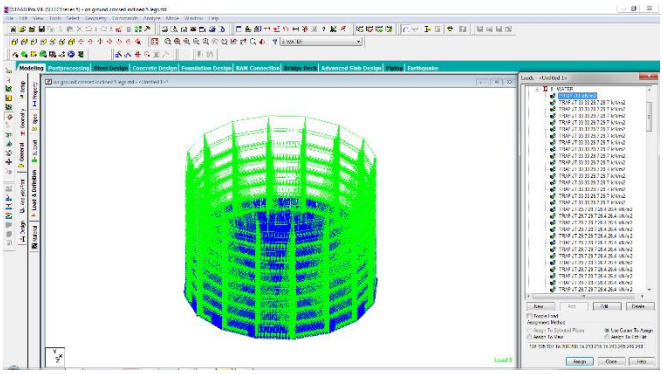

Fig 4: Assigning loading

Step 7: Assigning Wind Pressure as per I.S. 875-III:2015 (39 m/s wind speed) or Seismic force as per I.S. 1893-I:2016

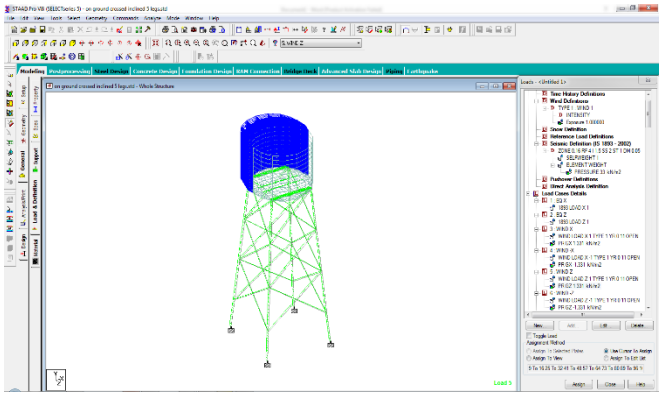

Fig 5 : Seismic loading

Step 8: F.E.M. Analysis of structure using analysis tool Staad.pro

V. ANALYSIS RESULTS

Table 3 : Forces at top ring beam

Maximum Forces on Top Ring Beam						
Degree	Axial Force kN	Shear-Y kN	Shear-Z kN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
0	51.46	7.96	10.12	0	36.01	-7.49
2	51.46	7.96	10.12	0	36.01	-7.49
4	51.2	7.7	9.86	0	35.75	-7.75
6	50.73	7.23	9.39	0	35.28	-8.22
8	51.34	7.84	10	0	35.89	-7.61
10	51.79	8.29	10.45	0	36.34	-7.16
12	52.58	9.08	11.24	0	37.13	-6.37

Table 4 : Forces at bottom ring beam

Maximum Forces on Bottom Ring Beam						
Degree	Axial Force kN	Shear-Y kN	Shear-Z kN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
0	51.42	14.64	14.987	0	46.75	3.34
2	51.42	14.64	14.987	0	46.75	3.34
4	51.01	14.23	14.577	0	46.34	2.93
6	50.39	13.61	13.957	0	45.72	2.31
8	51.1	14.32	14.667	0	46.43	3.02
10	51.74	14.96	15.307	0	47.07	3.66
12	52.57	15.79	16.137	0	47.9	4.49

Table 5 : Cost Analysis

CASE	QTY of concrete cu.m.	Rate of Concrete	QTY of Rebar Kg	Rate of Rebar	Concrete Rate	Rebar Rate
0°	78.4	3200	8021	61.5	250976	492911.34
2°	78.4	3200	8021	61.5	250944	492911.34
4°	76.2	3200	7878	61.5	243872	484130.75
6°	72.3	3200	7490	61.5	231392	460278.94
8°	72.5	3200	7562	61.5	231840	464703.95
10°	75.9	3200	7623	61.5	242880	468426.59
12°	78.1	3200	7905	61.5	249952	485731.53

VI. CONCLUSION

- In the present study finite element modelling of an elevated storage will be proposed to carried out using software package Staad.Pro V8i with the capacity of 50 m3 with the top of water level at about 11.5 m above ground. The shape of the tank is considered to be circular with the aspect ratio as =.75, 4.4 m in diameter and 3.5 m in height.
- The fixed support constitutes four vertical circular columns and these columns were connected through a rectangular beam at internals as 2m, 3m and 3m. The support consists of 4 vertical circular columns and the columns are connected by the rectangular beams at intervals 2m, 3m and 3m.
- Seismic analysis as per IS 1893 Part I 2016 for zone II and basic wind speed 39m/s as per IS 875 Part III 2015 was done using Staad.Pro for full water level conditions.
- Shear force slantly decreases from 0 degree to 8 degree by 8%, but from 10 degree it rises again up to 12 degree case.
- In terms of moment it has been observed that there is a gradual decline in moment upto 6 degree case by 4.5% but afterwards it gradually rising.
- In terms of Axial force we observed that values continuously declining by almost 5% upto 6 degree case but afterwards again shooting upward.
- In terms of cost analysis it has been observed that 6 degree and 8 degree cases are

More cost effective in terms of concrete and rebar requirement as analyzed in software using Optimization.

Summary: Here in paper as per results observd it can be said that inclined columns are more stable and economical upto 6 degree after that it has been observed that higher degrees are showing towards unstability of the structure.

VII. FUTURE SCOPE

1. In this structure we are considering seismic forces whereas in future one can select dynamic forces.
2. In this study we are considering circular elevated tank whereas in future we can consider underground tank.
3. In this study we are analyzing using staad.pro whereas in future any other analysis tool can be use.

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