Seismic Analysis of An Underground Water Tank Considering Fill Condition Using Analysis Tool Staad.Pro

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Abstract- *Water tanks and reservoirs are used to store liquids like water, petroleum or chemicals. For any household and business purposes, water tanks are an exceptionally fundamental need to meet their everyday use. In this project an analysis is made to plan the rectangular and circular underground tank, the tank is to keep up with atmospheric temperature and gave ideal height to simple pumping of water to the upward tank. Since it is underground water tank thel lateral earth pressure and water pressure additionally considered for the plan computations, so the plan is to be done according to IS code standards. Underground water tank is utilized for putting away liquids (oil, water, gas, and so on) these tanks are exposed to water tension from inside and earth strain from outside. The foundation of tanks is exposed to water tension from inside and soil response from under. Continuously these are covered at the top.*

This project deals with analysis and design of underground water tank of 2-lakhliter capacity. The design in this project comprises of side walls, base slab and roof slab. The analysis and design of underground water tank is done using Staad.Pro. For this design project limit state method is used.

In this study we are considering square and circular water tank with four different seismic zones as per I.S. 1893-I:2016 and three different fill conditions.

Keywords- Water tank, seismic load, staad.pro, hydraulic load, pressure, force.

I. INTRODUCTION

Now days, expressive constructions were taking place in hilly areas due to lack of plain ground. As a result the mountain areas have marked effect on the buildings in terms of style, material and method of construction leading to lot of structures in hilly areas. Due to sloping profile, the different levels of such structures step back towards the hill slope and may also have setback also at the same time. These structures become highly uneven and unsymmetrical, due to different version in mass and stiffness distributions on different upwards and downwards axis at each floor. Such construction in seismic prone areas attracts greater shear forces and torsion compared to usual construction.

In some parts of world, mountain area were more likely to get earthquakes; e.g. northeast area of India. In this hilly areas, usually material like, the clay, brick, stone masonry and dressed stone masonry, timber reinforced concrete, bamboo, etc., which is locally available, is used for the construction of houses. The money based growth and rapid growth of the cities with more people in hilly areas has speed up the Real Estate Development.

RCC water tank design should be based on sufficient resistance to cracking to avoid leakage and adequate strength. For achieving these following assumptions are made:

- Plain section before bending remains plain after bending
- Both concrete and steel are perfectly elastic and modular ratio value has a value given in IS 456.
- In calculation of stresses. Both for flexural and direct tension or combination thereof relating to resistance to cracking, the entire section of concrete including the cover together with reinforcement can be taken into consideration provided that tensile stress in concrete limited to values.
- Neglect concrete tensile strength during strength calculation.

II. LITERATURE REVIEW

Suraj P. Shinde (2018) research paper presented a comparative analysis of the computer-aided design of an underground water tank. Manual Analysis and design of the Underground Water tank by using IS code method was presented comparing with STAAD-PRO and SAP software design result, comparison of reinforcement was done and optimize results are determined. This report gives in brief, the theory behind the design of liquid retaining structure (Rectangular water tank) using working stress method. This water tank of 1,00,000-10,00,000 liters capacity was designed in computer added analysis. The deflected shape was analyzed and also the axial force of respected tank cases and develop programs for the design of water tank of flexible base and rigid base and the underground tank to avoid the tedious calculations. Comparison was made between IS code method design and various software design result to understand governing loads and carry out literature review related to underground water tank. The base deflection criteria, shell stresses and joint reaction of underground water tank structure by considering dynamic type of loading when the tank is empty and full water level conditions was presented.

Results stated that the calculation of deflection in the manual design and the deflection results from STAAD and SAP software were nearly same. The shell stresses in full water condition and full empty condition was within the permissible limit that was not greater than 7000 kN/m2 and mainly the results obtained from both software's were same. If suppose tank has less dimension then unsatisfied results were obtained.

Suraj Tripathi et al (2020)the examination paper presenetd seismic investigation of an Underground water tank with built up substantial organizing structure. The construction was planned by IS code arrangement to decrease Effect and limit the result of seismic wave. The time-history evaluation was done by a nitty gritty limited component reenactment of the UG water tank. For the investigation of nonlinear powerful examination, SAP 2000 programming for various seismic intensity.The consequence of the review shows the avoided state of tank at various condition considered as unfilled and full. Time history strategy becomes important to guarantee wellbeing against seismic tremor powers. the rectangular shape UG water tank of limit 80000 liter. The component of UG tank was 6m*4m*3.5m. IS:456 2000 was been utilized and for seismic investigation IS:1893 2002. In the wake of giving all expected underlying arrangement dole out time history information of Nepal tremor which was occurred in 2015/04/25 (LAMJUNG, NEPAL) greatness of (7.8).

The diverted state of UG tank by the activity of time history strategy for various instance of capacity not entirely settled . Since time history examination was a practical and essentially utilized for the assurance and plan of better construction by considering element of wellbeing according to IS Code. On investigating the design with various time history information one get different method of avoided shape for void tank along with for full tank for UG repository.

Komal K Wagh et al (2021) research paper presented the design of underground water tank of Rectangular shape was designed and analysed using Staad pro. Underground water tank faces different type of loads compared to other structures, they mainly face horizontal or lateral loads due to earth pressure and water pressure or any liquid pressure which was stored in the tank. The side walls of the underground water tank will face greater load at the bottom and the load linearly decreases towards the top.The analysis and design were done according to standard specifications using IS-456:2000 & SP-16, for the design of the STRUCTURAL MEMBERS. i.e., followed the LIMIT STATE method. Materials used are M20 grade concrete and Fe 415 steel unless mentioned in the particular design elements.

Conclusion stated that STAAD Pro gives satisfactory results when compare with manual design also. STAAD PRO analysis and design is always beneficial over the conventional method of analysis and design of water tank. Manual analysis and design requires lengthy and complicated procedure while STAAD PRO requires less time & easy design &analysis process. By using STAAD PRO software there is saving of 15% to 20 % of total steel in the whole structure.

A. C. Chougule et al (2017)the examination paper led parametric concentrate on spring mass model, Time period in rash and convective mode, Design even seismic coefficient, Base shear and Hydrodynamic tension because of imprudent and convective mass of water was thought of. It was tracked down that under impact of seismic powers with expanding proportion of most extreme profundity of water to the measurement of tank (h/D) the more mass of water will energize in imprudent mode while diminishing proportion of (h/D) more the mass of water will energize in convective mode. The time of Impulsive mode increment with expansion in (h/D) proportion and Time period in convective mode decline with expansion in (h/D) proportion. It was accepted that tank is situated in seismic zone IV.

The outcomes presumed that For round water tank with same capacity limit and different level; the Base shear, Bending Moment and Max. Hydrodynamic tension steadily increments with expansion in h/D proportion in the event of rectangular water tank with same capacity limit and different level of tank wall if the h/L proportion ultimately depends on 0.6 the base shear, Bending Moment& Max. Hydrodynamic strain increments step by step and if the h/L proportion in the middle between 0.6 to 0.8; it out of nowhere increments and after that it diminishes slowly. So for water tank at ground level the h/L proportion up to 0.6 is possible. For roundabout and rectangular water tank with same capacity limit yet unique level of tank wall, sloshing wave level builds up as far as possible and after that it diminishes step by step. The expansion in the proportion of most extreme profundity of water to the breadth of tank for example (h/D) or (h/L) will prompt expansion in imprudent mass support variable and reduction in convective mass cooperation factor. The chart likewise represent that the amount of mass support factor (indiscreet and convective) show the unit esteem up and down the even axis. In instance of round water tank for h/D proportion 0.4, the mass cooperation factor for incautious and convective are almost equivalent. In the event of rectangular water tank for h/L proportion 0.5, the mass cooperation factor for rash and convective are almost equivalent.

Anshuman Nimade et al (2018) the research paper presented finite element model of underground water tank using Staad.Pro software and analyze the behavior of underground water tank for different L/B ratio. The Node displacement and Stress pattern of underground water tank was compared for different L/B ratio in order to the base Pressure, Plate moments of underground water tank structure by considering the tank was empty and full water level conditions.

III. OBJECTIVES

The main objectives of this study are –

1. To prepare a comparative study of water tank square and circular with different water proportion as per I.S. 3370 L.S.M. as per Indian standards.
2. To determine the effect of lateral forces on a under-ground water reservoir.
3. To determine the effect of ground vibrations over the surfaces of underground water tank.
4. To prepare the modelling and analysis of the underground water tank using staad.pro.

IV. METHODOLOGY

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

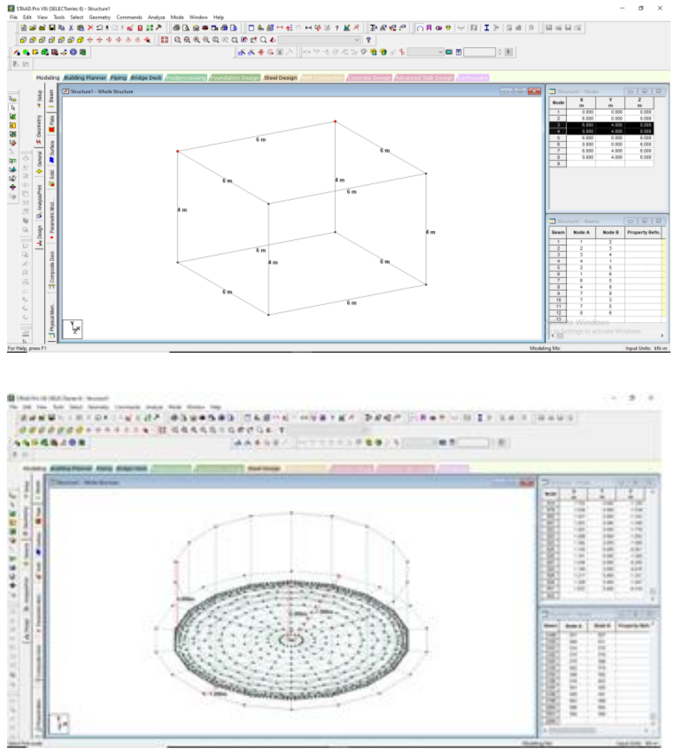


Fig 1: Plan of the Geometry

Step 3 To create material for structural sections

Step 4 To Assign and create sectional properties

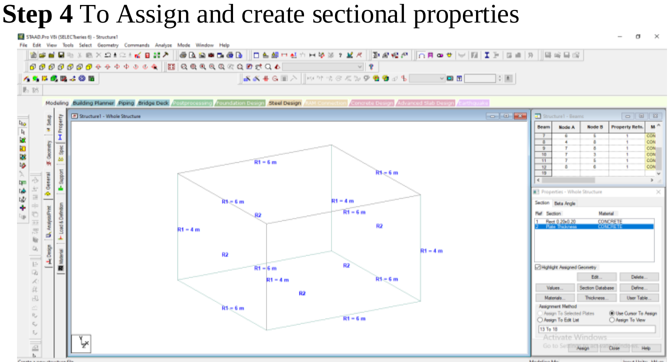


Fig 2: Section Details

Step 5: Assign supports at base beams and side walls

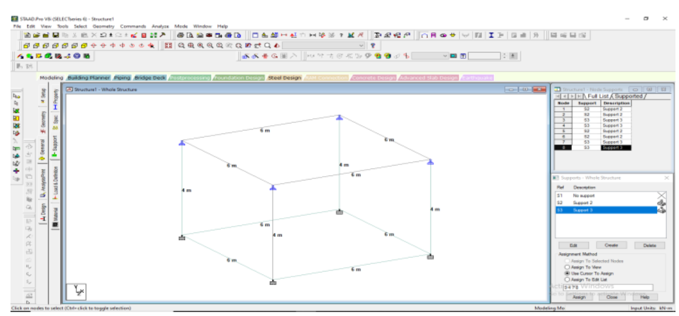


Fig 3: Support Condition

Step 6: Assigning Hydrostatic Pressure (full condition)

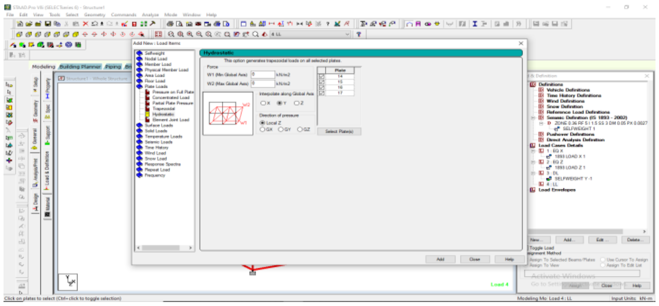


Fig 4: Hydrostatic Pressure

Step 7: Assigning Seismic force as per I.S. 1893-I:2016

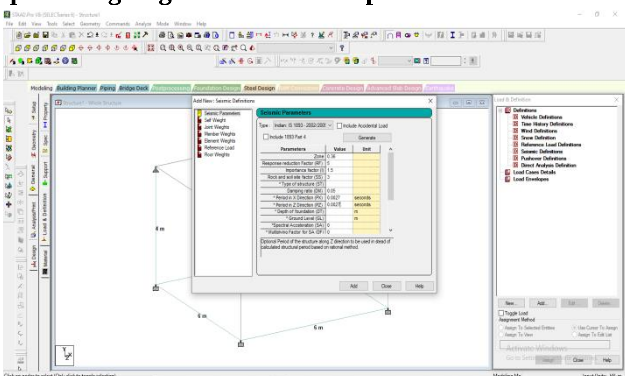


Fig 5: Assigning Seismic Load

Step 8: Assigning Backfill Condition

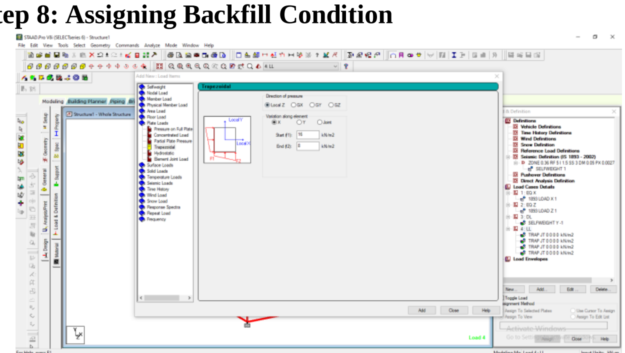


Fig 6: Backfill condition

Step 9: Analysis of structure using analysis tool Staad.pro

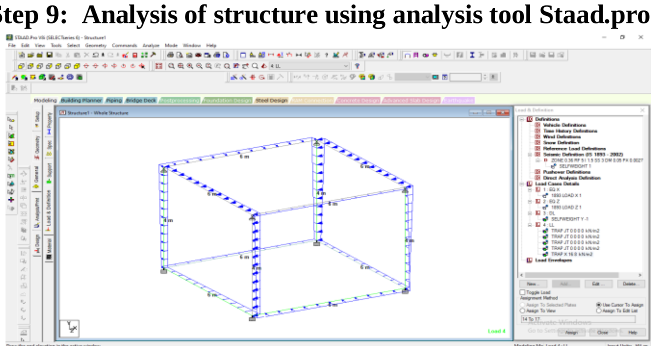


Fig 7: Analysis of the structure

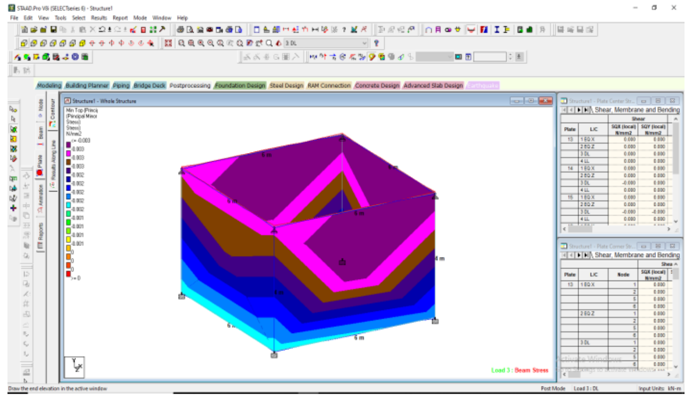


Fig 8: Stress Analysis

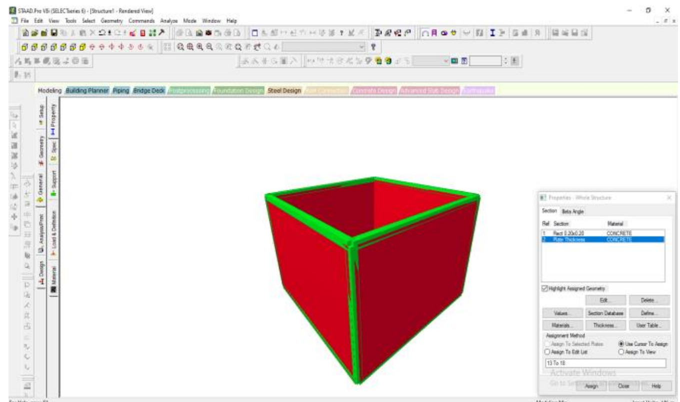
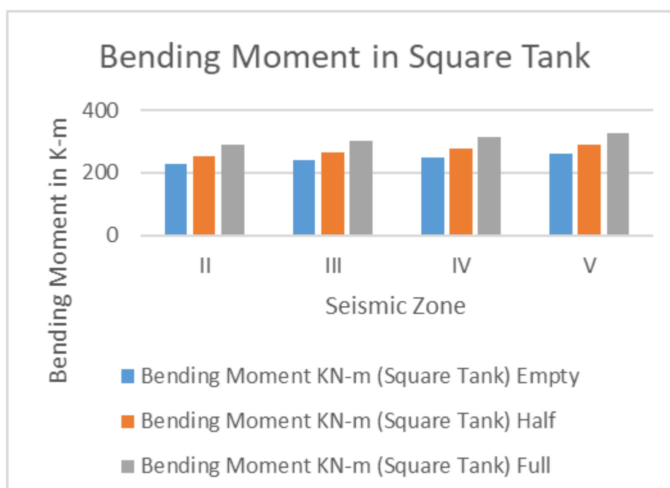


Fig 9: predefined view

V. ANALYSIS RESULTS

Bending moment KN-m



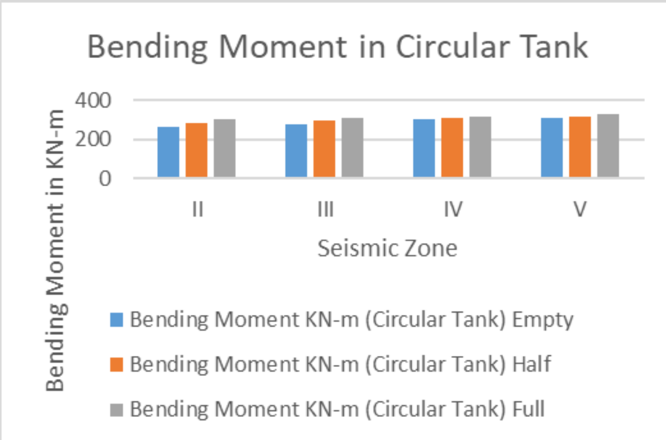
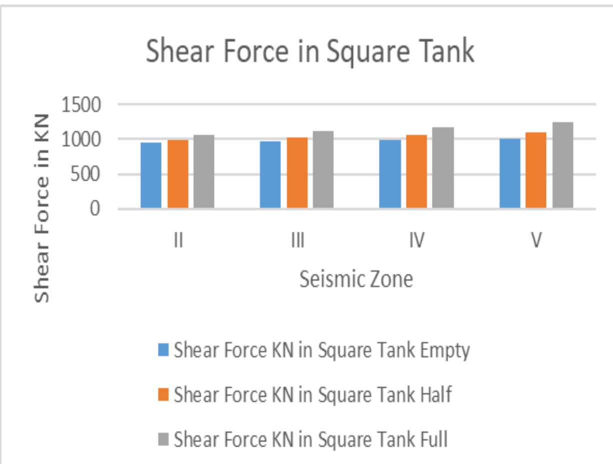


Fig 10: Bending moment

Shear Force KN



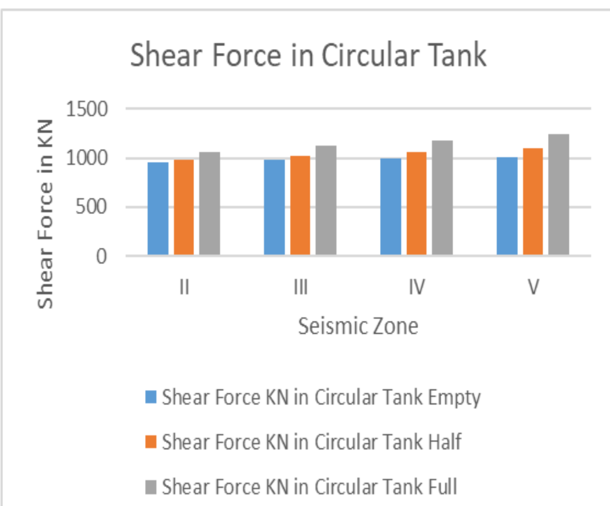
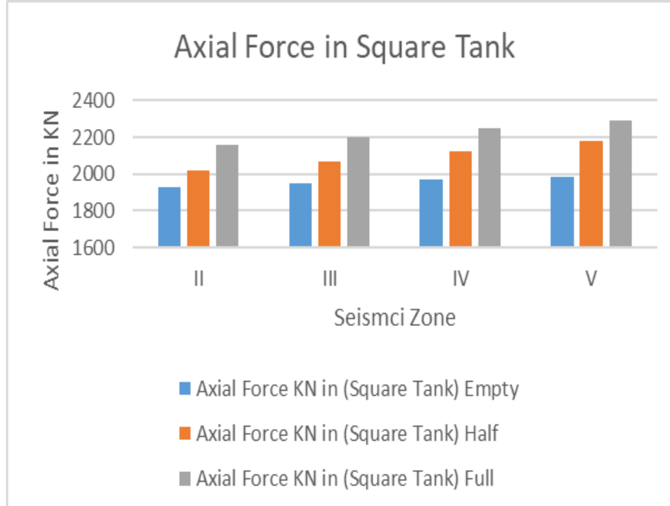


Fig 11: Shear force

Axial Force



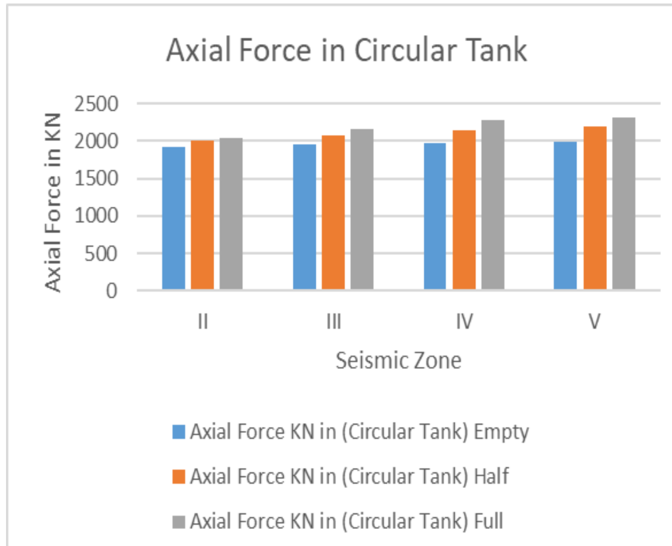


Fig 12: Axial force

VI. CONCLUSION

- In terms of bending moment we observed that as we are comparing empty and fill a rise of 13% is observed in square tank whereas in circular tank a rise of 15.5% is observed.
- In terms of shear force a gradual rise in forces observed that fill condition is observing 8% rise in values in square tank whereas in terms of circular tank a variation of 12 % is observed.
- In terms of axial force we observed that values declined by 14% in empty condition as hydraulic pressure is released in square tank whereas in circular tank variation is of only 10% observed.
- Support Condition: Here it is observed that support condition is showing variation of 18% as comparing empty condition with full condition in both the cases.
- In terms of stresses it can be said that in both conditions, pressure induced inside walls depending upon the

hydraulic pressure and backfill condition.

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