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Computer aided analysis and Design of Underground water tank as per BIS

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Abstract —*Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential. The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio.*

Where space is limited, underground tanks can be placed under driveways or lawns. Underground tanks are protected from fires and other natural disasters such as hurricanes. In an agricultural or wildlife situation, underground tanks are protected from animal that may rub against or otherwise damage above ground tanks. Manual Analysis and design of Underground Water tank by using IS code method is compare with STAAD-PRO and SAP software design result, comparison of reinforcement is 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 is designed in computer added analysis.

***Keywords**- UG tank, design, analysis, STAAD Pro and SAP software, criteria, damage, actions, dead load.*

I. INTRODUCTION

For storage of large quantities of liquids like water, oil, petroleum, acid and sometime gases also, containers or tanks are required. These structures are made up of masonry, steel, reinforced cement concrete and pre stressed concrete. Out of these, masonry and steel tanks are used for the smaller capacities. The cost of steel tanks is high and hence they are rarely used for the water storages. Reinforced concrete tanks are very popular because, besides the construction and design being simple, they are cheap, monolithic in nature and can be made leak proof. Generally no cracks are to be allowed to take place in any part of the structure of Liquid Retaining R-C.C. tanks and they are made water tight by using richer mix (not less than M 30) of concrete. In addition sometimes water proofing materials also are used to make tanks water tight.

II. OBJECTIVES OF INVESTIGATION

1. Analysis and design of water tanks.
2. Study the guidelines for the design of liquid retaining structure according to the IS Code.
3. To know about the design philosophy for the safe & economical design of water tank.
4. The deflected shape is analyzed and also the axial force of respected tank cases.
5. To develop programs for the design of water tank of flexible base and rigid base and the underground tank to avoid the tedious calculations.
6. Comparison between is code method design and various software design result.
7. To understand governing loads and carry out literature review related to underground water tank.
8. To study 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.

III. CLASSIFICATION

A) Classification of R.C.C. tanks

In general they are classified in three categories depending on the situation.

1. Tanks resting on the ground.
2. Tanks above the ground level (Elevated tanks).
3. Underground water tanks.

1. Tanks resting on ground

These are used for clear water reservoirs, settling tanks, aeration tanks etc. these tanks directly rest on the ground. The wall of these tanks are subjected to water pressure from inside and the base is subjected to weight of water from inside and soil reaction

Fig 1.1 Ground water tank

2. Elevated tanks

These tanks are supported on staging which may consist of masonry walls, R.C.C tower or R.C.C. column braced together. The walls are subjected to water pressure from inside. The base is subjected to weight of water, weight of walls and wt. of the roof. The staging has to carry load of entire tank with water and is also subjected to wind loads.

Fig 1.2 Elevated Tanks

3. Under Ground tanks

These tanks are built below the ground level such as clarifiers' filters in water treatment plants, and septic tanks .The walls of these tanks are subjected to water pressure from inside and earth pressure from outside. The base of tanks is subjected to water the pressure from inside and soil reaction from underneath. Always these are covered at top. These tanks should be designed for loading which gives the worst effect. The design and principles of underground tanks are same as for tanks resting on the ground. The walls of the underground tanks are subjected to the internal water pressure and outside earth pressure. The section of wall is designed for water pressure and earth pressure acting separately as well as acting simultaneously.

Fig 1.3 Underground water tanks

A water tank is used to store water to tide over the daily requirement. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential. Safe drinking water is one of the basic elements for humans to sustain healthy life. Reservoir is common term applied to liquid storage structures and it can be below or above the ground level. Reinforced concrete overhead water tanks are widely used to provide the safe drinking water. Most water supply systems in developing countries, such as India, where urbanizing is increasing day by day rely on overhead storage tanks and hence there is need to construct more number of water tanks. the permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on the water cement ratio .The increase in water cement ratio results in increase in the permeability .The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. Cracks can be prevented by avoiding the use of thick timber shuttering which prevent the easy escape of heat of hydration from the concrete mass. The risk of cracking can also be minimized by reducing the restraints on free expansion or contraction of the structure.

Storage reservoirs and overhead tank are also used to store liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. Earlier design of water tanks was being done using the working stress method given in IS: 3370:1965. This method leads to thicker and heavily reinforced sections. The use of limit state method of design has been adopted in the revised code IS 3370: 2009 and provision for checking the crack width is also included in this code. All tanks are designed as crack free structures to eliminate any leakage. STAAD Pro is also used to analyze and design the elevated water tank.

In water retaining structure a dense impermeable concrete is required therefore, proportion of fine and coarse aggregates to cement should be such as to give high quality concrete. Concrete mix weaker than M20 is not used. The minimum quantity of cement in the concrete mix shall be not less than 30 KN/m3.The design of the concrete mix shall be such that the resultant concrete is sufficiently impervious. Efficient compaction preferably by vibration is essential. The permeability of the thoroughly compacted concrete is dependent on water cement ratio. Increase in water cement ratio increases permeability, while concrete with low water cement ratio is difficult to compact. Other causes of leakage in concrete are defects such as segregation and honey combing. All joints should be made water-tight as these are potential sources of leakage. Design of liquid retaining structure is different from ordinary R.C.C, structures as it requires that concrete should not crack and hence tensile stresses in concrete should be within permissible limits. A reinforced concrete member of liquid retaining structure is designed on the usual principles ignoring tensile resistance of concrete in bending. Additionally it should be ensured that tensile stress on the liquid retaining face of the equivalent concrete section does not exceed the permissible tensile strength of concrete. For calculation purposes the cover is also taken into concrete area. Cracking may be caused due to restraint to shrinkage, expansion and contraction of concrete due to temperature or shrinkage and swelling due to moisture effects. Such restraint may be caused by

i. The interaction between reinforcement and concrete during shrinkage due to drying.
ii. The boundary conditions.
iii. The differential conditions prevailing through the large thickness of massive concrete.

Use of small size bars placed properly, leads to closer cracks but of smaller width. The risk of cracking due to the temperature and shrinkage effects may be minimized by limiting the changes in moisture content and temperature to which the structure as a whole is subjected. The risk of cracking can also be minimized by reducing the restraint on the free expansion of the structure with long walls or slab founded at or below ground level, restraint can be minimized by the provision of a sliding layer. This can be provided by founding the structure on a flat layer of concrete with interposition of some material to break the bond and facilitate movement. In case length of structure is large it should be subdivided into suitable lengths separated by movement joints, especially where sections are changed the movement joints should be provided. Where structures have to store hot liquids, stresses caused by difference in temperature between inside and outside of the reservoir should be taken into account.

IV. DESIGN STEPS FOR UG RECTANGULAR WATER TANK

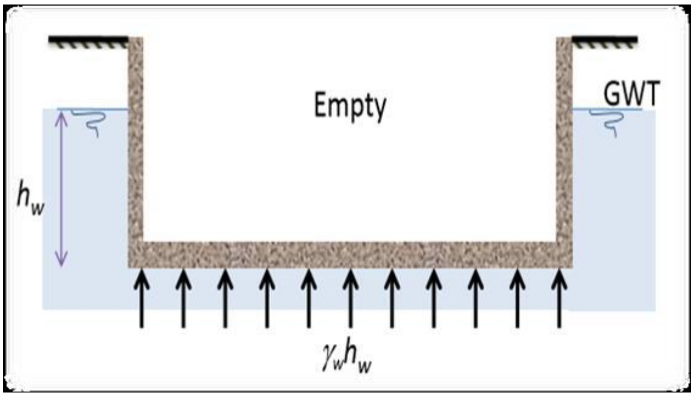
Design steps are involving:

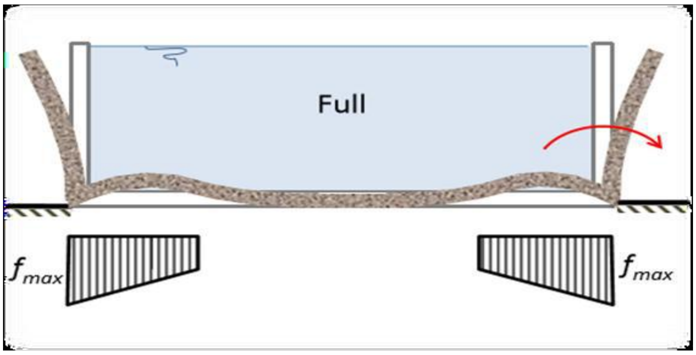
1. Stability

a. Uplift Check
b. Check of Stresses on Soil

2. Strength

a. Design of Critical Sections.





Sketches Show the results when tank empty as well as full

V. PRIMARY DATA OF UNDERGROUND RECTANGULAR WATER TANK IN STAAD-PRO

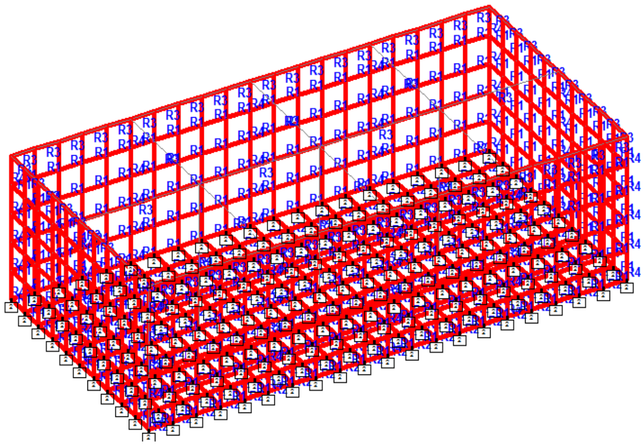
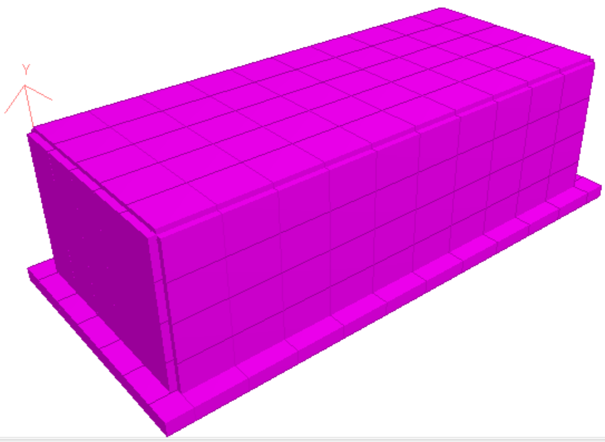


Figure shows the primary data in STAAD Pro design for UG Rec. Water tank

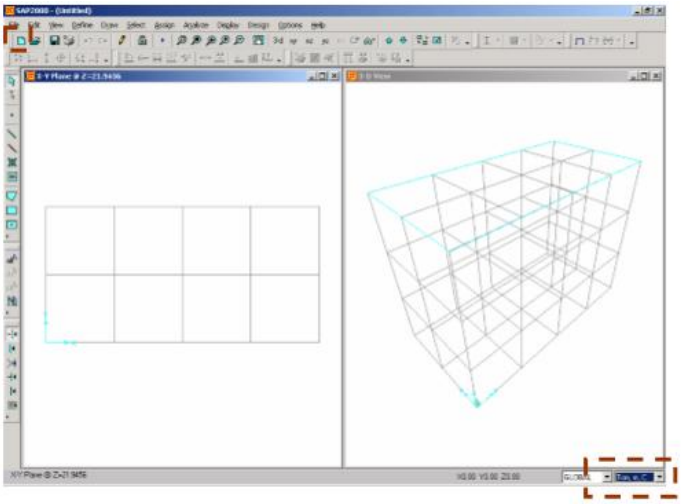


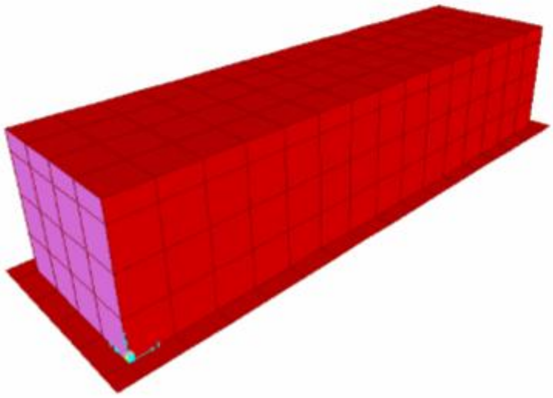
3d view of the rectangular tank in STAAD PRO software

VI. PRIMARY DATA OF UNDERGROUND RECTANGULAR WATER TANK IN SAP SOFTWARE

Start Model with Template

Select Working Unit and Start New Model with Template Start up screen of SAP2000, select working unit to be “ton-m” at drop-down menu on the bottom-right of screen and click on to start new model with template.





3d view of the rectangular tank in SAP Software

V. SUMMARIZATION OF PRIMARY DATA

1. User defined material data like span, load and grade of concrete and steel are to be given as input.
2. Maximum bending moment and shear force has to be calculated.
3. The deflected shape is analyzed and also the axial force of respected tank cases.
4. We have taken two cases with different data as input:
The size of water tank is 10m x 4m x 3m.

VI. SCOPE OF FUTURE WORK

1) Furthermore, the analysis can be carried out by considering Circular shape as well as other shapes of underground water tanks.
2) The above analysis should be verified for soil structure Interaction effect.
3) The present work is extended to carry out seismic analysis as per BIS code.

VII. RESULTS AND DISCUSSION

As per by considering the result we don’t calculate the deflection in the manual design but the deflection results from STAAD and SAP software should be nearly same. The shell stresses in full water condition and full empty condition are with in the permissible limit that Should not be greater than 7000 kN/m2 and mainly the results obtained from both of software’s should be nearly same.

Also the joint reaction in full water condition of manual designed is calculated. In that case results obtained from manual design as compared with software's probably the same.

VIII. CONCLUSION

Based on experimental observations, following conclusions can be established:

1.Underground water tank is a great alternative to concrete cisterns.
2.Uplift check (in case of ground water, during maintenance): Must be Dead loads > Uplift loads.
3. Stresses on soil (in case of full tank, just after construction): Must be Stresses on soil < allowable stress.
4. If the criteria are not to be fulfilled (as in point 2 and 3) or if unsafe then,
   a. Increase floor thickness.
   b. Use plain concrete inside tank (above RC floor)
   c. Use plain concrete below RC floor (connected with steel dowels).
   d. Use toe to include soil weight.
   e. Use tension piles.
5. If we are not chooses the proper section of tank, it will be fail. As in case 2 with compare to case 1, the sections are used (thickness of slab and walls).
6.If suppose tank having a less dimension then unsatisfied results will be obtained.

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