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Design and Analysis of Under Ground Rectangular Water Tank by using STAAD.PRO

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ABSTRACT

Storage reservoirs and underground 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. This project gives in brief, the theory behind the design of liquid retaining structure (circular water tank with flexible and rigid base and rectangular underground water tank) using working stress method. This report also includes computer subroutines to analyze and design circular water tank with flexible and rigid base and rectangular underground water tank. The program has been written as Macros in Microsoft Excel using Visual Basic programming language. In the end, the programs are validated with the results of manual calculation given in Concrete Structure book.

1. INTRODUCTION

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. Water or raw petroleum retaining slab and walls can be of reinforced concrete with adequate cover to the reinforcement. Water and petroleum and react with concrete and, therefore, no special treatment to the surface is required. Industrial wastes can also be collected and processed in concrete tanks with few exceptions. The petroleum product such as petrol, diesel oil, etc. are likely to leak through the concrete walls, therefore such tanks need special membranes to prevent leakage. Reservoir is a common term applied to liquid storage structure and it can be below or above the ground level. Reservoirs below the ground level are normally built to store large quantities of water whereas those of overhead type are built for direct distribution by gravity flow and are usually of smaller capacity.

A water tank is a container for storing liquid. The need for a water tank is as old as civilization, to provide storage of water for use in many applications, drinking water, irrigation, agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses, Water tank parameters include the general design of the tank, and choice of construction materials, linings. Reinforced Concrete Water tank design is based on IS 3370: 2009 (Parts I-IV). The design depends on the location of tanks, i.e. overhead, on ground or underground water tanks. The tanks can be made of RCC or even of steel. The overhead tanks are usually elevated from the ground level using number of columns and beams. In the other hand the underground tanks rest below the ground level.

Types of Water Tanks

In this section, the types of water tanks are discussed in detail. There is different type of water tank depending upon the shape, position with respect to ground level etc. From the position point of view, water tanks are classified into three categories. Those are,

a) Underground tanks
b) Tanks resting on ground
c) Overhead water tanks.

Rectangular tanks:

The walls of rectangular tank are subjected to bending moments both in horizontal as well as in vertical direction. The analysis of moment in the wall is difficult since water pressure results in a triangular load on them. The magnitude of the moment will depend upon the several factors such as length, breadth and height of tank, and conditions of the support of the wall at the top and bottom edge. If the length of the wall is more in compression to its height the moment will be mainly in vertical direction i.e. the panel will bend as a cantilever. If, however, height is larger in comparison to length, the moments will be in horizontal direction, and the panel will bend as a thin slab supported on the edges. The wall of the tank will thus be subjected to both bending moment as well as direct tension.

Scope of the Project

• To make the study about the analysis and design of water tank.
• To make the guidelines for the design of liquid retaining structure according to IS code.
• To know about design philosophy for safe design of water tank
• To develop program for water tank to avoid tedious calculations.
• To know economical design of water tank,
This report is to provide guidance in the design and construction for various types of water tanks.

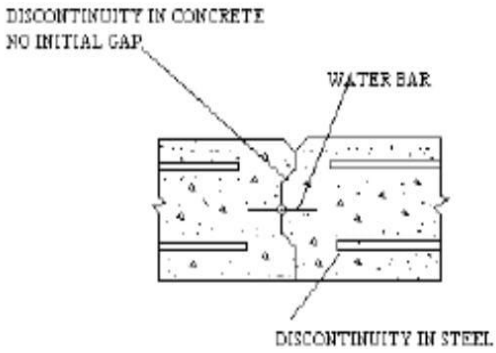
2. LITERATURE

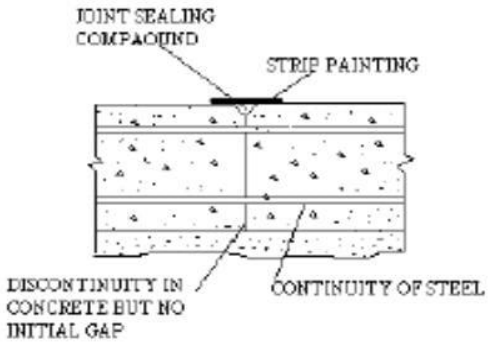
Wagh et al (2021) research paper presented the design of underground water tank of Rectangular shape was designed and analysed using Staad pro. Underground water tank faces different type of loads compared to other structures, they mainly face horizontal or lateral loads due to earth pressure and water 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. Dubey et al (2021) the primary objective of the research was to investigate the behaviour of underground water tanks subjected to seismic loading and soil structure interaction and comparison of their output result to understand its behaviour. For the study existing underground water tank was used and finite element modelling of the same tank was done in ETABS17 for two different soil conditions as per IS 1893 part- 2-2014. The existing water tank situated at Solsinda, Sanwer, Indore (M.P) was considered in the investigation. Clay of high Compressibility (CL) and Silt of high.

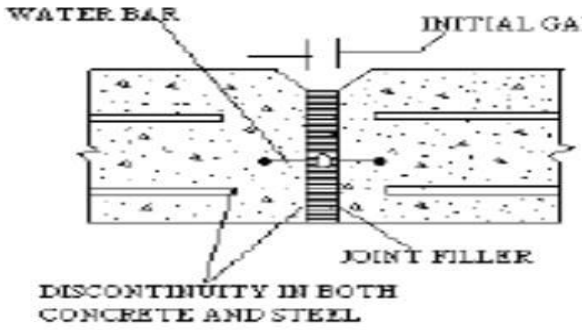
3. METHODOLOGY

3.1 Design Requirement of Concrete

In water retaining structure a dense impermeable concrete is required therefore, proportion of fine and course 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 issufficiently 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 RCC 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 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 as given in table 1. 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.
Joints in liquid retaining structure
Movement Joints: There are three types of movement joints.
Contraction Joint: It is a movement joint with deliberate discontinuity without initial gap between the concrete on either side of the joint. The purpose of this joint is to accommodate contraction of the concrete.
Expansion Joint: It is a joint with complete discontinuity in both reinforcing steel and concrete and it is to accommodate either expansion or contraction of the structure. A typical expansion.
Sliding Joint: It is a joint with complete discontinuity in both reinforcement and concrete and with special provision to facilitate movement in plane of the joint.







Spacing of joints:
Unless alternative effective means are taken to avoid cracks by allowing for the additional stresses that may be induced by temperature or shrinkage changes or by unequal settlement, movement joints should be provided

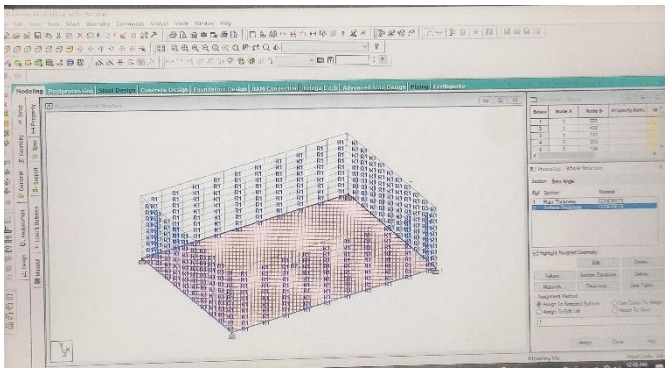
Axial Load Application on Wall of Water Tank:

If the walls are non-monolithic with the floor slab, such as in cases where movement joints have been provided between the floor slabs and walls, the floor shall be designed only for the vertical loads on the floor.

(c) In continuous T-beams and L-beams with ribs on the side remote from the liquid, the tension in concrete on the liquid side at the face of the supports shall not exceed the permissible stresses for controlling cracks in concrete. The width of the slab shall be determined in usual manner for
calculation of the resistance to cracking of T-beam, L-beam sections at supports.

(d)The floor slab may be suitably tied to the walls by rods properly embedded in both the slab and the walls. In such cases no separate beam (curved or straight) is necessary under the wall, provided the wall of the tank itself is designed to act as a beam over the supports under it.

(e)Sometimes it may be economical to provide the floors of circular tanks, in the shape of dome. In such cases the dome shall be designed for the vertical loads of the liquid over it and the ratio of its rise to its diameter shall be so adjusted that the stresses in the dome are, as far as possible,
wholly compressive. The dome shall be supported at its bottom on the ring beam which shall be designed for resultant circumferential tension in addition to vertical loads.



Walls

(I)Provision of joints

(a)Where it is desired to allow the walls to expand or contract separately from the floor, or to prevent moments at the base of the wall owing to fixity to the floor, sliding joints may be employed.

(b)The spacing of vertical movement joints should be as discussed in article 3.3 while the majority of these joints may be of the partial or complete contraction type, sufficient joints of the expansion type should be provided to satisfy the requirements given in article

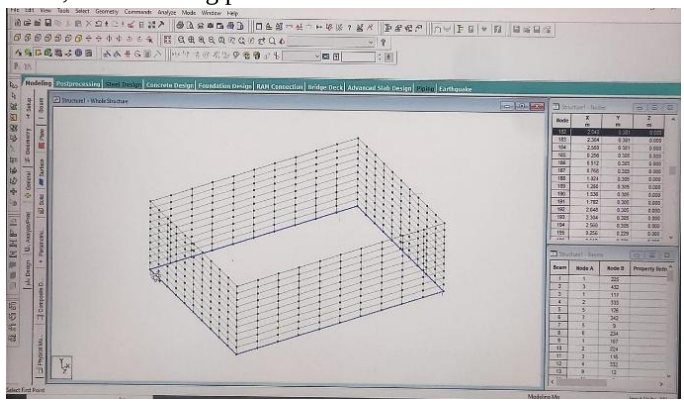
(ii)Pressure on Walls.

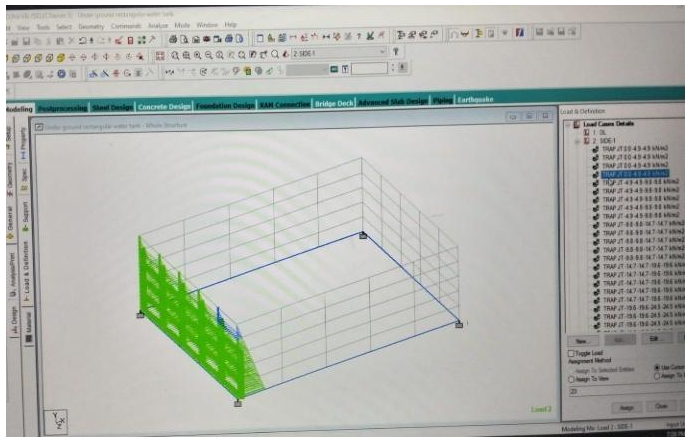
(a) In liquid retaining structures with fixed or floating covers the gas pressure developed above liquid surface shall be added to the liquid pressure.

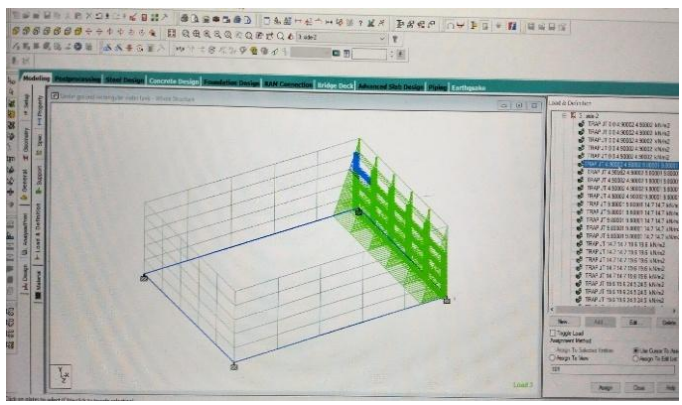
(b)When the wall of liquid retaining structure is built in ground, or has earth embanked against it, the effect of earth pressure shall be taken into account.

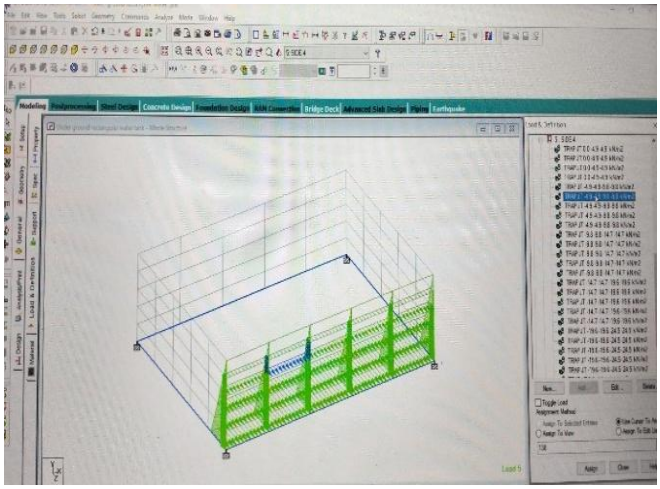
(c) Walls or Tanks Rectangular or Polygonal in Plan.

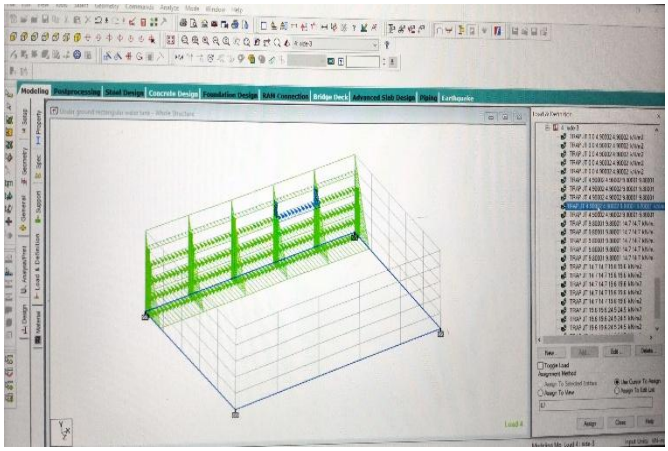
While designing the walls of rectangular or polygonal concrete tanks, the following points should be borne in mind.

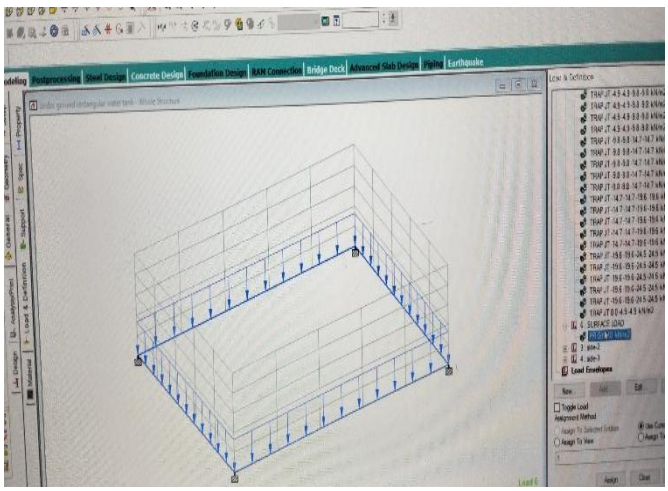


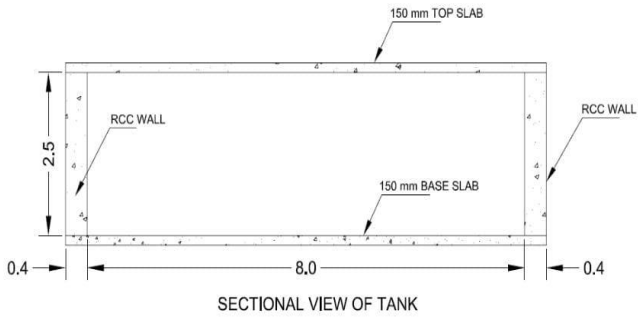




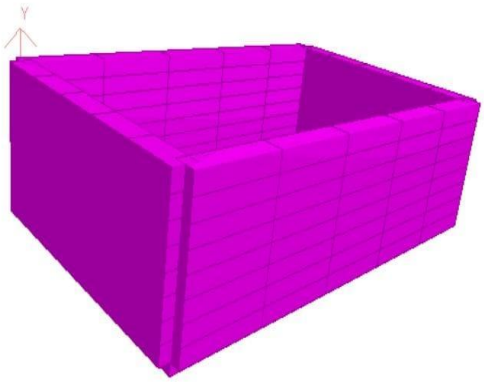








SECTIONAL VIEW OF TANK



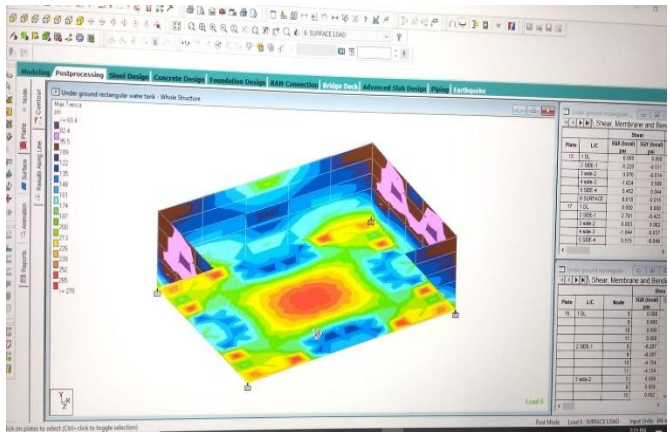


Plate Load on Water Tank:

(i)Water thightness. In case of tanks intended for the storage of water for domestic purpose, the roof must be made water-tight. This may be achieved by limiting the stresses as for the rest of the tank, or by the use of the covering of the waterproof membrane or by providing slopes to
ensure adequate drainage.

(ii) Protection against corrosion. Protection measure shall be provided to the underside of the roof to prevent it from corrosion due to condensation.

4. CONCLUSION

Storage of water in the form of tanks for drinking and washing purposes, swimming pools for exercise and enjoyment, and sewage sedimentation tanks are gaining increasing importance in the present life. For small capacities we go for rectangular water tanks while for bigger capacities we provide circular water tanks.

Design of water tank is a very tedious method. Particularly design of underground water tank involves lots of mathematical formulae and calculation. It is also time consuming. Hence program gives a solution to the above problems.

There is a little difference between the design values of program to that of manual calculation. The program gives the least value for the design. Hence designer should not provide less than the values we get from the program. In case of theoretical calculation designer initially add some extra values to the obtained values to be in safer side.

From the results, the height to diameter ratio 0.45 is safest economical design.

- Increase in shear force & bending moment becomes milder as one goes towards downwards side of slope.
- The thickness of cylindrical wall, conical dome and bottom dome of Inter water tank are increased due to the considerations of new IS code: 3370-2009 and earth quake forces.
- It can be clearly seen from the results that the formwork required for the constructions of water tanks is minimum for circular shaped tank as compared to square shaped and rectangular shaped tanks.
- It is possible to formulate and obtain solution for the minimum cost design for underground rectangular tank.

Limit state method was found to be most economical for design of water tanks as the quantity of steel and concrete needed is less as compared to working stress method.

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