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Design of Circular Water Tank by using STAAD Pro Software

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Abstract: ***Water tank are very useful for storage of water to occupy the consumption of water we need to hold the capacity of water as much required. Nowadays water tank are suitable for all types of atmosphere we live as old and civilized technique. 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. In this project, we have planned and designed a circular reinforced cement concrete tank. A circular water tank is manually designed. It is further analyzed using the premiere analysis software STAADPRO. The design and detailed drawings are presented in this project work. Limit state design method for water retaining structure was not adopted so far as liquid retaining structure should be crack free. However, this edition of Indian standard adopts limit state method mainly considering two aspects. Firstly it limits the stresses in steel so that concrete is not over stressed and in second aspect it limits the cracking width. Structure has been designed using the LSM, as the LSM gives less area of reinforcement of steel and hence the check for crack width has been done. Further to make the structure most economical STAAD. Pro is used. For quick cost prediction of tanks, this study therefore examines the cost effectiveness in terms of amount of materials. At the end of the project it concludes that total amount of concrete and steel used for construction of circular tank. Water tank are provides for the storage of water for drinking, irrigation, agriculture, fire suppression, paper industry and any more.***

1. Introduction

The profile of water tanks begins with the application parameters, thus the type of materials used and the design of water tank was dictated by these variables:

1) Location of the water tank.
2) Volume of water tank need to hold.
3) What the water will be used for?
4) Temperature of area where will be stored, concern for freezing.
5) Pressure required delivering water.
6) How the water to be delivers to the water tank.
7) Wind and earthquake design considerations allow water tanks to survive seismic and high wind events.

Throughout history, wood, ceramic and stone have been used as water tanks. These were all naturally occurring and manmade and some tanks are still in service. There are many custom configurations that include various rectangular cubes shaped tanks, cone bottom and special shapes for specific design requirements. A functional water tank/container should do no harm to the water is susceptible to a number of ambient negative influences, including bacteria, viruses, algae, changes in pH, and accumulation of minerals. Correctly designed water tank systems work to mitigate these negative effects.

1.1 Design Philosophies

There are three philosophies for the design of Structures:

1) Working stress method
2) Ultimate load method
3) Limit state method

1.2 Stages in Structural Design

1) Planning of Structure
2) Drawing Study
3) Load Combinations
4) Analysis of Structures
5) Structural Design

1.3 Objective

Following are the objectives:

1) Modeling the Water Tank by using the software STADD PRO V8I
2) Applying the properties of water tank.
3) Applying the different load combinations as per I.S. code
4) Analyzing and designing of Water Tank.
5) Study in area under the condition of Bilaspur Chhattisgarh.

2. Literature Review

2.1 Water distribution system is mainly based on network of pipes by connecting other components to provide a stability & disinterested service. These connecting networks are sometimes used underground and exposed to surface. Due to the erosion of pipes through the soil, pipes are used mechanically on the availability at the time. Failure in water distribution may occurs surrounding soil, increase in internal water pressure, surface traffic, Which disrupts water supply to consumers and these cause reduction in reliability of the system. It is found that about 35% to 60% of the supplied volume is wasted due to pipe leakages Therefore, inspection, control and planned maintenance and rehabilitation programs are necessary to properly operate existing water distribution systems.

2.2 S.K. Khariya, (2019)75 K.L. capacity overhead tank at village Bargaon, Block Pathariya on 12 M. staging use the different portion are different concrete mix for economical design Water tank is the most important container to store water therefore, Crack width calculation of water tank is also necessary.

2.3 Problem Identification

To design the circular water tank by study of provisions in IS 3370 (2009), Double dome type of water tank was taken. Then it was designed manually following Limit State Method. After that STAAD. Pro is used to match the design and make structure optimize and economical by trying different dimension for same capacity tank. For quick cost prediction of tanks, this study therefore examines the cost effectiveness in terms of amount of materials. In case of real life structure are used for working stress method because the structure are crack free.

3. Methodology

To achieve the objectives of the study that is to analyze and design water tank using STADD PRO method, which meets the basic requirements such as safety, durability, it has been proposed to follow the following methodology.

1) Site survey.
2) Soil investigation.
3) Structural planning.
4) Analysis and design in STADD PRO
5) Detailing.

3.1 The study is done in two phase

1) Planning
2) Designing

3.1.1 Planning

3.1.1.1 Sources of Water Supply

The various sources of water can be classified into two categories -

Surface sources, such as:

1) Ponds and lakes.
2) Streams and rivers.
3) Storage reservoirs.
4) Oceans, generally not used for water supplies, at present.

Sub-surface sources or underground sources:

1) Springs.
2) Infiltration wells and
3) Wells and Tube-wells.

3.1.1.2 Water Quantity Estimation

1) The quantity of water required for municipal uses for which the water supply scheme has to be designed requires following data:
2) Water consumption rate (Per Capita Demand in liters per day per head) Population to observed.
3) Quantity = per demand x Population

3.1.1.3 Water Consumption Rate

It is very difficult to precisely assess the quantity of water demanded by the public, since there are many variable factors affecting water consumption. various types of water demands, which a city may have to fulfill.

3.1.1.4 Factors affecting per capita demand:

Size of the city: Per capita demand for big cities is generally large as compared to that for smaller towns as big cities have skewered houses.

1) Presence of industries.
2) Climatic conditions.
3) Habits of economic status.
4) Quality of water**:** If water is aesthetically people and their
5) Medically safe, the consumption will increase as people will not resort to private wells, etc.
6) Pressure in the distribution system.
7) Efficiency of water works administration: Leaks in water mains and services; and UN authorized use of water can be kept to a minimum by surveys.
8) Cost of water.

Policy of metering and charging method: Water tax is charged in two different ways:

On the basis of meter reading and on the basis of certain fixed monthly rate.

3.1.1.5 Fluctuations in Rate of Demand:

Average Daily per Capita Demand =Quantity Required in 12 Months/ (365xPopulation)

If this average demand is supply data the times, it will not be sufficient to meet the fluctuations.

- **Seasonal variation**: The demand peaks during summer, Fire, breakouts are generally more in summer, increasing demand So, there is seasonal variation.
- **Daily variation** depends on the activity. People draw out more water on Sundays and Festival days, thus increasing demand on these days.
- **Hourly** variations are very important as they have a wide range. During active household working hours i.e. from six to ten in the morning and four to eight in the evening, the bulk of the daily requirement is taken. During other hours the requirement is negligible. Moreover, if a fire breaks out, a huge quantity of water is required to be supplied during short duration, necessitating the need for a maximum rate of hourly supply.

So, an adequate quantity of water must be available to meet the peak demand. To meet all the fluctuations, the supply pipes, service reservoirs and distribution pipes must be properly proportioned. The water is supplied by pumping directly and the pumps and distribution system must be designed to meet the peak demand. The effect of monthly variation influences the design of storage reservoirs and the hourly variations influences the design of pumps and service reservoirs. As the population decreases, the fluctuation rate increases.

Maximum daily demand = 1.8 x average daily demand
Maximum hourly demand of maximum day i.e. Peak demand
=1.5 x average hourly demand
=1.5 x Maximum daily demand/24
=1.5 x (1.8 x average daily demand)/24

=2.7 x average daily demand/24
=2.7 x annual average hourly demand

3.1.1.6 Design Periods & Population Forecast

This quantity should be worked out with due provision for the estimated requirements of the future. The future period for which a provision is made in the water supply scheme is known as the design period.

Design period is estimated based on the following:

- Use fulfils of the component, considering obsolescence, wear, tear, etc.
- Expandability aspect.
- Anticipated rate of growth of population, including industrial, commercial developments& migration-immigration.
- Available sources.
- Performance of the system during initial period.

3.1.1.7 Population Forecasting Methods

The various methods adopted for estimating future populations are given below. The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discretion and intelligence of the designer.

1) Incremental Increase Method
2) Decreasing Rate of Growth Method
3) Simple Graphical Method
4) Comparative Graphical Method
5) Ratio Method
6) Logistic Curve Method
7) Arithmetic Increase Method
8) Geometric Increase Method.

3.1.1.8 Classifications

Classification based on under three heads:

1) Tanks resting on ground
2) Elevated tanks supported on staging
3) Underground Tanks.

Classification based on shapes:

1) Circular Tanks.
2) Rectangular Tanks.
3) Spherical Tanks.
4) Intze Tanks.
5) Circular tanks with conical bottom

3.1.1.9 Pipeline Distribution Network

Pipeline distribution networks are aimed at design of suitable routes for piping. It is very important for proper water pressure, capital cost and operation and maintenance cost. Different types of networks are adopted looking to the pressure requirement, operation and maintenance strategy adopted, cost parameter and overall length of distribution system

- Dead end distribution system
- Grid Iron System
- Ring System
- Radial System

3.2.2 Design Components of Type Tank

The components of R.C.C overhead circular tank. The various components of elevated tank are as follows

1) Top Roof Dome The dome at top usually 100mm to 150mm thick with reinforcement along the meridian and latitudes. The rise is usually 1/5th of the span.
2) Ring Beam The ring beam is necessary to resist the horizontal component of the thrust of the dome. The ring beam will be designed for hoop tension induced.
3) Circular Wall this has to be designed for hoop tension caused due to horizontal water pressure and to resist bending moment induced to wall by liquid load.
4) Bottom Slab this will be designed for total load above it. The slab will also be designed for the total load above it. The slab will also be designed as a slab spanning in both directions.
5) Bottom Beams the bottom beam will be designed as continuous beam to transfer all the load above it to the columns.

3.2.2.1 Staging Portion

1) Columns & Braces

- Columns - These are to be designed for the total load transferred to them. The columns will be braced at intervals and have to be designed for wind pressure and seismic loads whichever govern.
- Braces-The braces are the members connecting the columns at intermediate height of columns. It is provided in slender columns to increase the column's load carrying capacity.

2) Foundation - As per IS: 11682-1985, a combined footing or raft footing with or without tie beam or raft foundation should be provided for all supporting columns

3.2.2.2 Design data using in water tank :

Assuming Data:

- Capacity of water tank 1.50 Lakhs Liters
- Staging of height in water tank 15.00 M.
- Size of water tank Ø 7.00 M. Height 4.00 M.
- Free Board 0.10 M.
- Rise of Top Dom 3.00 M.
- 1 person is use water 135 LPCD
- Design for 1000 Person
- Thickness of Bottom slab 0.18 M.
- Thickness of Top Dom 0.10 M.
- Thickness of Cylindrical wall 0.15 M.
- Top Ring beam 0.23 x 0.23 M.
- Bottom Ring beam 0.30 x 0.60 M.
- Column size 0.35 x 0.35 M.
- Braising size 0.23 x 0.30 M.
- Parapet wall thickness 0.125 M. x height 1.2 M.

Designing of Circular Water Tank in STAAD Pro

Figure 1: Node Diagram

1) **Assigning the material:** As after creating the beams and columns we will assign material to them as we require. Our design is concrete design hence we have assigned the concrete material to the beams and columns.

Figure 2: Properties Diagram

2) **Specifying Supports:** The supports are first created (as we created fixed supports) and then these are assigned to all the lowermost nodes of structure where we are going to design the foundation.

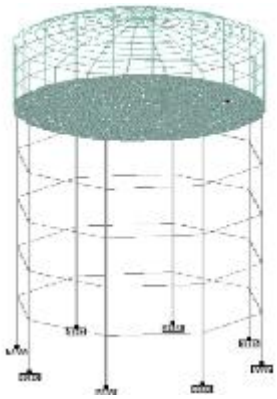


Figure 3: Support Diagram

4. Results & Discussion

4.1 Results

4.1.1 Bending moment

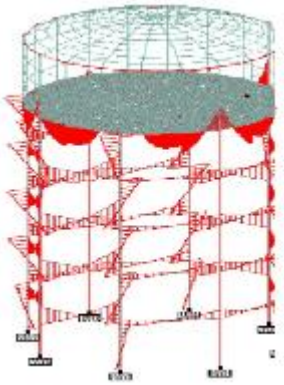


Figure 4

4.1.2 Shear Force

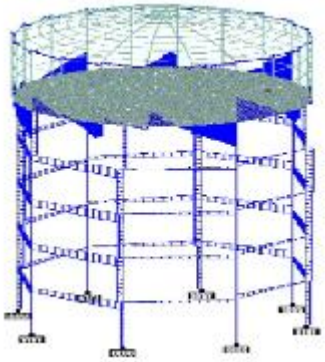
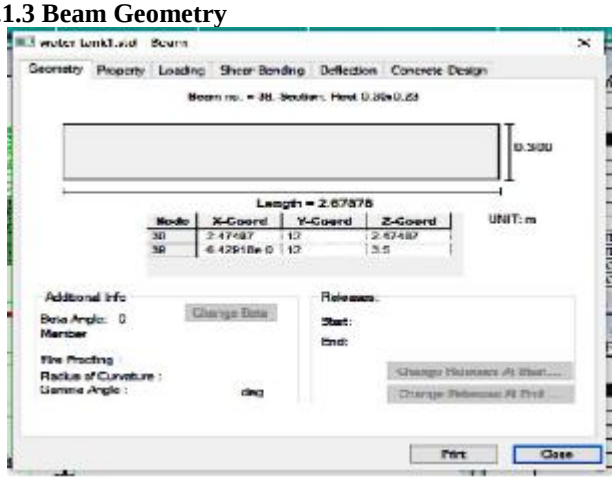
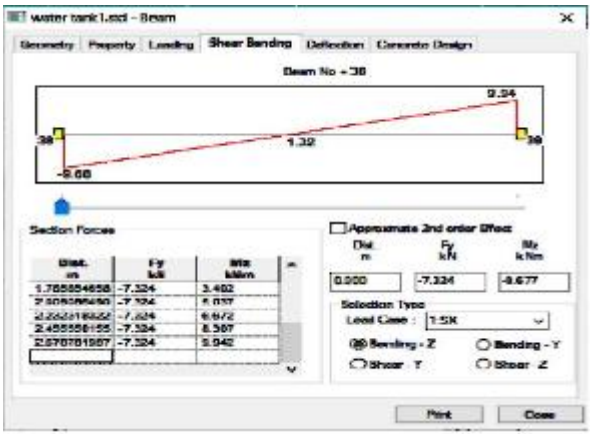


Figure 4

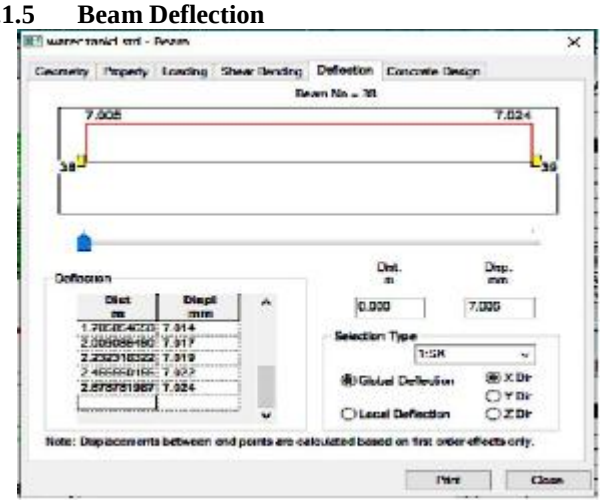
4.1.3 Beam Geometry



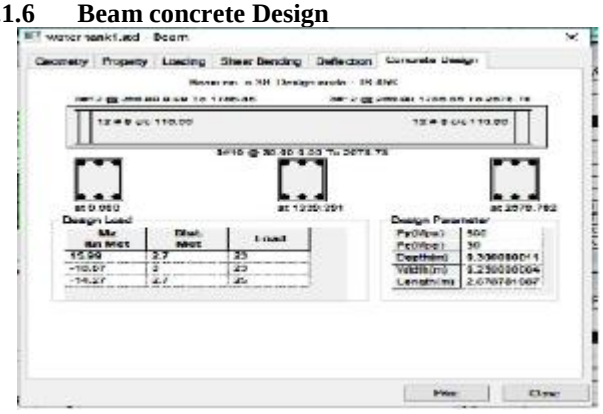
4.1.4 Beam Shear Bending



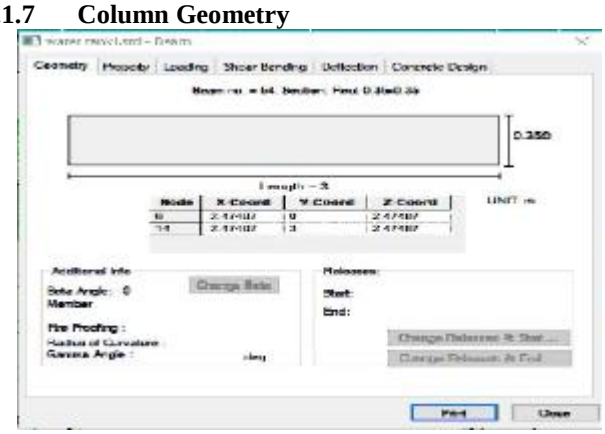
4.1.5 Beam Deflection



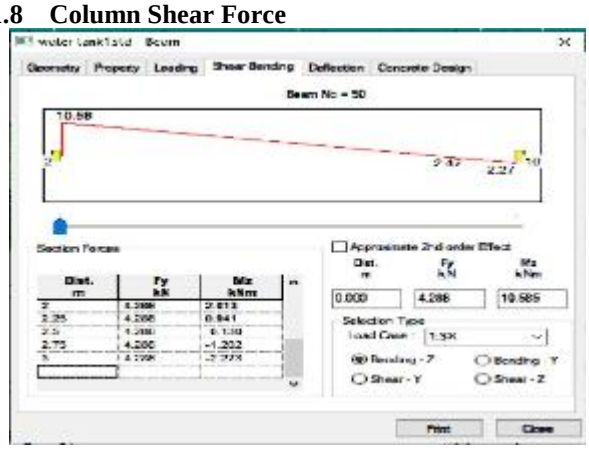
4.1.6 Beam concrete Design



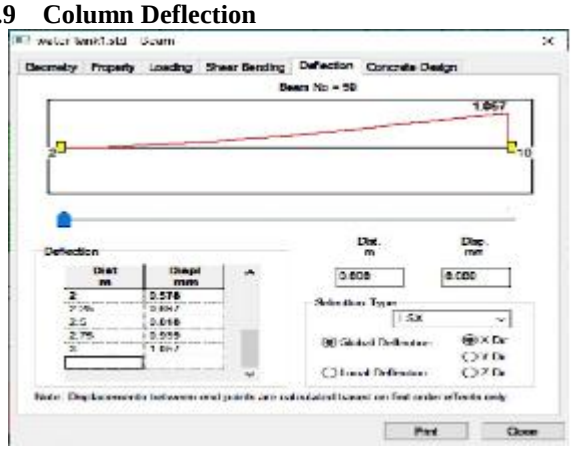
4.1.7 Column Geometry



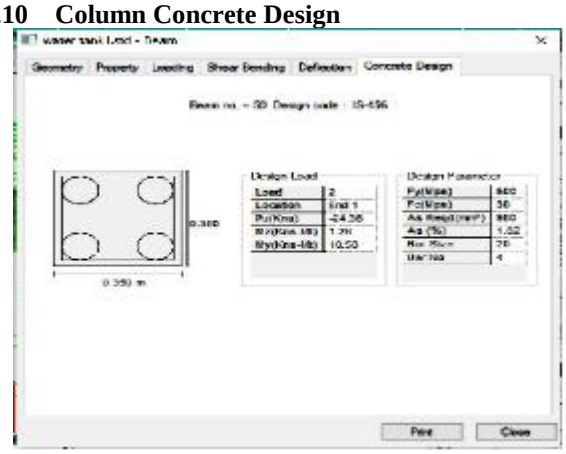
4.1.8 Column Shear Force



4.1.9 Column Deflection



4.1.10 Column Concrete Design



5. Conclusion

It concludes that the efficiency and reliability of the software in the field of designing is much better to that of the manual work. It has been seen that the software generated results were more efficient and economical which included the various different conditions under the designing conditions which are difficult to consider when done manually

1) The structural elements of water tank are safe in leakage free, flexure and shear.
2) Quantity of steel provided for structure is economical and adequate.
3) Proposed sizes of structural elements can be used in water tank as it is.
4) The design of beam, slab, column, footing and stair case are safe in deflection, bending, shear and other aspects.

Water tanks are considered to be expensive; but they are constructed to reach present and future population. They are considered to highly economical and safely store the portable water. Water can be distributed to number of houses, Industries and public places by means of a network of a distribution system. In circular tanks, as height increases as side wall thickness also increases and roof slab and floor slab depth decreases. Circular tanks are economical for moderate capacities. 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.

6. Scope of Further Work

The scope of the study encompasses various aspects in the structural analysis & design of water tank using STADD PRO nowadays most of the civil engineering projects are done using this software having done this project it enabled as to gain exposure in various computer applications related to civil engineering. 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 exhausting method. It involves lots of mathematical calculation& uses of formulas for particularly design of overhead water tank. 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.

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