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Design of Circular Water Tank Using STAAD.PRO

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Abstract - *we're talking about designing a circular water tank using this software called STAAD.PRO. It's a big deal in the structural analysis world. The whole idea is to make sure the tank can handle all sorts of stuff thrown at it, like water pressure, earthquakes, and even wind. The tank's got parts like walls, a base, and a roof, and it's tested against different scenarios like water pressure and seismic activity.*
STAAD.PRO uses something called finite element analysis (FEA) to check how the tank holds up. It makes sure everything sticks to the rules, like IS 456-2000 standards. This software is pretty smart—it helps pick the right materials and checks if everything's safe and solid by looking at stress and movement in the tank.
The cool part? Using STAAD.PRO makes the design process way easier. You don't have to do all those pesky calculations by hand. It bumps up accuracy and gives structural engineers a slick way to design these tanks without breaking the bank. Sounds like a win-win, right?

Key Words: Staad Pro V8i, Auto Cad 2016, IS: 456-2000 RCC Design Code

1. INTRODUCTION

So, let's talk about water tanks for a second. They're basically there to make sure we have enough water to get through the day, right? Now, when you're building something out of concrete to store water (or any liquid, really), it's super important that the concrete doesn't let any water seep through. The key to this is the water-cement ratio. If you add more water, the concrete becomes more permeable, which isn't great. But if you add too little, it can be tough to mix and might even cause problems. It's a bit of a balancing act.

When designing structures that hold liquids, like water tanks, you want to avoid cracks in the concrete. This means paying attention to how strong the concrete is when it gets pulled apart. Cracks can be a real headache! One way to prevent them is by not using thick wooden Molds, which trap heat inside the concrete as it hardens. You can also reduce the chances of cracking by letting the structure expand and contract freely without too much restraint.

1.1 OBJECTIVE

Next, we're going to throw some load cases at it. We're talking about hydrostatic pressure, dead load, live load, wind load, and even seismic load. It's like putting the tank through its paces to make sure it can handle whatever Mother Nature throws its way. Then comes the serious stuff—structural analysis using STAAD.PRO's finite element analysis. It's like giving the tank a full check-up to see how it performs under all those different conditions. We got to make sure everything's shipshape and Bristol fashion.
And of course, we can't forget about the rules. We need to make sure our design plays nice with all the relevant codes and standards like IS 456-2000 for concrete structures. It's like following the recipe to bake the perfect cake.

1.2 SOURCES OF WATER SUPPLY

Water comes from all sorts of places, and you can basically split them into two big groups. First, you've got the surface sources. These are things like ponds and lakes, streams and rivers, and storage reservoirs. Oceans too, but we don't really use those for water supplies right now. Then, there are the underground sources. These include springs, infiltration wells, and wells or tube-wells. Pretty straightforward, right? But have you ever thought about how crazy it is that we can get water from all these different spots? It's like nature's own little treasure hunt!

1.3 WATER QUANTITY ESTIMATION

Ever wondered how much water a city needs for all its daily stuff? Well, to figure out the water supply for a town, you got to know two things: how much water each person uses every day and how many people live there. It's like this: the amount of water needed equals the water use per person times the number of people.

Quantity = Per Capita Demand × Population

Table -1: Water Consumption For Various Purposes

S.no	Types of Consumption	Normal Range (lit/Capita/day)	Average	%
1	Domestic Consumption	65-300	160	35
2	Industrial and commercial demand	45-450	135	30
3	Public including Fire demand	20-90	45	10
4	Losses and waste	45-150	62	25

1.4 METHODS FOR ESTIMATION OF FUTURE POPULATIONS

Following are the various methods adopted to estimate future populations. The choice of method is different for a given case or city and depends widely on factors discussed in various methods and is left solely to the discretion and judgement of the designer.

1. Method of Incremental Increase
2. Constant Rate of Decrease method
3. Simple Graphic Method
4. Comparative Graphics Method
5. Proportional Method
6. Logistic Curve Method
7. Arithmetic Increase Method
8. Geometric Increase Method.

2. LITERATURE REVIEW

1. Advancements in Water Tank Design using STAAD.PRO

The inclusion of STAAD.PRO in the design of water tanks has greatly improved the accuracy and reliability of structural analysis. With prior designs for water tanks generally undertaken manually through simplified assumptions which leads to more conservative designs to cause over usage of materials applied, this is changed and greatly replaced by STAAD.PRO allowing for better modeling of such components, including walls and base slabs and especially roofs as well as for simulating real-world cases like fluid-structure interactions.

Mehta (2019) used STAAD.PRO to model circular water tanks subjected to various load cases, including hydrostatic, seismic, and wind loads. They emphasized that the software is capable of simulating dynamic and static loads with great accuracy, making it possible to understand the tank's performance more realistically. The finite element analysis method used by STAAD.PRO allows for the identification of critical stress points, ensuring the safety of the structure of the tank.

Patel et al. (2017) further highlighted how the user-friendly interface and versatile features of STAAD.PRO, such as automatic load application and result visualization, can help engineers design tanks with optimized materials and structural components. They applied STAAD.PRO to model a variety of circular water tanks with different diameters and heights and found that the software significantly reduced the design time while ensuring compliance with relevant design codes like IS 456-2000.

2. Optimization of Circular Water Tanks Using STAAD.PRO

The biggest advantage of designing circular water tanks with the help of STAAD.PRO is optimizing designs such that the same material will be reduced along with maintaining safety and usability. In this context, **Das and Kumar (2018)** discuss the optimization process of a circular water tank by parametric studies concerning wall thickness, geometry of tanks, and strength of the concrete by using STAAD.PRO. This found that, by using STAAD.PRO, the best possible structural configuration that gives minimum cost with preservation of structural integrity is available. The use of a different load combination has further led to optimizing the minimum amount of material to be used in designing a large structure, such as water tank

Besides, **Bhandari and Gupta (2020)** explained how STAAD.PRO could be utilized to analyze tanks under conditions of temperature variation and seismic activity. They performed comprehensive structural analysis to optimize the design of the tank both in static and dynamic condition and ensure that the tank withstands operational and environmental stress. This approach ensured durability as well as improved performance of the tank in seismic zones.

3. BASIS OF CONCRETE WATER TANK DESIGN

One of the vital considerations for design of tanks is that the structure has adequate resistance to cracking and has adequate strength. For achieving these following assumptions are made:

➢ Concrete is capable of resisting limited tensile stresses the full section of concrete including cover and reinforcement is taken into account in this assumption.

➢ In strength calculation, the tensile strength of concrete is neglected to avoid structural failure.

➢ Lower values of permissible stresses in steel are used in design in steel.

3.1 CIRCULAR WATER TANK

The simplest form of water tank is circular tank. For the same amount of storage, the circular tank requires lesser amount of material. More over for its circular shape it has no corner and can be made water tight easily. It is very economical for smaller storage of water up to 20000000 liters and with diameter in the range of 5 to 8 m. The depth of

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the storage is between 3 to 4 m. The side walls are designed for hoop tension and bending moments.

3.2 PERMISSIBLE STRESSES IN CONCRETE

To ensure impervious concrete mixture linear than M 20 grade is not normally recommended to make the walls leak proof the concretes near the water face need to such that no crack occurs. To ensure this member thicknesses are so designed that stress in the concrete is lesser then the permissible as given in table

Table -2: Permissible stresses in concrete

Grade of Concrete	Permissible Stress		Shear Stress
	Direct Tension N/sq.mm	Tension due to bending N/sq.mm	N/sq.mm
M15	1.1	1.5	1.5
M20	1.2	1.7	1.7
M25	1.3	1.8	1.9
M30	1.5	2.0	2.2
M35	1.6	2.2	2.7
M40	1.7	2.4	2.7

3.3 THE PERMISSIBLE STRESS IN STEEL

The stress in steel should not be allowed to exceed the following values under different positions to avoid cracking of concrete.

When steel is placed near the face of the members in contact with liquid 115 N/ sq mm for MS Bars and 150 N/ sq mm for HYSD bars. When steel is placed on face away from liquid for members less than 225 mm in thickness same as earlier. When the steel is placed on the face away from the liquid for members 225 mm or more in thickness: 125 N/ sq mm for M.S. bars and 190 N/sq mm for HYSD bars.

4. DESIGN OF CIRCULAR WATER TANK

4.1 TANK DESIGN

Define Parameters

Capacity of the tank (V)

Height of the tank (h)

Radius (r)

4.2 COLUMN DESIGN

Columns bear the tank's structural frame. For this design, we will assume that the columns are distributed equidistantly along the tank's perimeter.

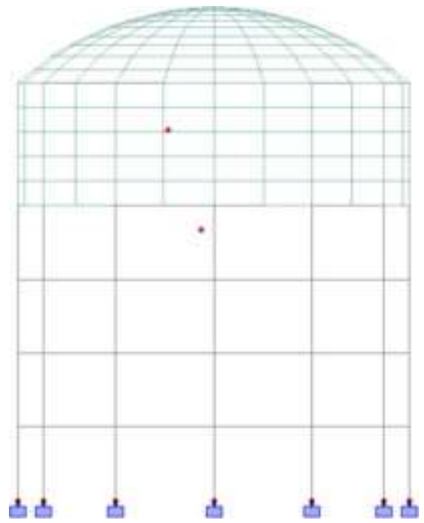
Columns are designed to carry both dead loads, which include the weight of the tank and water, and live loads, which include wind and seismic forces. These loads are calculated and reinforced accordingly.

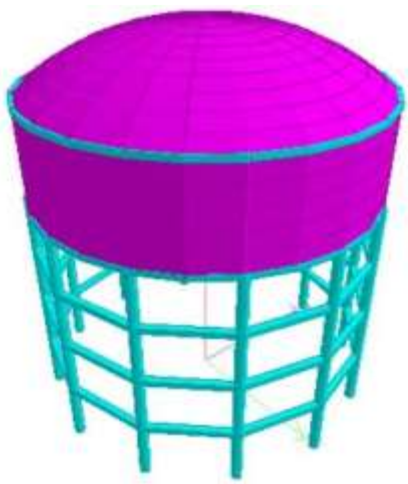
For each column, we need to calculate the axial load they will bear, based on the weight of the water (which can be calculated from its volume) and the tank's self-weight.

4.3 DESIGN OF BEAM

Beams are provided to transmit the loads from the top of the tank (dome and walls) to columns. They are subjected to bending, shear, and torsion as stresses.

Beam Material: Reinforced concrete or steel, as size and weight of the tank permit. • Beam Location: Beam extends horizontally between columns at several levels, usually near top of the wall and at the bottom slab level. The beams must have the ability to bear the loads based on the calculated bending stress and shear stresses.





5. 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-day 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. Without power also we can consume water by gravitational force.
According to the specification, the water tank stand design is made. Modal and structural analysis is done and got accurate results. Comparison of the two materials of different loads of two types is made as per the analysis result the structural steel is concluded to be better when compared with iron.
According to the results gained from equivalent stress and total deformation for structural steel is more as compared to iron. This is suggested after the comparison was done for two load conditions. In model analysis, the density of structural steel is more than iron, so that the mode shapes of structural steel are more than iron. The structural analysis has a significant effect on the overall stresses in the water tank stand.

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