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# Analysis of a Circular Water Tank Considering Lateral Load Using Analysis Tool



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**ABSTRACT**

Circular water tanks are widely used in water distribution systems due to their efficient design and cost-effectiveness for storing moderate water volumes. However, ensuring their structural integrity under water pressure and external loads is crucial. This research utilizes STAAD Pro, a popular structural analysis and design software, to model and analyze a circular water tank, evaluating its response to various loading conditions.

**KEYWORDS:** Circular Water Tank, hydrostatic pressure, seismic analysis, Staad Pro.

**In this paper we are conducting a research on "design of circular water tank".**

## INTRODUCTION

Circular water tanks play a vital role in various sectors, serving as indispensable components of water storage and distribution systems worldwide. These tanks, characterized by their cylindrical shape, offer a plethora of advantages, making them suitable for diverse applications ranging from residential to industrial settings. In this comprehensive study, we delve into the design principles, applications, and key considerations associated with circular water tanks, highlighting their significance in ensuring water security, efficiency, and sustainability.

## LITERATURE REVIEW

**Mohammed azgar et. al. (2017),** in this study, an overhead circular water tank is designed with a water distribution system to fulfill the requirement of a continuously increasing population. By using STAAD PRO, the modeling and designing processes were completed. The main objective of this research was to design a water tank that would be used to store and distribute water to each person. Also during this project, a method was developed to determine the optimal layout for a braced distribution system.
From the obtained results, it was clear that water storage in the form of storage tanks for washing and drinking purposes, for swimming, and for enjoyment is gaining importance day by day. Rectangular water tanks store less water, while circular water tanks store more water as compared to rectangular water tanks. In this study, the method of water tank design was found to be a time-consuming method. There was a small difference between manual calculation and programmed values. Also, it was found that if the manually calculated value is found to be less than the programmed value, then it is necessary to provide some additional value to the calculated value for safety.

**Mainak Ghosal (2019),** In this study, using STAAD PRO, the author tried to design and analyze elevated overhead water. This study was conducted to solve the problem of those people who were living in the region, where water scarcity is on top. There were people who suffered from insufficiency of water. From this problem, a solution was

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developed to design a water storage system for these types of regions. The limit-state method is used for design in STAAD PRO. This study involved different loadings, such as dead load, self-weight, wind load, and hydrostatic pressure, which are produced by water.
The result concluded the goal that was created at the beginning of the project that was archived, but according to the Bureau of Indian Standards, the minimum domestic water supply in cities that should be provided is 200 lit. Per capita/day. It also found that the scarcity of water in that region is over now.

**Issar Kapadia et. al.(2017),** in this research, the author conducted a brief study on an intez-type water tank under the hydrostatic pressure that was produced by water. The design and analysis process of this overhead water tank is done using STAAD PRO analysis and design software. IS 456-2000 was used for concrete, and IS 3370 was used for the design of the water tank. The main objective of this research was to analyze an overhead intez water tank to calculate deflection, stress, etc. due to hydrostatic pressure.
From the calculated result, it was found that the Intez-type water tanks are the simplest in nature as well as in design as compared to all other water tanks. An increase was found in the moment with the increase in the height of the structure, and by using fixed joints at the base of the structure, it can reduce the base settlement. The inclination in staging was provided to this underground overhead water tank because this type of inclination in staging leads to better performance of the water tank as compared to straight staging.

**Himanshu Dwivedi et. al. (2019),** in this research the author had planned and developed a circular reinforced cement concrete tank for this project. A circular water tank is created by hand. The top analysis program STAADPRO was used to conduct additional analysis on it. This project work presented the design and comprehensive drawings. The liquid retaining structure did not have any cracks, so the limit state design technique has not been used for water retaining structures.
As per the obtained results, it was observed that the structural members are safe enough and the STAAD Pro provide concrete's cumulative volume of concrete to plates and beam also it gives steel's cumulative reinforcement weight to plates and beams only. It was observed that the 8.6m, 10m and 7m diameter water tank's concrete are found to be 8.6 cubic, 5.7cubic meter and 4cubic meter respectively. It was also observed that the 8.6m, 10m and 7m diameter water tank's steel are found to be 769kg, 440kg and 300kg respectively. By utilizing three distinct circular water tanks with varying dimensions with equivalent capacity, we can maximize the cost of the project. By utilizing three distinct circular water tanks with varying dimensions with equivalent capacity, we can maximize the cost of the project.

**Chirag N. Patel et. al. (2016),** in this study, the author compares the analytical and software-based approaches used to analyze concrete circular water tanks that were underground. The Portland Cement Association (PCA) and IS 3370 both have analytical methods that were taken into consideration. These methods were then compared to the findings of FE analysis conducted using the program Staad Pro. The purpose of this study was to investigate the real behavior of a tank under static loading conditions, with a focus on IS:3370, PCATable, and STAAD Pro software. Various tanks with identical storage capacities of one lac liter was evaluated for investigation based on characteristics such as dimensional aspect ratio H2/Dt and end conditions at the bottom with free at the top.
As per the findings, it was observed that the results obtained from IS 3370:2009 were exactly the same as the PCA table for circular water tank, but on the other hand, the results obtained from STAAD Pro showed several variations as compared to the PCA table. The value of hoop tension was consistently decreasing as the H2/DT ratio decreased to 14–.08. The circular water tank's wall is one meter high, and the graphs for every H2/DT Ratio indicate that the maximum hoop tension value is close to that height. The circular water tank study, which used varied ratios for the same capacity, yielded a greater Hoop Tension value at ratio H2/DT = 14 than at lower ratios H2/DT = 8, 4, and 0.8.

**Komal K Wagh et. al. (2021),** in this research the author conducted a study on a rectangular shaped underground water tank that was analyzed and designed in STAAD Pro analyzing software. The temperature in underground

water tank is comparatively lesser than overhead water tanks but there are many loads acting on water tanks such as lateral pressure and water pressure etc. as compare to all other structures. Limit state method was considers for structural design and SP-16 and IS -456:2000 codes was use for designing.



As per the calculated results Staad Pro was found to be premium software for design and analysis in construction industry, also the use of STAAD Pro was always found to be beneficial when it comes to design and analyze of water tank. Also manual design method found to be time taken as compare to STAAD Pro design. The results given by STAAD Pro were found to be more satisfactory as compare to manual calculation. By the using of STAAD Pro, it saved 15-20% of total steel as compared to manual design.

**Ajmal Tokhi et. al. (2019),** in this study, the author considered different type of water tanks such as circular, overhead intez and rectangular water tank for response spectrum and seismic analysis. The main objective behind this study was to analyze and make comparison between all these water tanks with empty and half filled condition for reaction spectrum and seismic analysis. The design and analysis process of these water tanks was done by using STAAD Pro V8i SS6 software. Zone III and severe seismic zone IV was considered for the study.

As per the finding, the value of base shear was found to be greater in fully filled reservoirs in both the III and V seismic zones as compared to empty and half-filled reservoirs. So all design data was considered as per the design data for the full tank condition. In all three types of water tanks, such as circular, overhead, and rectangular, the value of base shear increased during the zone change from zone III to zone V. The value of maximum displacement increased in severe seismic zone V as compared to zone III in all the considered water tanks in full tank condition. The design of an elevated water tank was found to be more difficult as it involves mathematical calculations. However, Staad Pro provided all the important parameters.

**Tayyaba Anjum et. al. (2021),** in this study, the author conducted a brief research on elevated water tank's efficacy. In this study, the author created models based on data from raised water tanks that are now in the Nanded district of Maharashtra, India, and conducted a non-linear time history analysis on those models. The effectiveness of raised water tanks was predicted using the engineering demand data that were acquired.

From the evaluated result, it was found that the structure's natural frequency was decrease with water storage increases. In different type of water tanks, the time period was found to be varied. As the water level increases, the nodal displacement, value to base moment and base shear were found to be increased.

**Raji Ruth George et. al. (2016),** in this work, ANSYS software was used to model and evaluate an elevated cement concrete rectangular water tank. By using the accelerogram of the 1995 Kobe earthquake as input, static structural, modal, and transient studies were carried out, and the reaction behavior of the tank under 25% , 50%, 75% and 100% water fill circumstances was examined.

As per the results, with the decrease in water level, the stress and deformation were decreased under the condition of static loading. As the water level rises, the raised tank's inherent frequencies drop. Under dynamic loading, the raised rectangular tank experiences more deformation and strains as the water level rises. Hence, it was clear that when the water level rises, an RCC raised rectangular tank's reaction behavior increases.

**Priyanka M. Mankar et. al. (2021),** This aimed to evaluate the value of continuity analysis in real-world scenarios and examine raised circular water tanks using the STAAD Pro program. The continuity effect is used to look at the water tank's bottom joint. The foundation slab, wall, bottom ring beam, gallery, column, and base beam all link at one single joint. Water causes a water tank to experience both hydrostatic pressure and self-weight. The continuity effect increases stress, BM, and hoop tension, for this reason, it must be taken into account while constructing the tank.

The result's observation was that the stiffness of parts such a wall, foundation slab, bottom ring beam, and gallery meeting the point causes the Continuity effect to grow near joint Hoop Tension. It also noted that the wall stresses for the capacities of 55 m3, 125 m3, and 221 m3 range from 0.0119 N/mm2 to 0.0520 N/mm2, 0.0477 N/mm2 to

0.8008 N/mm2, and 0.0680 N/mm2 to 1.81004 N/mm2. The strength, stability, and lifespan of water tanks are increased when the design is completed after the bottom joint is analyzed and the crack width standards are verified. Circular water tank design and analysis was done with STAAD Pro V8iis although the program does not provide direct values for various parameters.



**H. Shakib et. al. (2010),** in this research, three raised concrete water tanks made of reinforced concrete, measuring 25, 32, and 39 meters in height and having a capacity of 900 cubic meters, were exposed to an ensemble of earthquake data. It was thought that the behavior of the concrete material was nonlinear. The raised water tanks' seismic requirement for a variety of structural parameters was evaluated.
As per the findings, there was around a 60% to 70% dispersion of answers in the mean minus standard deviation and mean plus standard deviation and, overturning moment, base shear, displacement, and hydrodynamic pressure increased by 13–32%, 10–20%, 10–15%, and 8–9%, respectively, as a result of the combined impacts of mass increase and stiffness decrease of tank staging.

**Soheil Soroushnia et. al. (2011),** in this study, a tank with 900 cubic meters under one earthquake record have been studied and analyzed by using dynamic time history analysis. In order to offer patterns for these damages in buildings, this research first examines the losses that happened in reservoirs during previous earthquakes and the reasons why these damages occurred. The seismic behavior of reinforced concrete raised water tanks with frame staging has been found to be more resilient to lateral stresses when compared to those with shaft staging. In this research, dynamic time history analysis has been used to study and evaluate a sample of an elevated water tank made of reinforced concrete, containing 900 cubic meters under one seismic record.
From the concluded results the field investigations and published earthquake reports have indicated that shear and bending modes in beams, axial modes in columns, fractures in joints, and torsion modes are the mechanisms of failure of reinforced concrete raised tanks with frame staging. It was established through numerical research in an elevated tank made of reinforced concrete that has a capacity of 900 cubic meters as to which shear force failure modes in beams and which axial force failure mode predominate in this reservoir. The outcomes demonstrated that numerical studies and field investigations are well implemented.

**Jitendra Kumar et. al. (2023),** this research attempts to identify the features of different staging patterns. In order to be ready to improve the conventional staging technique and give better performance during a seismic event, A similar static test is conducted to determine the best bracing method to use for the raised circular water tank staging in zone V. use STAAD Pro. The base shear and maximum displacement of the circular water tank in the X, Y, and Z axes are compared. A parametric study is carried out using severeal bracing patterns used during the staging of an elevated water tank.
From the result concluded, the basal shear value for alternating bracing patterns in staging clearly declines with the bracing pattern modifications. This was seen by the general reduction in stiffness of the structure. Given the above information, it can be concluded that the most effective technique to lessen lateral loading-related displacement was by the use of cross bracing in staging, which may successfully reduce displacement by 81.10% in the X direction and 92.95% in the Z direction when compared to a structure without bracings. A study of displacement for different bracing systems and replacement bracing indicates that the cross bracing design offers the least amount of displacement.

**Rajkumar et. al. (2017),** in this investigation, twelve numbers of Raised two-liter circular and Intze water tanks sustained under seismic stresses on RCC frame staging as Part II of IS 1893: 2002 is deemed to be outside of the draft code. They comprise six circular type models and six Intze type types. Analysis of the response spectra for enhanced circular and Intze water tanks in the states of being empty partially filled and full STAAD Pro V8i SS6 is used to conduct seismic zones II and V.
From the calculated result the base shear in both full tank conditions is greater than that in empty and half-filled conditions in seismic zones II and V for Intze and circular types of tanks, so that the design data was considers as

per the full tank design data. In both circular and Intze type water tanks, the base shear increases significantly when the water tank's zone changes from Zone II to Zone V. The findings of the analysis show that the most displacement happens at the top node and is highest in the Intze type O water tank



**Ritu Parashar et. al.(2021),** in this research, the hydrostatic pressure was considers for the study of circular elevated water tank with slant column. In this study the slant heights with 0 degree, 4 degree, 6 degree, 8 degree, 10 degree and 12 degree slope were considered for this circular elevated water tank. IS 3370 and limit state method was used for this particular study and the modeling and design process of the water tank was done by using STAAD Pro V8i software. Staad.Pro was used to do seismic analysis in accordance with IS 1893 Part I 2016 for zone II and basic wind speed of 39 m/s in accordance with IS 875 Part III 2015 for full water level circumstances.
From the calculated result it was observed that, up to 6 degree, the moment and axial force were decreased gradually by 4.5% and 5% respectively. but above the 6 degree it was gradually increased. Degree 6 and degree 8 were found to be more cost effective in the requirement of rebar and concrete. Also up to degree 6, it was observed that the incline columns were found to be more stable.

**Anjana M.V. et. al. (2021),** this involves study the manual design of raised circular water tanks utilizing the limit state method of structure design with codes IS 3370-2009 part I to IV, IS 456-2000), and software design completed by using ETABS software. Lastly, contrast the outcomes from the program and the manual methods. Also both cases manual and software designed structure were compared to each other. In this study the shape and the size were taken as per the capacity of the water tank and according to the construction work the use of material and cost was considered.
As per the obtained results, the requirement of the steel was found to be lesser in software design as compare to manual design. The steel requirement as per software design was 9334 mm2 and as per manual design it was found to be 9948 mm2 also manual design process was found to be time taken and complicated process as compare to software design.

**Deepshikha Gadekar et. al. (2022),** this research was based on the design of a subterranean water tank with a capacity of two lakh liters is the focus of this project. The design of the water tank includes side walls, a base slab, and a roof slab. STAAD Pro was used for the study and design of underground rectangular water tanks. For the design of the water tank the limit state method was used also the water tank was design to maintain atmospheric temperature.
From the results it was observed that the bending moment in filled water tank shown 13% rise as compare to empty water tank, 8% increase was found in shear force of filled water tank as compare to empty water tank and the axial force found to be 14% less in empty water tank condition as compare to full water tank condition. The variation of 14% was found in supporting condition in full tank as compare to empty tank.

**M. Kranthi Kumar et. al. (2022),** the investigation was conducted on twelve elevated circular and H-intake storage tanks with a combined capacity of two lakh liters, in accordance with draught code Part II of IS 1893:2002. Response spectrum study of elevated circular and H-shaped water intake tanks in seismic zones II and V is carried out using STAAD Pro V8i. Every value gathered for the base shear axial force and lateral displacements was compared in this study. Analysis of a comparison of two water tanks shows that there is a small variance and a divergence in the H-tank.
As per the results it was observed that, the hemodynamic pressure surges suddenly and falls suddenly when h/L ratio lies between 0.6 to 0.8. For circular and rectangular water tanks with the same amount of storage capacity but varying tank wall thicknesses, the sloshing wave height rises to a certain limit and then progressively falls.

**Abhinav Kumar Anand et. al.(2023),** in this study a variety of evaluations, including stability, dynamic, and static assessments also this research assesses the water tank's structural reaction. Advanced analytic tools in STAAD Pro was used to evaluate the impacts of various load combinations, pinpoint important spots, and pinpoint probable failure mechanisms. The design changes and reinforcements needed to improve the tank's overall

stability, strength, and durability are guided by the analytical results. Important design factors including temperature fluctuations, water pressure, and corrosion prevention techniques are also taken into account in this study.



As per the result, it was observed that the STAAD Pro software was found to be more effective for the design of the elevated water tank. It ensures the stability and safety of these tanks by allowing engineers to precisely model and evaluate their structural integrity. The sophisticated features and functionalities of Staad Pro simplify the design process and enable effective analysis and optimization. All things considered, Staad Pro improves the dependability and effectiveness of raised water tank design and analysis, helping to build a solid and long-lasting water infrastructure.

**Shahid Nazir et. al. (2022),** in this research the researcher conducted a study on overhead circular intez water tank. The modeling and design process was done by using STAAD Pro V8i SS6 software. Storage reservoirs and overhead tanks hold liquids such as water, petroleum products, and similar liquids. The force analysis of reservoirs or tanks was essentially the same regardless of the substance's chemical composition. One of the main issues with water supply planning was water demand. To resolve this problem, this water tank was designed. This water tank was the most efficient storage space used for domestic or even commercial projects.

As per the findings, the design outcomes were found to be safe and error-free. The quantity of reinforcement in the design findings was matched with manual calculation. After receiving error-free design results from STAAD Pro, we came to the safe design of this water tank.

## CONCLUSION

In this paper, we have summarized the research papers of several authors who investigated different types of water tanks using different design and analysis software.

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