Analysis of underground rectangular water tank under earth pressure using STAAD.Pro V8i software: A Review

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ABSTRACT

Compared to conventional manual computations, this method offers several advantages. STAAD Pro simplifies the analytical procedure, making it possible to efficiently take into account a variety of loading scenarios and intricate geometries. A thorough grasp of the tank's structural behavior is made possible by the program's visualization features, which offer distinct graphical depictions of stress and deformation patterns. Engineers can also experiment with different tank designs and material qualities using STAAD Pro's iterative design optimization feature, which helps them come up with a safe, affordable design that satisfies all project specifications. In conclusion, structural engineers can examine rectangular water tanks with the use of STAAD Pro. It encourages effective design methods and guarantees the dependability and security of these crucial water storage facilities.

In this paper we are conducting an literature review regarding underground rectangular water tank.

Keywords: Rectangular Water Tank, Earth pressure, seismic analysis, Staad Pro.

I. INTRODUCTION

Among the planet's most precious resources, water finds application in a wide range of contexts, including commercial and residential settings, agriculture, and industry. Farmers may maximize water resources and increase crop yields in a sustainable manner by using these tanks to collect and irrigate rainwater in agricultural settings. Rectangular tanks are used by industrial organizations to store chemicals, wastewater, and process water in order to support production operations and comply with strict regulations. It was necessary to have an effective distribution and storage system in place to guarantee water availability and accessibility. We shall discuss a rectangular water tank with a capacity of 350 cubic meters in this study.

II. LITERATURE REVIEW

REVIEW OF LITERATURE

Vineet Kumar Sahaa and Ashish Nim (2019), The paper focuses on analytical comparison to support the effectiveness of rectangular water tanks for nominal capacity in terms of material feasibility design using the IS code approach and the approximation method. In several metrics, such as moment, direct tension, and the depth of both vertical walls and slabs, the IS code technique performed better than the approximate method, according to comparative analysis. The IS coding technique proved to be both economical and useful during design. Leveled

ground directly supports the tanks that are on the ground, and the weight of the liquid causes upward soil pressure at the tank's base while hydrostatic pressure acts on the walls of the tanks. The base has no special structural function and can be made with the least amount of steel required. In addition to offering a thorough construction overview that includes technical and financial estimation of rectangular RCC water tanks, our main objective is to deliver a first-rate service with functional utility at a fair price. According to the results, the Approximate Method performs better in terms of endurance than the IS Code Method. However, the IS Code approach is more robust and financially sound, while the approximation method is not cost-effective.

Abba Mas'ud Alfanda et al (2017), This study investigates the efficiency of rectangular or rectangular tanks with a 40,000-liter capacity in order to draw reasonable conclusions regarding the form design effectiveness of tanks, the relative cost implications of various tank types, and structural capacities. The fundamental materials used in tank construction are steel reinforcement, concrete, and formwork that are derived from approved structural designs. According to the materials take-off result, a rectangular tank used fewer individual materials than a non-rectangular one. Rectangular-shaped tanks will have a higher preference when it comes to selection, even though some other factors still need to be considered.

Although it is clear that a rectangular water tank requires comparatively more resources to construct than a circular one, the circular water tank is more challenging to construct than the rectangular one. The design outcome, the possible cost implications of its material requirements, and the relative ease of construction would therefore be taken into consideration for the proposed water tank of any capacity; however, some other aspects still require evaluation.

Himanshu Dwivedi et. al. (2019), A circular reinforced cement concrete tank was designed and built for this project by the study's author. A circular water tank is constructed by hand. It was subjected to additional analysis using STAADPRO, the best analysis program. In this project effort, the design and detailed drawings were provided. The limit state design technique has not been applied to water retaining structures because the liquid retaining structure was free of cracks.

The findings showed that the structural members are adequately safe, and the STAAD Pro only offers plates and beams that have the total volume of concrete and the total weight of steel reinforcement. 8.6 cubic meters, 5.7 cubic meters, and 4 cubic meters of concrete were found to be present in the water tanks with diameters of 8.6 meters, 10 meters, and 7 meters, respectively. Furthermore, it was found that the water tanks with diameters of 8.6 meters, 10 meters, and 7 meters had steel weights of 769, 440, and 300 kilograms, respectively. Using three different circular water tanks with the same capacity but varying sizes could lower the project's cost. Using three different circular water tanks with the same capacity but varying sizes could lower the project's cost.

Mohammed azgar et. al. (2017), In this study, an above circular water tank with a water distribution system is built to meet the needs of a population that is continuously expanding. Using STAAD PRO, the modeling and design processes were completed. The main objective of this study was to design a water tank that would store and distribute water to each person. A method for determining the optimal braced distribution system layout was also developed during this study.

The findings made it clear that the importance of water storage in the form of tanks for swimming, drinking, washing, and recreation is growing daily. Water tanks that are circular in shape can hold more water than those that are rectangular in shape. This investigation found that the water tank design method was time-consuming. There was a small discrepancy between the manually calculated values and the ones that were programmed. In the event that the

manually calculated value proves to be less than the programmed amount, it was also found that an additional value must be added to the computed value for safety.

Mainak Ghosal (2019), Using STAAD PRO, the author of this work tried to construct and analyze elevated above water. Finding a solution for the local population in an area where water scarcity is the primary problem was the aim of this study. Some people suffered from a lack of water. To address this problem, a water storage system was created for these kinds of locations. The limit-state approach is used in the design of STAAD PRO. Water-generated loadings such as dead load, self-weight, wind load, and hydrostatic pressure were all included in this study. The project's original goal was achieved, and it was archived. Nonetheless, cities should have a minimum of 200 liters of water per resident per day, according to the Bureau of Indian Standards. It also found that there is no longer a water shortage in that region.

Issar Kapadia et. al.(2017), This study's author took a quick look at an intez-style water tank under the hydrastatic pressure that water produces. The design and analysis of this overhead water tank were done using STAAD PRO analysis and design software. While IS 3370 was used to design the water tank, IS 456-2000 was used to design the concrete. The main objective of this study was to analyze an overhead intez water tank because of hydrostatic pressure in order to determine deflection, stress, etc.

According to the calculated result, the Intez-type water tanks are the most straightforward in nature and design when compared to all other water tanks. The use of fixed joints at the base of the structure can reduce base settlement, and the moment increased as the height of the structure increased. Because an incline in staging enhances the performance of the water tank more than straight staging, this subterranean overhead water tank was given one.

Chirag N. Patel et. al. (2016), In order to examine underground concrete circular water tanks, the author of this study compares analytical and software-based approaches. Additionally, analytical methods from the Portland Cement Association (PCA) and IS 3370 were considered. These methods were then compared with the outcomes of FE analysis carried out using the Staad Pro tool. The purpose of this study was to examine the real behavior of a tank under static loading conditions using IS: 3370, PCATable, and STAAD Pro software. A number of tanks with comparable one lac liter storage capacities were evaluated for additional research based on characteristics such as the dimensional aspect ratio H2/Dt and end conditions at the bottom with free at the top.

The results showed that the PCA table for circular water tanks and the IS 3370:2009 results were identical; however, the STAAD Pro results showed several discrepancies from the PCA table. The hoop tension value decreased steadily as the H2/DT ratio decreased to 14–.08. The circular water tank's one-meter-high wall is where the highest hoop tension value is found, according to the graphs for each H2/DT Ratio. In the circular water tank investigation, which used various ratios for the same capacity, a higher Hoop Tension value was obtained at ratio H2/DT = 14 than at lower ratios H2/DT = 8, 4, and 0.8.

Komal K Wagh et. al. (2021), This study focused on a rectangular subterranean water tank that was analyzed and designed using the STAAD Pro analysis program. Compared to all other buildings, underground water tanks are subject to a variety of stresses, such as water pressure and lateral pressure, despite having a lower temperature than above tanks. The limit state approach was taken into consideration, and the structural design was done in accordance with IS-456:2000 and SP-16 regulations.

STAAD Pro was found to be the best design and analysis software in the construction industry based on the calculated results. It has also been repeatedly demonstrated to be helpful for the analysis and design of water tanks. Additionally, it was found that the manual design process took longer than STAAD Pro design. The results from STAAD Pro were found to be more satisfactory than those from manual calculation. STAAD Pro saved 15–25% of the total steel when compared to manual design.

Ajmal Tokhi et. al. (2019), The author of this work considered different types of water tanks, such as round, above-intez, and rectangular water tanks, for seismic analysis and response spectrum. Comparing and assessing each of these water tanks in both their empty and partially filled states for seismic and response spectrum research was the main objective of this study. These water tanks were designed and analyzed using STAAD Pro V8i SS6 software. Zone III and severe seismic zone IV were considered for the study.

The findings showed that empty and partially filled reservoirs had lower base shear values than fully filled reservoirs in both the III and V seismic zones. As a result, all design data was considered in compliance with the design data for the entire tank condition. All three types of water tanks round, overhead, and rectangular saw an increase in base shear value during the zone transition from zone III to zone V. The maximum displacement value was greater in severe seismic zone V than in zone III for all of the water tanks that were taken into consideration in full tank condition. It was found that because it involved mathematical calculations, designing an elevated water tank was more difficult. However, Staad Pro provided all of the important parameters.

Tayyaba Anjum et. al. (2021), The efficacy of elevated water tanks was briefly examined by the paper's author. The author of this paper created models and conducted a non-linear time history analysis on data from raised water tanks in the Nanded region of Maharashtra, India. The effectiveness of higher water tanks was predicted using the engineering demand data that was acquired.

The results of the analysis showed that the natural frequency of the structure decreased as water storage increased. Depending on the kind of water tank, the duration varies. It was found that as the water level rose, so did the nodal displacement, value to base moment, and base shear.

Raji Ruth George et. al. (2016), In this work, ANSYS software was used to model and evaluate a rectangular raised cement concrete water tank. Accelerograms from the 1995 Kobe earthquake were used as input for static structural, modal, and transient tests. Additionally, the reaction behavior of the tank was examined at 25%, 50%, 75%, and 100% water fill.

The results showed that when the water level dropped, stress and deformation under static loading conditions decreased. As the water level rises, the raised tank's inherent frequencies fall. The elevated rectangular tank experiences more strains and deformation when the water level rises under dynamic loads. Consequently, 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 applicability of continuity analysis in real-world scenarios and examine raised circular water tanks using the STAAD Pro tool. The continuity effect is used to analyze the water tank's bottom joint. The foundation slab, wall, bottom ring beam, gallery, column, and base beam are all joined by a single joint. When a water tank is filled with water, it experiences both hydrostatic pressure and self-weight. Because the continuity effect increases stress, BM, and hoop tension, it must be taken into account when building the tank.

The results demonstrated that the stiffness of elements like a wall, foundation slab, bottom ring beam, and gallery meeting the point causes the continuity effect to increase near joint hoop tension. Furthermore, it stated that the wall stresses for the capacities of 55 m3, 125 m3, and 221 m2 range from 0.0119 to 0.0520 N/mm2, 0.0477 to 0.8008 N/mm2, and 0.0680 to 1.81004 N/mm2, from that order. The design is complete once the bottom joint is inspected and the necessary crack width is verified, extending the water tank's durability, strength, and stability. The circular water tank was designed and analyzed using STAAD Pro V8iis, even though the program does not provide exact values for several parameters.

H. Shakib et. al. (2010), In this study, an ensemble of seismic data was collected from three reinforced concrete raised concrete water tanks that had a 900 cubic meter capacity and were 25, 32, and 39 meters high. It was thought that the behavior of the concrete material was nonlinear. The raised water tanks' various structural elements were evaluated for seismic requirements.
The results showed that the combined effects of tank staging's increased mass and decreased stiffness led to a dispersion of responses in the mean minus standard deviation and mean plus standard deviation of roughly 60% to 70%. Furthermore, there was an increase of 13–32%, 10–20%, 10–15%, and 8–9% in the overturning moment, base shear, displacement, and hydrodynamic pressure, respectively.

Soheil Soroushnia et. al. (2011), This study examined and evaluated a 900 cubic meter tank under a single seismic record using dynamic time history analysis. In order to identify trends for these building damages, this study first examines the losses that happened in reservoirs during previous earthquakes and the reasons behind these damages. The seismic behavior of reinforced concrete raised water tanks with frame staging has been found to be more resistant to lateral loads than those with shaft staging. In this study, dynamic time history analysis was used to analyze and assess a sample of a 900 cubic meter reinforced concrete elevated water tank under a single seismic record.
According to field tests and published earthquake reports, the mechanisms of failure of reinforced concrete raised tanks with frame staging include shear and bending modes in beams, axial modes in columns, joint cracks, and torsion modes. The dominant axial and shear force failure modes in beams in an elevated reinforced concrete tank with a 900 cubic meter capacity were identified through numerical research. The findings demonstrated the effectiveness of both numerical studies and field research.

Jitendra Kumar et. al. (2023), This study aims to identify the features of different staging schemes. In order to be ready to improve the conventional staging technique and offer better performance during a seismic event, a similar static test is conducted to determine the best bracing technique to use for the raised circular water tank staging in zone V. Utilize STAAD Pro. The maximum displacement along the X, Y, and Z axes and the base shear of the circular water tank are compared. In a parametric study, severe bracing designs are used in the staging of an elevated water tank.
The findings clearly show that for alternating bracing patterns in staging, changing the bracing pattern reduces the basal shear value. This was shown by the overall reduction in the rigidity of the structure. The most effective technique for minimizing displacement brought on by lateral loading in staging, based on the information above, was cross bracing. This technique may effectively 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 found that the cross-bracing design offers the least amount of displacement.

Rajkumar et. al. (2017), Twelve elevated two-liter circular and Intze water tanks that were supported by seismic stresses on RCC frame staging are listed in Part II of IS 1893: 2002. The purpose of this study is to determine the characteristics of various staging schemes. A similar static test is carried out to ascertain the most effective bracing technique to employ for the raised circular water tank staging in zone V in order to be prepared to enhance the conventional staging technique and provide better performance during a seismic event. Make use of STAAD Pro. A comparison is made between the circular water tank's base shear and its maximum displacement along the X, Y, and Z axes. In a parametric study, an elevated water tank is staged using severe bracing designs.

The results unequivocally demonstrate that altering the bracing pattern lowers the basal shear value for alternating bracing patterns in staging. The overall decrease in the structure's rigidity demonstrated this. According to the information above, cross bracing was the most efficient method for reducing displacement caused by lateral loading in staging. When compared to a structure without bracings, this technique may successfully reduce displacement by 81.10% in the X direction and 92.95% in the Z direction. The cross-bracing design provides the least amount of displacement, according to a study of displacement for various bracing systems and replacement bracing.

deemed to be outside of this study's draft code. They include six models of the circular type and six types of the Intze type. The response spectra for enhanced circular and Intze water tanks in the empty, partially filled, and full states are analyzed using the STAAD Pro V8i SS6 in seismic zones II and V. Because the calculated result indicated that 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, the design data was taken into consideration in accordance with the full tank design data. In both circular and Intze-type water tanks, the base shear increases significantly as the water tank's zone moves from Zone II to Zone V. The results of the analysis show that the top node, which is the Intze type O water tank, has the largest displacement.

Ritu Parashar et. al.(2021), According to Part II of IS 1893: 2002, the study's draft code excludes twelve raised two-liter circular and Intze water tanks that were supported by seismic stresses on RCC frame staging. Six Intze type kinds and six circular type models are among them. The STAAD Pro V8i SS6 is used to analyze response spectra for enhanced circular and Intze water tanks in the empty, partially filled, and full states in seismic zones II and V.

The design data was taken into consideration in accordance with the full tank design data because the calculated result in seismic zones II and V showed that the base shear in both full tank conditions is greater than that in empty and half-filled conditions for Intze and circular types of tanks. This study examined a circular elevated water tank with a slant column while accounting for hydrostatic pressure. This investigation focused on a circular elevated water tank with slopes of 0, 4, 6, 8, 10, and 12 degrees. The water tank for this study was modeled and designed using STAAD Pro V8i software, adhering to IS 3370 and the limit state method. According to IS 1893 Part I 2016, Staad.Pro was used for zone II seismic analysis; IS 875 Part III 2015 stipulated a basic wind speed of 39 m/s for full water level conditions.

Up to 6 degrees, the calculated result indicated a significant decrease of 4.5% in the moment and 5% in the axial force. But above 6 degrees, it rose gradually. Degrees 6 and 8 were found to be more cost-effective in terms of the requirement for concrete and rebar. Up to degree 6, it was found that the incline columns were more stable.

When the water tank's zone shifts from Zone II to Zone V, the base shear in both circular and Intze-type water tanks increases noticeably. The results of the analysis show that the Intze type O water tank's top node has the biggest displacement.

Shahid Nazir et. al. (2022), Twelve raised two-liter circular and Intze water tanks that were supported by seismic stresses on RCC frame staging are deemed to be outside the draft code for this study in accordance with Part II of IS 1893: 2002. They include six models of the circular type and six types of the Intze type. The response spectra for enhanced circular and Intze water tanks in the empty, partially filled, and full states are analyzed using the STAAD Pro V8i SS6 in seismic zones II and V.

Because the calculated result indicated that 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, the design data was taken into consideration in accordance with the full tank design data. In both circular and Intze-type water tanks, the base shear increases significantly as the water tank's zone moves from Zone II to Zone V. The results of the analysis show that the top node, which is the Intze type O water tank, has the largest displacement.

Anjana M.V. et. al. (2021), Twelve raised two-liter circular and Intze water tanks that were supported by seismic stresses on RCC frame staging are deemed to be outside the draft code for this study in accordance with Part II of IS 1893: 2002. They include six models of the circular type and six types of the Intze type. The response spectra for enhanced circular and Intze water tanks in the empty, partially filled, and full states are analyzed using the STAAD Pro V8i SS6 in seismic zones II and V.

\Because the calculated result indicated that 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, the design data was taken into consideration in accordance with the full tank design data. In this study, a circular elevated water tank with a slant column was studied while taking hydrostatic pressure into account. Slant heights with slopes of 0 degrees, 4 degrees, 6 degrees, 8 degrees, 10 degrees, and 12 degrees were taken into consideration for this circular elevated water tank in this study. For this study, IS 3370 and the limit state method were employed, and STAAD Pro V8i software was used for the water tank's modeling and design. In accordance with IS 1893 Part I 2016 for zone II seismic analysis and IS 875 Part III 2015 for full water level conditions, a basic wind speed of 39 m/s was performed using Staad.Pro.

According to the computed result, the moment and axial force gradually decreased by 4.5% and 5%, respectively, up to 6 degrees. However, it was progressively raised above 6 degrees. It was discovered that degrees 6 and 8 were more economical when it came to the need for concrete and rebar. Additionally, the incline columns were found to be more stable up to degree 6.

The base shear in both circular and Intze-type water tanks increases significantly when the water tank's zone changes from Zone II to Zone V. The results of the analysis show that the top node, which is the Intze type O water tank, has the largest displacement.

Shahid Nazir et. al. (2022), This involves looking into the manual design of raised circular water tanks using the limit state method of structure design with codes IS 3370-2009 part I to IV, IS 456-2000. ETABS software is used to complete the software design. Lastly, contrast the outcomes of the program and the manual methods. Furthermore, a comparison between the software-designed and manual structures was conducted. The water tank's capacity dictated the study's size and shape, and the cost and material consumption were considered throughout the building process.

The information gathered showed that software design used less steel than human design. The manual design required 9948 mm2 of steel, while the software design required 9334 mm2. Additionally, it was discovered that the software design process was simpler and less time-consuming than the manual design process.

Deepshikha Gadekar et. al. (2022), This study was based on the design of a subsurface water tank that holds two lakh liters. The water tank has a base slab, a roof slab, and side walls. STAAD Pro was used to study and design rectangular subterranean water tanks. The limit state method was used in the design of the water tank in order to maintain the atmosphere's temperature.

The results showed that the axial force dropped by 14% in comparison to a full water tank, the shear force of a filled water tank increased by 8% in comparison to an empty one, and the bending moment increased by 13% in comparison to an empty one. Between the full and empty tanks, the supporting condition varied by 14%.

M. Kranthi Kumar et. al. (2022), The investigation, conducted in accordance with IS 1893:2002's draught code Part II, focused on twelve raised circular and H-intake storage tanks with a combined capacity of two lakh liters. Response spectrum analyses of elevated circular and H-shaped water intake tanks in seismic zones II and V are carried out using STAAD Pro V8i. All of the data gathered for the base shear axial force and lateral displacements were compared in this study. Analysis of two water tanks shows a small divergence and difference in the H-tank.

The results show that the hemodynamic pressure suddenly increases and decreases when the h/L ratio is between 0.6 and 0.8. For circular and rectangular water tanks with the same amount of storage capacity but different tank wall thicknesses, the sloshing wave height rises to a certain point before progressively falling.

Abhinav Kumar Anand et. al.(2023), This study employed a variety of evaluations, including stability, dynamic, and static assessments. This study also assesses the water tank's structural response. To determine likely failure modes, evaluate the impact of various load combinations, and pinpoint critical locations, STAAD Pro's advanced analytical tools were employed. The design changes and reinforcements necessary to improve the tank's overall stability, strength, and durability are guided by the analytical results. Important design factors like water pressure, temperature variations, and corrosion prevention techniques are also taken into account in this study.

The results showed that the STAAD Pro program performed better for the design of the elevated water tank. It ensures the stability and safety of these tanks by giving engineers the ability to precisely model and evaluate their structural integrity. The sophisticated features and functionalities of Staad Pro streamline the design process and enable effective analysis and optimization. Overall, by improving the reliability and effectiveness of elevated water tank design and analysis, Staad Pro contributes to the development of a robust and long-lasting water infrastructure.

Shahid Nazir et. al. (2022), The researcher studied the overhead circular intez water tank in this study. The modeling and design process was carried out using STAAD Pro V8i SS6 software. Storage reservoirs and overhead tanks hold liquids such as water and petroleum products. The force analysis of tanks or reservoirs was basically the same regardless of the material's chemical composition. One of the main issues with water supply planning was water demand. The purpose of this water tank was to solve this problem. This water tank was the most efficient storage space for homes or even businesses.

Based on the results, it was concluded that the design was safe and error-free. The amount of reinforcement in the design findings was matched by a manual calculation. After receiving the error-free design results from STAAD Pro, we came up with the safe design for this water tank.

III. Conclusion

Here in this paper, we are concluding several research papers regarding different type of water tanks.

IV. REFERENCE

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