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Design and Analysis of Circular Water Tank with Rigid Base Resting on Ground

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ABSTRACT: In some locations, A water tank is a structure that stores water for the purpose of providing drinking water to households, cooling water for industries, and irrigational water for agricultural use. Water tanks are categorized based on their shape and structural location. Water tanks come in a variety of capacities, depending on the demands of a municipal organization. Water covers approximately 71% of the earth's surface. Dead and live loads are applied using IS codes. A water storage container is a ground-level water tank. It was discovered that limit state design had a reduced cost. The cost of a circular water tank is less than that of a square tank. A circular water tank with a circular wall designed as a liquid retention structure demonstrates the theory behind the design of this work. To resist lateral stresses, the water tank is modelled and studied using dynamic analysis, and the design is done manually using the working stress method. Staad pro software is used for the design. This study provides numerous design requirements that influence the structure's strength and support condition for safe tank construction. The focus of this case study is on liquid retaining structures that are composed of reinforced concrete and sit on the ground.

KEYWORDS: Water, Circular Tank., STAAD Pro, analysis, Design as per IS code: IS-3370:2009, IS-456:2000.

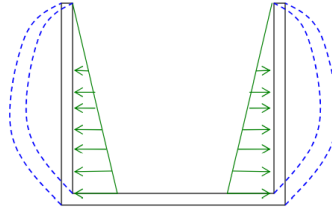
I. INTRODUCTION

A water tank is a field used to store water. Water is regarded as the source of life for all creatures, as well as an essential component of a healthy lifestyle. Safe drinking water is one of the most important factors in maintaining a healthy lifestyle. As one cannot live without water, the demand for safe and easy water is increasing by the day. Water tanks are used to store water for a variety of applications such as drinking water, irrigation agriculture, fire suppression, agricultural farming (both for plant life and livestock), chemical manufacturing, food training, and many others. The overall design of the tank, as well as the desire to manufacture substances and linings, are all water tank criteria. As a result, water must be stored simply and effectively. In garage reservoirs and water tanks, liquid petroleum, petroleum products, and analogous liquids are routinely stored. The force evaluation of the reservoir or tank is the same regardless of the chemical type of the product. To prevent leakage, all tanks are designed as crack-free systems. Water or raw petroleum preserving slabs and partitions might be reinforced concrete with a suitable reinforcing cowl. No extra treatment is required because water and petroleum react with concrete. The need for a water tank is as old as civilization itself, as it provides a storage space for water that may be used for a variety of purposes. Water tanks are commonly classified as round, square, or conical, depending on their size and position. The tanks could be made of metal or concrete. Tanks that sit on the floor are usually round or square and are used to hold large amounts of water. The overall layout of the tank, as well as the desire to create substances and linings, are all considered water tank factors. Water tank layout components must be followed as closely as possible to books, and masses must be properly carried out.

II. METHODOLOGY

Manual Design

Design a circular water tank for a capacity of 600000 liters resting on the ground. It is fixed @ base and free at the top. Take $\gamma_w = 10 \text{ kN/m}^3$. Use M30 / Fe415 materials.



Provide 5m depth let the free board be 0.3m

Let D=diameter of the tank

Considering 20mm thick waterproof plaster

$$\therefore \text{Net diameter} = D - (2 \times 0.02) \\ = (D - 0.04) \text{ m}$$

$$\text{Net height} = (5 - 0.3 - 0.02) \\ = 4.68 \text{ m}$$

$$\text{Volume} = 600000 \text{ litre} = 600 \text{ m}^3$$

$$\therefore 600 = \frac{\pi}{4} \times (D - 0.04)^2 \times 4.68$$

$$D = 12.81$$

Provide D=12.85, H=5m

Assume thickness t=250mm=0.25m

$$\therefore \frac{H^2}{Dt} = \frac{5^2}{12.85 \times 0.25} = 7.78$$

Hoop tension consideration

From table 9, pg.no 35 of IS:3370 (part iv)

In the table, we have to search for the max coefficient

Here max coefficient is at 0.6H

$$\text{Hoop tension} = k_1 \cdot \frac{\gamma H D}{2} \gamma = \text{unit weight of water}$$

$$T = k_1 \cdot \frac{10 \times 5 \times 12.85}{2} \\ = 321.25 k_1$$

$$@ 0.6H \Rightarrow \frac{H^2}{Dt}$$

$$6 \quad - \quad 0.514$$

$$7.78 \quad - \quad ?$$

$$8.0 \quad - \quad 0.575$$

By interpolation $k_1 = 0.5684$

$$T = 321.25 \times 0.5684 = 182.60 \text{ kN}$$

$$\therefore \text{Hoop steel} = \frac{182.60 \times 10^3}{130} = 1404.61 \text{ mm}^2 \\ t = 250 \text{ mm}$$

$$A_{st \min} = \frac{0.24}{100} \times 1000 \times 250 \\ = 600 \text{ mm}^2$$

Max spacing = 300mm

$$\therefore \text{Spacing of 12mm bars} = \frac{\frac{\pi}{4} \times 12^2 \times 100}{\frac{1404.61}{2}} = 161.03 \text{ mm}$$

Provide 12mm bar @ 160mm c/c (both faces)

$$\therefore A_{st \text{ provided}} = \frac{2 \times \frac{\pi}{4} \times 12^2 \times 1000}{160} = 1413.72 \text{ mm}^2$$

$$\text{Tensile stress in concrete} = \frac{T}{bxt + (m-1)A_{stp}}$$

$$= \frac{182.6 \times 10^3}{(1000 \times 250) + (9.33 - 1) \times 1413.72}$$

$$= 0.7 \text{ N/mm}^2 < 1.5 \text{ N/mm}^2$$

HENCE OK



BENDING MOMENT

$$H = k_2 \gamma_w H^3$$

$$= k_2 \times 10 \times 5^3$$

$$= 1250 k_2$$

From table 10 of IS:3370 (part iv)

In the table, we have to search for max coefficient

Here max coefficient is @ 1.0H

$$6 = -0.0187$$

$$7.78 = ?$$

$$8 = -0.0146$$

By interpolation, $k_2 = 0.01547$

$$M = (1250 \times 0.015047) = -18.81 \text{ KNm}$$

$$D = 250 - 45 - 10 - 5 = 190 \text{ mm}$$

From table 10, Pg.no 36 of IS:3370 (part iv)

$$M = Q b d^2$$

$$Q = 0.5 \sigma_{cbc} k j$$

$$\sigma_{cbc} = 10 \text{ MPa}$$

$$k = \frac{m \sigma_{cbc}}{m \sigma_{cbc} + \sigma_{st}}$$

$$= \frac{9.33 \times 10}{9.33 \times 10 + 130}$$

$$= 0.4178$$

$$= 0.5 \times 100 \times 0.4178$$

$$j = 1 - k/3 = 0.86$$

$$Q = 1.79$$

$$18.81 \times 10^6 = 1.75 \times 1000 \times d_{req}^2$$

$$d_{req} = 102.51 \text{ mm} < d$$

$$\text{available Ast required} = \frac{m}{\sigma_{st} j d} = \frac{18.81 \times 10^6}{130 \times 0.86 \times 190} = 885.509 \text{ mm}^2$$

Provide 10mm bar @ 170mm c/c [462mm²] for full height of the wall + 10mm bar @ 170mm c/c 462mm² for short length of 1000mm

$$A_{st} = 462 + 462 = 924 \text{ mm}^2$$

Max shear @ base

From table 2 of IS:3370 (part iv)

$$V = \text{Coef} \times \gamma_w H^2$$

$$6 = +0.197$$

$$7.78 = ?$$

$$8 = +0.174$$

By interpolation, Coefficient = 0.177

$$V = 0.177 \times 10 \times 5^2$$

$$= 44.25 \text{ KN}$$

Nominal Shear Stress

$$\tau_v = \frac{44.25 \times 10^3}{1000 \times 190} = 0.2328 \text{ N/mm}^2$$

$$\frac{100 A_s}{b d} = \frac{100 \times 924}{1000 \times 190} = 0.486\%$$

$$\tau_c = 0.3 \text{ N/mm}^2 \text{ for } P_t = 0.486\%$$

Here $\tau_c > \tau_v$

HENCE OK

STADD PRO DESIGN

Step 1: Geometry design

Put all nodal and connect beam

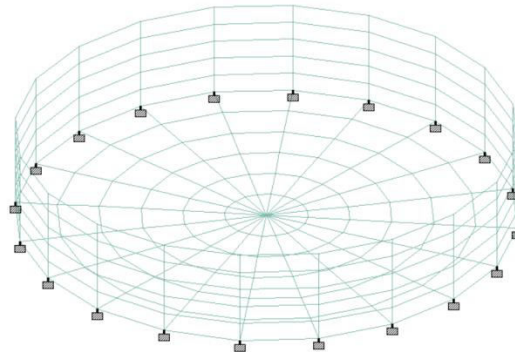


Fig 1: All plates are connected

Step 2: Design an end property

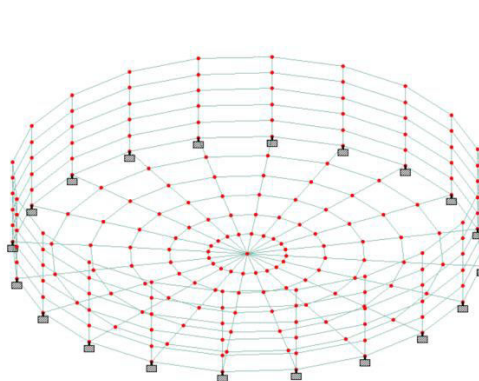


Fig 2: Isometric view of the nodes of tank

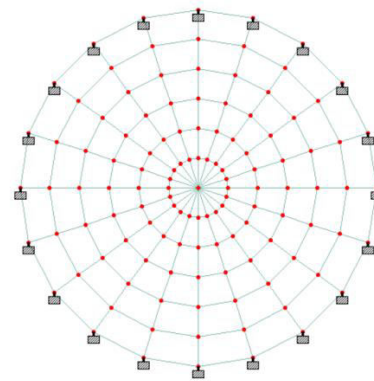


Fig 3: Top view of the nodes of tank

Step 3: Material

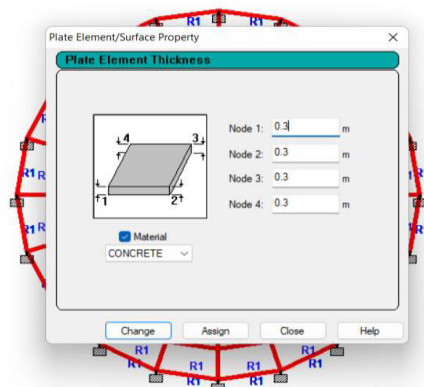


Fig 4: Assigning thickness of tank

Step 4: Select all members and given property

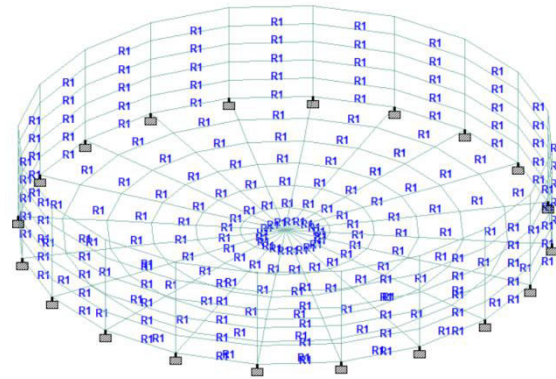


Fig 5: Applied thickness of tank

Step 5: Load and Combination

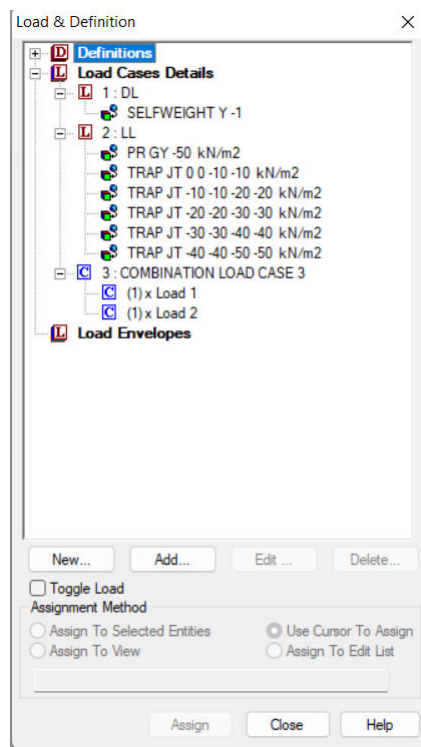


Fig 6: Load and combination

Step 6: Analysis and print

Add IS code and specification IS 456

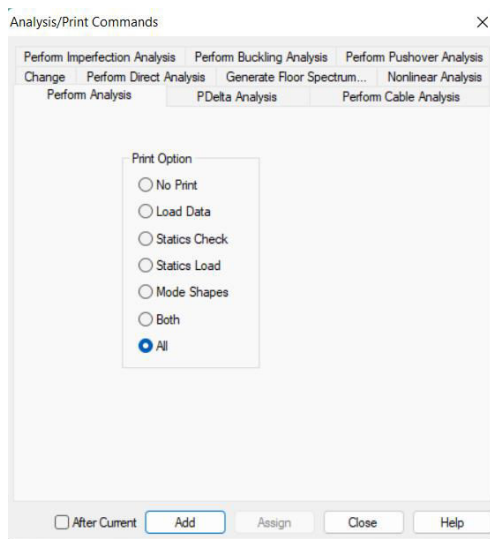


Fig 7: Analysis and printing commands

III. EXPERIMENTAL RESULTS

STEP 7: RUN PROGRAM

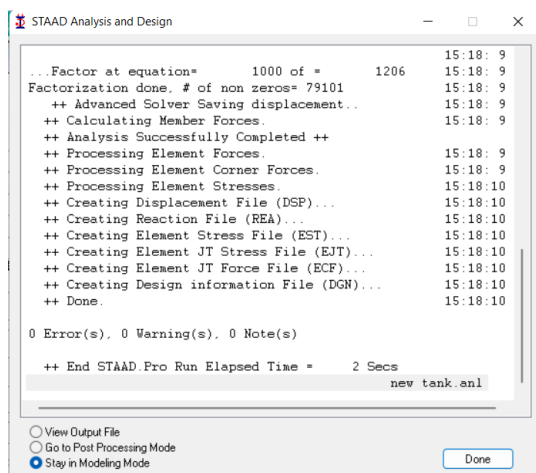


Fig 8: The result of analysis of Staad pro

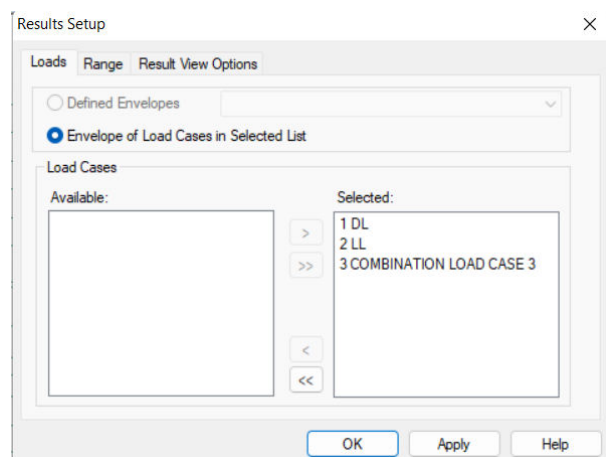


Fig 9: Results of the setup

STEP 8: PRINCIPAL STRESSES ON PLATES

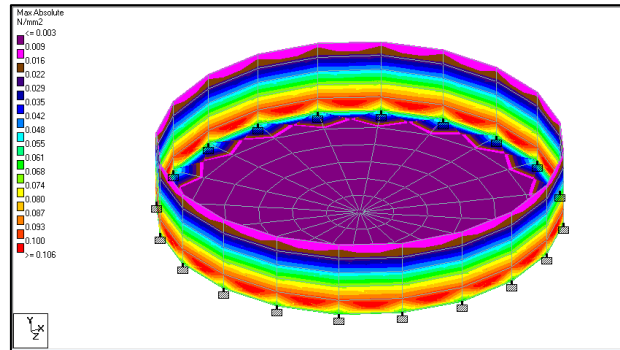


Fig 10: Principal stresses of plates

STEP 9: RESULT

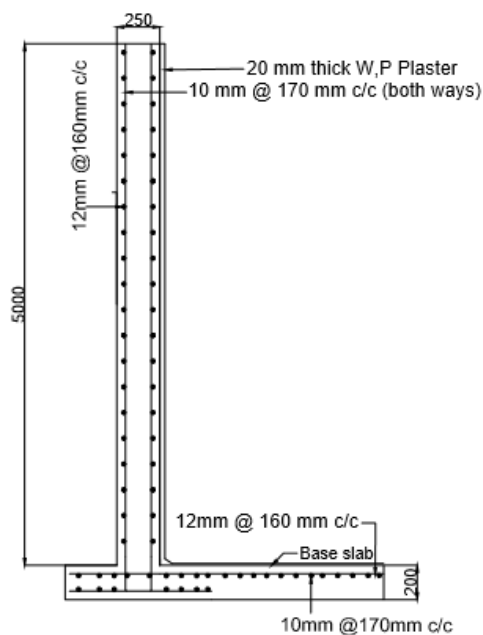


Fig 11: Elevation Detail by Manual Calculation

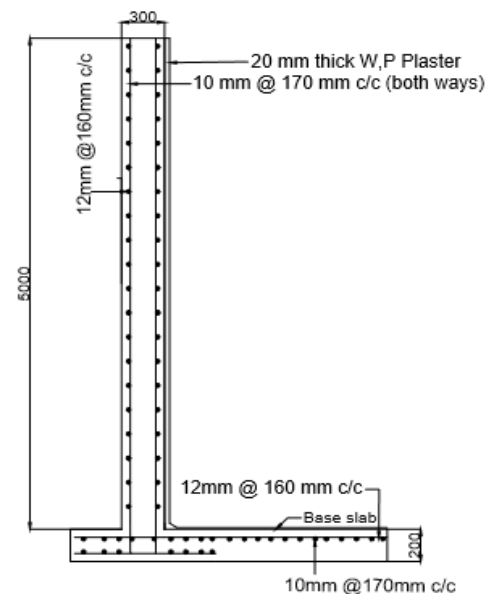


Fig 12: Elevation Detail by Staad Pro

IV. CONCLUSION

Water storage in the form of tanks for drinking and laundry, swimming pools for exercise and recreation, and waste matter alluviation tanks are becoming increasingly important in modern life. The design of a water tank is a time-consuming process. Manual design necessitates the use of numerous mathematical formulas and calculations. It takes time as well. As a result, the software provides a solution to the above mentioned challenge. There is a slight variation between software design values and manual calculation values.



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