

# Analysis of underground rectangular water tank under earth pressure using STAAD.Pro V8i software

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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.

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

## I. INTRODUCTION

One of the most precious resources on Earth, water is utilized in a wide range of contexts, including business and household settings, agriculture, and industry. These tanks make it easier to collect and irrigate rainfall in agricultural settings, enabling farmers to maximize water resources and increase crop yields in an environmentally friendly manner. Industrial firms use rectangular tanks to store chemicals, wastewater, and process water to assist production operations and meet strict regulations. An effective distribution and storage system was needed to guarantee water accessibility and availability. A rectangular water tank with a capacity of 350 cubic meters will be the subject of this investigation.

### Need for Storage Tank

A reservoir can be above or below ground level and is a building used to store liquids. Subterranean reservoirs are usually built to store massive amounts of water, whereas above reservoirs are usually smaller in capacity and intended for direct distribution by gravity flow. Storage reservoirs and water tanks hold water, petroleum products, liquid petroleum, and other similar liquids. The force analysis of the tanks or reservoirs is approximately the same regardless of the chemical composition of the substance. All tanks are designed to be structurally solid in order to avoid leakage. As long as the reinforcement is well covered, reinforced concrete can be used to create retaining walls and slabs for raw petroleum or water. There is no need for extra surface treatment because concrete reacts with both water and petroleum.

## Different type of resting on ground water tanks

### Stainless steel

Stainless steel tanks are widely valued for being the ideal choice for storing a range of liquids due to their durability and resistance to corrosion. These tanks are commonly found in industries like food and beverage, pharmaceutical, chemical, and water storage where maintaining high levels of hygiene is crucial.

### Fiberglass

Fiberglass tanks can be used to store a variety of liquids, including caustic ones, due to their remarkable resistance to corrosion. Because of their resilience to degradation from chemicals and environmental factors, they are assured to maintain their integrity over time, even under the most severe situations. The main benefit of fiberglass tanks over heavier alternatives like concrete tanks is their light weight, which facilitates handling and installation.

### Polyethylene

Polyethylene tanks are praised for being easy to handle and install due to their lightweight nature. This characteristic is particularly useful in locations where transportation may be challenging because the tanks are simple to move and set up. Due to its ease of handling, polyethylene tanks are commonly used in rural areas, especially for agricultural purposes such as storing water for irrigation, livestock, or other essential requirements.

### Corrugated steel

Corrugated steel tanks are an affordable and versatile option for a variety of storage needs due to their reputation for durability. They can withstand harsh weather conditions and offer long-lasting performance with minimal maintenance due to their robust design. Large-scale water storage, firefighting, industrial, and agricultural applications are all common uses for these tanks.

## Effects of Seismic Forces

Depending on the size of the tank, the soil, and the magnitude of the seismic event, seismic forces can have a substantial impact on a rectangular water tank that is resting on the ground. The primary effects are as follows:

- **Base Uplift:** Seismic forces can cause the earth to shake, which could cause the tank's base to rise off the ground. This could result in an unstable situation, especially if the tank is not firmly attached to the ground.
- **Lateral Forces:** The tank may move sideways during an earthquake due to lateral forces produced by horizontal ground motion. Shear pressures could result in cracking or structural damage if the tank walls are not constructed to support such a load.
- **Internal Fluid Movement:** The water in the tank behaves as a dynamic mass during seismic activity. When designing the tank, the extra effects of water sloshing which can exert pressure on the walls and floor must be taken into account.
- **Structural Damage:** Seismic activity could cause structural damage to the tank's walls, joints, and foundation.
- **Foundation Displacement:** During an earthquake, ground movement could cause the tank's base to shift. Tanks without anchors may tilt, misalign, or even collapse as a result of this if the base moves a lot.
- **Vibration and Resonance:** Resonance in the tank may result from the seismic waves' vibration frequency, especially if the intrinsic frequency of the tank and the earthquake's vibration frequency match.

## II. LITERATURE REVIEW

**Vineet Kumar Sahaa and Ashish Nim (2019)**, The research focuses on analytical comparison to support the effectiveness of rectangular water tanks for nominal capacity in terms of material feasibility design utilizing the IS code technique and the approximation method. In several metrics, such as moment, direct tension, and the depth of both vertical walls and slabs, the IS code strategy performed better than the approximate method, according to comparative study. The IS coding technique proved to be both economical and useful throughout design. Levelled ground immediately 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 foundation has no special structural function and can be made with the least quantity of steel required. In addition to offering a thorough construction overview that includes technical and financial assessment 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 utilized in tank construction are steel reinforcement, concrete, and formwork that are developed 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 certain other factors still need to be considered.

Although it is clear that a rectangular water tank requires comparatively more resources to create 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, several other elements still require evaluation.

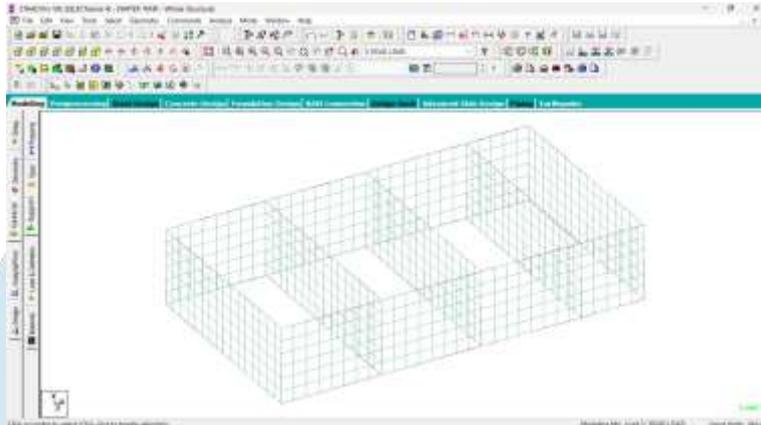
**Himanshu Dwivedi et. al. (2019)**, A circular reinforced cement concrete tank was designed and built for this project by the study's author. A circular water tank is constructed by hand. It was subjected to additional analysis using STAADPRO, the top analysis program. In this project endeavor, the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

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.

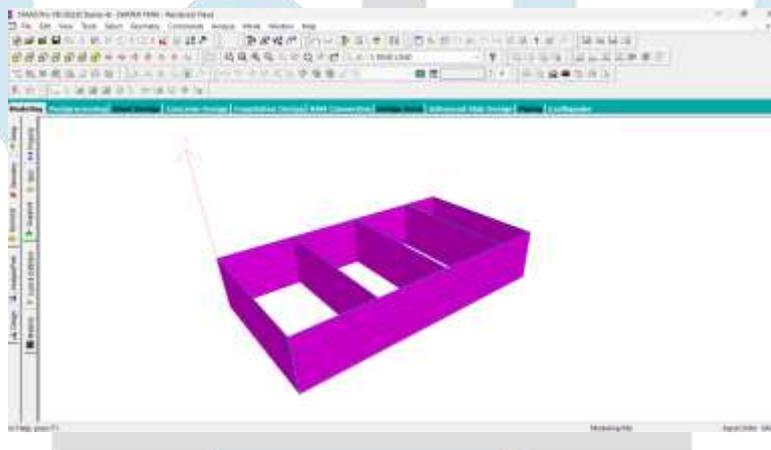
### III. METHODOLOGY

#### Steps of modelling and analyzing in STAAD.Pro

Step 1: Initializing the model of RCC rectangular water tank by using STAAD Pro V8i SS6.



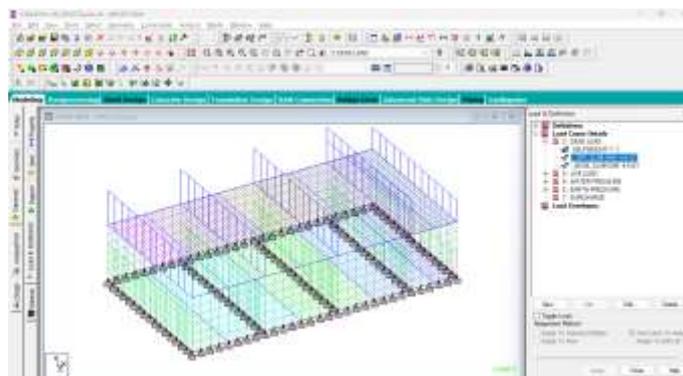
**Fig. 1: Modelling of water tank**



**Fig. 2: 3D model**

Step 2: Assigning fixed support to the whole structure.

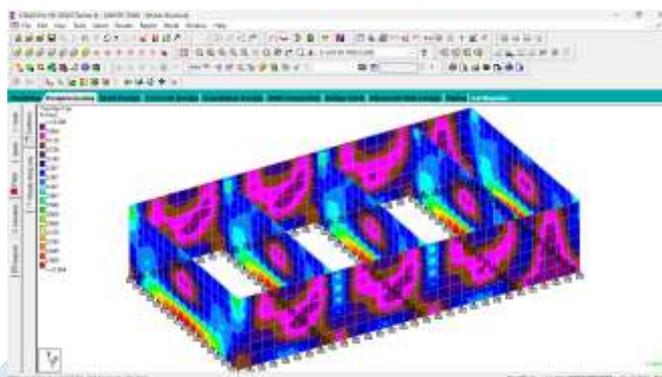
Step 4: providing load data such as dead load, live load, hydrostatic pressure and seismic load to the structure.



**Fig. 3: Assigning load of top slab**

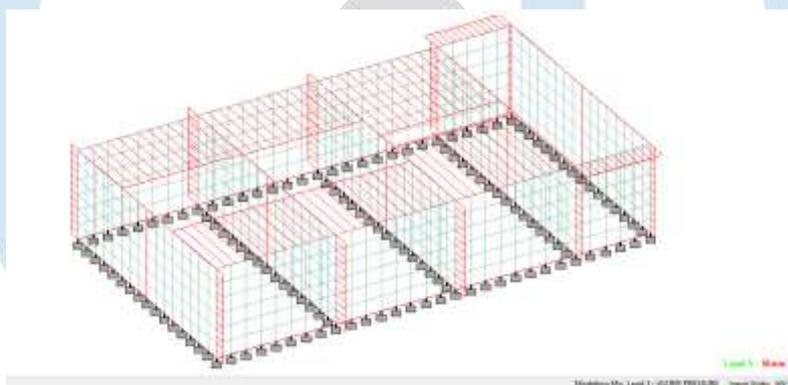
Step 5: providing seismic data to the structure as per IS 1893:2016.

Step 6. checking for base pressure.



**Fig. 5: Base pressure**

Step 6: analyzing the model for dead load, displacement, bending moment, shear force and torsion.



**Fig. 6: Bending moment diagram in Z-direction**

#### IV. PROBLEM IDENTIFICATION

**Table 4.1 Geometrical Specifications of the Rectangular Water Tank**

Particular	Parameters
Capacity of tank	350000 liters
Volume of tank	350cubic meters
Thickness of retaining wall	250mm
Length of the water tank	6m
Width of the water tank	120mm
Height of water tank	14.50m
Thickness of top slab	150mm
Thickness of base slab	150mm

#### Earthquake load (EL)

The earthquake load is considered as per the IS 1893-2002 (Part I). The factors considered are

Zone factor = 0.16 (Zone III)

Importance factor = 1

Response reduction factor = 1

Soil condition = II(medium soil)

Hard soil Damping = 5 %

### V. RESULTS & DISCUSSION

#### Axial force in KN

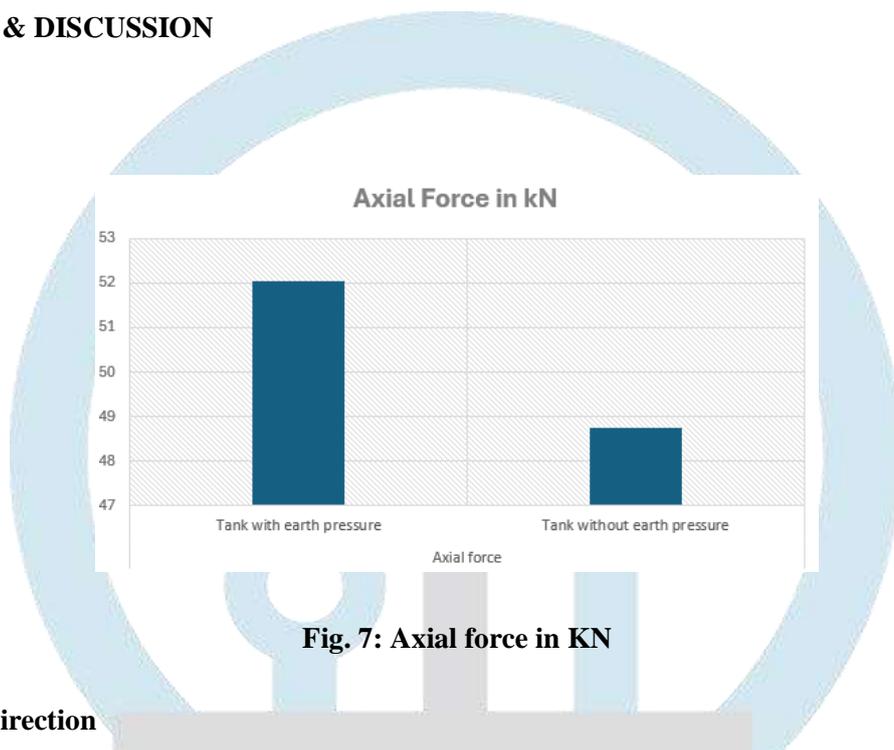


Fig. 7: Axial force in KN

#### Shear force in Y-Direction

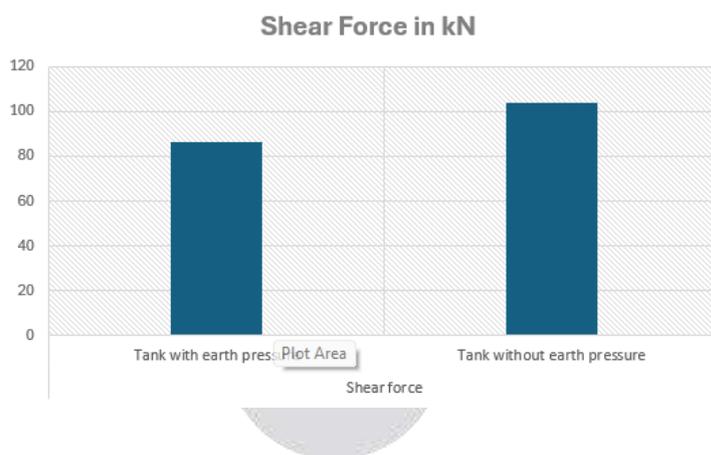


Fig 8: Shear force in KN

#### Torsion in kn-m

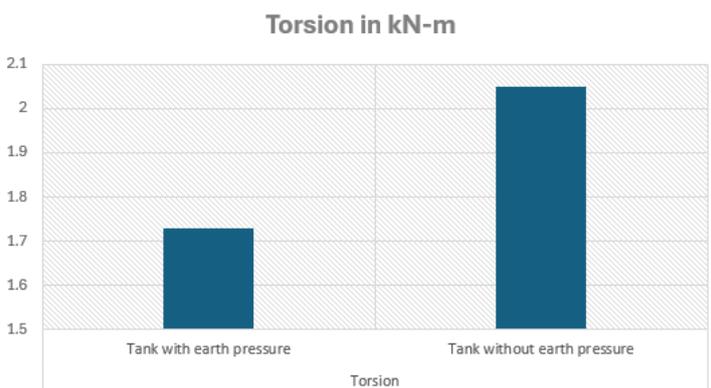
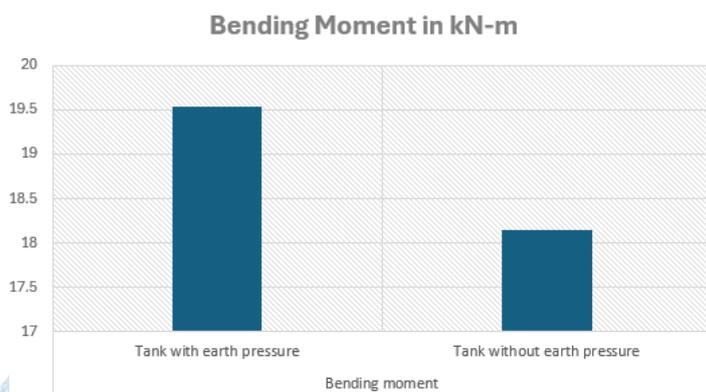


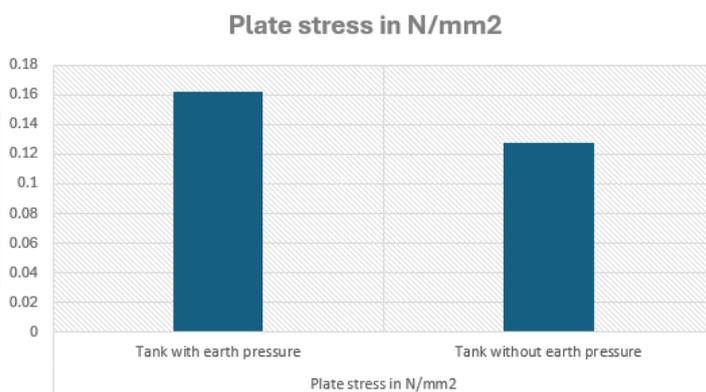
Fig 9: Torsion in kn-m

**Bending moment in Z-Direction**



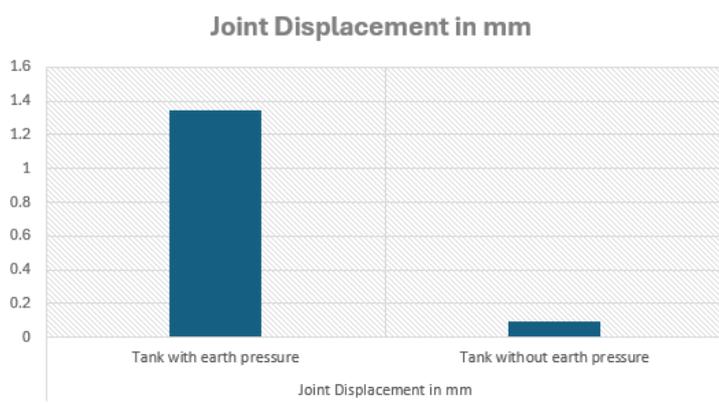
**Fig 10: Bending moment in kn-m**

**Plate stress**



**Fig 11: Plate stress in N/mm2**

**Joint displacement in mm**



**Fig 12: Joint displacement in mm**

**VI. CONCLUSION AND FUTURE SCOPE**

- The primary focus of this section is the research's significant findings. A rectangular overhead water tank of a reinforced concrete building was examined using STAAD Pro V8i SS6 software. Severe seismic zone II is taken into account for the study.

- The result shows how ground pressure has a major impact on the overall force operating on the tank structure, indicating that it should be considered during design and analysis to ensure structural stability and safety.
- This implies that earth pressure reduces the tank structure's shear stress, which may affect structural and design problems. These forces need to be accurately evaluated in order for the design process to be secure and stable.
- Engineers need to be well-versed in the relationship between ground pressure and torsion in order to guarantee the structural integrity of the tank. This will allow them to make designs that are more resilient to the various forces operating on the structure. Engineers need to be well aware of how ground pressure impacts torsion in order to ensure the tank's structural integrity.
- This will enable them to create better designs that effectively offset the various forces acting on the building, enhancing its robustness and security.
- Engineers must carefully consider this additional displacement to ensure that the tank's design can handle such movements and retain durability and safety under a variety of scenarios.
- Engineers must account for this extra stress in order to ensure that the plate can withstand the higher forces and, ultimately, ensure the stability and safety of the tank under a variety of loading conditions.

## VII. REFERENCE

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