ANALYSIS AND DESIGN OF WATER TANK BY USING STAAD PRO

Submitted in partial fulfilment of the requirements

For the degree of

BACHELOR OF ENGINEERING

in

CIVIL ENGINEERING

by

KHAN NURUL HASSAN ZAHIRUDDIN (17CE26)

KHAN MOHD ASAD ABUL WAFA (17CE24)

MD MAKHDOOM RAZA AWAIS ANSARI (17CE32)

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Under the guidance of

Pof. VEDPRAKASH MARALAPALLE

Department of Civil Engineering

School of Engineering and Technology

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New Panvel, Navi Mumbai-410206

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CERTIFICATE

This is to certify that the project entitled **“Analysis and design of water tank by using staad.pro”** is a bona fide work of **khan Nurul Hassan Zahiruddin, khan Mohd Asad Abul wafa, Ansari MD Makhdoom Raza Awais, Khan Mohd Aquib Javed Ahemed** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of “Bachelor of Engineering” in “Civil Engineering”.

Pof. Vedprakash Maralapalle

(Supervisor)

Dr. R. B. Magar

(Head of Department)

Dr. Abdul RazakHonnutagi

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APPROVAL SHEET

This dissertation report entitled **"Analysis and design of water tank by using staad. pro"** by **khan Nurul Hassan Zahiruddin, Khan Mohd Asad Abul wafa, Ansari MD Makhdoom Raza Awais, khan Mohd Aquib Javed Ahemed** is approved for the degree of "Civil Engineering".

Examiners:

1. …………………………

2. …………………………

Supervisors:

1. …………………………

2. …………………………

Date :

Place : Panvel

DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that, we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Khan Nurul Hassan Zahiruddon (17CE26) …………..

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Mohd Aquib Javed Ahmed (17CE34) …………..

Date :

ABSTRACT

Water tank is a structure used to store water for supplying to households as drinking purpose, for industries as a coolant and irrigational water for agricultural farming in some areas. Water tanks are classified on bases of their shapes and position of structure. In this paper, we had discussed about the design of water tanks of overhead circular, overhead rectangular and underground rectangular tanks are designed and analysed using STAAD-PRO. All tanks are designed as crack free structures to eliminate any leakage. From the analysis results concluding about the influence of shape factor in design loads and comparing all types of tanks which is most economical. Manual Analysis and design of Water tanks by using IS code method is compare with STAAD-PRO design result, comparison of reinforcement is done and optimize results are determined. After completion of project we do estimation of all tanks. All water tanks of 5MLD capacity is designed.

Keywords—water tanks, Analysis and design, STAAD-PRO, Load application, Manual calculation

CONTENTS

ABBREVIATION NOTATION AND NOMENCLATURE

L_{eff}	Effective length of slab or beam
A_{SC}	Area of reinforcement in concrete
A_C	Area of concrete
A_g	Gross area of element
P_t	percentage of steel in structure
D	Overall depth of element
d	Effect depth of element
S_v	Spacing of reinforcement
V_c and V_s	shear resistance by concrete and stirrups
C_1	Cracking stress
m	Modular Ratio
j	lever arm constant
k	coefficient of constant
T	Hoop tension
P_n	Ultimate load carried by structures

Chapter 1

Introduction

1.1 General

Water tanks are structures require to contain or exclude water and used for storing drinking potable water. All tanks are designed as crack free structures to eliminate any leakage. Water plays predominant role in day-to-day life, so water storage is not a need it is necessary to store the water. Most municipalities in India have water supply system which depends on elevated water tanks for storage. Elevated water tank is a large elevated water storage container constructed for the purpose of holding a water supply at a height sufficient to pressurize a water distribution system. Water tanks are classified into two types based on position and shape of the tank.

Based on the location the water tanks are classified into three ways:

1) Underground water tanks

2) Tank resting on grounds

3) Elevated or overhead water tanks

Also, the water tanks are classified based on shape:

1) Circular tanks

2) Rectangular tanks

3) Intez tanks

4) Square tanks

1.2 Objective

The main objective of our project is

1. To make a study on analysis and design of three different types of water tanks i.e,
   a) Overhead circular water tank
   b) Overhead Rectangular water tank and
   c) Underground water tank, for 5MLD capacity to all types of tank
2. To carry out the static analysis of the tank finally
3. To know about the design philosophy for the safe and economical design of water tank

1.3 Introduction to STAAD Pro

The STAAD.pro is explained briefly in the section below.

1.3.1 Introduction

STAAD Pro is one of the most widely used structural analysis and design software products worldwide. From model generation, analysis and design to visualization and result verification, STAAD Pro is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more. STAAD Pro features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and static and dynamic analysis capability.

The STAAD Pro Structure Wizard contains trusses, frames and solid model. Use the Structure Wizard to quickly generate models by specifying height, width, breadth and number of bays in each direction. Create any customizable parametric structures for repeated use. Ideal for skyscrapers, bridges and roof structures ect.

STAAD Pro is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was bought by Bentley Systems.

1.3.1 Advantage of STAAD Pro

i. STAAD Pro shows accurate results in the measurement of Shear Force and Bending Moment
ii. STAAD Pro does not involve any manual calculation; hence, it saves time and increases efficiency
iii. STAAD Pro helps the engineers in improving the structure, Section and dimensions
iv. STAAD Pro offers faster methods of designing the structure
v. STAAD Pro is ideal for measuring a wide range of loads such as Live load, Dead Load, Wind Load, Snow Load, Area Load, Hydrostatic load or Floor Load.

1.3.2 Load Types and Generation

i. Categorized load into specific load group types like dead, wind, live, seismic, snow, user defined, etc. Automatically generate load combinations based on standard loading codes such as ASCE etc.
ii. Element pressure loads can be applied along a global direction on any imaginary surface without having elements located on that surface.
iii. In load definition there is a wind definition here we put wind intensity pressure upto certain height of structure then generate load according to ASCE
iv. One way loading to simulate load distribution on one-way slab

Chapter 2

Literature Review

2.1 General

The work done by the various investigators is referred and summarized here in this chapter. The referred journal and conference papers and reports are presented below.

At the end, the research gaps have been reviewed.

2.2 Review of Literature

Issar Kapadia et al. (2017), they have designed underground rectangular water tanks and checked for stability and strength using STAAD Pro software. They considered two cases of different beam section, column section, wall thickness, floor thickness, cover thickness. They had obtained Displacement due to dead load, due to water present in tank, due to external soil pressure, soil pressure around the tank and Deflected shape of the tank due to BM, AF and shear. They had compared the results of those two cases. They found that plastic underground water tanks is a great alternative to concrete tanks. Uplift check must be: dead loads > Uplift loads, Stresses on soil (in case of full tank, just after construction): Must be Stresses on soil < allowable stress, If the criteria are not to be fulfilled or if unsafe then Increase floor thickness, Use plain concrete inside tank (above RC floor), Use plain concrete below RC floor (connected with steel dowels).

Suraj P. Shinde et al. (2018), they have designed underground rectangular water tank in STAAD Pro and 3D view in SAP software and obtain the Deflected shape when tank is full and empty. They found that .If suppose tank having a less dimension then unsatisfied results will be obtained and if we are not chooses the proper section of tank, it will be fail.

Neha. S. Vanjari et al. (2017), they concluded that Elevated water tanks provide head for supply of water. When water has to be pumped into the distribution system at high heads without any pumps for supply however pumps are necessary for pumping only till tank is filled. Once it is stored in tank. The gravity creates the pressure for free, unlike pumps. We need pressurized water to fledge and make taps eject water at an appropriate rate. Elevated tanks do not require continuous operation of pump, as it will not affect the distribution system since the pressure is maintained by gravity. Strategic location of tank can equalize water pressure in the distribution system The pressure of water flowing out of an elevated tank depends upon the depth of the water in tank .A nearly empty tank probably will not provide enough pressure while a completely full tank may provide too much pressure the optimal pressure is achieved at only one depth

.While elevated tank provide can provide the best pressure, they are far more expensive and generally, it is used where supply is high demand Elevated circular water tanks with large capacity and flat bottom needs large reinforcement at the ring beams. To overcome this in intze tank, by providing a conical bottom and another spherical bottom reduces the stresses in ring beams. Intze tank is more economical for high capacity reducing the steel requirement.

Thalapathy.M et al. (2016), they considered overhead, underground, tank resting on ground of different sizes and compared the results. They found that The thickness of cylindrical wall, conical dome and bottom dome of intze water tank are increased due to the considerations of new IS code: 3370-2009 and earth quake forces, the formwork required for the constructions of water tanks is minimum for circular shaped tank as compared to square shaped and rectangular shaped tanks, It is possible to formulate and obtain solution for the minimum cost design for underground rectangular tank.

Mainak Ghosal, (2019), they concluded that Most Finite Element software do not directly compute steel directly from stress resultants in applications that include membrane stresses. But yes, you can design the concrete slab using STAAD Pro, with plate elements and meshing it appropriately. But the best practice is to take the analysis results from the STAAD Pro and do the manual design. The deterioration of modern concrete structures resulted in the inclusion of durability concepts in the recent revision of the Indian codes. Though several factors affect the durability, it was thought that by controlling the crack widths, the durability can be enhanced. In the recent revision an appendix was added to calculate the crack width of flexural and tension member through Limit State Methods. However, due to the complexity of the equations, the design engineers seldom do these calculations. Cracks can be formed due to bending (tension cracks) or due to shear (shear cracks).To prevent tension cracks, provide a bit extra steel than required which we anyways do. To prevent shear cracks, place the stirrups closely near the edges (as maximum shear develops at the edges and hence cracks). As per IS 3370, the crack width has to be limited to 0.2 mm only and not 0.1 mm. Only in aggressive environments we need to limit the crack width to 0.1 mm. Interestingly, as per IS 456, it is enough if we restrict the crack width to 0.3 mm. Clause 35.3.2 of IS 456 also mentions that in liquid retaining structures the crack width should be restricted to 0.2 mm.

M. Ravikanth et al. (2019), they have design overhead circular water tank for different earthquake zone as like **II, III, IV, V.** They found that Design of water tank in zone V is highly expensive. Expect zone V, zone II III, IV have the same similar dimensions for plate thickness, column, beam dimensions with little changes. Other than zone 5 regions, zone 4 can applicable easily for any region of the country. Throughout India these zones are applicable everywhere. Sometimes zone V is also taken in consideration due to high Richter scale values in that area.

W. O. Ajagbe et al. (2018), they study on the analysis and design of a fully submerged underground reinforced concrete water tank using the principle of beam on elastic foundations is reported in this paper. The soil was considered as not totally rigid but acting as a bed of springs, the roof slab was analysed as four sided discontinuous slab while the walls and the base slabs were taken as an entity. Limit state philosophy is utilised for this study because it provides a more rational method for determining safety factor and enables the different failure modes of structures to be identified so that premature form of failure may be prevented. Likewise, it ensured that failure for water structures have low permeability so as to prevent leakage through the concrete and also provide adequate durability and prevention against corrosion of the reinforcement. A Microsoft Excel Spread sheet. Design and Analysis Program (MESDAPro) was generated for quick assessment of various moments of the tank, geometrical features and soil conditions for both full and empty conditions of the tank. It was observed that the moments of wall, wall base and base slab decreases with increase in soil sub-grade modulus at constant capacity, height and breadth of the tank while they increase with increase in height of the tank at constant value of sub-grade modulus, tank capacity and breadth. In all the examined cases, the moments obtained is higher when the tank is considered empty than when considered full. The developed program, MESDAPro facilitates a very quick and accurate analysis and design for reinforced concrete water tanks thereby eliminating tedious and repetitive calculations often encountered by Engineers in practice.

Manoj Nallanathel et al. (2018), they design Underground rectangular, square and circular also overhead circular, overhead rectangular and square .they compared all the stresses results. They concluded that corner stresses and maximum shear and bending stresses are found to be less in case of circular tanks than remaining other designs and the shapes of water tanks plays vital role in the stress distribution and overall economy. By using Staad pro, the results obtained will be very accurate than conventional results. In Underground tank, Uplift pressure plays predominant role in design which is caused by surrounding soil on outside walls of tank. The shape of the tanks plays predominant role in the design of overhead and underground water tanks. Usage of Staad pro in design gives accurate results for shear force and bending moment than convenient method.

Sagar Mhamunkar et al. (2018), they collected data from that area and find out water requirement, and design an intze tank for that area. They concluded that Elevated circular water tank with large capacity and flat bottom needs large reinforcement at the ring beam, to overcome this in intze tank, by providing a conical bottom and another spherical bottom reduces the stresses in ring beams. Intze tank is more economical for high capacity reducing the steel requirement. Per capita demand has been calculated which helped us, to know about the water consumption in residential area and further helped in design the tank. Limit state method was found to be most economical for design of water tank as the quantity of steel and concrete needed is less as compare to working stress method.

Mainak Ghosal (2019) they design overhead circular water tank they consider dead load, live load, wind load along Y direction, wind load along X direction and seismic load is considered.

2.3 Gaps and Findings

The gap in Literature is that they didn't considered Underground Rectangular, Overhead Rectangular and Overhead Circular tanks. Also they designed for small capacities and also no estimation for the underground rectangular, overhead rectangular and overhead circular. So, in this report we consider three reinforced concrete water tanks and compare them using the result of STAAD Pro.

2.4 Summary

In the Literature, it can be found that they considered Underground Rectangular and circular, overhead rectangular and circular water tanks and design it in the STAAD Pro Software. They assumed different thickness of walls, slab thickness, floor thickness and the dimension of column and beams. They designed the overhead tanks in the different seismic zones and compare the result. Limit State Method is most economical for design of water tank as the quantity of steel and concrete needed is less as compare to working stress method. Elevated circular water tank with large capacity and flat bottom needs large reinforcement at the ring beam, to overcome this in intze tank, by providing a conical bottom and another spherical bottom reduces the stresses in ring beams. Intze tank is more economical for high capacity reducing the steel requirement.

Chapter 3

Design Consideration

3.1 Design Requirement of Concrete (IS-3370)

The design of the concrete mix shall be such that the resultant concrete is sufficiently impervious. Efficient compaction preferably by vibration is essential. The grade of concrete should not less than M30 and the minimum quantity of cement in the concrete mix shall be not less than 330 kN/m2. The permeability of the thoroughly compacted concrete is dependent on water cement ratio. Increase in water cement ratio increases permeability while concrete with low water cement ratio is difficult to compact. Other causes of leakage in concrete are defects such as segregation and honey combing. All joints should be made water-tight as these are potential sources of leakage. Structures as it requires that concrete should not crack and hence tensile stresses in concrete should be within permissible limits. Cracking may be caused due to restraint to shrinkage, expansion and contraction of concrete due to temperature or shrinkage and swelling due to moisture effects.

The cement content not included fly ash and ground granulated blast furnace slag in excess of 400kg/m3 should not be used in design to the increased risk of cracking due to drying shrinkage or temperature change. The coefficient of expansion due to temperature change is taken as 11 x 10-6 /° C and coefficient of shrinkage may be taken as 450 x 10-6 for initial shrinkage and 200 x 10-6 for drying shrinkage.

3.2 Joint in liquid Retaining Structure

3.2.1 Movement joints: There are three types of movement joints are following

(i) Contraction Joint: It is a movement joint with deliberate discontinuity without initial gap between the concrete on either side of the joint. The joint is shown in Fig.3.1 (b). .A contraction joint may be either complete contraction joint or partial contraction joint. A complete contraction joint is one in which both steel and concrete are interrupted and a partial contraction joint is one in which only the concrete is interrupted shown in Fig.3.1.

(ii) Expansion Joint: It is a joint with complete discontinuity in both reinforcing steel and concrete. A typical expansion joint is shown in Fig.3.1. This type of joint requires the provision of an initial gap between the adjoining parts of a structure.

(iii) Sliding Joint: It is a joint with complete discontinuity in both reinforcement and concrete and with special provision to facilitate movement in plane of the joint. A typical joint is shown in Fig.3.1.This type of joint is provided between wall and floor in some cylindrical tank designs.

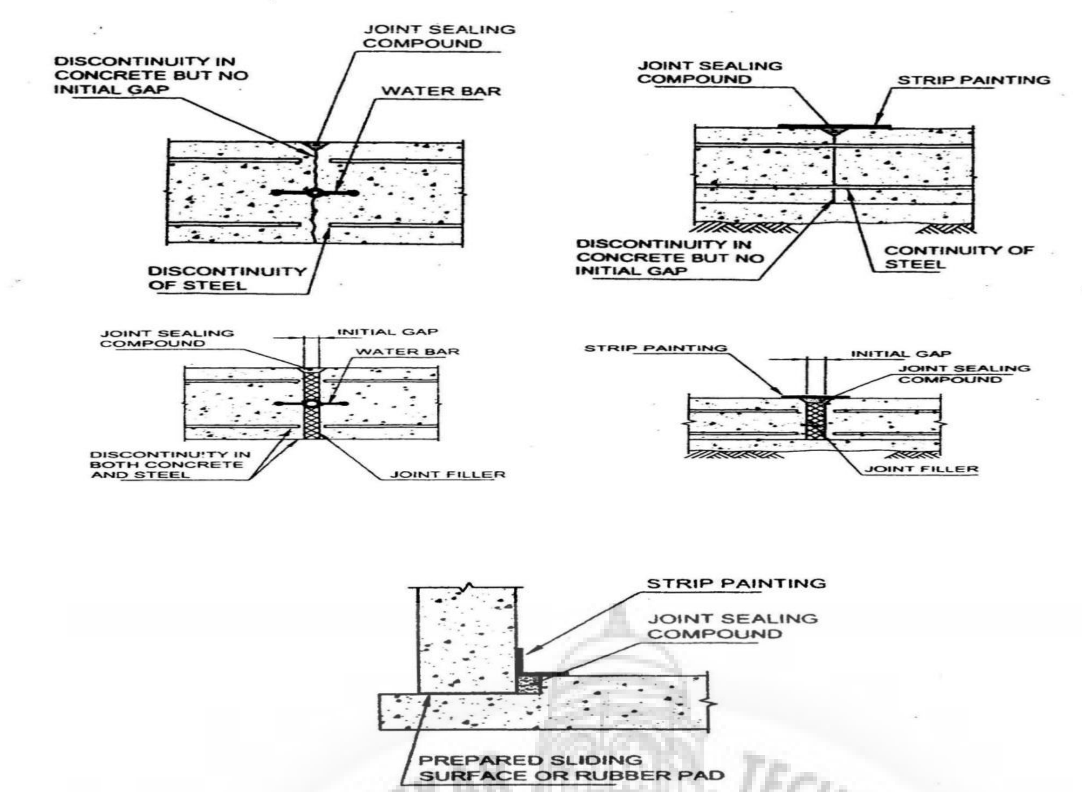


Fig 3.1 Different types of joints

3.2.3 Temporary Joints:

A gap is sometimes left temporarily between the concrete of adjoining parts of a structure which after a suitable interval and before the structure is put to use, is filled with mortar or concrete completely as shown in Fig.3.2 or with suitable jointing materials. In the first case width of the gap should be sufficient to allow the sides to be prepared before filling.

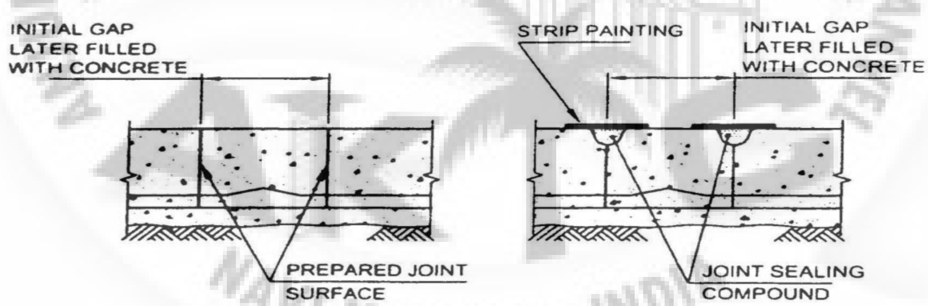


Fig 3.2 Temporary joint

3.3 General Design Requirement (IS-3370)

3.3.1 Permissible Stresses in Concrete:

(a) For resistance to cracking: For calculations relating to the resistance of members to cracking, the permissible stresses in tension (direct and due to bending) and shear shall confirm to the values specified in Table 1.

Table 3.1.Permissible concrete stresses in calculations relating to resistance to cracking.

Grade of concrete	Permissible concrete stress N/mm2		Shear KN/mm2
	Direct tension	Bending	
M30	1.5	2.0	2.2
M35	1.6	2.2	2.5
M40	1.8	2.4	2.7
M45	2.0	2.6	2.9

3.3.2 Permissible Stresses in Steel:

For resistance to cracking: When steel and concrete are assumed to act together for checking the tensile stress in concrete for avoidance of crack.

Table 3.2 Permissible stresses in steel

Type of stress in steel Reinforcement	Permissible stresses N/mm3	
	Plain Round Mild Steel Bars	High Strength Deformed Bars
Tensile stress in members under direct tension, bending and shear	115	130
Compression stress in column subjected to direct load	125	140

3.3.3 Floors:

If the tank is supported on walls or other similar supports the floor slab shall be designed as floor in buildings for bending moments due to water load and self weight. The floor slab may be suitably tied to the walls by rods properly embedded in both the slab and the walls. In such cases no separate beam (curved or straight) is necessary under the wall, provided the wall of the tank itself is designed to act as a beam over the supports under it.

3.3.4 Walls:

The tensile stresses due to the combination of direct horizontal tension and bending action shall satisfy the following condition is given below

$(fct/\sigma ct)+ (fcbt /\sigma cbt) \leq 1$

fct = calculated direct tensile stress in concrete

σct = permissible direct tensile stress in concrete (Table 1)

fcbt = calculated tensile stress due to bending in concrete.

cbt = permissible tensile stress due to bending in concrete.

3.3.5 Minimum Reinforcement:

The minimum reinforcement in walls, floors and roofs in each of two directions at right angles shall have an area of 0.3 per cent of the concrete section. In no case the percentage of reinforcement in any member be less than 0.15% of gross sectional area of the member.

3.3.6 Minimum Cover to Reinforcement:

The minimum cover to all reinforcement should be 25mm or the diameter of the main bar whichever is greater. In the presence of the sea water and soils and water of corrosive characters the cover should be increased by 12mm but this additional cover shall not be taken into account for design calculations.

3.4 Methodology

i. Design 3 types of water tanks with 5MLD capacity and comparing all of them which is economical.
   a) Underground water tank
   b) Overhead circular water tank
   c) Overhead rectangular water tank
ii. In this project we do both manual calculation and software analysis. After that we comparing result and values
iii. Material properties used for all tanks concrete grade should not less than M30 and steel grade Fe 415. Dry density of soil is 16KN/m^3.
iv. Water tank are used to store water for many application like drinking water, irrigation agriculture, fire suppression, chemical manufacturing, etc.
v. Overhead water tank deliver water at constant pressure level. If there is situation of power failure in line with one pump then the water pressure reserves itself at constant level due to gravity.
vi. Underground water tank have capacity to stored large amount of water and it save spacing for other activity on it.

Chapter 4

Design of Water Tanks

4.1 Design of Overhead Circular Water Tank

Overhead water tanks are used for water storage purposes. These tanks come in different shape and size such as circular, rectangular and square etc. overhead water tank have flexible and rigid joints. If there is a situation where power get fail in line with one pump itself, the water pressure reserves itself to a constant level, due to gravity force water can reach to meet the demand of water. Overhead circular water tank is used in many local areas to store water for drinking purpose and it is applicable for large capacity of water demand.

4.1.1 STAAD Pro Design of Water Tank

STAAD Pro is used to design any structure. It give result of maximum bending moment and shear force. It give resultant reaction after analysis of the applied load. It make structure engineer life easy to design any structure.

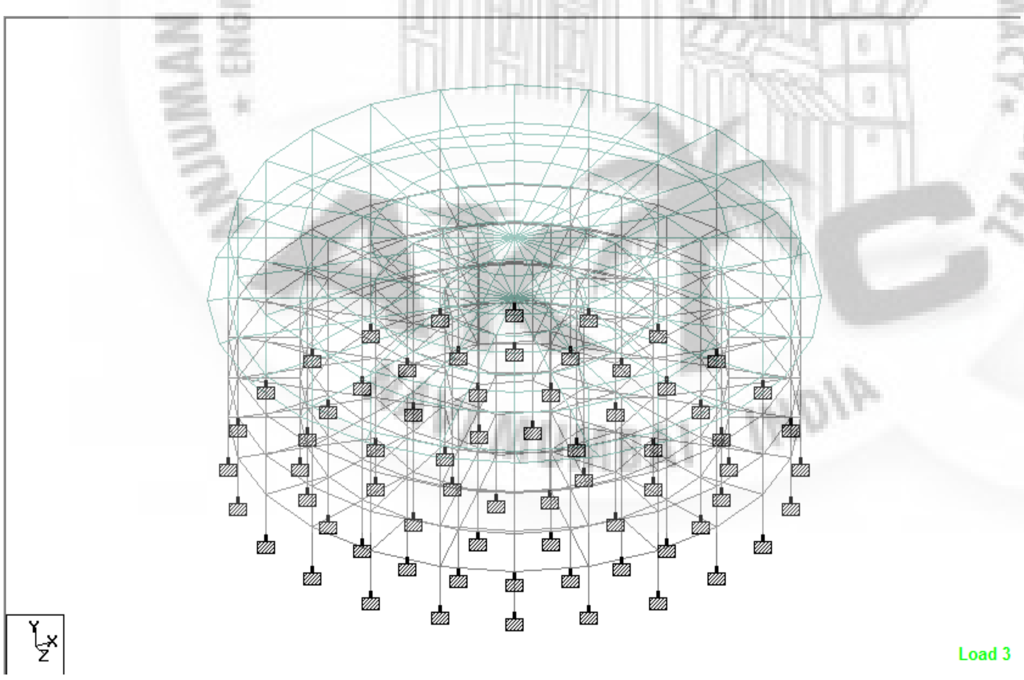


Fig 4.1 Model of overhead circular water tank

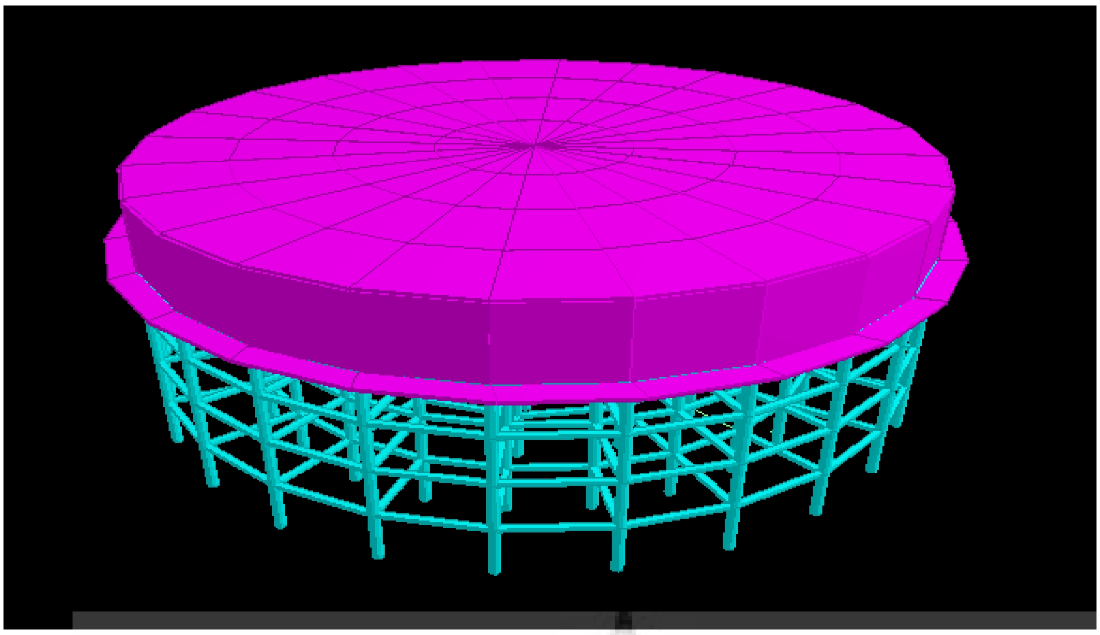


Fig 4.2 3D view of overhead circular water tank

Table 4.1 Design parameter consider for overhead circular water tank

Capacity	5MLD
Grade	M35 and Fe415
Diameter of circular tank	40m
Height of tank from bottom slab	4.5m
Height of one column	3m
Numbers of bay	4
Number of column	68
Overall height	16.5m
Thickness of wall	300mm
Thickness of bottom slab	350mm
Thickness of top slab	300mm
Projection of slap	1.5m
Size of beam	250mm x 300mm
Diameter of column	500mm

4.1.1.1 Loading Combination Consideration for Overhead Circular Water Tank:

- 1.5 (DL + LL + Wx + Generate India code)

4.1.1.2 Result:

Plate stress: refers to the bending of plates due to application of loads on the plates results in the deflection of plates. The stresses in the plate can be calculated from these deflections. Once the stresses coming on plates are known, then failure theories can be applied to determine whether these plates will fail under a given load or not. Below figures shows stress contouring on plates which is obtained after analysis in STAAD Pro shows in different colours for different values of stresses on plates.

Total unfactored weight of the structure obtain after analysis is 31438.191KN.

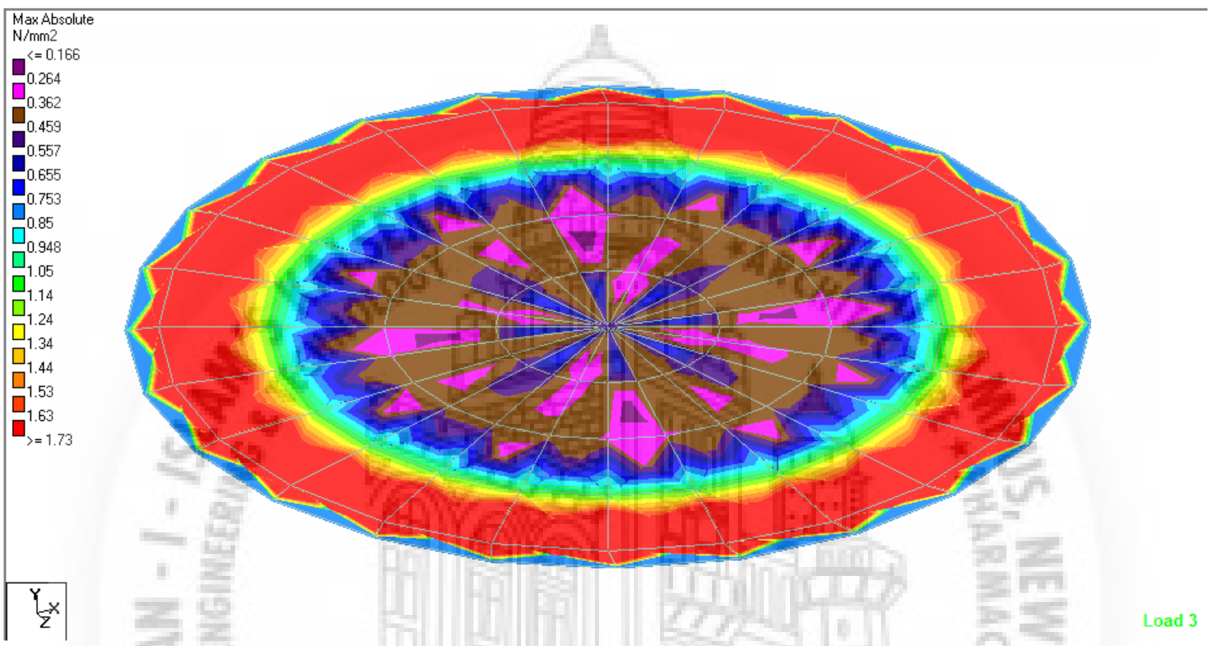


Fig 4.3 Plate stresses on bottom plate of circular water tank

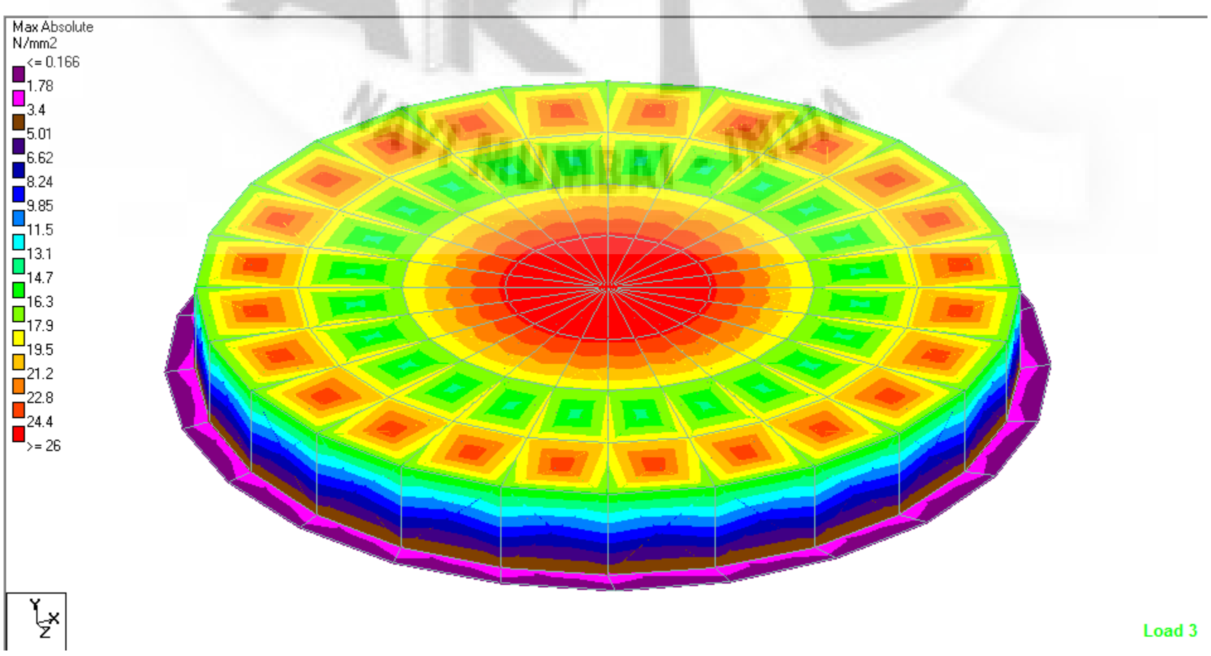


Fig 4.4 Plate stresses on circular water tank

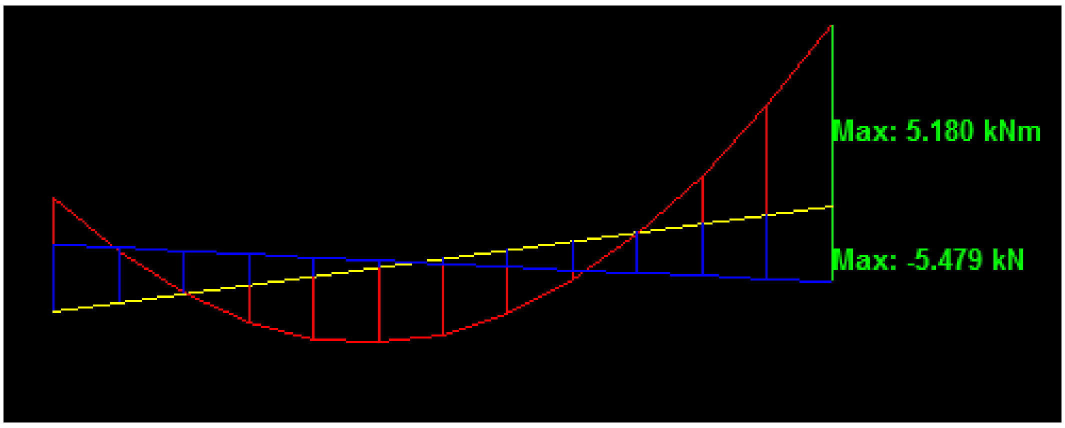


Fig 4.5 Maximum share force and bending moment act on one beam member

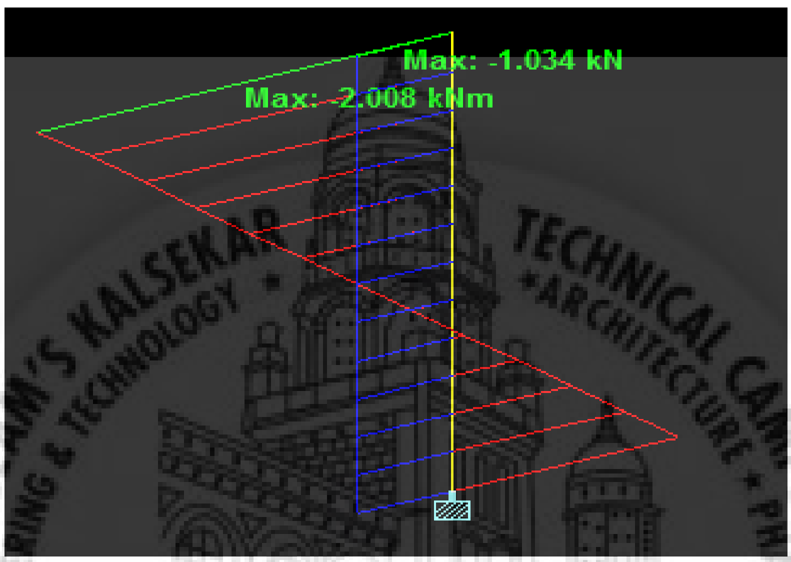
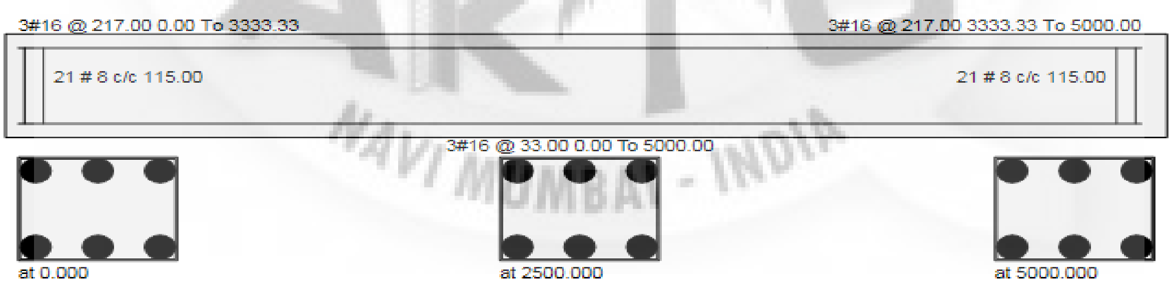


Fig 4.6 Maximum share force and bending moment on column

STAAD.Pro Query Concrete Design

Beam no. 121

Design Code: IS-456



Design Load

Mz(Kn Met)	Dist.et	Load
7.680000	0.000000	4
-4.540000	0.000000	3
-7.900000	5.000000	3

Design Parameter

Fy(Mpa)	415.000000
Fc(Mpa)	35.000000
Depth(m)	0.250000
Width(m)	0.300000
Length(m)	5.000000

Fig 4.7 Cross section of beam obtain after analysis in STAAD Pro

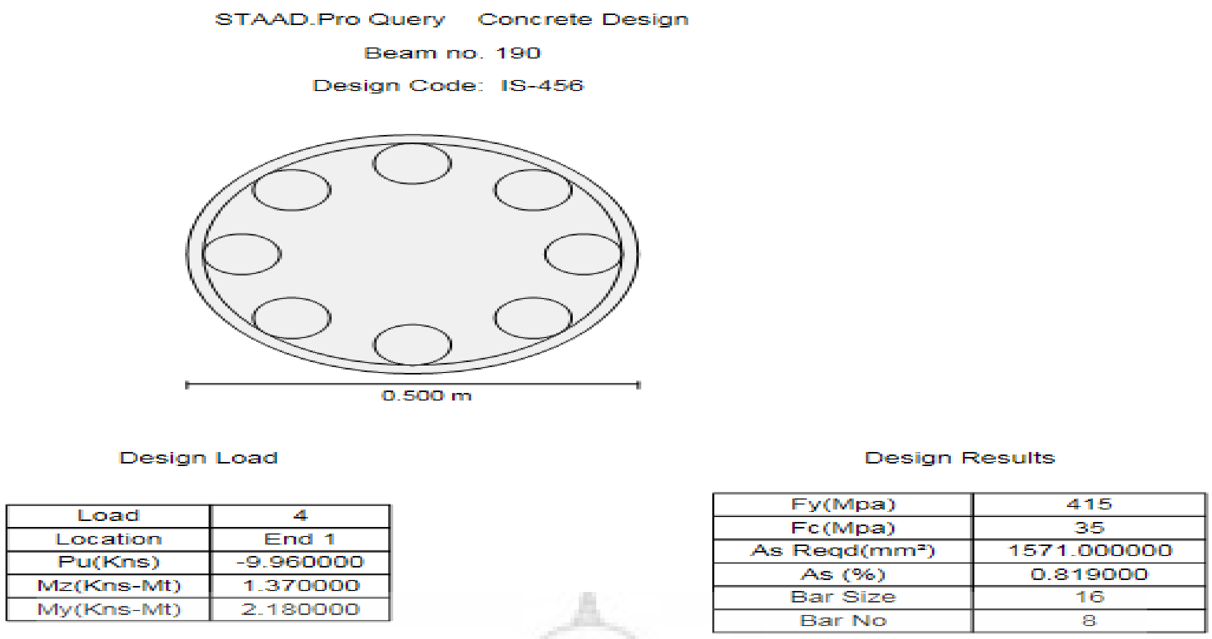


Fig 4.8 Cross section of column obtain after analysis

Table 4.2 Local shear stress and bending moment value obtain after analysis

L/C		Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	Loads	0	-35158.307	0	-144.365	0	-1355.239
	Reactions	0	35158.307	0	144.372	-0.025	1355.239
	Difference	0	0	0	0.007	-0.025	0
2	Loads	0.002	-55904.82	0	0.086	-0.024	0.096
	Reactions	-0.002	55904.82	0	-0.086	0.024	-0.096
	Difference	0	0	0	0	-0.001	0
4	Loads	691.755	0	923.425	2770.277	61.858	-2558.841
	Reactions	-691.755	0	-923.425	-2770.277	-61.858	2558.842
	Difference	0	0	0	-0.001	0	0.001

4.1.2 Manual Calculation of Overhead Water Tank

Step 1:- Design of tank wall:

Grade of concrete M35

Grade of steel Fe 415

Let consider flexible joint between wall and slab

Let consider capacity of tank (V) = 5MLD (5000 m3)

Let consider height of tank (h) = 4.5m

Put above value we find diameter of tank (D)

We have $V = \pi /4 \times D^2 \times h$

We get D = 40M

Pressure intensity at bottom of cylindrical wall (P) = $\gamma_w \times h = 10 \times 4.5 = 45$K N/m^2

Hoop tension = PD/ 2 = 45 ×40/2 = 900KN/m^2

∴ Ast_{req}= 900000 / 130 = 6923.07 mm^2 .....(Stress in tension =130 from table no 4.2)

Spacing of 12 mm diameter bars

Spacing = $\pi /4 \times 12^2 \times 1000/ 6923.07 = 16.33$ mm

∴ $Ast_{provide} = \pi /4 \times 12^2 \times 1000/ 16.33 = 6925.74$ mm^2

Provide 12 mm φ bars @110 mm centre near each face at $Ast_{provide}$ = 6925.74mm^2

Thickness of wall

$C_t = \{T / [1000\ t + (m-1)Ast]\}$ N/mm2 < 1.6

$\{900000 / [1000t + (8-1) \times 6923.07]\} < 1.6$ N/mm2

∴ 514.03 < t

Provide t = 520 mm

Distribution steel:

∴ Ast_{min} = (0.30/100) × 1000 ×520 = 1560mm^2

Spacing of 8 mm φ bars = 50 ×1000 /1560 = 32.05mm

$Ast_{provide}$ = 50 × 1000 / 32.05 = 1560.06 mm^2

Provide 8 mm φ bars @ 100 mm centre near each face at vertical direction

DL load of wall = 0.520 × 25 = 13 KN/m^2

FL load of wall = 1 KN/m^2

Total DL load = 14KN/m^2

Weight of water = $\pi /4 \times 40^2 \times 4.5 \times 10$ = 55474.24KN

Step 2:- Design Constants

According to IS 3370 (part 2) Table 2&Table 4

σ_{cbc} = 11.66Mpa , σ_{st}= 130Mpa

$m = \frac{280}{3\sigma cbc} = \frac{280}{3\times11.66} = 8$

$k = \frac{m\,\sigma cbc}{m\,\sigma cbc+\sigma st} = \frac{8\times11.66}{8\times11.66+130} = 0.41$

$j = 1-(\frac{k}{3}) = 1 - (\frac{0.41}{3}) = 0.86$

$Q_{bal} = \sigma_{cbc}kj/2 = 11.66\times0.41\times 0.86/2 = 2.055$

Step 3:- Design of top slab:

Assume thickness of slab t_1 = 300mm

Ast_{min} = 0.30% × 1000 × 300 = 900 mm^2

Provide 12mm φ bar

Spacing = π /4 × 12^2 ×1000/ 900 = 125.66 mm

Provide 12mm φ bar @ 130mm centre near each face

DL for top slab = 0.300 × 25 = 7.5KN/m^2

Finish load = 1 KN/m^2

Total DL load = 8.5KN/m^2

Step 4:- Design of bottom slab:

i. Load from cylindrical wall = π ×40× (4.5- 0.300) ×14= 7389.02KN
ii. Load from top slab = π /4 × 40^2 ×8.5 = 10681.41KN
iii. Load from weight of water = 55474.24KN

DL for top slab = 0.350 × 25 = 8.75KN/m^2

Finish load = 1 KN/m^2

Total DL load = 9.75KN/m

Total upward force on beam = 73544.67KN

h^2 /Dt = 4.5^2/ (40 x 0.350) = 1.44

Corresponding to h = 4.5m we get depth from bottom slab is 0.9h as per IS 3370 (3)

Corresponding to h^2/Dt and 0.9h from table 9 of IS 3370 Part 3

k = 0.020

Assume slab thickness t_2 = 350mm

Bending moment :- $M = k \times \gamma_w \times h^3 = 0.020 \times 10 \times 4.5^3$

M = 18.225KNm

Equating M.R to B.M $M = Q_{bal} \times bd^2$

$18.225 \times 10^6 = 2.055 \times 1000 \times d^2$

$d = 94.17mm < d_{provided} = 320mm$ ...safe O.K

$A_{st, required} = M / (\sigma st\ j\ d) = 18.225 \times 10^6 / (130 \times 0.86 \times 0.320) = 509419.72\ mm^2$

Ast = [0.30/100] × 350 × 1000 = 1050mm²

Spacing = $\pi /4 \times 12^2 \times 1000/ 1050 = 107.71$ mm = 100 mm

Provide 12mm φ bar @ 100mm centre near each face

Load from bottom slab = $\pi /4 \times 40^2 \times 9.75 = 12252.21$KN

Assume beam size 250mm x 300mm

DL of beam = 0.250 × 0.30 × 25 = 1.875KN/m²

Step 5:- Design of circular column:

Ultimate load carried by column is given by

$P_u = 0.4F_{ck}\ A_c + 0.67\ F_y\ A_{sc}$ .....eq 1

$P_u = 1.5\ (1.875 + 9.75 + 14 + 8.5) = 51.18KN/m^2$

$A_g = A_c + A_{sc}$

A_g = gross area of column

A_c= concrete area

A_{sc} = steel area

We assume $A_{s\ c}$ = 1% of A_g and $A_c = 0.99A_g$

Put all above value in equation 1 we get gross area of column

$51.18 \times 1000 = 0.4 \times 35 \times 0.99A_g + 0.67 \times 415 \times 0.01\ A_g$

$A_g = 3075.62\ mm^2$

$A_g = \pi /4 \times d^2$

$3075.62 = \pi /4 \times d^2$

d = 600mm

Diameter of circular column is 600mm

4.2 Design of Underground Rectangular Water Tank

Underground water storage is ideal for those who want to economize space. In some case, property owners have built modular structure on top of an underground tank. Underground water tanks is higher cost as compare to overhead water tank. It can be difficult to find crack formed in the tank after installation of tank. Underground tank is used for large capacity of water demand.

4.2.1 STAAD Pro Design of Water Tank:

STAAD Pro is used to design any structure. It give result of maximum bending moment and shear force. It give resultant reaction after analysis of the applied load. It make structure engineer life easy to design any structure.

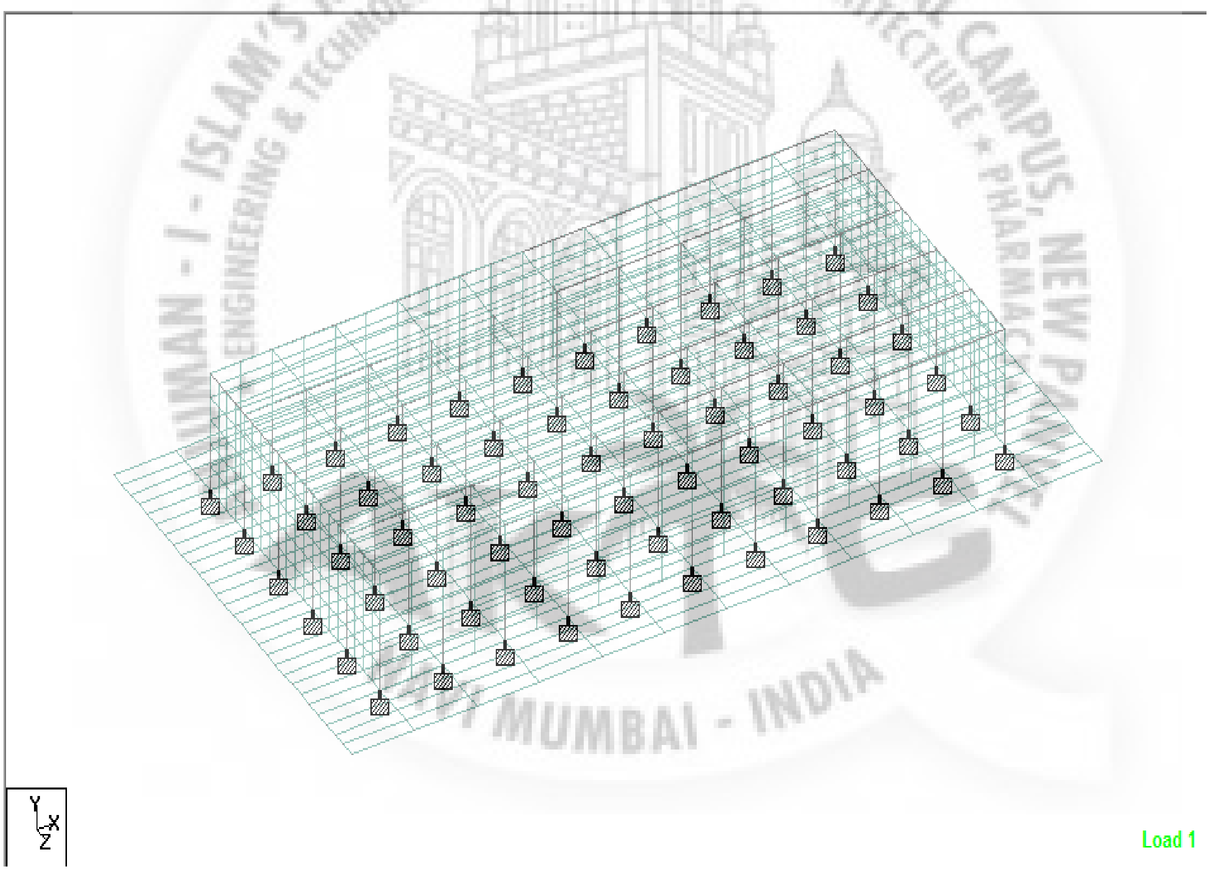


Fig 4.9 Model of underground rectangular water tank

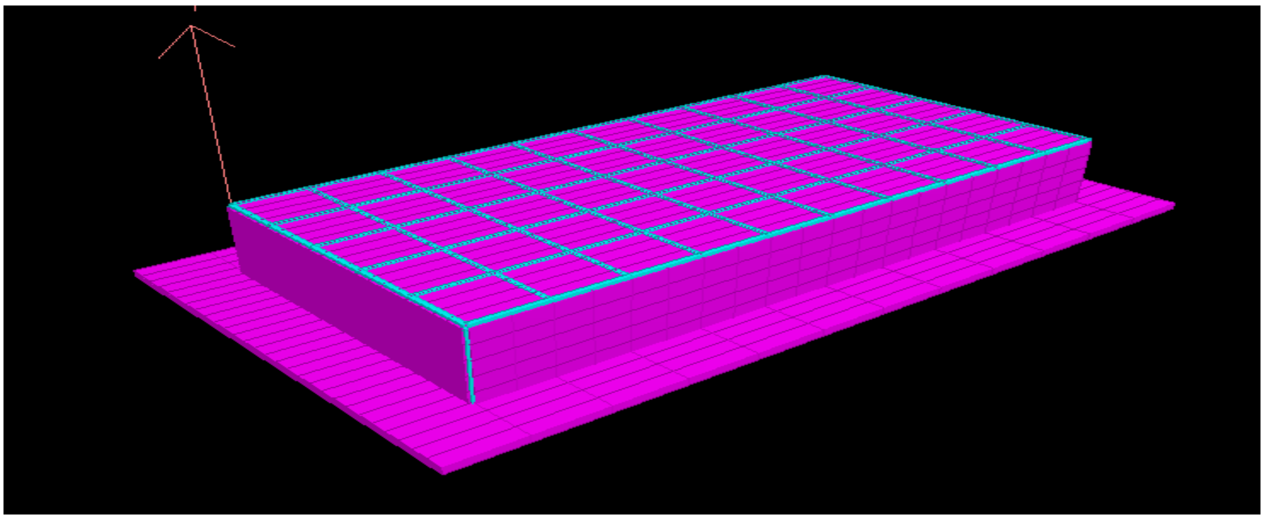


Fig 4.10 3D view of underground rectangular water tank

Table 4.3 Design parameter consider for underground water tank

Capacity	5MLD
Grade	M40 and Fe415
Size of water tank	45m x 21m x 5.8m
Height of tank from bottom slab	5.8m
Height of one column	5.8m
Number of column	50
Overall height	6.7m
Thickness of wall	500mm
Thickness of bottom slab	600mm
Thickness of top slab	300mm
Projection of slap	3m
Size of beam	300mm x 450mm
Size of column	300mm x 300mm

4.2.1.1 Loading Combination Consideration for Underground Rectangular Water Tank:

- (DL + LL + Generate Indian code)

4.1.1.2 Result:

Plate stress: refers to the bending of plates due to application of loads on the plates results in the deflection of plates. The stresses in the plate can be calculated from these deflections. Once the stresses coming on plates are known, then failure theories can be applied to determine whether these plates will fail under a given load or not. Below figures shows stress contouring on plates which is obtained after analysis in STAAD Pro shows in different colours for different values of stresses on plates.

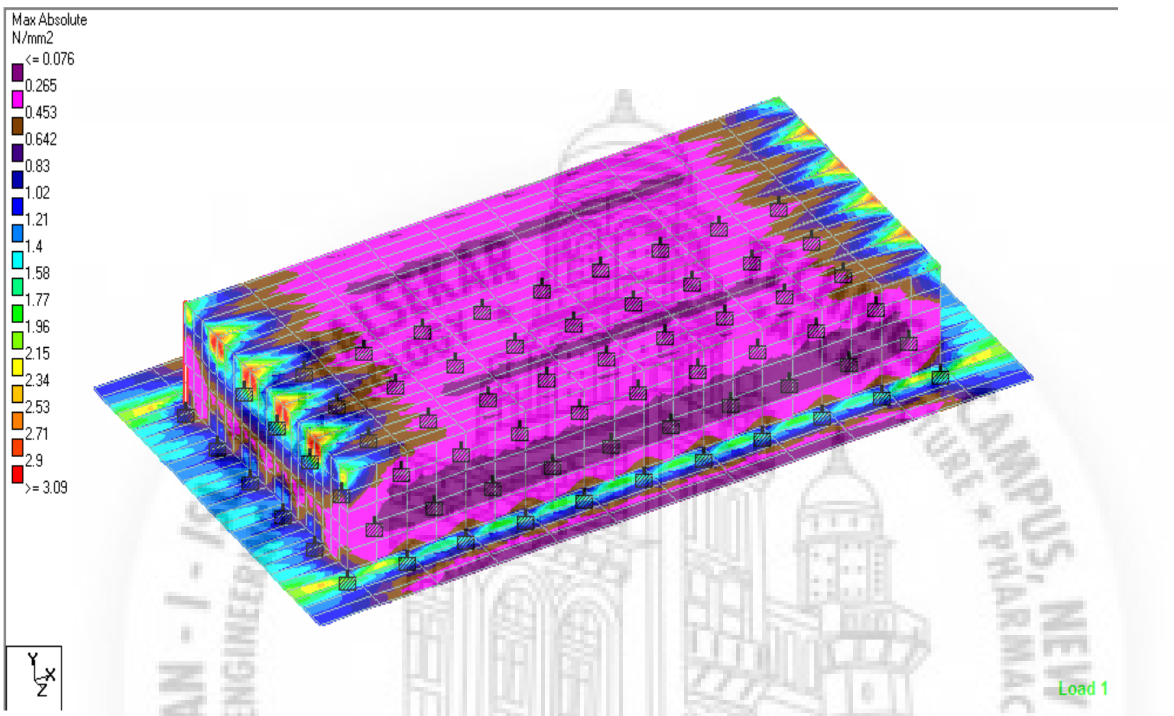


Fig 4.11 Plate stresses on underground rectangular water tank

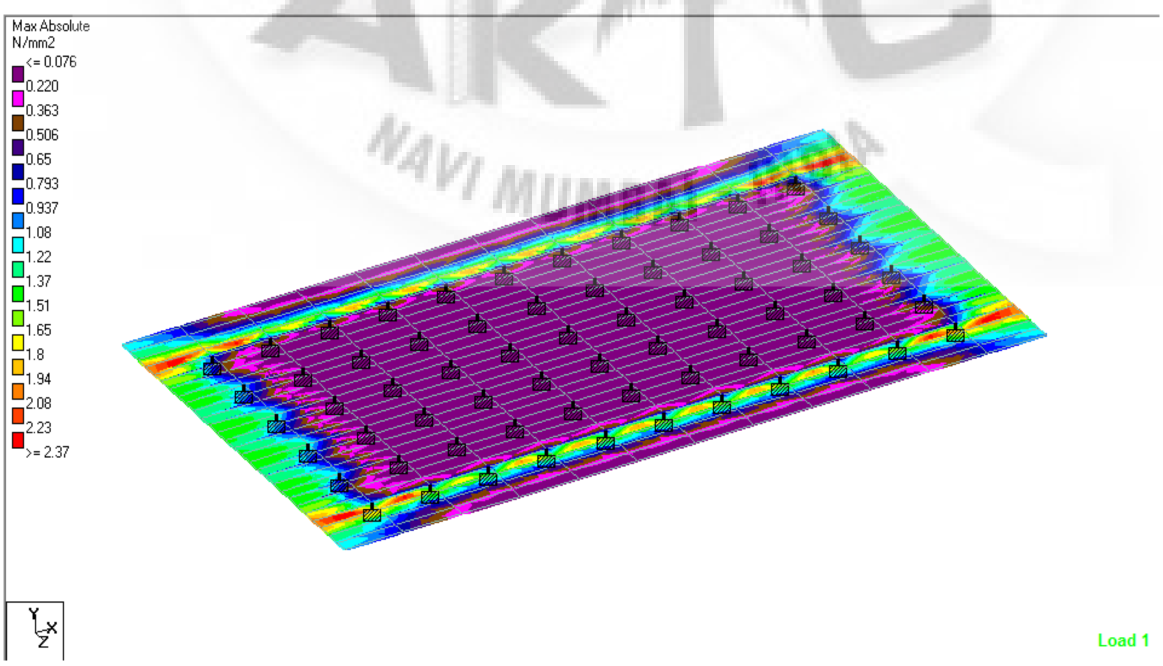


Fig 4.12 Plate stresses on bottom of underground water tank

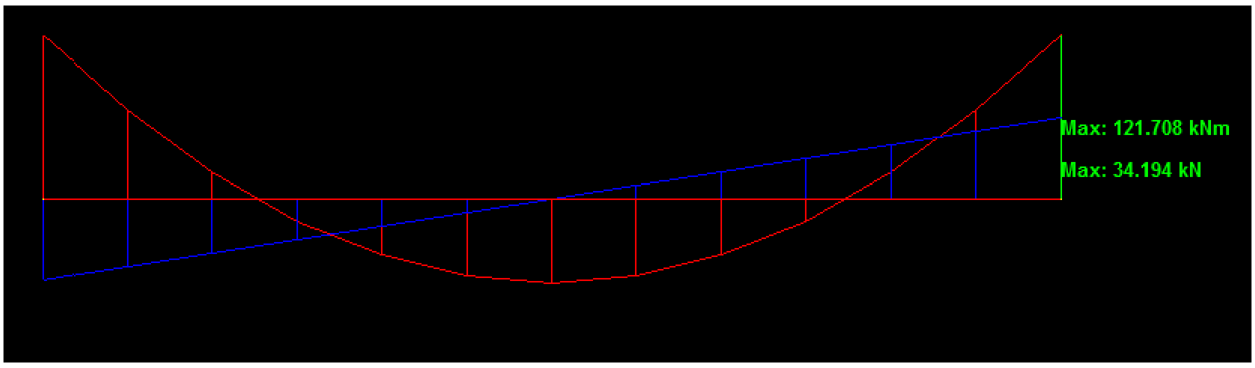


Fig 4.13 Maximum SF and BM diagram of beam

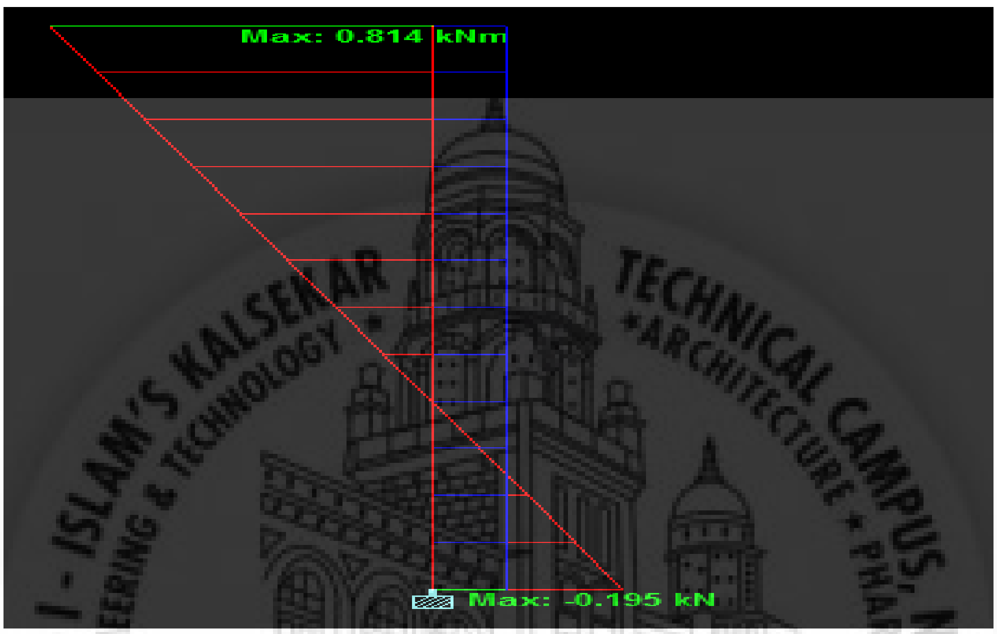
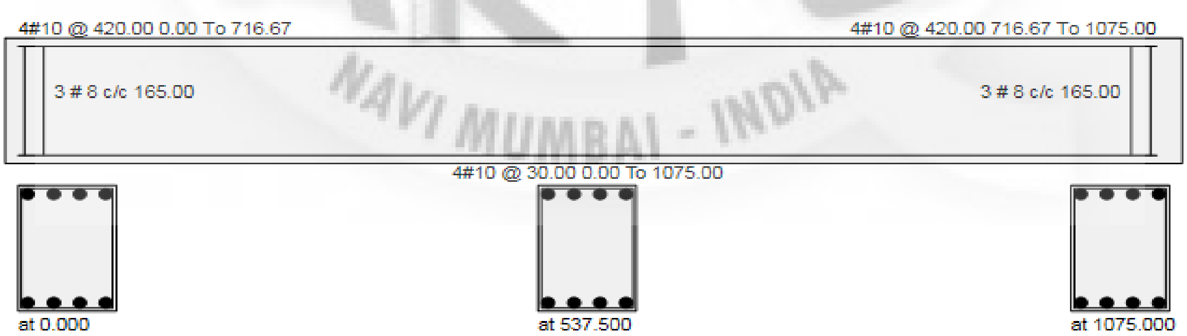


Fig 4.14 Maximum SF and BM diagram of column

STAAD.Pro Query Concrete Design

Beam no. 998

Design Code: IS-456



Design Load

Mz(Kn Met)	Dist.et	Load
26.980000	0.300000	4
-1.540000	0.300000	3
-2.090000	1.100000	3

Design Parameter

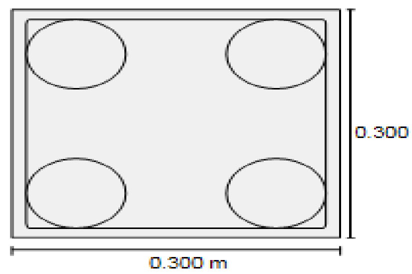
Fy(Mpa)	415.000000
Fc(Mpa)	40.000000
Depth(m)	0.450000
Width(m)	0.300000
Length(m)	1.074999

Fig 4.15 Cross section of beam in underground water tank

STAAD.Pro Query   Concrete Design

Beam no. 793

Design Code: IS-456



Design Load

Load	4
Location	Long Col
Pu(Kns)	44.340000
Mz(Kns-Mt)	0.550000
My(Kns-Mt)	3.670000

Design Results

Fy(Mpa)	415
Fc(Mpa)	40
As Reqd(mm²)	142.000000
As (%)	0.503000
Bar Size	12
Bar No	4

Fig 4.16 Cross section of column in underground water tank

Table 4.4 Local shear stress and bending moment value obtain after analysis

L/C		Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	Loads	0	-49428.46	0	531.05	0	-1.1206
	Reactions	0	49428.46	0	-531.05	0	1.1206
	Difference	0	0	0	0	0	0
2	Loads	0	-59673.264	0	641.05	0	-1.3606
	Reactions	0	59673.264	0	-641.05	0	1.3606
	Difference	0	0	0	0	0	0
3	Loads	0	0	0	0	0	0
	Reactions	0	0	0	0	0	0
	Difference	0	0	0	0	0	0

4.2.2 Manual Calculation of Underground Rectangular Water Tank

Step 1:- Design of walls

Grade M40 and Fe 415

Capacity V = 5MLD height of tank (H) = 5.8m

Case 1: When tank is full

Maximum soil pressure = $K_a \times \Upsilon_d \times h = \frac{1-\sin\Phi}{1+\sin\Phi} \times \Upsilon_d \times h = \frac{1-\sin 30}{1+\sin 30} \times 16 \times 5.8 = 30.93 kN/m^2$

Maximum water pressure = Υ_w x H = 10×5.8 = 58kN/m^2

Net max. pressure = 58-30.93 = 27.07kN/m^2

Max BM producing tension away from the water side

$Ph^2/33.5 = 27.07 \times 5.8^2/33.5 = 27.18 kNm$

Max BM producing tension near the water face

$Ph^2/15 = 27.07 \times 5.8^2/15 = 60.71 kNm$

Case 2: When tank is empty

Max soil pressure = 30.93kN/m^2

Max BM producing tension near the water face

$Ph^2/33.5 = 30.93 \times 5.8^2/33.5 = 31.06 kNm$

Max BM producing tension away from the water side

$Ph^2/15 = 30.93 \times 5.8^2/15 = 69.37 kNm$

Case	BM producing tension on water face	BM producing tension away from water face
Case 1	60.71kNm	27.18 kNm
Case 2	31.06 kNm	69.37 kNm

Outer wall must be designed from cracking stress consideration.this stress must be limited to 1.8N/mm^2

$M.R = \frac{1}{6} f b D^2 = \frac{1}{6} \times 1.8 \times bD^2 = 0.3 bD^2$

$69.37 \times 10^6 = 0.3 \times 1000 D^2$

D = 480.87mm

Provide D = 500mm

D =500-50 = 450mm

Ast for 60.71kNm = $\frac{60710000}{130 \times 0.86 \times 450}$ = 1206.72mm^2

Provide 16mm Φ bars@160mmC/C. (1407.43 mm^2)

Ast for 69.37kNm = $\frac{69370000}{130\times0.86\times450}$ = 1378.85 mm^2

Provide 16mm Φbars@140mmC/C. (1407.43 mm^2)

Check for cracking stresses

Position of actual NA

$(1000x^2/2) + (7.18-1)1407.43(x-50) = \{1000(500-x)^2/2] + (7.18-1)1407.43(500 - x-5)$

X = 250mm

Cracking stress due to BM of 69.37kNm

Total Tension = $1000\times250\times\frac{C1}{2} + (7.18)1407.43\times\frac{200}{250}C1$ = 131958.33C1 N

Equating MR to BM

$131958.33C1\times 0.82 \times 450 = 69.37\times10^6$

C1 = 1.42N/mm^2<1.8 N/mm^2

Cracking stress due to BM of 60.17knm

Total Tension = $1000\times 250 \times\frac{C1}{2}+(7.18-1)\times 1407.43 \times\frac{200}{250}C1$ = 131958.3C1N

$131958.3C1\times 0.82 \times 450 = 60.71\times10^6$

C1= 1.25N/mm^2<1.8 N/mm^2

Distribution Steel

Ast = 0.35× 1000 × 450/100 = 1575mm^2

Provide 12mm Φbars@70mm c/c.

Design of Roof Slab

Lx = 4.3m ly = 4.55m

$\frac{ly}{lx} = \frac{4.55}{4.3}$ = 1.06<2 Two way slab

Assume d = $\frac{leff}{26\times1.4} = \frac{4300}{26\times1.4}$ = 118.13mm

D =118.13+50 = 168.13mm

Provide D =170mm & d =120mm

Loads on slab

Self weight =0.17× 25 = 4.25kN/m

LL = 5kN/m

W = 9.25kN/m

Using case 4 of Table 26 of IS 456

α^+_x= 0.0506 α^-_x= 0.038

$\alpha^{+}_{y} = 0.047$ $\alpha^{-}_{y} = 0.035$

$M^{+}x = \alpha^{+}_{x} \times w \times lx^2 = 0.0506 \times 9.25 \times 4.3^2 = 8.65kNm$

$M^{-}x = \alpha^{-}_{x} \times w \times lx^2 = 0.038 \times 9.25 \times 4.3^2 = 6.5$ kNm

$M^{+}y = \alpha^{+}_{y} \times w \times lx^2 = 0.047 \times 9.25 \times 4.3^2 = .8.04$ kNm

$M^{-}y = \alpha^{-}_{y} \times w \times lx^2 = 0.035 \times 9.25 \times 4.3^2 = 6$ kNm

Design Constants Calculation

Consider tank of size 45m×21m×5.8m

Required volume = 45×21×5.8 = 5481m^3

M40/Fe415, Υ_d =16kN/m^3

According to IS 3370 (part 2) Table 2 & Table 4

$\sigma_{cbc} = 13$Mpa , $\sigma_{st} = 130$Mpa

$m = \frac{280}{3\sigma cbc} = \frac{280}{3\times13} = 7.18$

$k = \frac{m\sigma cbc}{m\sigma cbc+\sigma st} = \frac{7.18\times13}{7.18\times13+130} = 0.42$

$j = 1-(\frac{k}{3}) = 1-(\frac{0.42}{3}) = 0.86$

$Q_{bal} = \sigma_{cbc}kj/2 = 13\times0.42\times 0.86/2 = 2.35$

Check for Flexure

$M = Qbal \times b \times d^2$

$8.65\times10^6 = 2.35\times 1000 \times d^2$

D = 60.67mm <120mm …..Safe

Calculation of Reinforcement

Along short span (4.3m)

dx =170-50 =120mm

dy = 170-50-8/2 = 111mm

At Bottom:

$Ast,req = \frac{M}{\sigma st\ jd} = \frac{8650000}{130\times0.86\times120} = 644.75mm^2$

Use 10mmΦbars@120mm C/C

At top:

$Ast,req = \frac{6500000}{130\times0.86\times120} = 484.5mm^2$

Use 10mmΦbars@160mm C/C

Along Long Span (4.55m)

At Bottom:

Ast,req = $\frac{8040000}{130 \times 0.86 \times 111}$ = 647.88 mm^2

Use 8mmΦbars@70mm C/C

At Top:

Ast,req = $\frac{6000000}{130 \times 0.86 \times 111}$ = 483.49 mm^2

Use 8mmΦbars@100mm C/C

Step 2:- Design of Bottom Slab

Case 1: When tank is full

Consider 1m run of the tank

Weight of roof slab:

22× 0.17 × 25=93.5kN/m

Walls:

2× 0.5 × 21 × 25 =525kN/m

= 618.5KN/m

Net Upward reaction = 618.5/36 = 17.18 kN/m^2

BM at centre due to the above loading = 309.25(10.75-9) = 541.19kNm

producing tension on the water side

total BM at the centre = 541.19+60.71= 601.9kNm

producing tension on the water side

BM at the end Hogging BM = 60.71kNm

Sagging BM = 17.18×7.5^2/2 = 483.18kNm

Net BM = 483.18-60.71 = 422.47kNm

producing tension on water side

Case 2: When the tank is empty

BM at centre due to vertical loads = 541.19kNm

producing tension on the water side

BM due to soil pressure on the vertical walls = 69.37kNm

producing tension away from water side

Net BM at the centre = 541.19-69.37 = 471.82kNm

producing tension away from the water side

BM at the end = 483.18+69.37 = 552.55kNm

Producing tension away from the water side

Case	BM at end section (kNm)	BM at mid span(kNm)	BM produces tension
Case 1	422.47	601.9	On water side
Case 2	552.55	471.82	Away from water side

Let the thickness of base slab is D mm

From cracking stress consideration

$0.3bd^2 = 0.3\times1000\times D^2 = 601.9\times10^6$

D =1416.45mm

Provide D =1450mm

d=1450-50 =1400mm

Steel for BM of 552.55kNm

Ast $=\frac{55250000}{130\times0.86\times1400} = 3530.22mm^2$

Provide 16mmΦ bars@50mm c/c.(3619.11 mm^2)

Steel for a BM of 601.9kNm

Ast $=\frac{601900000}{130\times0.86\times1400} = 3845.51\ mm^2$

Provide 16mmΦbars@50mm c/c(4021.24 mm^2)

Step 3:- Design of Beams

Beam along longer direction

Load=2×Trapezoidal Area = $2\times \frac{wLx}{3}[1-\frac{1}{2\beta}] = 2\times \frac{9.25\times4.3}{3}[1-\frac{1}{2\times1.06}]$ = 14kN/m

Assume D = 450mm ……. (excusive of self weight)

Self weight of beam = 25×0.3×0.4 5= 3.375kN/m

UDL = 14+3.375 = 17.375kN/m = 20kN/m

BMmax = $20\times4.55^2/8$ = 51.76kNm

$M = Qbal\times bd^2$

$51.76\times10^6 = 2.35\times300\times d^2$

d = 271.53mm<400mm

Ast = $\frac{51760000}{130\times0.86\times400}$ = 1157.42

Use 20mmΦbars -4Nos

V = 20×4.55/2 = 45.5kN

Tv =V/(bd) =45.5×10^3/(300×400)=0.38MPa<2.5MPa

Ast = 4× $\frac{\Pi}{4}$ ×20^2 = 1256.64

Steel % = (Ast/bd) ×100 = (1256.64/300×400)×100 = 1.05%

From table 23 of IS 456 τ_c = 0.428MPa

Here, $\tau_v < \tau_c$ So shear design is not need only nominal shear steel is enough

Provide 2-legged 8mmΦ stirrups

Asv = 2×(Π/4)×8^2 = 100.53

The spacing (Sv) of the stirrups shall not exceed the least of the following:

(1) 300mm

(2) (0.75×d) = (0.75×400) =300mm

(3) (0.87fyAsv)/(0.4b) = (0.87× 415 × 100.53)/(0.4×300) = 302.46mm

Provide 2-legged 8mm stirrups at 300mm c/c.

300x2/2 =7.18×1256.64(400-x)

X = 127.93mm

Xbal = kd = 0.42×400 = 168mm>127.93mm…..Under Reinforced section

Beam along shorter direction

Load=2×Triangular = 2× $\frac{wLx}{3}$ = 2× $\frac{9.25\times4.3}{3}$=26.52kN/m(exclusive of self weight)

Assume D = 450mm

Self weight of beam = 25×0.3×0.45 = 3.375kN/m

UDL=26.52+3.375=29.895 ≅ 30kN/m

BMmax = 30×4.3^2/8 = 69.34kNm

M = Qbal×bd^2

69.34×10^6 = 2.35×300× d^2

d = 313.6mm<400mm

Ast = $\frac{69340000}{130\times0.86\times400}$ =1550.54

Use 20mmΦbars -5Nos

V=30×4.3/2= 64.5kN

τ_v=V/(bd) =64.5×10^3/(300×400) =0.54MPa<2.5MPa

Ast=5× $\frac{\Pi}{4}$ ×20^2=1570.8

Steel % = (Ast/bd)×100 = (1570.8/300×400)×100=1.31%

From table 23 of IS 456 τ_c = 0.467MPa

Here $\tau_v > \tau_c$ shear design is needed

Shear resistance of concrete,Vc = τ_c bd = 0.467×300×400 = 56.04kN

Shear ti be resisted by stirrups = Vs =V-Vc= 64.5-56.04 = 8.46kN

Provide 2-legged 8mm stirrups

Sv=Asv×σsv×d/Vs=100.53× 130 × 400/8460=617.91mm

(1)300mm

(2) (0.75×d) = (0.75×400) =300mm

(3)(0.87fyAsv)/(0.4b) = (0.87× 415 × 100.53)/(0.4×300) =302.46mm

Provide 2-legged 8mm stirrups at 300mm c/c.

Step 4:- Design of columns

Leff = 6635mm

$\frac{leff}{D} = \frac{6635}{300}$ = 22.12>12…..Long Column

Load = 2×45.5+2×64.5 = 220kN

Reduction coefficient = 1.25-$\frac{leff}{48b}$ = 1.25 - $\frac{6635}{48\times300}$ = 0.79

Assume 1% steel area.Asc = 0.01A&Ac = 0.99A

Load=Reduction coefficient×load on short column

220×10^3 = 0.79× {σccAc+ σscAsc} = 0.79{10(0.99A) + (190× 0.01A)}

A = 23600.09 mm^2

Provide size of column 300mm× 300mm

Asc = 900 mm^2

Provide 6 bars of 16mmΦ

Lateral ties provide 8mmΦ

B = 300mm

16× 25 = 400mm

48×8 = 384mm

Pitch of 300mm

4.3 Design of Overhead Rectangular Water Tank

Overhead water tanks are used for water storage purposes. These tanks come in different shape and size such as rectangular, circular and square etc. overhead water tank have flexible and rigid joints. If there is a situation where power get fail in line with one pump itself, the water pressure reserves itself to a constant level, due to gravity force water can reach to meet the demand of water. Due to economical overhead rectangular water tank is used only for small capacity of water demand.

4.3.1 STAAD Pro Design of Water Tank

STAAD Pro is used to design any structure. It give result of maximum bending moment and shear force. It give resultant reaction after analysis of the applied load. It make structure engineer life easy to design any structure.

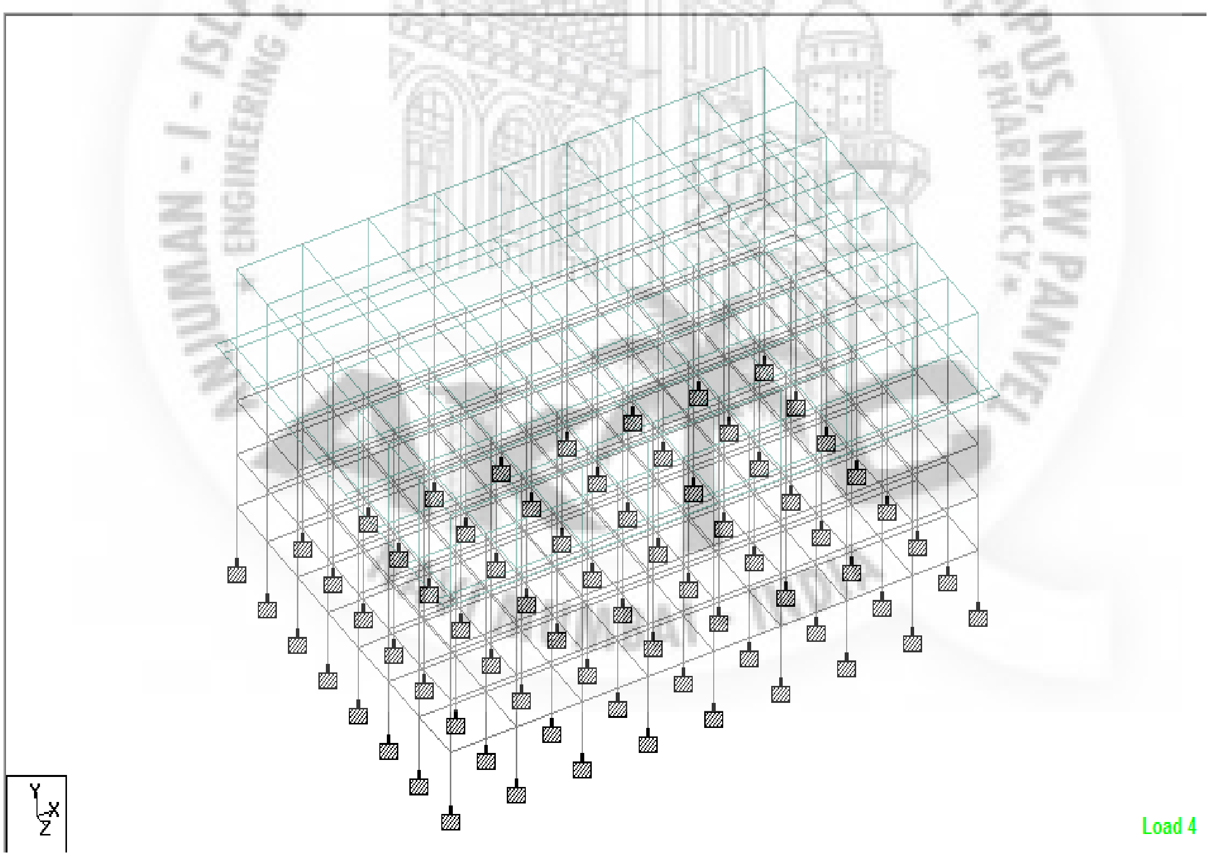


Fig 4.17 Model of overhead rectangular water tank

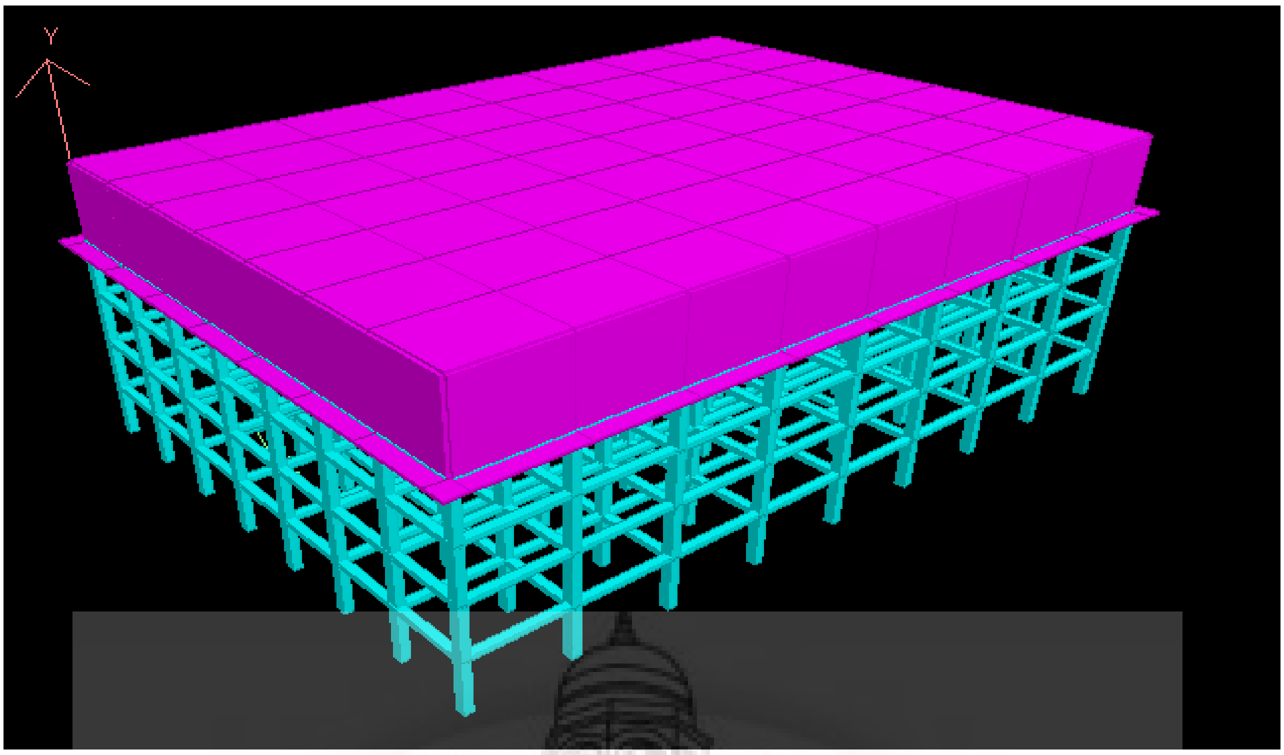


Fig 4.18 3D view of overhead rectangular water tank

Table 4.6 Design parameter consider for overhead rectangular water tank

Capacity	5MLD
Grade	M35 and Fe415
Size of water tank	40m x 28m x 4.5m
Height of tank from bottom slab	4.5m
Height of one column	3m
Number of column	72
Overall height	16.5
Thickness of wall	300mm
Thickness of bottom slab	250mm
Thickness of top slab	250mm
Projection of slap	1m
Size of beam	300mm x 400mm
Size of column	400mm x 500mm

4.3.1.1 Loading Combination Consideration for Underground Rectangular Water Tank:

- 1.5 (DL + LL + Generate Indian code)

4.3.1.2 Result:

Plate stress: refers to the bending of plates due to application of loads on the plates results in the deflection of plates. The stresses in the plate can be calculated from these deflections. Once the stresses coming on plates are known, then failure theories can be applied to determine whether these plates will fail under a given load or not. Below figures shows stress contouring on plates which is obtained after analysis in STAAD Pro shows in different colours for different values of stresses on plates.

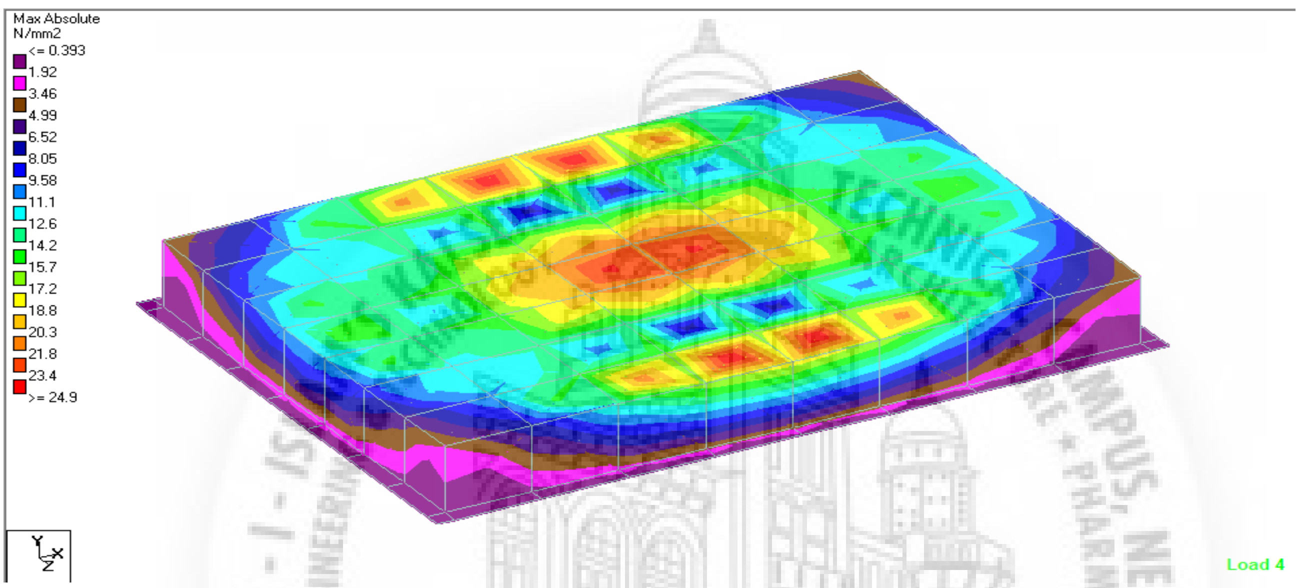


Fig 4.19 Plate stress on overhead rectangular water tank

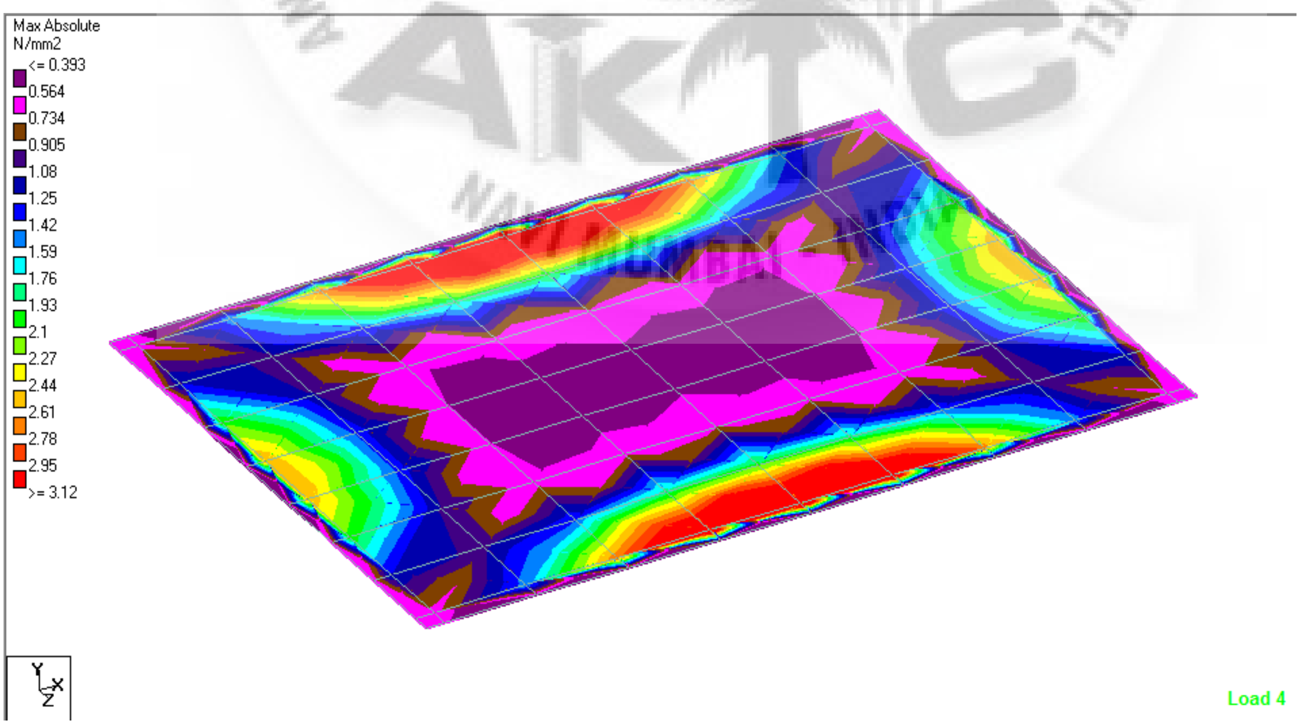


Fig 4.20 Plate stress on bottom slab of overhead rectangular water tank

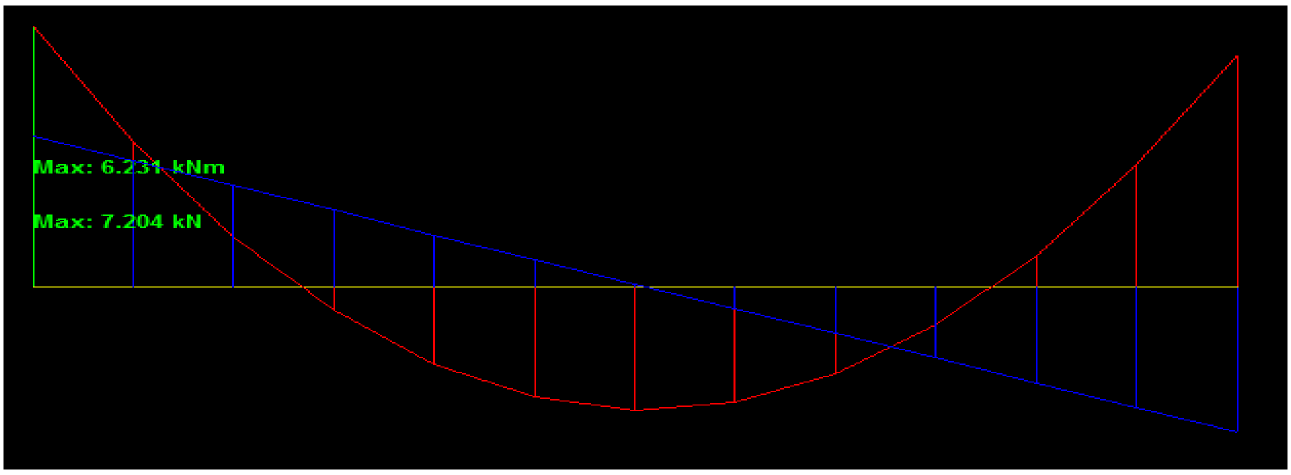


Fig 4.21 Maximum SF and BM of Beam

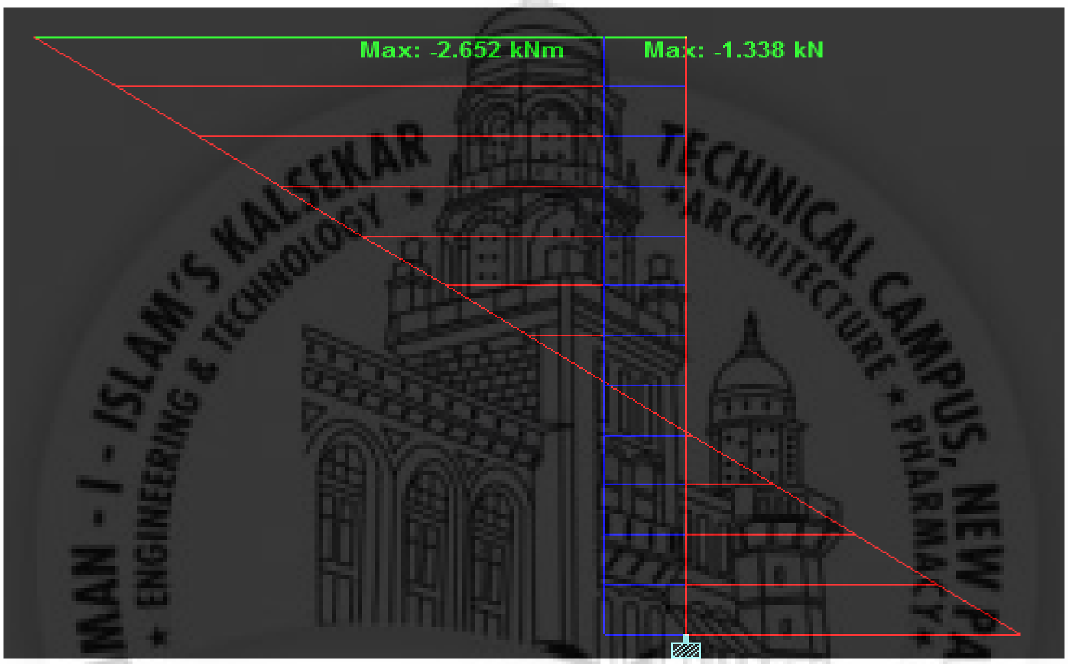
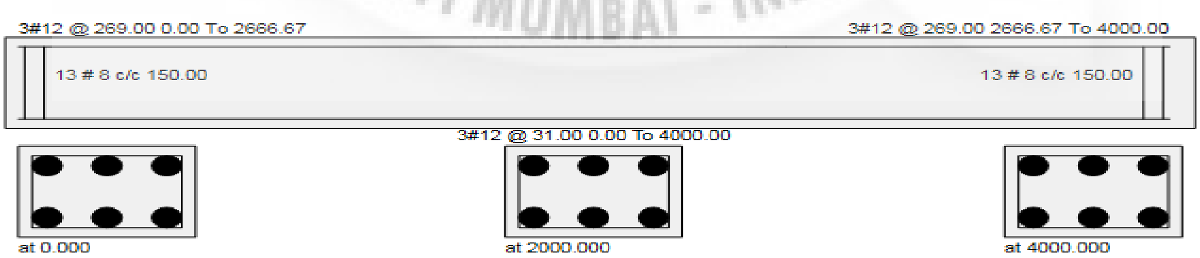


Fig 4.22 Maximum SF and BM of column

STAAD.Pro Query Concrete Design

Beam no. 836

Design Code: IS-456



Design Load

Mz(Kn Met)	Dist.et	Load
13.530000	0.000000	2
-6.010000	0.000000	4
-13.540000	4.000000	2

Design Parameter

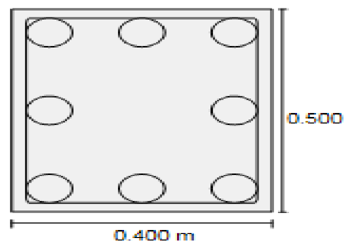
Fy(Mpa)	415.000000
Fc(Mpa)	35.000000
Depth(m)	0.300000
Width(m)	0.400000
Length(m)	4.000000

Fig 4.23 Cross section of beam

STAAD.Pro Query Concrete Design

Beam no. 939

Design Code: IS-456



Design Load

Load	4
Location	End 2
Pu(Kns)	651.929993
Mz(Kns-Mt)	2.040000
My(Kns-Mt)	1.340000

Design Results

Fy(Mpa)	415
Fc(Mpa)	35
As Reqd(mm²)	334.000000
As (%)	0.452000
Bar Size	12
Bar No	8

Fig 2.24 Cross section of column

Table 4.7 Local shear stress and bending moment value obtain after analysis

L/C		Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	Loads	0	- 28555.713	0	400.05	0	-5.7105
	Reactions	0	28555.713	0	400.05	0	5.7105
	Difference	0	0	0	0	0	0
2	Loads	1012.499	- 50399.988	1166.484	716.05	-1.2804	-1.0206
	Reactions	-1012.499	50399.988	-1166.484	-716.05	1.2804	1.0206
	Difference	0	0	0	0.003	0	-0.003

Chapter 5

Summary and conclusion

5.1 Summary

The storage water tank should be strength, durability and free to crack. We have designed circular and rectangular tanks for a particular capacity and performed its static analysis on STAAD Pro. Manual calculation is also performed in this work to compare difference between both result manual as well as software. The water tank can design as both working stress method as well as limit state method. Compare all three types of water tank to decide which is most economical according to shape and size.

5.2 Conclusion

From this designs it is showed that corner stresses and maximum shear and bending stresses are found to be less in case of underground Rectangular water tanks.

The shapes of water tanks plays vital role in the stress distribution and overall economy. By using STAAD Pro, the results obtained will be very accurate than conventional results but there is little difference between the design value of program to that of manual calculation.

According to shape and size of water tank underground rectangular water is most economical. For large quantity of water we go for underground rectangular water tank and for small capacity we go for rectangular water tanks.

In Underground water tank, Uplift pressure plays predominant role in design which is caused by surrounding soil on outside walls of tank. Usage of STAAD Pro in design gives accurate results for shear force and bending moment than convenient method.

Design of structure by using STAAD Pro give accurate result of bending moment, shear force, stresses, displacement, force reaction and load calculation but it does not give accurate detailing of reinforcement to structure. In that situation we use engineering skill for detailing of reinforcement.

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