“COMPARISON OF SQUARE AND CIRCULAR WATER TANKS”

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Mr. Abhilash Shukla

(Assistant Professor)

By

Vaibhav Sharma (121665)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173 234

HIMACHAL PRADESH INDIA

JUNE, 2016

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CERTIFICATE

This is to certify that the work which entitled " **COMPARISON OF SQUARE AND CIRCULAR WATER TANKS**" in partial fulfillment of the requirements for the award of the degree of Bachelor of technology in Civil Engineering by Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Vaibhav Sharma (121627)** during a period from July 2015 to June 2016 under the supervision of **Mr. Abhilash Shukla.** This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree/diploma.

The above statement made is correct to the best of my knowledge.

Date:…………………

Dr. Ashok Kumar Gupta	Abhilash Shukla	External Examiner
Professor & Head of Department	Assistant Professor	
Civil Engineering Department	Civil Engineering Department	
JUIT Waknaghat	JUIT Waknaghat	

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Vaibhav Sharma (121665)

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ABSTRACT

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. Tanks are designed as crack free structures to eliminate any leakage.

Design of square and circular tanks is done using STAAD.Pro having the same height and same length of side of square tank and radius of circular tank. Design is done in order to find out the maximum values of displacements, moments and forces acting on the tanks and comparing them.

Results obtained of absolute maximum value can be used by engineers to design the structure for ultimate load design of beams and column.

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CHAPTER 1
INTRODUCTION

1.1. General

Project starts with general study of water retaining structures from research papers. Further it includes the design of an overhead water tank for maximum forces and moments using STAAD pro. And finally it consists of comparison of the two overhead water tanks-square and circular.

1.2. Necessity of Project

The project is taken in order to learn how to design reinforced concrete structures using STAAD pro. Learning of STAAD pro would be very helpful for me as a future civil engineer. Tanks are considered because tanks are important structures and are used to store not only water but other liquids like petroleum and other petroleum products. Design of tanks is different from other RCC structure as we have to take care of cracks occurring inside the concrete beams.

1.3. Significance of the Project

Overhead water tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. Water or raw petroleum retaining slab and walls can be of reinforced concrete with adequate cover to the reinforcement. Water and petroleum can’t react with concrete and, therefore, no special treatment to the surface is required. Industrial wastes can also petrol, diesel oil, etc. are likely to leak through the concrete walls, therefore such tanks need special membranes to prevent leakage. Reservoir is a common term applied to liquid storage structure.. Reservoirs of overhead type are built for direct distribution by gravity flow and are usually of smaller capacity.

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CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

2.1.1. Design of Intze Tank in Perspective of Revision of IS: 3370 by Lodhi .R. S. et al.

Intze type tank is commonly used overhead water tank in India. These tanks are designed as per IS: 3370 i.e. Code of practice for concrete structures for storage of liquids. BIS implemented the revised version of IS 3370 (part 1& 2) after a long time from its 1965 version in year 2009. Presently large number of overhead water tanks is used to distribute the water for public utility. In which most of the water tanks were designed As per Old IS Code: 3370-1965 Without considering earthquake forces. The objective of this dissertation is to shed light on the difference in the design parameters of (a) intze water tanks without considering earthquake forces (b) intze water tanks designed with earthquake forces. First design is based on Indian standard code: 3370- 1965 and second design is based on Indian standard code: 3370-2009 and draft code 1893-Part 2, (2005) considering two mass modal i.e. impulsive and convective mode method. Intze tank supported on frame staging is considered in present study

2.1.2. Structural Control System for Elevated Water Tank by Falguni et al.

The paper presents the results of an analytical investigation of the seismic response of elevated water tanks using fiction damper. In This paper, the behavior of RCC elevated water tank is studied with using friction damper (FD). For FD system, the main step is to determine the slip load. In nonlinear dynamic analysis, the response of structure for three earthquake time history has been carried out to obtain the values of tower drift base shear and acceleration Time Period. These values are compared with original structure. Results of the elevated tank with FD are

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compared to the corresponding fixed-base tank design and indicate that friction damper is effective in reducing the tower drift, base shear, time period, and roof acceleration for the full range of tank capacities. The obtained results show that performance of elevated water tank with FD is better than without FD.

2.1.3. Comparison of R.C.C. Prestressed Concrete Circular Water Tanks by Sameer. R. et al.

This paper presents a Comparative study of R.C.C. water tanks. Prestressed concrete water tanks resting over firm ground. The work includes the design and estimates for circular R.C.C. water tanks and prestressed concrete water tanks of various diameter. At times the more than one choice available for construction types leads to confusion. The best way is to select the type of construction, depending on the circumstances and type of structure. The aim of this paper is to design medium diameter R.C.C water tanks as well as pre-stress concrete water tanks variety and then compare the results. Programming in MS EXCEL is done to design the water tanks. The idea is to reach a definite conclusion regarding the superiority of the two techniques over one another. Results reveal that an RCC water tank is cheaper than prestressed concrete water tank for smaller diameter but vice versa is true for larger diameter tanks

2.1.4. Parametric Study of an Intze Type Tank by Sharma. M. K. et al.

This paper includes the automation of analysis and design of an Overhead RCC Intze type tank with the help of software developed in C++. The software enables us to design and estimate the material cost of the tank with less time consumption. It explains the major design parameters which directly affects the material cost of the tank. It also consists of a parametric study and finding of conditions for the minimum material cost of the tank. The dynamic and hydrodynamic effects were not incorporated in the analysis.

2.1.5 Seismic Behavior of Elevated Water Tank by Patil. N. R. et al.

Hydrodynamic analysis of elevated water tank is a complex procedure involving fluid structure interaction. The elevated tank supports large water mass at the top of slender staging. In case of elevated tank the resistance against lateral forces exerted by earthquake is largely dependent of

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supporting system. Staging is considered to be a critical element as far as lateral resistance is concern. Satisfactory performance of staging during strong ground shaking is crucial. In this paper seismic behavior of elevated water tank in view point of their supporting system is evaluated using finite element software ETABS. The main objective is to evaluate a performance of different staging system for elevated water tank using finite element software ETABS. The spring mass model consisting of impulsive and convective masses as per IS 1893:2002 Part 2 has been used for the analysis. The parametric study is performed on mathematical model with different staging system to evaluate their performance with regard to lateral stiffness, displacement, time period, seismic base shear, overturning moment, flexure etc.

2.1.6 A Study on a seismic Verification and Retrofit Methods for An Elevated Water Tank Against Strong Earthquakes by Mori. A. et al.

This paper reports a case study on an aseismic verification procedure and seismic retrofit for an existing elevated steel water tank. As nature of elevated steel water tanks during earthquakes, such as the three-dimensional shape, center of mass located in high position and dynamic interaction between structure and contained water, complicated dynamic behavior of structures is expected. Because of both complicated structural behavior and large design earthquake (level 2 seismic motion), seismic diagnosis and seismic retrofit for the existing tanks have become a remarkable issue to be solved. The authors propose an aseismic verification procedure in this paper. Also retrofit techniques such as strength increase and seismic isolation, which are possibly effective to existing elevated tanks, are discussed.

2.1.7 Seismic Response of Elevated Water Tanks by Birtharia. A. et al.

Elevated storage reservoirs are the structures which need to remain functional after major seismic events and therefore should be designed accordingly to resist expected seismic vibrations. Depending upon the storage capacity and other considerations, these reinforced concrete tanks can be of different shapes. Failure of these structures adds to the misery of the

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affected population and adversely affects the post-earthquake relief operations. Extensive research on dynamic response of liquid filled tank traces its origin back to the middle of the last century. This paper summarizes the studies of seismic response for elevated water tanks.

2.1.8 Economics of R.C.C. Water Tank Resting Over Firm Ground By Snehal.M.S. et al.

Water tanks are used to store water and are designed as crack free structures, to eliminate any leakage. In this paper design of two types of circular water tank resting on ground is presented. Both reinforced concrete (RC) and prestressed concrete (PSC) alternatives are considered in the design and are compared considering the total cost of the tank. These water tank are subjected to the same type of capacity and dimensions. As an objective function with the properties of tank that are tank capacity, width & length etc.

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2.2. OBJECTIVES

1. Design and analysis of circular and square water tank for maximum forces, moments and deflection using STAAD pro.

2. Cost estimation of the project.

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CHAPTER 3

PLANNING OF WORK

In the planning of design of water tanks, two tanks are selected such that that the volume carrying capacity of circular tank is equal to the volume carrying capacity of square water tank.

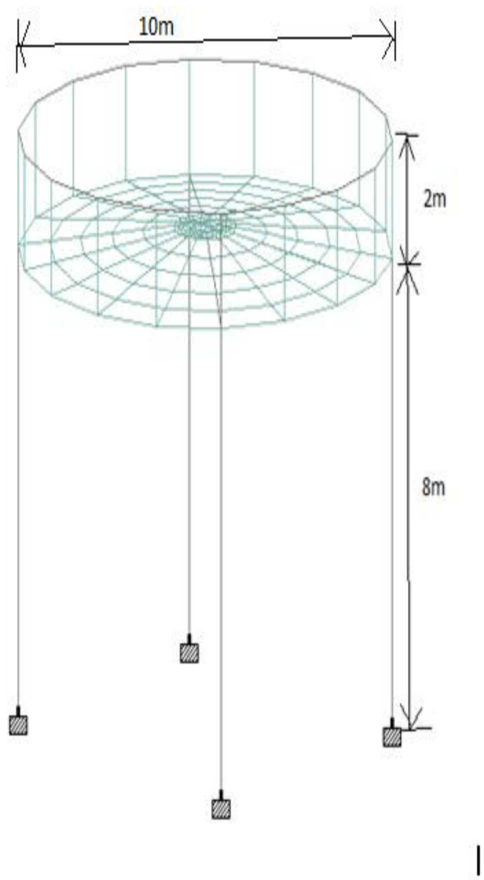

Figure 3.1: Dimensions of circular water tank.

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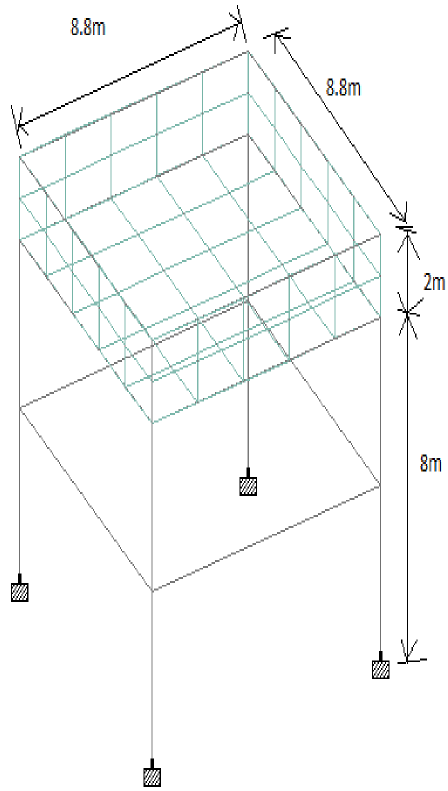

Figure 3.2: Dimensions of square water tank.

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3.2. DESIGN REQUIREMENT OF CONCRETE

In water retaining structure a dense impermeable concrete is required therefore, proportion of fine and course aggregates to cement should be such as to give high quality concrete.

Concrete mix weaker than M20 is not used. The minimum quantity of cement in the concrete mix shall be not less than 30 kN/m^3.The design of the concrete mix shall be such that the resultant concrete is sufficiently impervious.

Efficient compaction preferably by vibration is essential. 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.

Design of liquid retaining structure is different from ordinary R.C.C, structures as it requires that concrete should not crack and hence tensile stresses in concrete should be within permissible limits. A reinforced concrete member of liquid retaining structure is designed on the usual principles ignoring tensile resistance of concrete in bending. Additionally it should be ensured that tensile stress on the liquid retaining face of the equivalent concrete section does not exceed the permissible tensile strength of concrete For calculation purposes the cover is also taken into concrete area. 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. Such restraint may be caused by

(i) The interaction between reinforcement and concrete during shrinkage due to drying.

(ii) The boundary conditions.

(iii) The differential conditions prevailing through the large thickness of massive concrete.

Use of small size bars placed properly, leads to closer cracks but of smaller width. The risk of cracking due to temperature and shrinkage effects may be minimized by limiting the changes in moisture content and temperature to which the structure as a whole is subjected. The risk of cracking can also be minimized by reducing the restraint on the free expansion of the structure with long walls or slab founded at or below ground level, restraint can be minimized by the

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provision of a sliding layer. This can be provided by founding the structure on a flat layer of concrete with interposition of some material to break the bond and facilitate movement.

3.3. JOINTS IN LIQUID RETAINING STRUCTURES

3.3.1. MOVEMENT JOINTS.

There are three types of movement joints.

3.3.1.1. Contraction Joint

It is a movement joint with deliberate discontinuity without initial gap between the concrete on either side of the joint. The purpose of this joint is to accommodate contraction of the concrete.

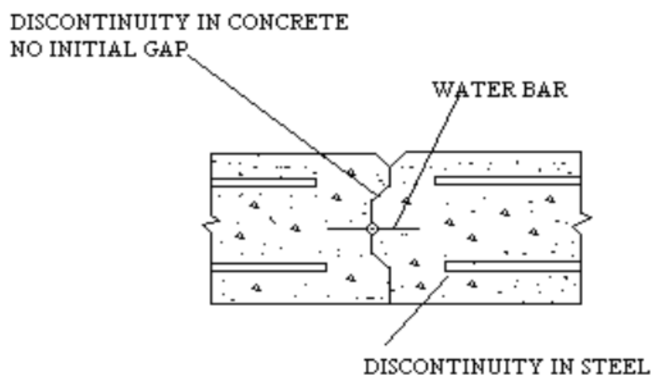

Figure 3.3: Complete Contraction Joint

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, the reinforcing steel running through.

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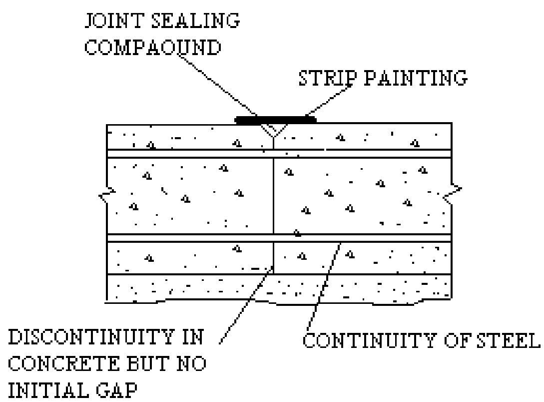

Figure 3.4: Partial Contraction Joint

3.3.1.2. Expansion Joint.

It is a joint with complete discontinuity in both reinforcing steel and concrete and it is to accommodate either expansion or contraction of the structure. A typical expansion joint is

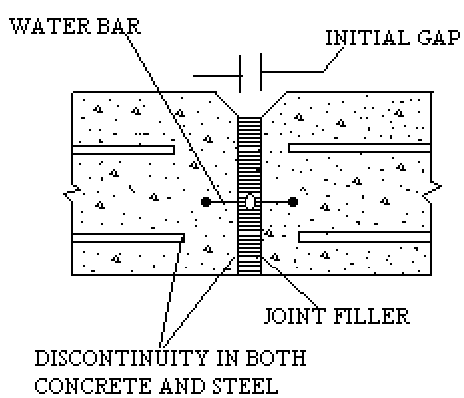

Figure 3.5: Expansion Joint

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This type of joint requires the provision of an initial gap between the adjoining parts of a structure which by closing or opening accommodates the expansion or contraction of the structure.

3.3.1.3. 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 figure.

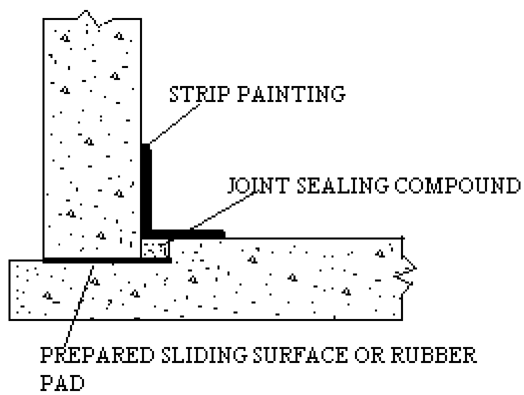

Figure 3.6: Sliding Joint

This type of joint is provided between wall and floor in some cylindrical tank designs.

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3.4. LOADS CONSIDERED

3.4.1. DEAD LOADS

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. The unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m^2 and 25 kN/m^2 respectively.

3.4.2. WIND LOADS

Wind load is acting in combination with dead load. It is acting in either positive or negative x direction or z directions. It is multiplied by the factor 1.5. Wind speed is taken as 100 mph which is assumed to be the maximum speed of wind. Design of wind loads is done with ASCE-7 code.

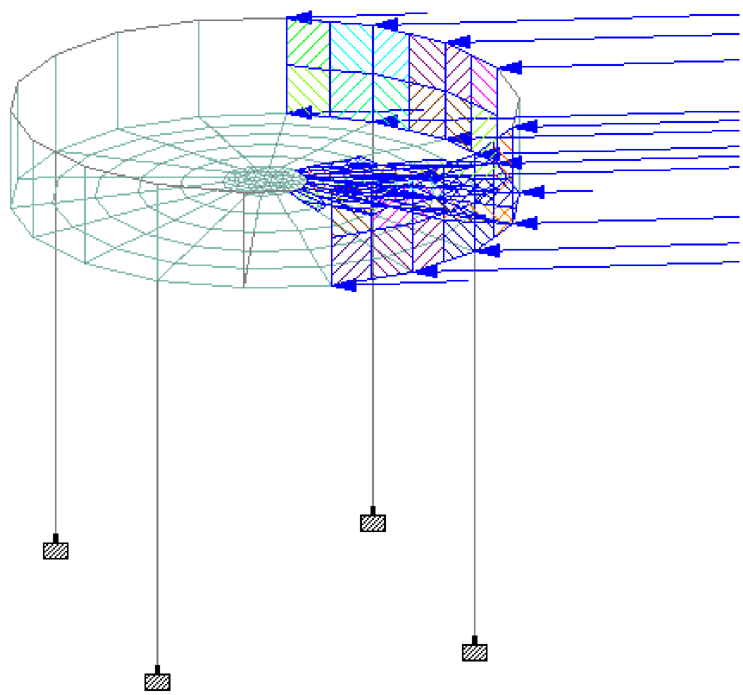

Figure 3.7: Wind load on circular tank

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3.4.3. HYDROSTATIC LOADS

Hydrostatic load is the load due to the pressure of the water inside the water tank which is acting on the walls and floor of tank. These loads are also considered as dead loads.

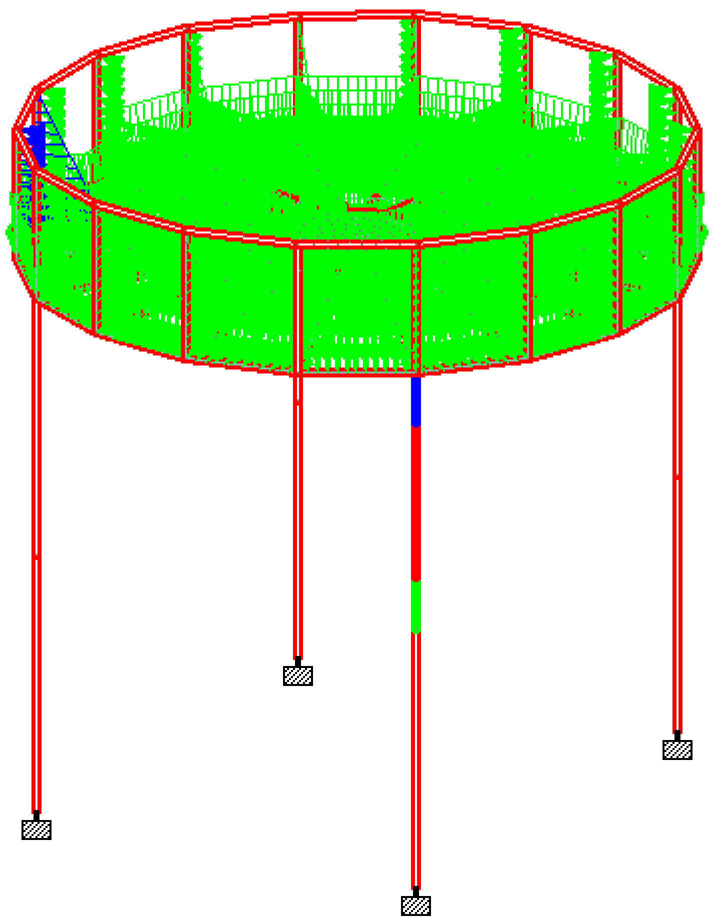

Figure 3.8: Due to hydrostatic load

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3.5. Working with STAAD pro

3.5.1. Input Generation

The GUI (or user) communicates with the STAAD analysis engine through the STD input file. That input file is a text file consisting of a series of commands which are executed sequentially. The commands contain either instructions or data pertaining to analysis and/or design. The STAAD input file can be created through a text editor or the GUI Modeling facility. In general, any text editor may be utilized to edit/create the STD input file. The GUI Modeling facility creates the input file through an interactive menu-driven graphics oriented.

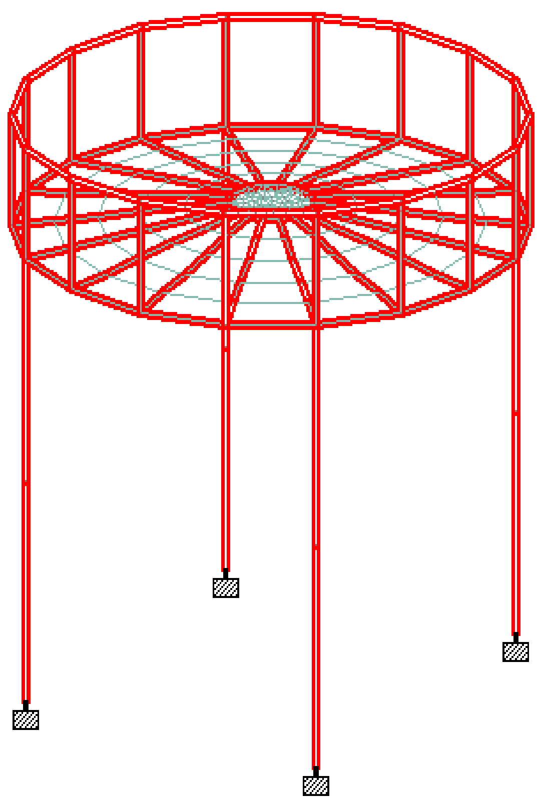

Figure 3.9: Beams and columns in the tank

3.5.2. Types of Structures

A STRUCTURE can be defined as an assemblage of elements. STAAD is capable of analyzing and designing structures consisting of frame, plate/shell and solid elements. Almost any type of structure can be analyzed by STAAD. A SPACE structure, which is a three dimensional framed structure with loads applied in any plane, is the most general. A PLANE structure is bound by a global X-Y coordinate system with loads in the same plane. A TRUSS structure consists of truss members which can have only axial member forces and no bending in the members.

3.5.3. Generation of the structure The structure may be generated from the input file or mentioning the co-ordinates in the GUI. The figure below shows the GUI generation method.

3.5.5. Plates

The structure of tank is considered to be made of plates. Plates are like small slabs between the beams. Plates can be added in STAAD pro by selecting the beams where we add the plates and then clicking on the option “fill floor grid with plates”.

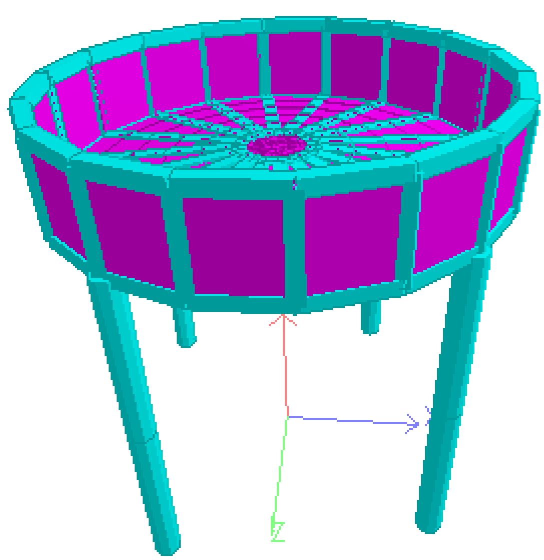

Figure 3.10: Plates in the tank

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3.5.7. Design of members

Thickness of beams and columns can be provided in property option of STAAD pro. Here the circular tank is assumed to be made of beams of dimensions 0.3m×0.3 m and columns are assumed to be made up of diameter of 0.6m.Rectangular slabs have beams of dimension 0.3m×0.3m and columns of 0.4m×0.3m. The design of structure is done using IS 456. We have to provide the grade of concrete we are using and grade of steel .Compressive strength of concrete is taken as 300000kN/m^2 and yield strength of steel both in main and secondary reinforcement is taken as 41500kN/m^2.

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CHAPTER 4

COST ANALYSIS

4.1 Calculation of concrete required

a) In circular water tank

Radius of water tank = 5m

Thickness of slab =0.2

Volume of concrete required at slab=3.14×5×5×0.2=15.7 m^3

Length of walls of tank=2m

Thickness of walls=0.2m

Volume of concrete required at the walls=2×3.14×5×2×0.2=12.56 m^3

Additional concrete volume because of thicker beams than slab by 0.1m

At slab=0.1× (5-0.820) ×0.3×18+3.14×0.82×0.82×0.2=2.67m^3

At walls=2×0.3×0.1×0.1×3.14+18×0.1×2=3.61m^3

Total concrete required=34.54m^3

b) In square water tank

Length of side of water tank=8.8m

Thickness of slab=0.2

Volume of concrete=8.8×8.8×0.2=15.488m^3

Length of wall of tank=2m

Thickness of wall=0.2m

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Volume of concrete required at the walls=4×2×8.8×0.2=14.08m^3

Additional concrete required because of thicker beams than slab by 0.1m

At slab=0.1×8.8×0.3×6+0.1×(8.8-6×0.3)×0.3×6=2.844m^3

At wall=(0.1×2×0.3)×5×4+(0.1×8.8×0.3)×3×4=4.368m^3

Total concrete required=36.78m^3

Concrete required at columns of the tank

a) Circular tank

There are 4 columns of 0.3 radius. Therefore volume of concrete required=4×3.14×0.3×0.3×10=11.304m^3

b) Square tank

There are 4 columns of 0.4×0.3 dimensions. Therefore volume of concrete required=4×0.4×0.3×10=4.8m^3

4.2 Calculation of reinforcement in beams by Staad.Pro

a) Circular tank

Staad pro gives reinforcement area of 165.29sq.mm in all the beams but beams have different lengths. There are 8 beams of 1736.5mm, 18 beams of 2000mm, 120beams of 837.5mm and 12 beams of 289.4mm length both in top and bottom reinforcement.

Adding all these we get, 0.5086m^3 of reinforcement.

b) Square tank

There are lesser number of beams in square tank. But they are longer as compared to circular tank. There are 21 beams which are 8800mm long and have 165mm^2 area of reinforcement, 4 beams which are 8800mm long and have 227.35mm^2 of reinforcement and 2 beams of 2000mm length and 165mm^2 of area.

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Total volume of reinforcement=0.09mm^3 of reinforcement.

Calculation of reinforcement in column by Staad Pro

Circular Tank

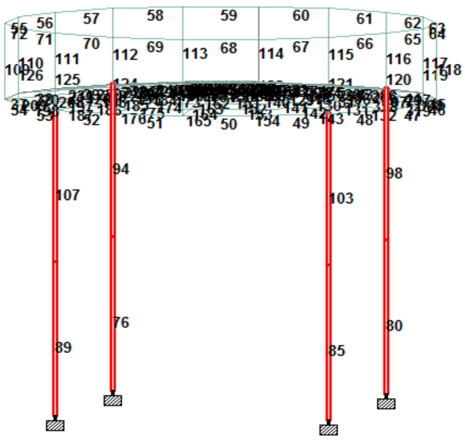

Figure 4.1 Column number of circular tank

Table 4.1: Column Reinforcement in Circular Tank

Column no.	Area(sq mm)	Length
76	2261.95	4
80	2261.95	4
85	2261.95	4
89	2261.95	4
94	2261.95	4
98	2261.95	4
103	2261.95	4
107	2261.95	4

Total reinforcement=0.072382m3

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Rectangular Tank

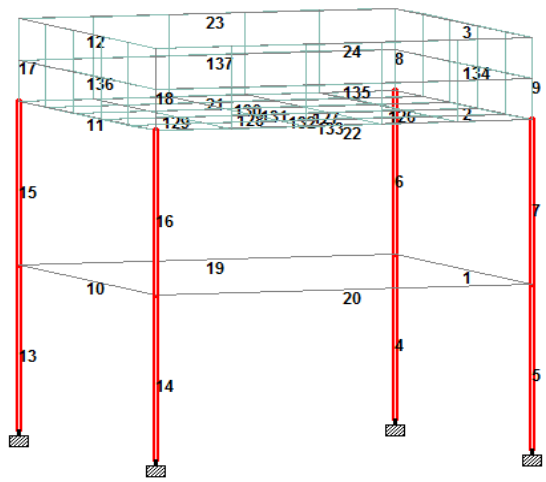

Figure 4.2 Column of rectangular water tank

Table 4.2: Column Reinforcement in Square Tank

Column no.	**Area (sq.mm.)**	**Length**
4	**960**	**4**
5	**960**	**4**
6	**960**	**4**
7	**960**	**4**
8	**720**	**4**
9	**720**	**4**
13	**960**	**4**
14	**960**	**4**
15	**960**	**4**
16	**960**	**4**

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17	**720**	**4**
18	**720**	**4**

Total reinforcement=0.042240m^3

4.3 Calculation of reinforcement of slab

Rectangular slab

The value of longitudinal and transverse reinforcement is 216 mm^2 for nearly all the slabs except a few exceptions. There are in total of 25 slabs in which18 have 216 m^2 of reinforcement,

Therefore for these 18 slabs reinforcement= 216×1760=380160mm^3

Total reinforcement=6842880mm^3 both along transverse and longitudinal direction in both top and bottom directions. Total reinforcement = 6842880×2×2=27371520 mm^3

Rest of the slabs has both longitudinal and transverse reinforcement of 379mm^2 on the top side and 216mm^2 on the bottom side

Therefore total reinforcement =380160×2×7+379×1760×7=14819980mm^3.

Adding above two terms we get reinforcement =42191500mm^3=0.4219m^3.

Circular Slab

Value of transverse and longitudinal reinforcement is 216mm^2. The structure is made up of 18 plates. Further these each 18 plates have 5 plates in them. We need to calculate reinforcement in 1 of these 18 plates and multiply by 18.

Transverse reinforcement=216×(0.087+0.261+0.4361+0.610+0.785) = 470680mm^3

For whole slab = 470680×18=8472240mm^3

Longitudinal reinforcement =5000×216=1080000mm^3

For whole slab=19440000mm^3

Adding, we get 27912240mm^3=0.02791m^3

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Now according to CPWD standards

Density of steel=8050kg/m^3

Density of concrete=2400kg/m^3

Rate of M30 concrete= Rs 37 /kg

Rate of Fe415= Rs 40/kg

Cost of concrete and steel for circular water tank

Total concrete required in beams, slabs and columns=45.844 m^3

Weight of concrete =110025.6 kg

Cost of concrete= Rs 4070947

Total steel required=0.6088m^3

Weight of steel=4901kg

Cost of steel=Rs 196063

Total cost=Rs 4267010

Cost of concrete and steel for square water tank

Total concrete required=41.58m^3

Weight of concrete =99792kg

Cost of concrete=Rs 3692304

Total steel required=0.55924 m^3

Weight of steel =4501.88kg

Cost of steel=Rs 180075

Total cost =Rs3872379

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CHAPTER 5

RESULTS

A comparison between two structures is made based on the displacement, moment along z direction, critical values of structure and maximum stresses on the plates. Loads combination of dead load + wind load is taken for the comparison of structures.

Comparison between the absolute maximum values is done. Also it is seen where the absolute maximum value of force displacement or moment is occurring in node, beam or plate.

5.1. Forces and Moments acting on the supports

Forces are acting on every node of the structure. Here are the maximum values of forces which are acting in a particular direction.

Table 5.1: Forces acting on the supports of square tank

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	2	7 COMBINATI	**11.539**	376.505	-0.460	-0.594	-0.001	-30.449
Min Fx	1	6 COMBINATI	**-11.543**	376.498	-0.460	-0.594	0.001	30.462
Max Fy	2	9 COMBINATI	0.818	**398.491**	10.229	26.196	0.004	-1.046
Min Fy	1	4 WL Z+VE	0.005	**-11.281**	-10.721	-26.858	-0.000	-0.006
Max Fz	10	9 COMBINATI	0.804	375.916	**11.192**	27.479	0.001	-1.027
Min Fz	2	8 COMBINATI	0.804	375.929	**-11.183**	-27.456	-0.001	-1.028
Max Mx	10	9 COMBINATI	0.804	375.916	11.192	**27.479**	0.001	-1.027
Min Mx	2	8 COMBINATI	0.804	375.929	-11.183	**-27.456**	-0.001	-1.028
Max My	10	6 COMBINATI	-9.873	397.902	0.477	0.628	**0.005**	28.270
Min My	9	7 COMBINATI	9.869	397.895	0.477	0.628	**-0.005**	-28.257
Max Mz	1	6 COMBINATI	-11.543	376.498	-0.460	-0.594	0.001	**30.462**
Min Mz	2	7 COMBINATI	11.539	376.505	-0.460	-0.594	-0.001	**-30.449**

Table 5.2: Forces acting on the supports of square tank

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	8	7 DEAD LOA	**12.887**	621.397	10.171	23.420	-0.103	-42.906
Min Fx	17	6 DEAD LOA	**-8.796**	630.332	-15.901	-48.139	-0.111	26.875
Max Fy	4	6 DEAD LOA	-5.620	**650.603**	13.817	33.334	0.303	17.994
Min Fy	8	2 WL X +VE	-3.064	**-5.625**	0.192	0.429	-0.005	13.260
Max Fz	4	9 DEAD LOA	-1.948	650.054	**16.797**	45.698	0.292	3.049
Min Fz	13	8 DEAD LOA	3.073	599.543	**-19.256**	-61.640	0.016	-11.135
Max Mx	4	9 DEAD LOA	-1.948	650.054	16.797	**45.698**	0.292	3.049
Min Mx	13	8 DEAD LOA	3.073	599.543	-19.256	**-61.640**	0.016	-11.135
Max My	4	8 DEAD LOA	-2.326	642.321	11.426	22.671	**0.311**	4.183
Min My	17	6 DEAD LOA	-8.796	630.332	-15.901	-48.139	**-0.111**	26.875
Max Mz	17	6 DEAD LOA	-8.796	630.332	-15.901	-48.139	-0.111	**26.875**
Min Mz	8	7 DEAD LOA	12.887	621.397	10.171	23.420	-0.103	**-42.906**

5.2. Displacement of nodes

Table 5.3: Displacement of nodes of square tank

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	34	6 COMBINATI	**11.202**	-1.762	0.080	11.340	0.000	0.001	-0.002
Min X	59	7 COMBINATI	**-11.198**	-1.762	0.080	11.336	0.000	-0.001	0.002
Max Y	5	4 WL Z+VE	0.001	**0.026**	9.686	9.686	0.000	-0.000	0.000
Min Y	78	8 COMBINATI	-0.008	**-16.534**	9.697	19.168	-0.002	0.000	-0.002
Max Z	48	8 COMBINATI	-0.083	-1.757	**14.111**	14.221	0.002	0.001	0.000
Min Z	22	9 COMBINATI	-0.083	-1.757	**-14.121**	14.230	-0.002	-0.001	0.000
Max rX	70	8 COMBINATI	-0.011	-10.119	9.658	13.989	**0.005**	-0.000	-0.001
Min rX	82	9 COMBINATI	-0.011	-10.119	-9.668	13.995	**-0.005**	0.000	-0.001
Max rY	31	7 COMBINATI	-4.766	-1.591	0.205	5.028	0.000	**0.002**	-0.001
Min rY	38	7 COMBINATI	-4.766	-1.591	-0.214	5.029	-0.000	**-0.002**	-0.001
Max rZ	80	7 COMBINATI	-6.746	-10.122	0.008	12.164	-0.001	0.000	**0.005**
Min rZ	77	6 COMBINATI	6.750	-10.122	0.008	12.166	-0.001	-0.000	**-0.005**
Max Rs	74	9 COMBINATI	-0.008	-16.534	-9.707	**19.173**	0.002	-0.000	-0.002

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Table 5.4: Displacement of nodes of circular tank

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	56	6 DEAD LOA	3.001	-2.797	0.685	4.159	-0.000	0.000	-0.002
Min X	64	7 DEAD LOA	-4.291	-2.838	1.544	5.371	0.000	-0.000	0.002
Max Y	65	2 WL X +VE	1.219	0.025	0.013	1.220	-0.000	0.000	-0.000
Min Y	171	8 DEAD LOA	-0.586	-5.688	2.138	6.105	-0.000	0.000	0.000
Max Z	62	8 DEAD LOA	-0.150	-0.860	3.656	3.759	0.001	-0.000	-0.000
Min Z	67	9 DEAD LOA	-0.706	-0.820	-1.450	1.810	-0.001	0.000	0.000
Max rX	139	8 DEAD LOA	-0.630	-1.795	1.863	2.663	0.002	0.000	-0.000
Min rX	94	9 DEAD LOA	-0.562	-1.703	0.334	1.825	-0.002	0.000	0.000
Max rY	57	8 DEAD LOA	0.561	-1.966	2.455	3.195	-0.000	0.001	-0.001
Min rY	63	8 DEAD LOA	-1.577	-1.971	2.881	3.830	0.000	-0.001	0.001
Max rZ	64	8 DEAD LOA	-3.138	-2.866	2.591	4.978	0.000	-0.000	0.002
Min rZ	56	8 DEAD LOA	1.862	-2.818	1.687	3.776	-0.000	0.000	-0.002
Max Rs	171	8 DEAD LOA	-0.586	-5.688	2.138	6.105	-0.000	0.000	0.000

5.3. Bending of beams

Table 5.5: Bending of beams of circular tank

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	5	9 COMBINATI	2	398.491	-0.818	10.229	0.004	-26.196	-1.046
Min Fx	22	6 COMBINATI	6	-38.133	0.000	0.000	0.000	0.019	-0.877
Max Fy	4	6 COMBINATI	1	376.498	11.543	-0.460	0.001	0.594	30.462
Min Fy	5	7 COMBINATI	2	376.505	-11.539	-0.460	-0.001	0.594	-30.449
Max Fz	14	9 COMBINATI	10	375.916	-0.804	11.192	0.001	-27.479	-1.027
Min Fz	5	8 COMBINATI	2	375.929	-0.804	-11.183	-0.001	27.456	-1.028
Max Mx	18	9 COMBINATI	14	83.573	1.299	-3.922	0.076	5.824	2.428
Min Mx	17	9 COMBINATI	13	83.576	-1.301	-3.922	-0.076	5.824	-2.430
Max My	5	8 COMBINATI	2	375.929	-0.804	-11.183	-0.001	27.456	-1.028
Min My	14	9 COMBINATI	10	375.916	-0.804	11.192	0.001	-27.479	-1.027
Max Mz	4	6 COMBINATI	1	376.498	11.543	-0.460	0.001	0.594	30.462
Min Mz	5	7 COMBINATI	2	376.505	-11.539	-0.460	-0.001	0.594	-30.449

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Table 5.6: Bending of beams of square tank

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	76	6 DEAD LOA	4	650.603	5.620	13.817	0.303	-33.334	17.994
Min Fx	37	7 DEAD LOA	37	-161.650	1.974	0.059	0.003	-0.327	-2.867
Max Fy	249	9 DEAD LOA	130	45.055	17.456	-0.333	-1.066	-0.210	7.130
Min Fy	187	6 DEAD LOA	53	11.133	-27.968	1.683	0.651	0.770	26.696
Max Fz	76	9 DEAD LOA	4	650.054	1.948	16.797	0.292	-45.698	3.049
Min Fz	85	8 DEAD LOA	13	599.543	-3.073	-19.256	0.016	61.640	-11.135
Max Mx	65	8 DEAD LOA	65	11.914	0.313	12.874	6.109	-14.580	-0.087
Min Mx	254	6 DEAD LOA	130	91.921	-17.640	-0.258	-6.335	-0.001	-10.651
Max My	94	9 DEAD LOA	40	596.758	1.948	16.797	0.292	88.676	-12.532
Min My	103	8 DEAD LOA	49	546.248	-3.073	-19.256	0.016	-92.409	13.452
Max Mz	98	7 DEAD LOA	44	568.102	-12.887	10.171	-0.103	57.952	60.193
Min Mz	107	6 DEAD LOA	53	577.037	8.796	-15.901	-0.111	-79.073	-43.493

5.4. Moments on Plates

Table 5.7: Moment and shear force of plates in square tank

			Shear		Membrane			Bending Moment		
	Plate	L/C	SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
Max Qx	111	7 COMBINATI	0.234	0.000	0.206	0.568	0.000	-10.611	8.709	-0.000
Min Qx	115	6 COMBINATI	-0.234	0.000	0.206	0.568	-0.000	-10.611	8.709	0.000
Max Qy	103	9 COMBINATI	-0.000	0.234	0.563	0.206	-0.000	8.693	-10.631	0.000
Min Qy	123	8 COMBINATI	-0.000	-0.234	0.563	0.206	0.000	8.693	-10.631	-0.000
Max Sx	103	8 COMBINATI	-0.000	0.231	0.564	0.203	-0.000	8.653	-10.669	0.000
Min Sx	88	8 COMBINATI	-0.000	-0.034	-1.278	0.019	-0.007	-10.841	-4.331	-0.014
Max Sy	115	7 COMBINATI	-0.231	0.000	0.203	0.568	-0.000	-10.654	8.666	0.000
Min Sy	44	6 COMBINATI	-0.079	0.188	-0.189	-0.310	-0.566	-3.041	7.655	-7.270
Max Sx	75	7 COMBINATI	-0.079	-0.188	-0.189	-0.310	0.566	3.042	-7.655	-7.269
Min Sx	82	6 COMBINATI	0.079	-0.188	-0.189	-0.310	-0.566	3.042	-7.655	7.270
Max Mx	113	8 COMBINATI	-0.000	-0.000	0.298	0.298	0.000	40.868	40.876	0.000
Min Mx	54	7 COMBINATI	-0.136	0.043	-0.025	0.073	-0.389	-10.992	-1.384	-3.936
Max My	113	6 COMBINATI	-0.000	0.000	0.300	0.296	0.000	40.865	40.880	0.000
Min My	97	7 COMBINATI	-0.000	-0.105	0.056	0.285	0.000	-8.351	-24.433	-0.000
Max Mx	105	6 COMBINATI	-0.032	0.020	0.168	0.203	-0.333	-5.548	-5.320	15.402
Min Mx	101	7 COMBINATI	0.032	0.020	0.168	0.203	0.333	-5.548	-5.320	-15.402

Table 5.8: Moment and shear force of plates in circular tank

	Plate	L/C	Shear		Membrane			Bending Moment		
			SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
Max Qx	452	7 DEAD LOA	**0.175**	0.031	0.070	1.559	-0.276	18.340	-1.055	3.361
Min Qx	373	6 DEAD LOA	**-0.227**	0.114	-1.306	-1.164	0.088	-19.644	-7.402	3.273
Max Qy	354	6 DEAD LOA	-0.137	**0.165**	-1.084	-1.069	0.214	-12.162	-12.814	6.851
Min Qy	393	7 DEAD LOA	0.054	**-0.198**	-0.921	-1.478	0.209	-5.635	-18.384	-0.990
Max Sx	501	6 DEAD LOA	0.003	-0.195	**1.590**	0.027	-0.001	1.969	-18.214	-0.739
Min Sx	361	9 DEAD LOA	-0.143	0.097	**-1.352**	-1.079	0.266	-12.846	-7.806	3.762
Max Sy	452	7 DEAD LOA	0.175	0.031	0.070	**1.559**	-0.276	18.340	-1.055	3.361
Min Sy	393	8 DEAD LOA	0.055	-0.197	-0.918	**-1.485**	0.210	-5.590	-18.408	-0.973
Max Sx	516	8 DEAD LOA	-0.006	-0.011	0.153	-0.220	**0.515**	-3.267	-4.879	3.733
Min Sx	407	9 DEAD LOA	-0.048	-0.095	-0.829	-0.821	**-0.652**	-7.537	-7.226	-5.083
Max Mx	452	8 DEAD LOA	0.174	0.030	0.074	1.553	-0.281	**18.386**	-1.068	3.335
Min Mx	373	6 DEAD LOA	-0.227	0.114	-1.306	-1.164	0.088	**-19.644**	-7.402	3.273
Max My	479	8 DEAD LOA	-0.001	-0.013	0.101	-0.518	-0.054	8.688	**13.632**	0.222
Min My	393	8 DEAD LOA	0.055	-0.197	-0.918	-1.485	0.210	-5.590	**-18.408**	-0.973
Max Mx	354	6 DEAD LOA	-0.137	0.165	-1.084	-1.069	0.214	-12.162	-12.814	**6.851**
Min Mx	391	6 DEAD LOA	-0.174	-0.006	-1.192	-0.694	-0.369	-13.807	-5.313	**-6.420**

5.5 Contours

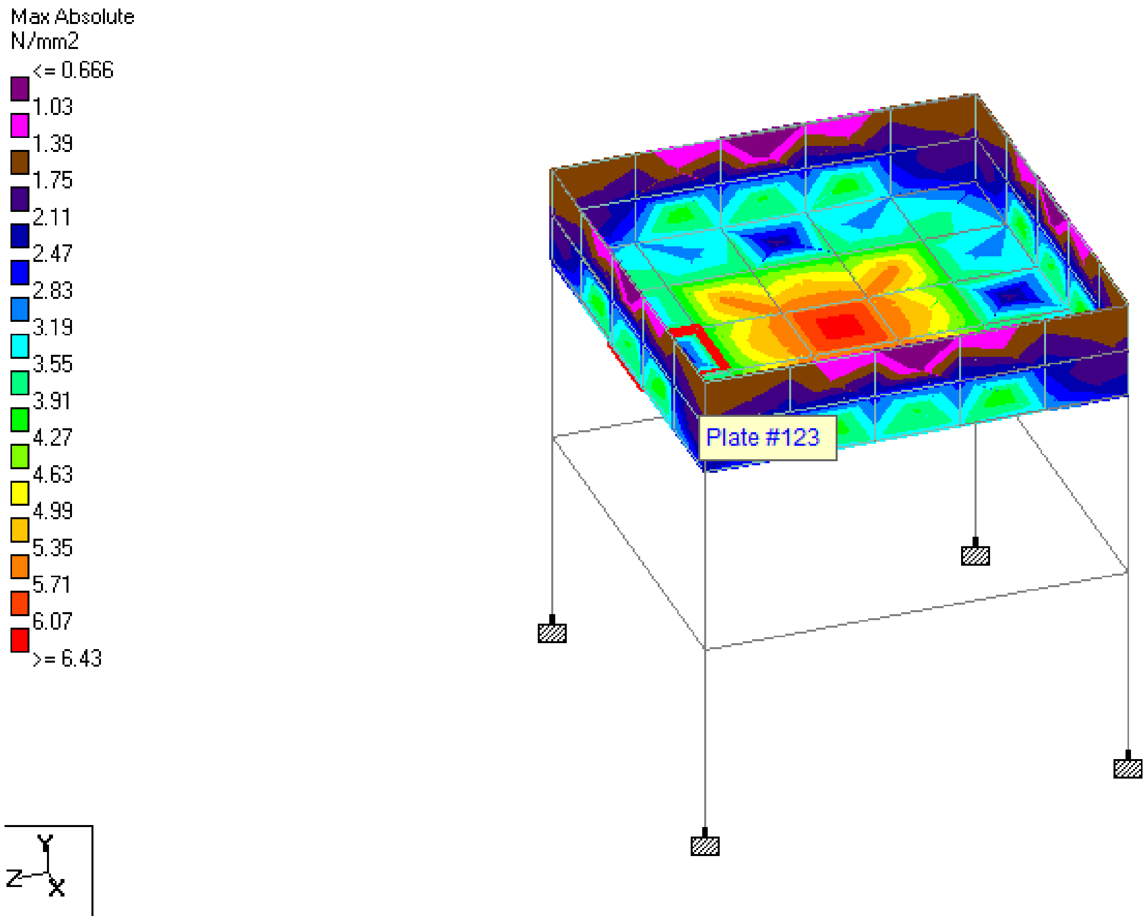

Figure 5.1: Maximum absolute stresses in rectangular tank

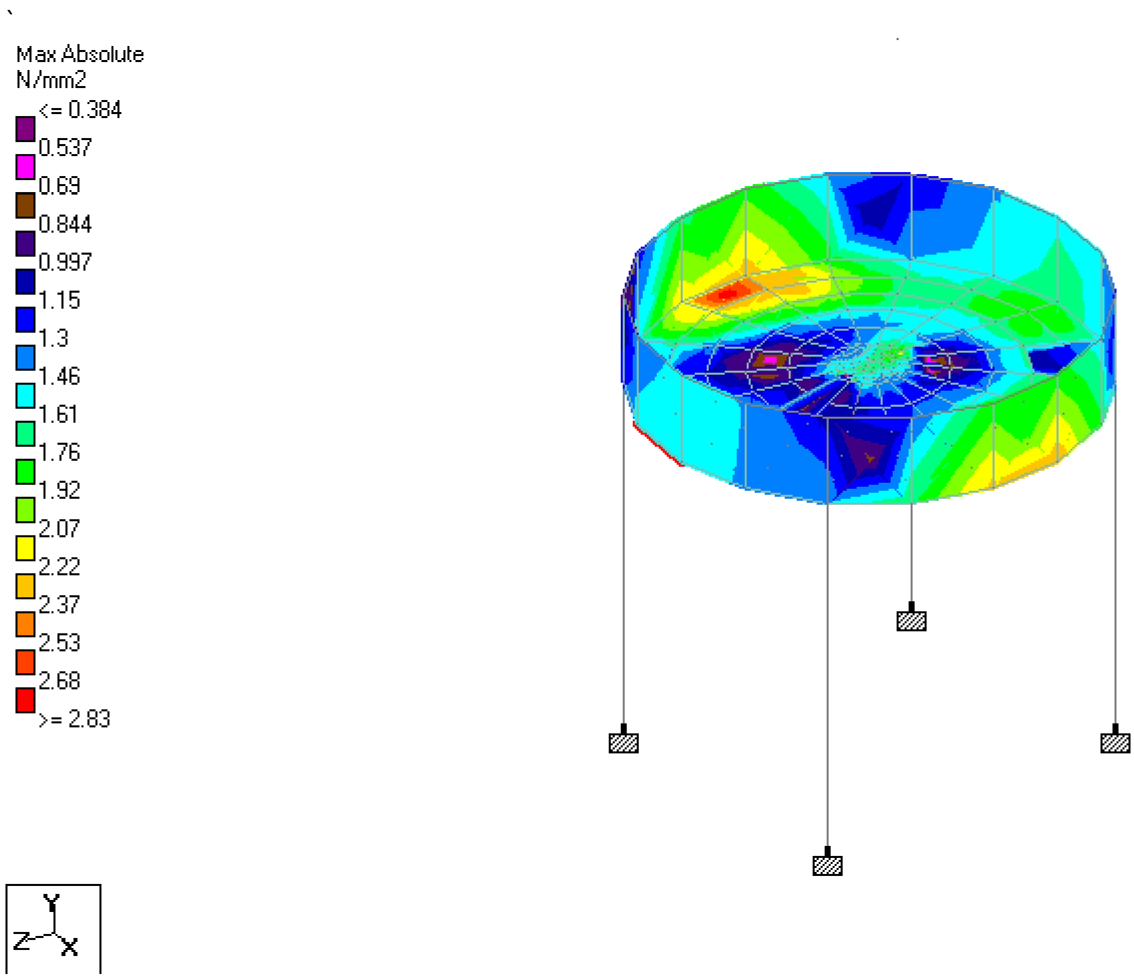

Figure 5.2: Maximum absolute stresses in circular tank

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CHAPTER 6

DISCUSSIONS

The following discussions were made in the analysis of circular and square water tank.

1. It can be seen that the maximum force on node is acting on the y direction. It is because the whole structures weight acts on the y direction. The absolute maximum value of force is 650.603kN in circular in y direction and 398.491kN in square water tank. It can be seen that one support of circular water tank is resisting a larger force as compared to square water tank. The maximum absolute moment on support acting is 30.449kN/m in square water tank whereas in circular it is 42.906kN/m.
2. In square tank the maximum value of displacement along y direction is16.634mm. It means that the structure is deflecting more towards ground than it is deflecting away from ground.figure. In circular tank maximum value of deflection is 5.688mm.
3. It can be seen that the maximum stress on the circular tank is 2.83kN/m where as in rectangular tank is 6.43kN/m for the same volume of tank. The middle portion of the tanks has the points of maximum stresses.
4. It is also seen that where the wind load is acting on the tanks the color of maximum plate stresses is different of that portion compared to the portion where wind loads are not acting.
5. Maximum and minimum displacement in z direction is occurring opposite to each other in both tanks. It is because of the symmetrical nature of forces.

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Chapter 7

CONCLUSION

1. Circular tank is more difficult to design as compared to square tank because the geometry of circular tank and more skilled labour is required for its construction.
2. We have to design the structure for maximum stresses, forces and bending moments. It is clearly seen that the maximum values of square water tank are higher. So we prefer circular tank over square seeing the maximum stresses.
3. Cost of material for circular water tank is Rs. 4267010 whereas for square water tank it is Rs.3872379. So if we want a cost effective model we would take square water tank.
4. Circular water tank is more pleasing to look and require lesser space because of its circular space. So if we have space problem we would chose circular tank.

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