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Seismic Analysis and Design of Circular RC Intze Water Tank Using Staad Pro. Software with Different Zones

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ABSTRACT-

Due to enormous need by the public, water has to be stored and supplied according to their needs. Water demand is not constant throughout the day. It fluctuates hour to hour. In order to supply constant amount of water, we need to store water. So to meet the public water demand, water tanks need to be constructed. They are grave elements in municipal water supply, firefighting systems and in many industrial amenities for storage of water. 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. 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 Intze water tank designed considering the earthquake forces according to Indian standard code: 3370-2009 and draft code 1893-Part 2, (2005) considering zone-II and III. Intze tank supported on frame staging. Also this report includes analysis by STAAD Pro for seismic forces .Finally the results are validated with the results of calculation from the present study. Before taking up the design, the designer should first decide the most suitable type of staging of tanks and correct estimation of loads including statically equilibrium of structure particularly in regards to overturning of overhanging members shall be made. The design should be based on the worst possible combination of loads, moments and shears arising from vertical loads and horizontal loads acting in any direction. In this research by performing the analysis of Intze tank, what is deflection shape due to hydrostatic pressure then stresses, etc. which are analyzed.

Keywords- STAAD Pro v8i, Intze water tank, IS: 3370-2009, displacement, Axial Force, Bending Moment

I. Introduction

Water is basic human needs for daily life sufficient water distribution depends on design of a water tank in certain area. Water supply is a life line facility that must remain functional even if disaster occurred. Elevated water tank is a water storage container constructed for the purpose of holding a water supply at a height sufficient to pressurize a water distribution system. In major cities the main supply scheme is augmented by individual supply systems of institutions and industrial estates for which elevated tanks are an integral part. Also at the times of cyclone it was observed that the storage tanks were displaced by few meters and some were overturned due to wind. They were swept away by the wind. Flying debris caused dents on the surfaces when they hit the tanks. So it is important to check the severity of these forces for particular region

The study of damage histories revealed damage/failure of reinforced concrete elevated water tanks of low to high capacity. Damage of the important lifeline facility like elevated water tanks often results in significant hardships even after the occurrence of the disaster, claiming human casualties and economic loss to build environment. Investigating the effects of wind has been recognized as a necessary step to understand the natural hazards and its risk to the society in the long run. Most water supply systems in developing countries, such as Ethiopia, depend on reinforced cement concrete elevated water tanks. The strength of these tanks against lateral forces, such as those caused by wind, needs special attention.

A water tower also serves as a reservoir to help with water needs during peak usage times. A water tower is an elevated structure supporting a water tank constructed at height sufficient to pressurize a water supply system for the distribution of potable water and to provide emergency storage for fire protection. In some places the term stand pipe is used interchangeably to refer a water tower especially one with tall and narrow proportions. Water towers are able to supply water even during power outages because they rely on hydrostatic pressure produced elevation of water (due to gravity) to push the water into domestic and industrial water distribution systems.

A. Need for study of Water Tanks

A water tank is used to store water to tide over the daily requirement. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential .The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio .The increase in water cement ratio results in increase in the permeability .The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. Cracks can be prevented by avoiding the use of thick timber shuttering which prevent the easy escape of heat of hydration from the concrete mass the risk of cracking can also be minimized by reducing the restraints on free expansion or contraction of the structure.

1. Water tanks are visually simple but structurally difficult
2. Difficult to take the load cases and load combinations
3. Distribution of stress in the structure
4. Distribution of mass
5. Hydro dynamic effects
6. Very critical problem is the slab and beam joints

B. Overhead Water Tanks and Towers

Overhead water tanks of various shapes can be used as service reservoirs, as a balancing tank in water supply schemes and for replenishing the tanks for various purposes. Reinforced concrete water towers have distinct advantages as they are not affected by climatic changes, are leak proof, provide greater rigidity and are adoptable for all shapes. Components of a water tower consists of-

(a) Tank portion with

a) Roof and roof beams (if any)
b) sidewalls
c) Floor or bottom slab
d) floor beams, including circular girder
e) Staging portion, consisting of
f) Columns
g) Bracings and
h) Foundations

C. Types of water Tanks

a) Circular tanks
b) Rectangular tanks
c) Spherical tanks
d) Intze tanks and
e) Circular tanks with conical bottoms.

Among these the circular types are proposed for large capacities. Such circular tanks may have flat floors or domical floors and these are supported on circular girder. The most common type of circular tank is the one which is called an Intze Tank. In such cases, a domed cover is provided at top with a cylindrical and conical wall at bottom. A ring beam will be required to support the domed roof. A ring beam is also provided at the junction of the cylindrical and conical walls. The conical wall and the tank floor are supported on a ring girder which is supported on a number of columns. Usually a domed floor is shown in fig a result of which the ring girder supported on the columns will be relieved from the horizontal thrusts as the horizontal thrusts of the conical wall and the domed floor act in opposite direction. Sometimes, a vertical hollow shaft may be provided which may be supported on the domed floor.

D. Objective

1. The main objective of this study to identify the dynamic behavior of elevated water tank under wind load.
2. To make a study about the analysis and design of water tanks.
3. To make a study about the guidelines for the design of liquid retaining Structure according to IS code.
4. To know about the design philosophy for the safe and economical design of water tank.
5. To develop programs for the design of water tank of flexible base and rigid base and the underground tank to avoid the tedious calculations.
6. In the end, the programs are validated with the results of manual calculation given in concrete Structure and then analyzed by STAAD pro.

2. Literature Review

Ronad et al. (2016) According to IS 1893:2002, an empty and fully filled water tank was investigated with the aid of a technique called the dynamic response spectrum utilising the procedure of the finite element model-based software called ETABS. It was studied for an empty tank and a tank that was fully filled using frame staging with a hexagonal layout for the building. When it comes to seismic zones 2, 3, 4, and 5, the soil media was categorised as soft, medium, and hard. The tank had a capacity of 250 cubic metres, had a column height of 16 metres, a tank height of 7.8 metres, a zone factor of 2.5, and an important factor of 1.5. The outcome comprises the parameter of base shear and base moment for each type of seismic zone and tank, both empty and filled.

Dhage et al. (2017) by comparing two instances of the same tank with comparable tank capacities, the dynamic analysis of RCC raised tanks was explored. Changes in the geometric features of the container demonstrate how the water tank responds to these changes. She came to the conclusion that static reaction has a higher scale value than dynamic response. The findings from using the various time periods are as follows. The structure collapsed due to hydrodynamic considerations, which were disregarded.

Rao et al. (2018) the effects of lateral forces (seismic and wind) on a tank have been examined and evaluated. This essay sheds some insight on structural elements such as axial forces, bending moments, shear forces, etc., and compares them to various tank structural elements. STAAD PRO V8i software is used for analysis. For analysis in this case, finite element approach is applied. The building of an elevated water tank with the aid of numerical modelling using the STAAD PRO V8i software is included in the specific research. The tank's primary structure is the subject of the examination. We get to the conclusion that the maximum bending moment for a column is 511.863 kNm, with a shear force of 252.673 kN. Maximum bending moment with shear is 382.35 kNm at the bottom of the tank.

P.Rakesh et al. (2021) the design and construction methods used in reinforced concrete are influenced by the prevailing construction practices, the physical property of the material and the climatic conditions. Any design of Water Tanks is subjected to Dead Load + Live Load and Wind Load or Seismic Load as per IS codes of Practices. Most of the times tanks are designed for Wind Forces and not even checked for Earthquake Load assuming that the tanks was safe under seismic forces once designed for wind forces. In this study Wind Forces and Seismic Forces acting on an Intze Type Water tank for Indian conditions are studied. According to seismic code IS 1893(Part-1) more than 60% of India is prone to earthquakes. The analysis was conducted as per the specifications of IS 3370, IS 456, IS 800, IS 875, IS 1893. The Intze type water tank was designed for 10Lakh Litres capacity of water for the Agiripalli Town at Krishna District in Andhra Pradesh. Different loads such as Dead Load, Live Load, and Wind load will be applied on STAAD.Pro model as well manual design at appropriate location as per codes used for Loading. All the results obtain from STAAD.Pro will be compared with the results of manual design

3. Design Requirements

A. Sources of water supply

The various sources of water can be classified into two categories:

Surface sources, such as

1. Ponds and lakes,
2. Streams and rivers,
3. Storage reservoirs, and
4. Oceans, generally not used for water supplies, at present.

Sub-surface sources or underground sources, such as

1. Springs,
2. Infiltration wells, and
3. Wells and Tube-wells.

B. Water Demand

a. Water Quantity Estimation

The quantity of water required for municipal uses for which the water supply scheme hasto be designed requires following data:Water consumption rate (Per Capita Demand in litres per day per head)Population to be served.

Quantity= Per demand x Population

b. Water Consumption Rate

It is very difficult to precisely assess the quantity of water demanded by the public, sincethere are many variable factors affecting water consumption. The various types of water demands, which a city may have, may be broken into following class

Table: 1 Water Consumption for Various Purposes

	Types of Consumption	Normal Range (lit/capita/day)	Average	%
1	Domestic Consumption	65-300	160	35
2	Industrial and Commercial Demand	45-450	135	30
3	Public including Fire Demand Uses	20-90	45	10
4	Losses and Waste	45-150	62	25

c. Design Periods & Population Forecast

This quantity should be worked out with due provision for the estimated requirements of the future. The future period for which a provision is made in the water supply scheme is known as the design period.

1. Design period is estimated based on the following:
2. Useful life of the component, considering obsolescence, wear, tears, etc.
3. Expandability aspect.
4. Anticipated rate of growth of population, including industrial, commercial developments& migration-immigration.
5. Available resources.
6. Performance of the system during initial period

d. Population Forecasting Methods:

The various methods adopted for estimating future populations are given below. The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discretion and intelligence of the designer.

1. Incremental Increase Method
2. Decreasing Rate of Growth Method
3. Simple Graphical Method
4. Comparative Graphical Method
5. Ratio Method
6. Logistic Curve Method
7. Arithmetic Increase Method
8. Geometric Increase Method

e. Design Requirement of Concrete (I. S. I)

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 lesser than M20 is not used. The minimum quantity of cement in the concrete mix shall be not less than 30 kN/m .The design of the concrete mix shall be such that the resultant concrete issue efficiently 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 watertight 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 ace of the equivalent concrete section does not exceed the permissible tensile strength of. 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.

The design of the tank will involve the following.

i. The dome: at top usually 100 mm to 150 mm thick with reinforcement along the meridians and latitudes. The rise is usually l/5th of the span.

ii. Ring beam supporting the dome: The ring beam is necessary to resist the horizontal component of the thrust of the dome. The ring beam will be designed for the hoop tension induced.

iii. Cylindrical walls: This has to be designed for hoop tension caused due to horizontal water pressure.

iv. Ring beam at the junction of the cylindrical walls and the conical wall: This ring beam is provided to resist the horizontal component of the reaction of the conical wall on the cylindrical wall. The ring beam will be designed for the induced hoop tension.

v. Conical slab: This will be designed for hoop tension due to water pressure. The slab will also be designed as a slab spanning between the ring beam at top and the ring girder at bottom.

vi. Floor of the tank. The floor may be circular or domed. This slab is supported on the ring girder.

vii. The ring girder: This will be designed to support the tank and its contents. The girder will be supported on columns and should be designed for resulting bending moment and Torsion.

viii. Columns: These are to be designed for the total load transferred to them. The columns will be braced at intervals and have to be designed for wind pressure or seismic loads whichever govern.

ix. Foundations: A combined footing is usually provided for all supporting columns. When this is done it is usual to make the foundation consisting of a ring girder and a circular slab.

Suitable proportions for the Intze.

For case (1) suggested by Reynolds.

Total volume ~0.585D

For case (2), the proportion was suggested by Grey and Total Volume is given by

$$V_1 = PD^{\frac{2}{4}} \times H = 0.39D^3. for\ H = D/2.$$

$$V_2 = \frac{p.h}{12} \times \left(D^2 + d^2 + d\right) = 0.102D$$

$$V_3 = \frac{ph_1}{6}\left(3r^2 + h_1^2\right) = 0.01D^3$$

With h_1= 3/25D and r = $0.0179D^3$

Volume V = $0.4693D^3$

Volume V = $0.493D^3$

4. Structural Modelling of Intz Water Tank

A. Modeling in Staad.Pro V8i

STAAD Pro features a state-of-the-art user interface, visualization tools, powerfull analysis and design engines with advanced finite element and dynamic analysis capabilities. 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.

Table 2: Specifications of Intz Water Tank

S. No.	Specifications	Data
1	Volume of tank	$1000m^3$
2	Thickness of Cylindrical wall	200mm
3	Rise of Top Dome	2 m
4	Rise of Bottom Dome	1.6
5	Angle of Conical Dome	30°
6	Size of Top Ring Beam	300X300mm

7	Size of Bottom Ring Beam	600X400mm
8	Size of Bottom Circular Girder	400X600mm
9	Thickness of Top Dome	150mm
10	Thickness of Bottom Dome	300mm
11	Thickness of Conical Dome	300mm
12	No. of Column	12
13	Size of Column	400X300mm

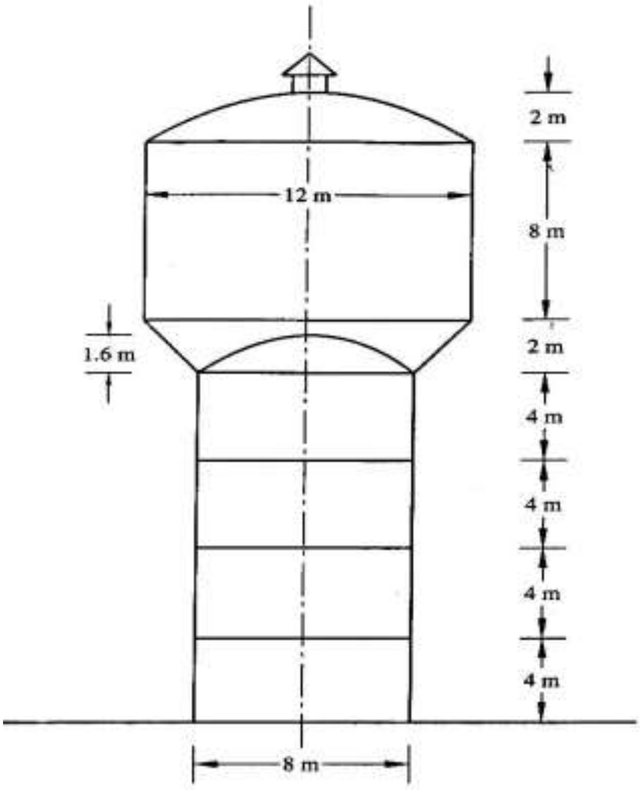


Figure 1. Intze Water Tank

B. Design Procedure in STAAD Pro

1. Open STAAD.pro. Click on new project > add file name>Select ‘space’. Length (in m), Force (in KN). Select add beam option and click on finish.
2. Geometry>Run structure wizard > select surface/plate model > cylindrical surface. Close it to transfer to modelling

Length: 12

Division along length: 1

Start radius: 3.5

Division along periphery: 12 (column)

End radius: 2.5

3. Using Add beam selecting top node and bottom node. Repeat along periphery for required number of columns.
4. Copy all vertical members using ctrl + C and paste aside using ctrl + V.
5. Add intermediate nodes along length to add required number of beams in horizontal direction.

Connect all node in a plane to form a circular beam.

6. Repeat the same process at top to get circular girder.
7. Geometry>Run structure wizard> select surface/plate model >Spherical cube, Select spherical cap (Bottom dome). Close it to transfer to modelling

Diameter of sphere:

Base Diameter:

8. Shift the obtained Spherical cap to top beam Measure distance using 'display node to node distance' tool Select all plates > Right click mouse>Move > add (-) sign to above distance to rest on top beam.

a) Geometry>Run structure wizard > select surface/plate model > cylindrical surface

Length: 2.12

Division along length: 1

Start radius: 35

Division along periphery: 12(column)

End radius: 2.5

b) Shift the obtained Conical dome to top beam, Measure distance using 'display node to node distance' tool, Select all plates > Right click mouse>Move > add (-) sign to above distance to rest on top beam.

c) Geometry>Run structure wizard > select, surface/plate model > cylindrical surface

Length: 2.12

Division along length: 1

Start radius: 35

Division along periphery: 8(column)

End radius: 2.5

d) Shift the obtained cylindrical surface to top beam, Measure distance using 'display node to node distance' tool, Select all plates > Right click mouse>Move > add (-) sign to above distance to rest on top beam.

e) Geometry>Run structure wizard> select surface/plate model >Spherical cube Select spherical cap (Top dome). Close it to transfer to modelling Diameter of sphere: Base Diameter:

f) Shift the obtained Conical dome to top beam Measure distance using 'display node to node distance' tool Select all plates > Right click mouse>Move > add (-) sign to above distance to rest on top beam.

g) Finally Check dimensions of tank using 'display node to node distance' tool to verify. Any corrections to be made are rectified.

General Properties

1. Click 'property' at left of screen> Define required dimensions for respective elements. Assign the property for various elements using any of the options present according to your convenient. Click 'Support' > Create >Select 'fixed' >click Add> assign at bottom part of beam.
2. Click 'Load and Definition' to apply wind load first we have to define it in first section. Enter your values. Keep exposure as –1. Click 'Load case details' to add DL, LL & WL. Add self-weight as DL Add Water load as LL Add Wind Load Select material as concrete and assign for entire tank

C. Design

1. Click on 'Design' >Select parameters to include in our design. Define parameters with respective values Select the required command to instruct software to design according to IS code. Detailing of reinforcement and quantity of concrete is present in output file.

Step 1: Geometry of Intz Water Tank

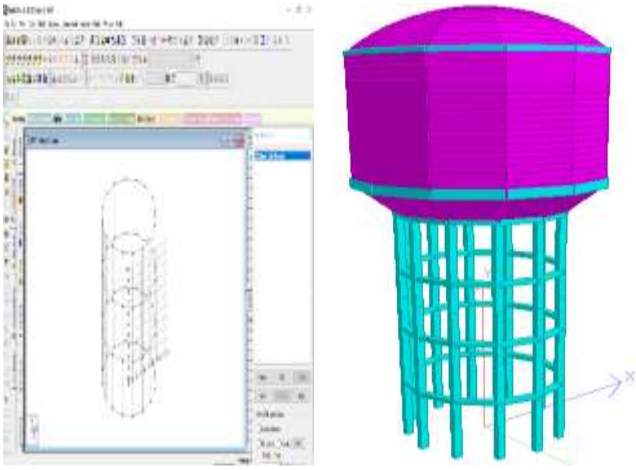


Figure. 2 Geometry of Intz Water Tank

Step 2: Material and Property

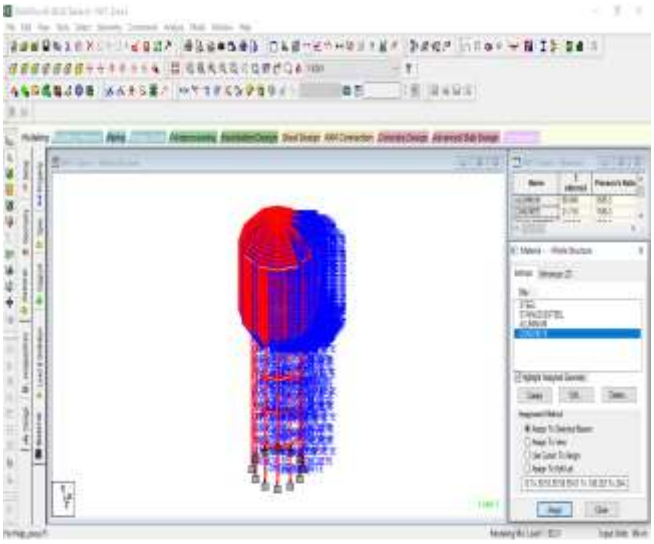


Figure. 3 Material and Property of Intz Water Tank

Step 3: Loads and Definitions

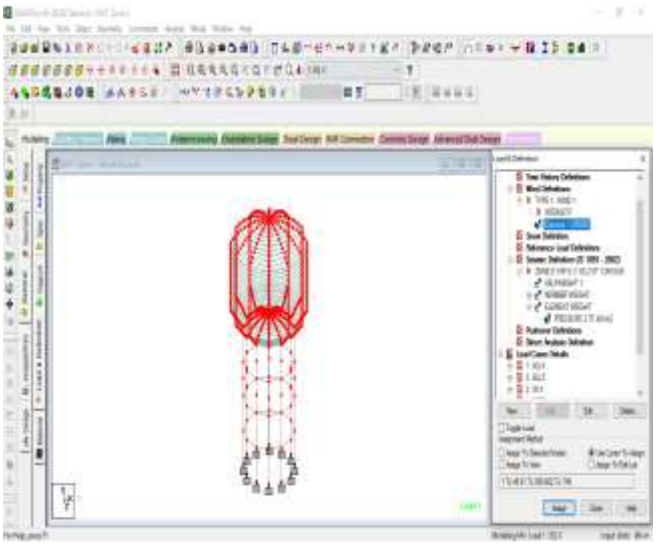


Figure. 4 Loads and Definitions

Step 4: Assign Support

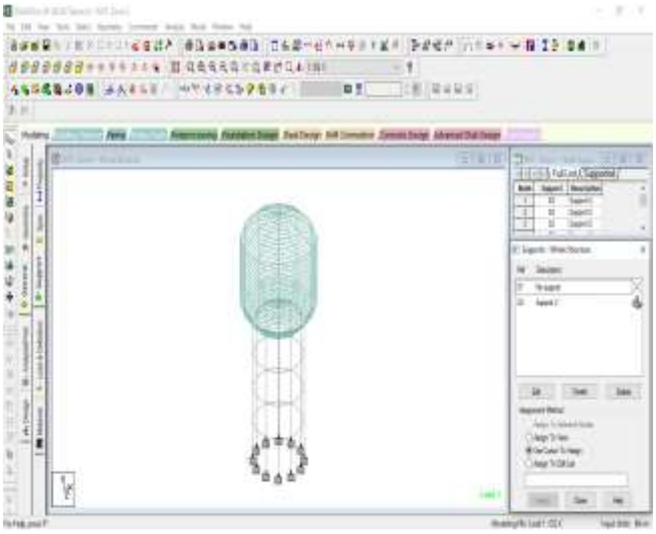


Figure. 5 Assign Support

Step 5: Run Analysis

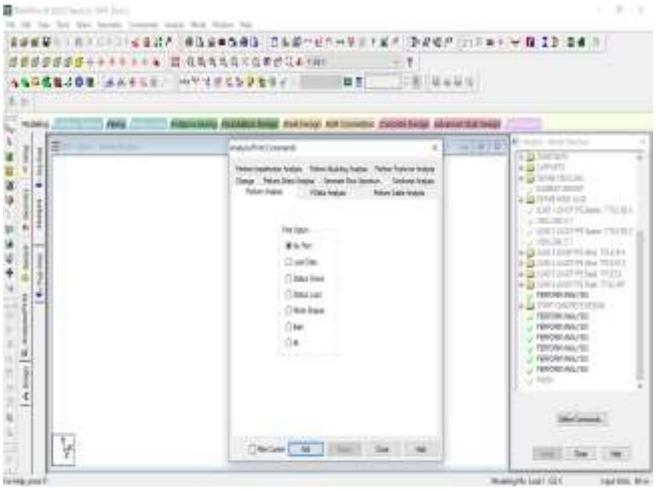


Figure. 6 Run Analysis

Step 6: Go to Post processing

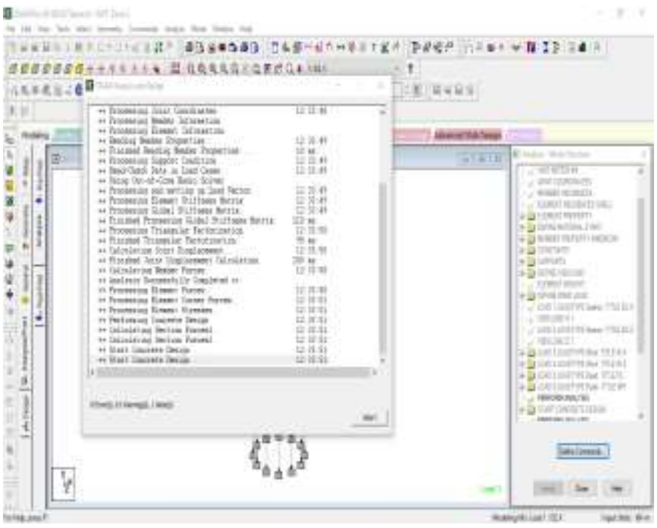


Figure. 7 Go to Post processing

Step 7: Analysis Drawings

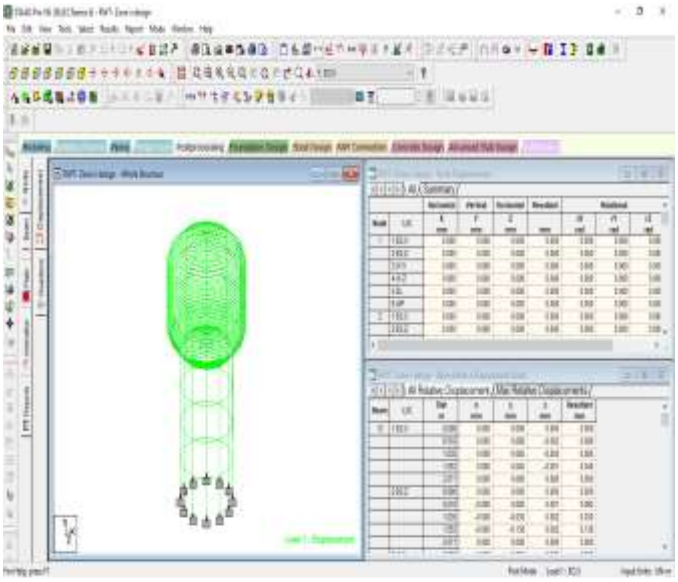


Figure. 8 Analysis Drawings of Intz Water Tank

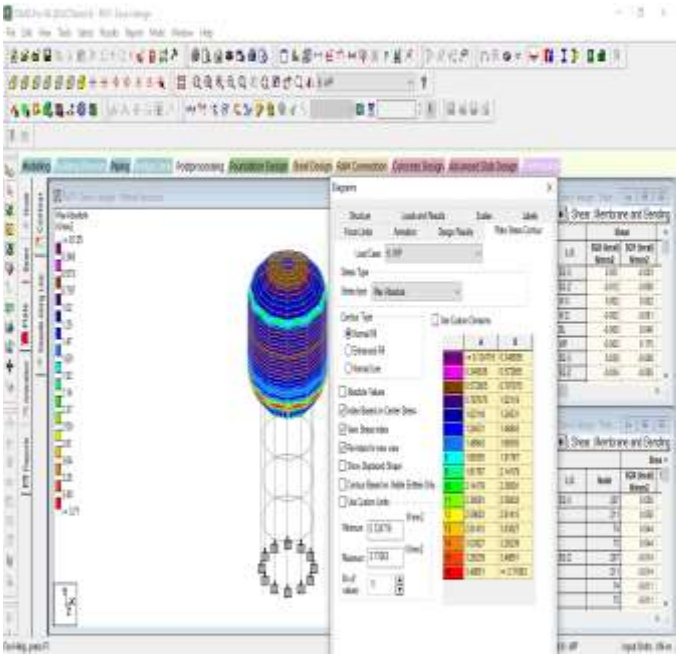


Figure. 9 Max absolute and max Principal stress

5. Results and Discussion

The result is based on the analysis of the intz tank model and the changes in the responses after using different seismic zones. The results include changes in time periods for node displacements axial forces, moments, lateral displacements, max shear force and max torsion for along X and Z direction considered individually for different earthquake intensities II and III by static method. The results of time period, for node displacements, axial forces, moments, lateral displacements, max shear force and max torsion for intz water tank and then compared with each other and a conclusion was then drawn.

A. Node Displacement

The maximum node displacement for Intz water tank are presented in Table-3

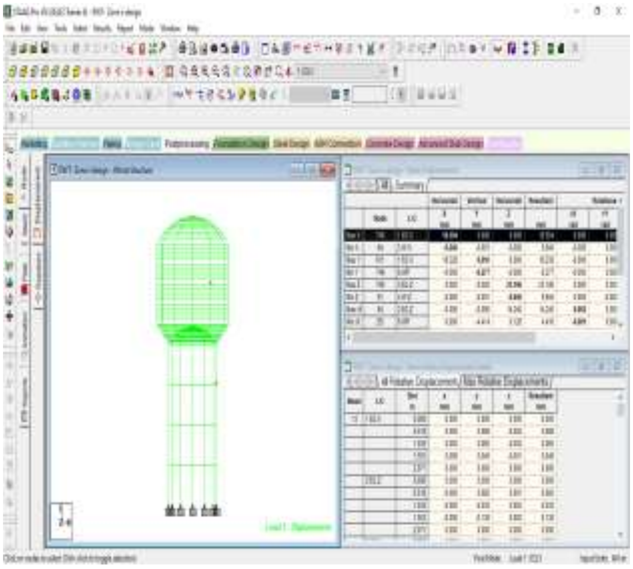


Figure 10 Maximum node displacement for Intz water tank Zone-II

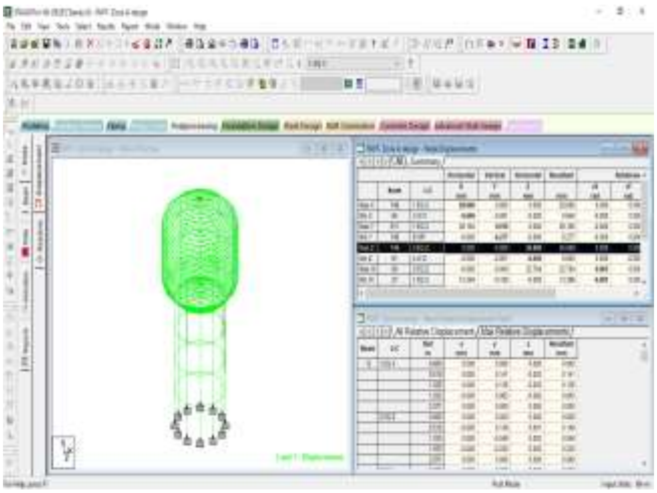


Figure 11 Maximum node displacement for Intz water tank Zone-III

Table-3: Maximum node displacement of Intz water tank for Different Zones

Zone	Soil Type	Node No	Max Delf. mm in X- dir	Node No	Max Delf. mm in Z- dir
II	Medium	746	18.504	746	23.106
III		746	29.606	746	36.969

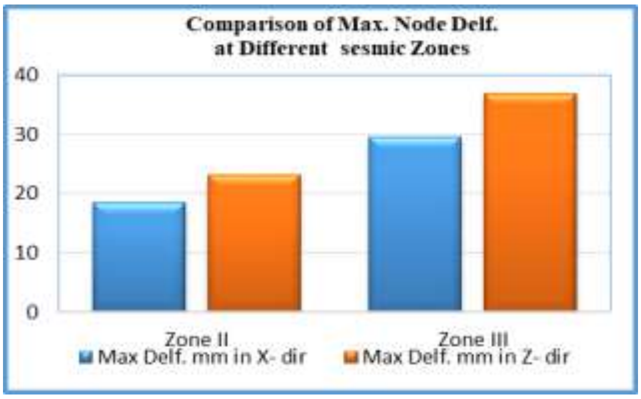


Figure 12 Maximum node displacement at different zones

B. Maximum Displacements

The maximum lateral displacement for Intz tank are presented in Table – 4

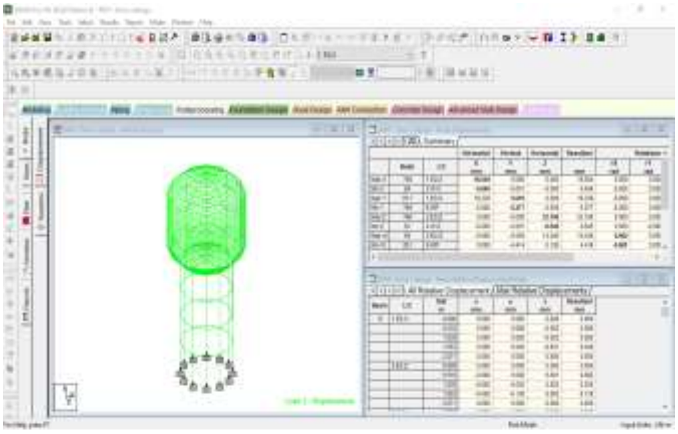


Figure 13 Maximum lateral displacement at Intz water tank for Zone-II

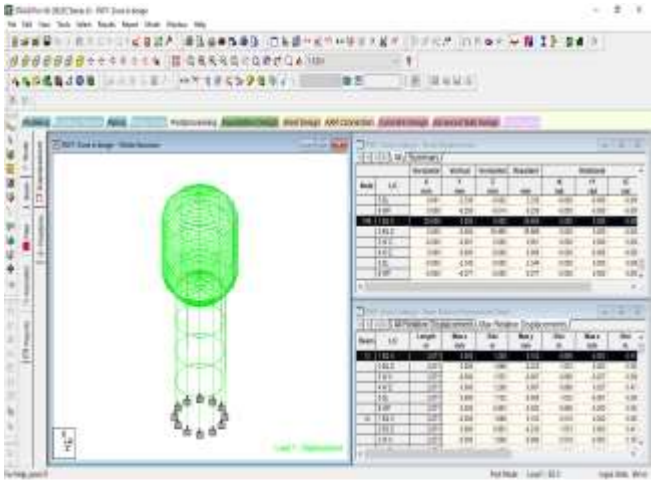


Figure 14 Maximum lateral displacement at Intz water tank for Zone-II

Table-4: Maximum lateral displacement for Different Zones

Zone	Soil Type	Beam No	Max Delf. mm in X- dir	Beam No	Max Delf. mm in Z- dir
II	Medium	686	18.228	688	22.831
III		686	29.164	688	36.530

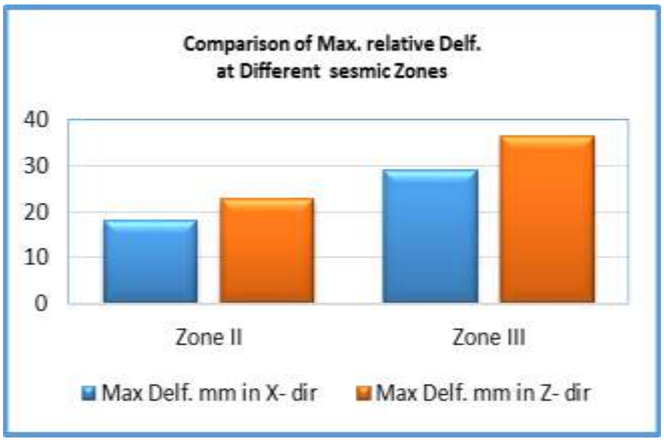


Figure 15: Comparison of Maximum lateral displacement at different seismic zones

C. Maximum Moment in columns

The maximum moment for for Intz tank are presented in Table 5

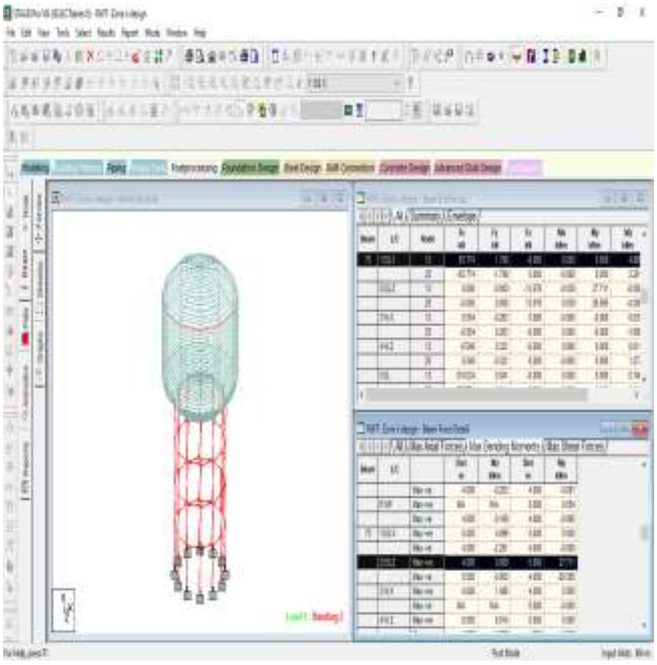


Figure 16 Maximum moment for Intz water tank Zone-II

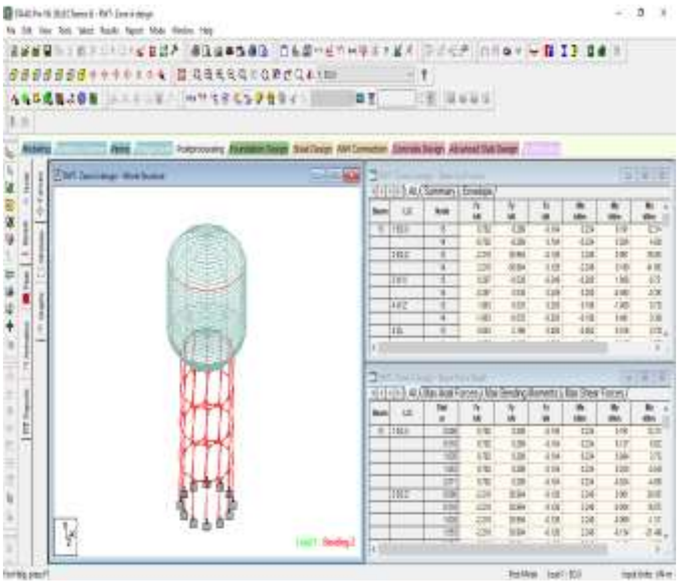


Figure 17 Maximum moment for Intz water tank Zone-II

Table-5: Maximum Moment in columns for Intz water tank Zone-II

Zone	**Soil Type**	**Beam No**	**Max Moment kNm in y- dir**	**Beam No**	**Max Moment kNm in Z- dir**
II	Medium	34	**2.075**	34	**30.274**
III		34	2.993	34	48.439

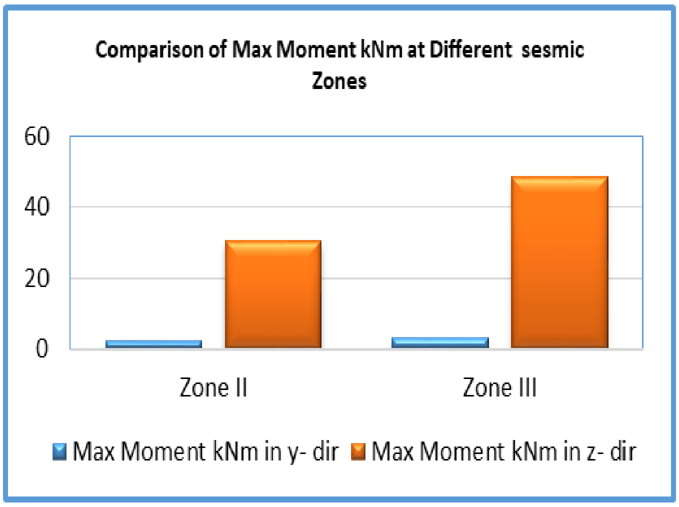


Figure 18: Comparison of Maximum Moment in columns

D. Maximum Torsion in beams

The maximum Torsion for Intz tank are presented in Table – 6

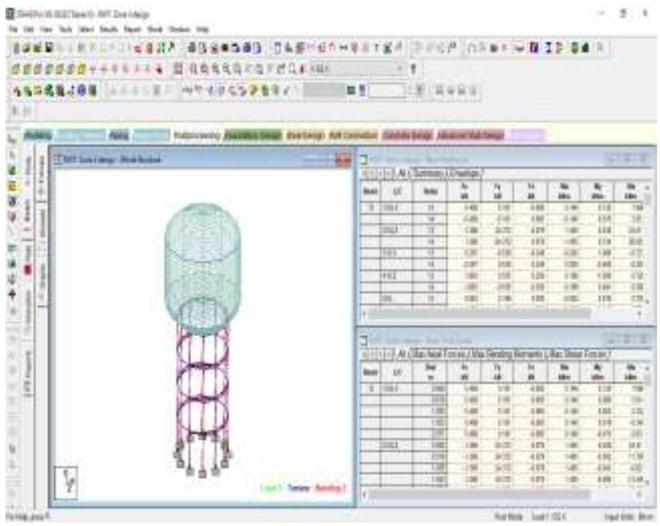


Figure 19 Maximum Torsion in beams

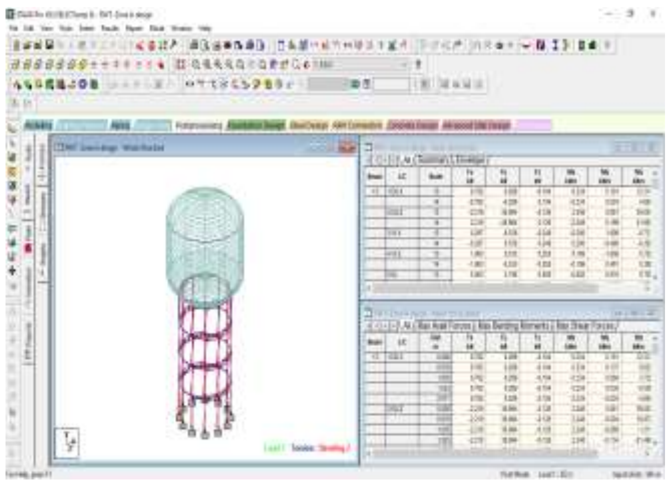


Figure 20 Maximum Torsion in beams

Table-6: Maximum Torsion in beams for Zone-III

Zone	Soil Type	Beam No	Max. Torsion KN-M
II	Medium	27	**1.871**
III		27	2.993

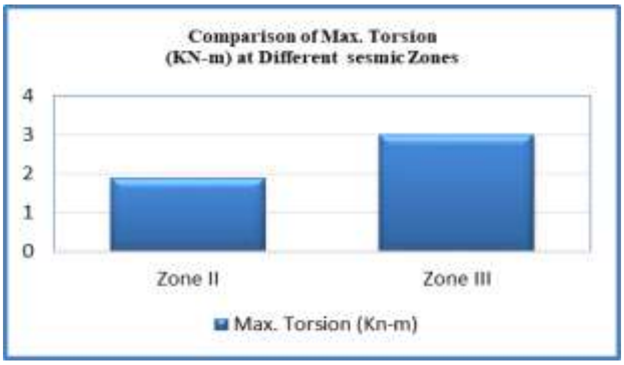


Figure 21: Comparison of Maximum Torsion

E. Maximum Shear Force in beams

The maximum shear force for Intz tank are presented in Table -7

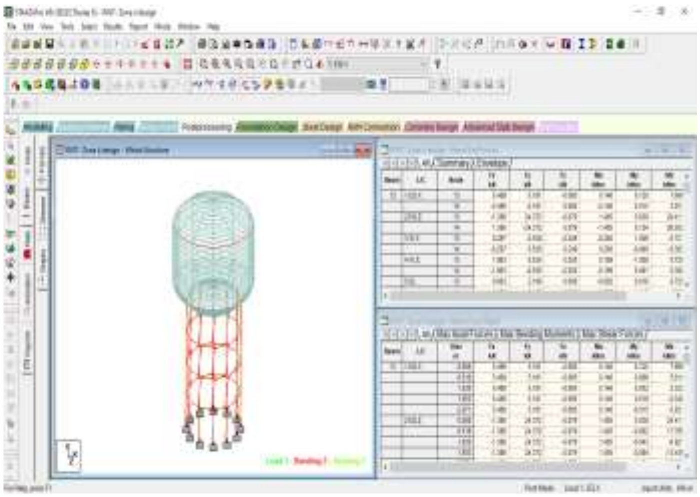


Figure 30 Maximum Shear Force in beams

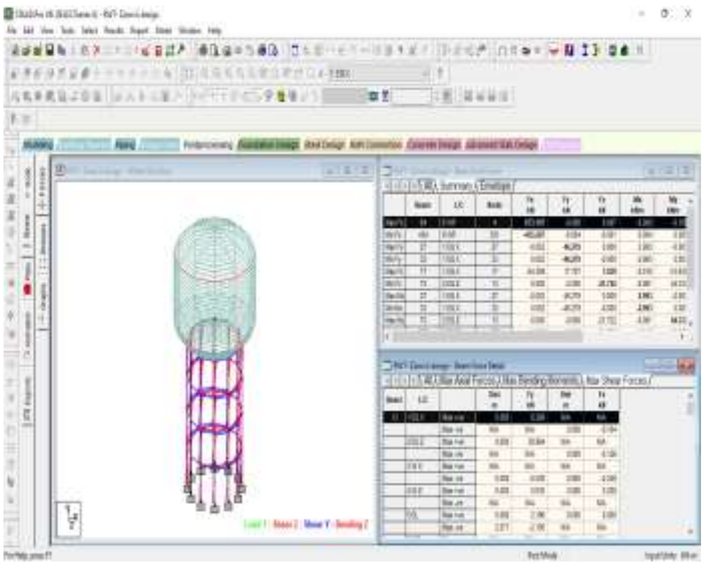


Figure 31 Maximum Shear Force in beams

Table-7 Maximum Shear Force in beams

Zone	Soil Type	Beam No	Max. Shear Force KN in Y- dir	Beam No	Max. Shear Force KN in Z- dir
II	Medium	27	28.925	73	4.899
III		27	46.279	73	7.839

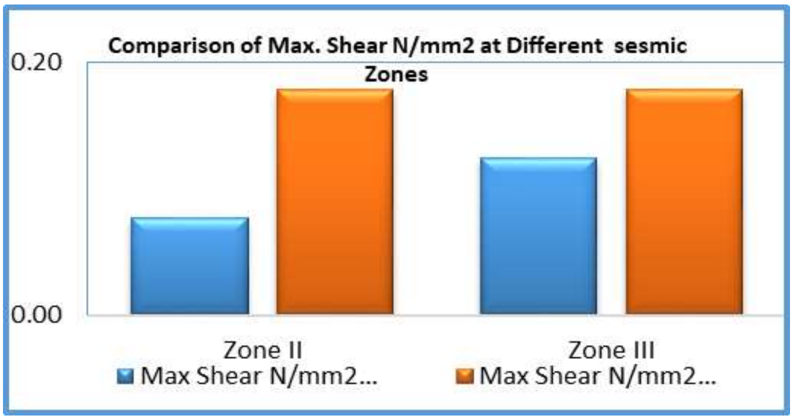


Figure 32: Comparison of Max. Shear Force

F. Maximum Bending Moments in Beam

The maximum Bending moments for Intz tank are presented in Table – 8

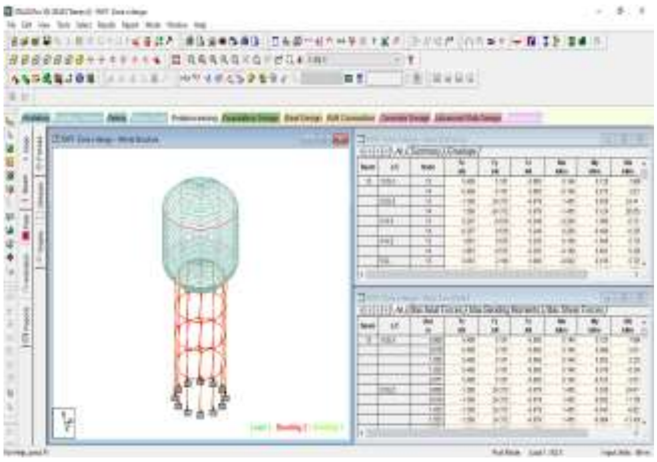


Figure 33 Maximum Bending Moments in Beam

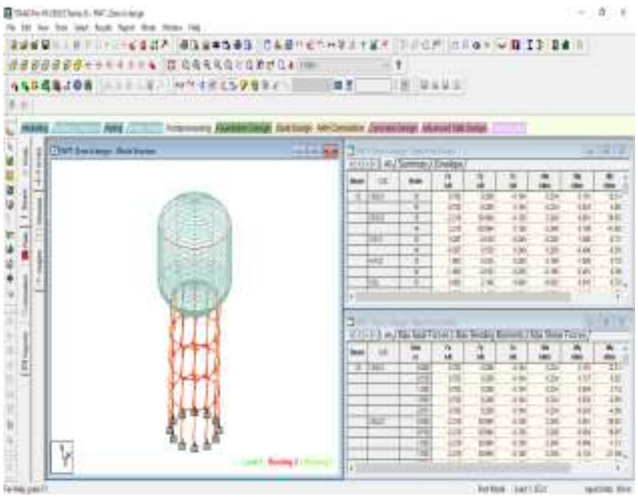


Figure 34 Maximum Bending Moments in Beam

Table. 8 Maximum Bending Moments in beam for Zone-III

Zone	Soil Type	Beam No	Max. Bending Moments KN in Y- dir	Beam No	Max. Bending Moments KN in Z- dir
II	Medium	73	**27.711**	76	**30.511**
III			44.337		48.818

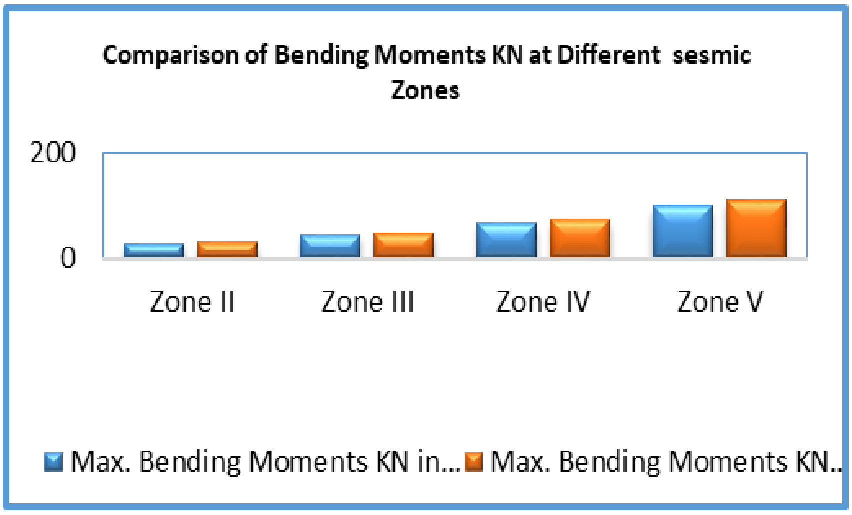


Figure 35: Comparison of Maximum Max. Bending Moment

DESIGN RESULTS:

1. Top Ring beam:
   B E A M N O. 688 D E S I G N R E S U L T S

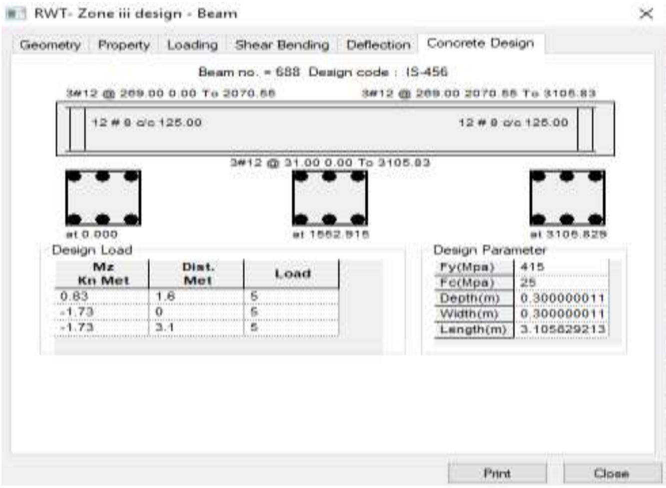
M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3105.8 mm SIZE: 300.0 mm X 300.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

```
-----------------------------------------------------------------------------
SECTION     0.0 mm     776.5 mm    1552.9 mm    2329.4 mm    3105.8 mm
-----------------------------------------------------------------------------
 TOP       165.29       165.29       165.29       165.29       165.29
REINF.    (Sq. mm)    (Sq. mm)    (Sq. mm)    (Sq. mm)    (Sq. mm)

BOTTOM     165.29       165.29       165.29       165.29       165.29
REINF.    (Sq. mm)    (Sq. mm)    (Sq. mm)    (Sq. mm)    (Sq. mm)
-----------------------------------------------------------------------------
                SUMMARY OF PROVIDED REINF. AREA
-----------------------------------------------------------------------------
SECTION     0.0 mm     776.5 mm    1552.9 mm    2329.4 mm    3105.8 mm
-----------------------------------------------------------------------------
 TOP      3-12í       3-12í       3-12í       3-12í       3-12í
REINF.  1 layer(s)  1 layer(s)  1 layer(s)  1 layer(s)  1 layer(s)
BOTTOM    3-12í       3-12í       3-12í       3-12í       3-12í
REINF.  1 layer(s)  1 layer(s)  1 layer(s)  1 layer(s)  1 layer(s)
SHEAR  2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í
REINF. @ 125 mm c/c @ 125 mm c/c @ 125 mm c/c @ 125 mm c/c @ 125 mm c/c
-----------------------------------------------
```



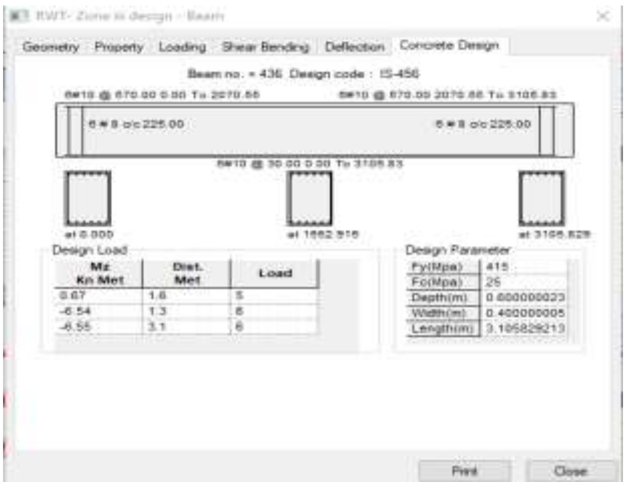
2. Bottom ring beam:

```
B E A M  N O.    436   D E S I G N  R E S U L T S

     M25                 Fe415 (Main)             Fe415 (Sec.)

    LENGTH:  3105.8 mm      SIZE:   400.0 mm X  600.0 mm   COVER: 25.0 mm

                   SUMMARY OF REINF. AREA (Sq.mm)
  ----------------------------------------------------------------------------
  SECTION      0.0 mm      776.5 mm     1552.9 mm     2329.4 mm     3105.8 mm
  ----------------------------------------------------------------------------
   TOP        466.99        466.99        466.99        466.99        466.99
  REINF.     (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)
   BOTTOM      466.99        466.99        466.99        466.99        466.99
  REINF.     (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)
  ----------------------------------------------------------------------------
                   SUMMARY OF PROVIDED REINF. AREA
  ----------------------------------------------------------------------------
  SECTION      0.0 mm      776.5 mm     1552.9 mm     2329.4 mm     3105.8 mm
  ----------------------------------------------------------------------------
   TOP      6-10í        6-10í        6-10í        6-10í        6-10í
  REINF.   1 layer(s)   1 layer(s)   1 layer(s)   1 layer(s)   1 layer(s)
  BOTTOM      6-10í        6-10í        6-10í        6-10í        6-10í
  REINF.   1 layer(s)   1 layer(s)   1 layer(s)   1 layer(s)   1 layer(s)
  SHEAR   2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í
  REINF.  @ 225 mm c/c  @ 225 mm c/c  @ 225 mm c/c  @ 225 mm c/c  @ 225 mm c/c
  ----------------------------------------------------------------------------
```



3. Bottom Ring girder:

B E A M N O. 266 D E S I G N R E S U L T S

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 2070.6 mm SIZE: 600.0 mm X 400.0 mm COVER: 25.0 mm

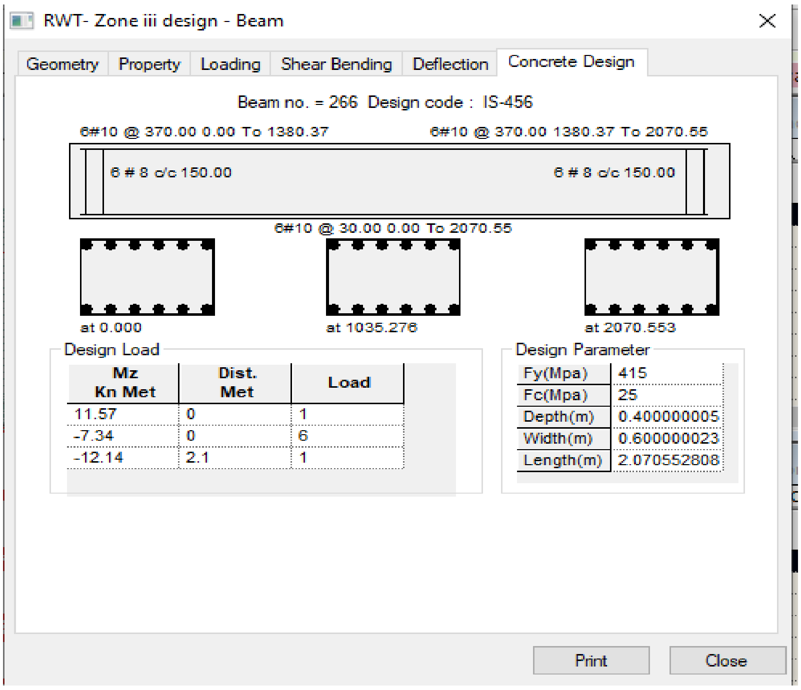
STAAD SPACE -- PAGE NO. 58

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	517.6 mm	1035.3 mm	1552.9 mm	2070.6 mm
TOP REINF.	454.70 (Sq. mm)	454.70 (Sq. mm)	454.70 (Sq. mm)	454.70 (Sq. mm)	454.70 (Sq. mm)
BOTTOM REINF.	454.70 (Sq. mm)	454.70 (Sq. mm)	454.70 (Sq. mm)	454.70 (Sq. mm)	454.70 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	517.6 mm	1035.3 mm	1552.9 mm	2070.6 mm
TOP REINF.	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)
BOTTOM REINF.	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)	6-10í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c



4. Design of column:

C O L U M N N O. 107 D E S I G N R E S U L T S

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3999.9 mm CROSS SECTION: 300.0 mm X 400.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 4 END JOINT: 47 TENSION COLUMN

```
 STAAD SPACE                                   -- PAGE NO.  109
REQD. STEEL AREA   :      960.00 Sq.mm.
REQD. CONCRETE AREA:   119040.00 Sq.mm.
MAIN REINFORCEMENT : Provide   4 - 20 dia. (1.05%,   1256.64 Sq.mm.)
                (Equally distributed)
TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
----------------------------------------------------------
Puz :   1638.00   Muz1 :     56.75   Muy1 :     40.72

INTERACTION RATIO: 0.04 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
----------------------------------------------------------
WORST LOAD CASE:     6
END JOINT:    47 Puz :   1726.99   Muz :    124.40   Muy :     86.31   IR: 0.31
====================================================================
```

Conclusions

By carried out the study with help of the STAAD Pro Software and results shown that members are not fail and the design is stable, We made the conclusion as pointed below:

1. Maximum node displacement of Intz water tank obtained by Staad Pro Results is observed that Maximum node displacement in node no 746 is 66.613 mm in in X- dir and 83.180mm in Z- dir increases as the zone increases form II to III.
2. Maximum lateral displacement of Intz water tank obtained by Staad Pro Results is observed that Maximum lateral displacement in column no 686 is 65.619mm in in X- dir and 82.191mm in Z- dir increases as the zone increases form II to III.
3. Maximum Moment in columns of Intz water tank obtained by Staad Pro Results is observed that max. Moment in column no 34 is 2.075 kNm in y- dir form II to III zone and max. Moment in column no 34 is 108.987 kNm in Z- dir increases as the zone increases form II to III.
4. Maximum Torsion in beams of Intz water tank obtained by Staad Pro Results is observed that max. Moment in beam no 27 is 6.735 kNm in x- dir increases as the zone increases form II to III.
5. Maximum Sheer Force of Intz water tank obtained by Staad Pro Results is observed that max. Sheer Force in beam no 27 is 104.129 kN in z-dir form II to III zone and max. Sheer Force in beam no 73 is 17.637kN in Z- dir increases as the zone increases form II to III.
6. Maximum Bending Moments of Intz water tank obtained by Staad Pro Results is observed that max. Bending Moment in beam no 73 is 104.129 kN in y- dir form II to III zone and max. Bending Moment in beam no 76 is 109.841kN in Z- dir increases as the zone increases form II to III.

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