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Analysis & Design of Intz Water Tank by Using Staad Pro

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ABSTRACT

The Intze principle is a name given to two engineering principles both named after the hydraulic engineer Otto Intze. In the one case the Intze principle relates to a type of water tower, in the other a type dam. Circular tanks with flat bottom as well as with domical bottom: In the flat bottom the thickness and reinforcement is found to be heavy. In the domed bottom though the thickness and reinforcement in the dome is normal, the reinforcement in the ring beam is excessive. Therefore in the cases of large diameter tanks and economical alternative would be to reduce its diameter at its bottom by conical dome. Such a tank is known as Intze tank and is very commonly used. The main advantage of Intze tank is that the inward radial thrust of the conical bottom balances the outward radial thrust of the spherical bottom.

KEYWORDS: *Intze, Circular, domical, tanks, diameter, conical dome*

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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.

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.

LITERATURE REVIEW

Chetanagari et al. (2019) studied the seismic analysis of water tank with different staging configuration in seismic zones 2,3,4 by response spectrum method using STAAD PRO V8i. Analysis is done on empty tank first and also with fully filled tank. Method involves the calculations if dynamic response spectrum by plotting curves of (SDOF) and earthquake frequency which is calculated by equation. The result analysis of empty and filled tank includes following parameter as displacement in tank, bending moment in tank, shear force in tank, base shear in tank individually. Base shear, shear force increases for higher seismic zones and displacement cause is reduce due to horizontal brace and bending moment value are changing in staging due to different bracings.

Singh et al. (2019) the storage reservoirs and overhead tanks are used to store water, liquid petroleum products and other similar liquids. In this research work, the five different cases of elevated shaft type intze water tank were studied having diameter (6m, 7m, 8m, 9m and 10m) with similar capacity. The diameter and height of the water tank changes to maintain same capacity in different cases.

The seismic analysis of water tank was performed as per IS: 1893:2014 (Part II) in which the impulsive and convective pressure were also considered. The analysis of tanks were also done using SAP v20 as per IS: 1893-2002. Comparison between analytical results and SAP results was also carried out. With considering the data of analysis, the economical section of water tank was found. From the results it is concluded that the 8m diameter of water tank is economical in all aspects

Dhage and Joshi (2020) the demand of water is not constant every time and it varies from time to time. For continue supply of water, we need to store the water at some place. In order to store the water, we use a structure known as elevated water tank. Intze type water can store large capacity of water for regular supply. Hence, these types of structures are huge in shape and size so these water tanks are very vulnerable to earthquake. Various researches has been done to find the effects of loads and forces such as wind, earthquake etc.

Acting on water tank with help of software like STAAD PRO, SAAP, ETABS etc. to minimize the collapse and any types of damage to the structure. The main objective of this paper is to analyse the earthquake effects and loads acting on the elevated water tank and to study its performance and behaviour under these conditions having different types of staging configuration in the structure of water tank with parameter like base moment, base shear, displacement, time period for empty tank, half-filled and completely filled water tank considering different types of soil and different seismic zones

Shaik 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.

Methodology:-

Water Quantity Estimation

The quantity of water required for municipal uses for which the water supply scheme has to 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

S. No.	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

Water Consumption Rate

It is very difficult to precisely assess the quantity of water demanded by the public, since there are many variable factors affecting water consumption. The objective of WDS is to deliver water to individual consumers with appropriate quality, quantity and pressure. The distribution system describes collectively the facilities used to supply water from its source to the point of usage. This may include extensive system of pipes, storage reservoirs, pumps and related appurtenances. The proper functioning of a water distribution system is critical to providing sufficient drinking water to consumers as well as providing sufficient water for fire protection. The various types of water demands, which a city may have, may be broken into following class

Fire Fighting Demand

The per capita fire demand is very less on an average basis but the rate at which the water is required is very large. The rate of fire demand is sometimes treated as a function of population and is worked out from following empirical formulae

Table: 3.2 Fire Fighting Demand

S. No.	Authority	Formula (P in thousands)	Q for 1 lakh Population)
1	American Insurance Association	Q(L/min)=4637P(1-0.01OP)	41760
2	Kuchling's Formula	Q(L/min)=3182 P	31800
3	Freeman's Formula	Q(L/min)=1136.5(P/5+10)	35050
4	Ministry of Urban Development Manual Formula	Q(kilo liters/d)=100P for P>50000	31623

As the population decreases, the fluctuation rate increases.

Maximum daily demand = 1.8 x average daily demand

Maximum hourly demand of maximum day i.e. Peak demand
= 1.5 x average hourly demand
= 1.5 x Maximum daily demand/24
= 1.5 x (1.8 x average daily demand)/24
= 2.7 x average daily demand/24
= 2.7 x annual average hourly demand

Table 4.1: 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 Bottum Ring Beam	600X400mm
8	Size of Bottum Circular Girder	400X600mm
9	Thickness of Top Dome	150mm
10	Thickness of Bottum Dome	300mm
11	Thickness of Conical Dome	300mm
12	No. of Column	12
13	Size of Column	400X300mm

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.
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

C. 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.

D. 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:

E. 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.

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

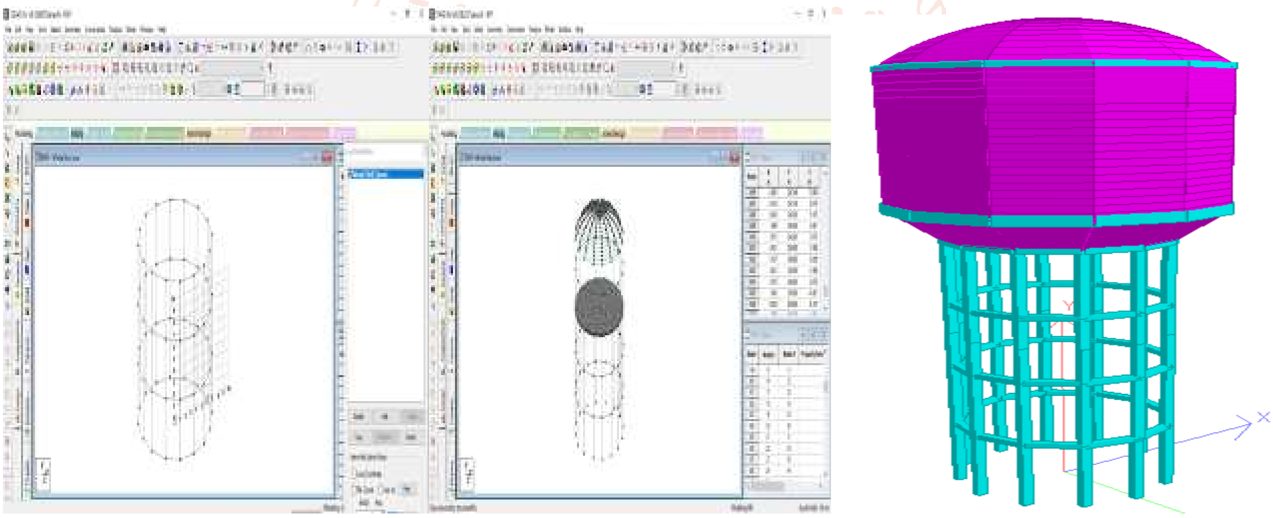

Figure.4.1 Geometry of Intz Water Tank

Step 2: Material and Property

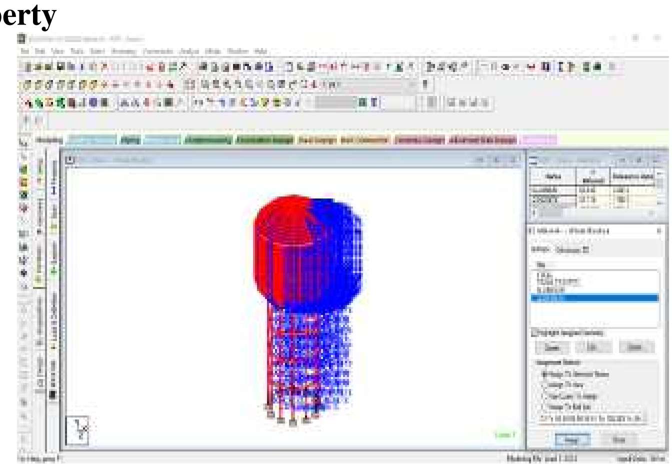

Figure.4.2 Material and Property of Intz Water Tank

Step 3: Loads and Definitions

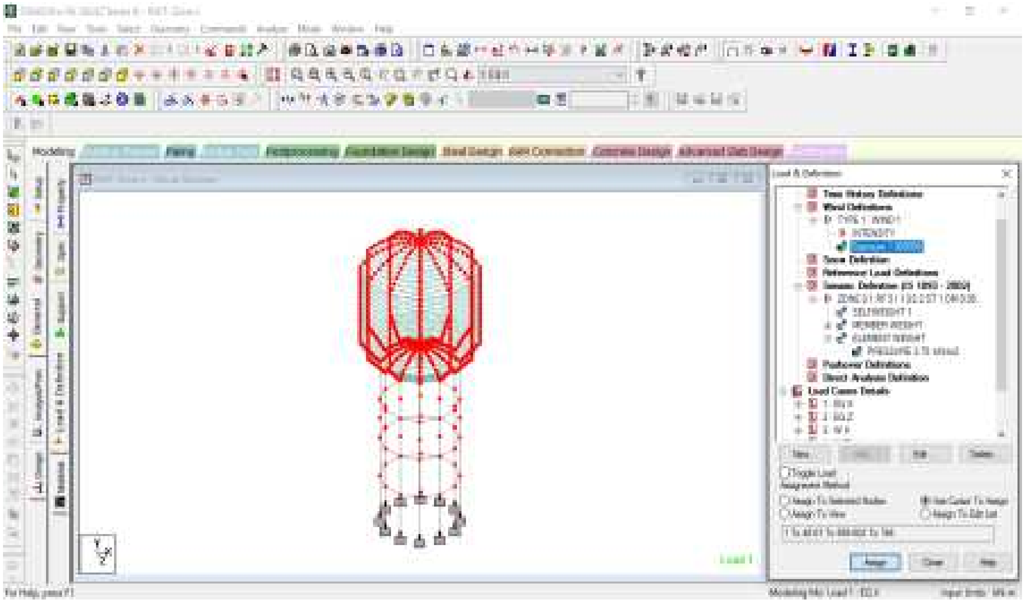

Figure.4.3 Loads and Definitions

Step 4: Assign Support

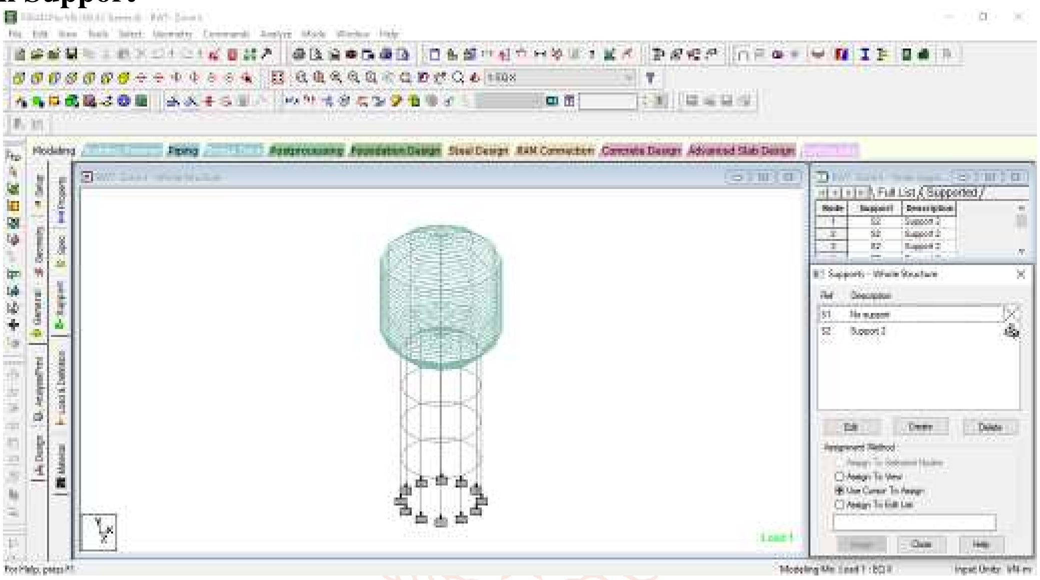

Figure.4.4 Assign Support

Step 5: Run Analysis

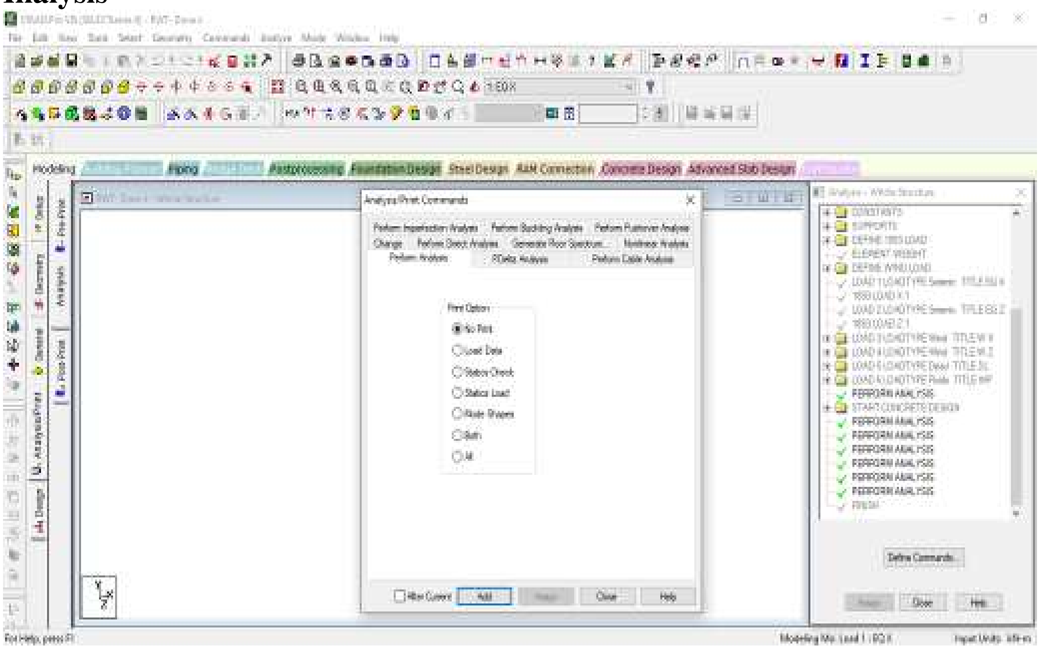

Figure.4.5 Run Analysis

Step 6: Go to Post processing

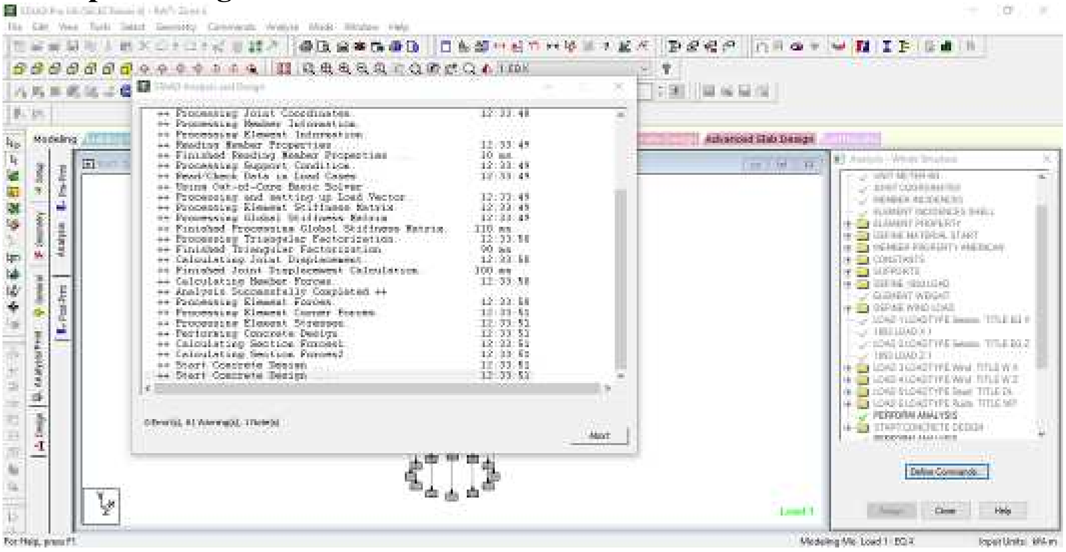

Figure.4.6 Go to Post processing

Step 7: Analysis Drawings

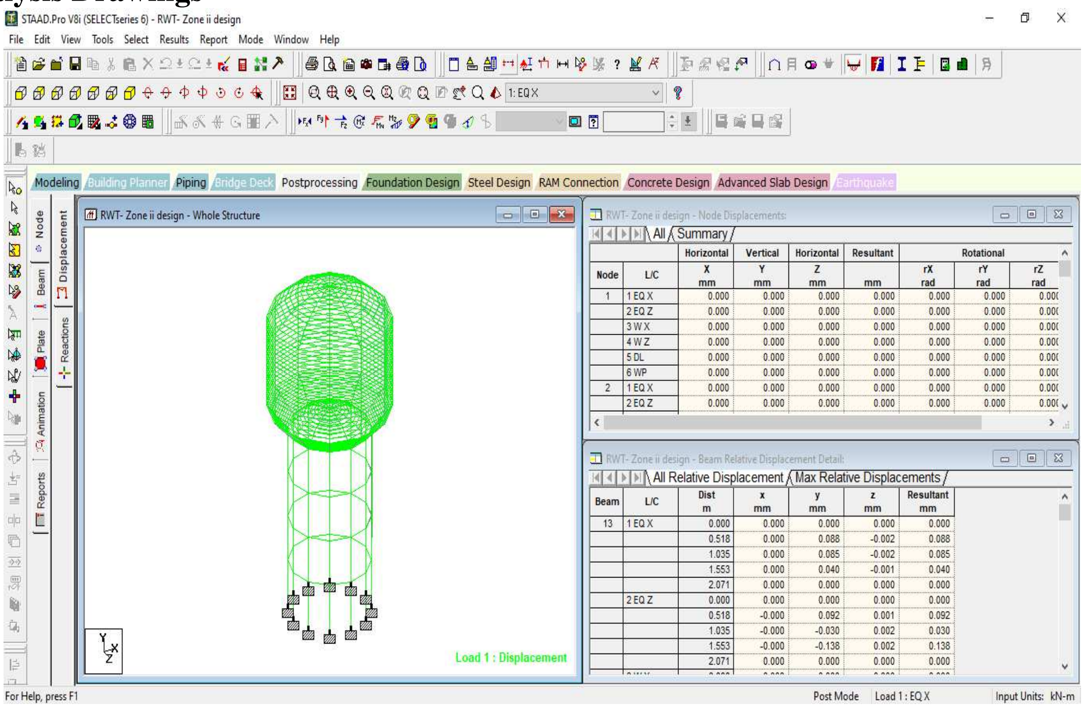

Figure.4.7Analysis Drawings of Intz Water Tank

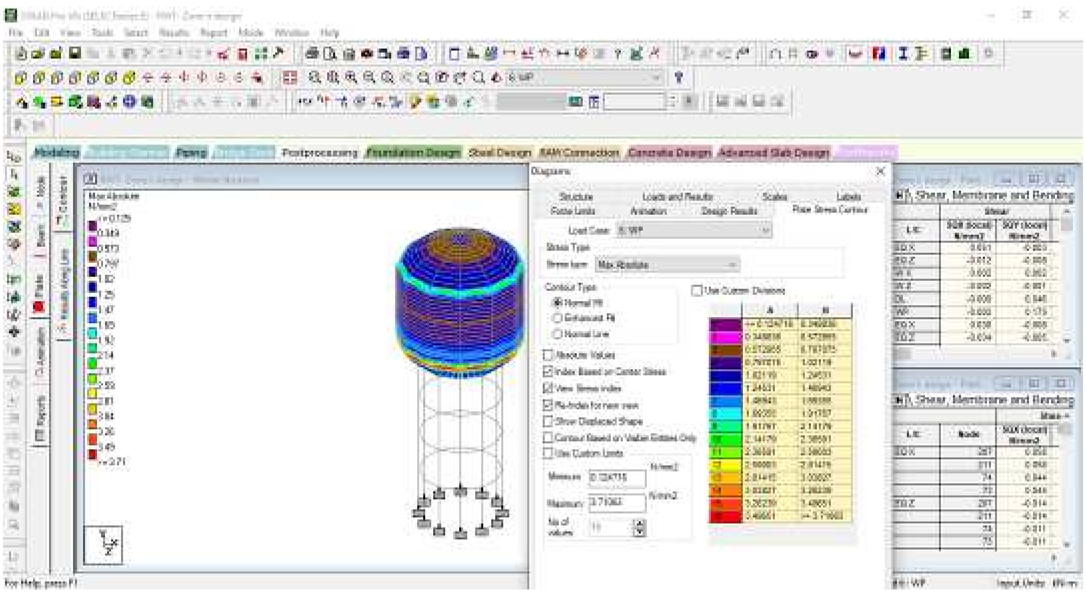

Figure.4.8 Max absolute and max Principal stress

Table-5.1: Maximum node displacement of Intz water tank for Different Zones

Zone	SoilType	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
IV		746	44.409	746	55.453
V		746	66.613	746	83.180

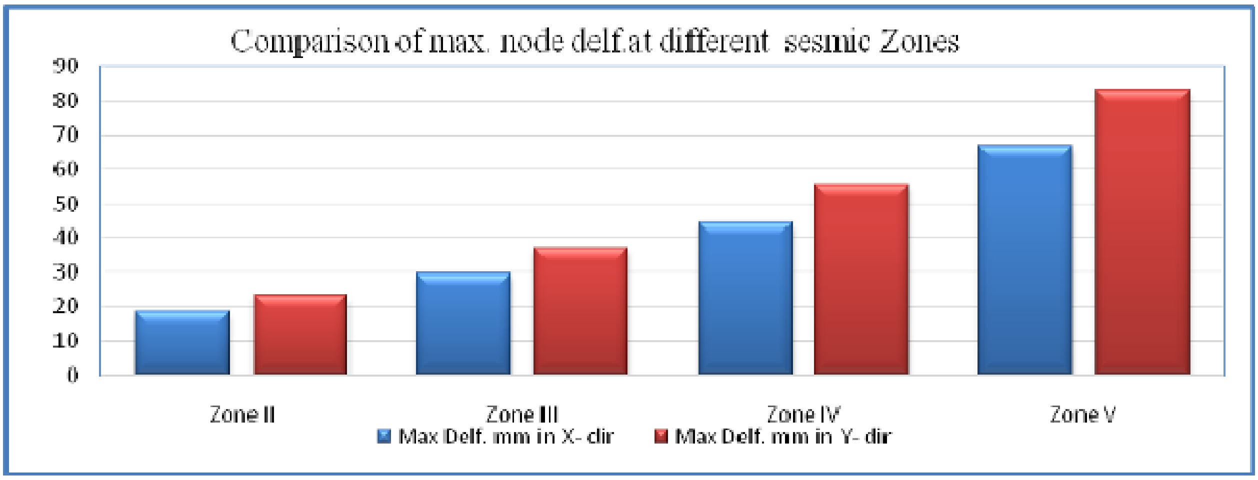

Figure 5.1 Maximum node displacement at different zones

Conclusion:- By carried out the present work 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 no746 is 66.613 mm in in X- dir and 83.180mm in Z-dirincreases as the zone increases form II to V. There is more node displacement in zone v as compare to zone II, III ,and IV.
2. Maximum lateral displacement of Intz water tank obtained by Staad Pro Results is observed that Maximum lateral displacement in column no 686 is65.619mm in in X- dir and 82.191mm in Z-dirincreases as the zone increases form II to V. There is more node displacement in zone v as compare to zone II, III,and IV.
3. Maximum Axial Force of Intz water tank obtained by Staad Pro Results is Results is observed that Maximum Axial Force in column no 64 is 673.197KN-m form II to V.
4. 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 V zone andmax. Moment in column no 34 is 108.987kNm in Z- dir increases as the zone increases form II to V. There is more node displacement in zone v as compare to zone II, III,and IV.
5. 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 V. There is more node displacement in zone v as compare to zone II ,III ,and IV.

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