Analysis and Design of Intze Type Water Tank

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Abstract:

Water is life line for every kind of creature in this world. All around the world liquid storage tanks are used extensively by municipalities and industries for water supply, fire fighting systems, inflammable liquids and other chemicals. Thus Water tanks plays a vital role for public utility as well as industrial structure having basic purpose to secure constant water supply from longer distance with sufficient static head to the desired location under the effect of gravitational force. In such situations elevated water tanks become an important part of life. According to seismic code IS 1893(Part-1):2000, more than 60% of India is prone to earthquakes. The analysis was conducted as per the specifications of IS 3370, IS 800:2002, IS 875, IS 1893. Design of tank by the dome, Ring beam supporting the dome, Cylindrical walls, Ring beam at the junction of the cylindrical walls and the conical wall , Conical slab, Floor of the tank, The ring girder, Columns, Tower with bracings, Foundations as per IS 3370 -Part III will be done by using 2-Dimensional STAAD model for different 2,50,000 Litres capacity tank . Different loads such as Dead Load, Live Load, Wind load, Earthquake Load will be applied on STAAD model at appropriate location as per codes used for Loading. All the results obtain from STADD are compared with the help of Excel sheets. With the standard dimensions of the Intze reservoir to be modeled be safe for wind loads, seismic loads etc.

Keywords: **Elevated water tank, Gravitational force, Intze reservoir, STAAD Pro.**

I. INTRODUTION

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. 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 and react with concrete and, therefore, no special treatment to the surface is required. Industrial wastes can also be collected and processed in concrete tanks with few exceptions. The petroleum product such as 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 and it can be below or above the ground level. Reservoirs below the ground level are normally built to store large quantities of water whereas those of overhead type are built for direct distribution by gravity flow and are usually of smaller capacity.

Storage reservoirs and overhead tank square measure wont to store water, liquid petroleum, fossil oil product. Tanks are concerning constant no matter the chemical nature of the merchandise. All tanks square measure designed as crack free structures to eliminate any run. Water or raw fossil oil holding block and walls can be of ferro concrete with adequate cowl to the reinforcement. Water and fossil oil and react with concrete and, therefore, no special treatment to the surface is needed. Industrial wastes may also be collected. The petroleum product like gasoline, diesel oil, etc. square measure probably to leak through the concrete walls, thus such tanks want special membranes to prevent run. Reservoir may be a common term applied to liquid storage structure and it is below or higher than the bottom level. Reservoirs below the ground level square measure usually designed to store massive quantities of water whereas those of overhead sort square measure designed for direct distribution by gravity flow and square measure typically of smaller capability.

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 rat io will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compact ion 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.

The pressure of the water flowing out of an elevated tank depends on the depth of the water in the tank. A nearly empty tank probably will not provide enough pressure while a completely full tank may provide too much pressure. The optimal pressure is achieved at only one depth.

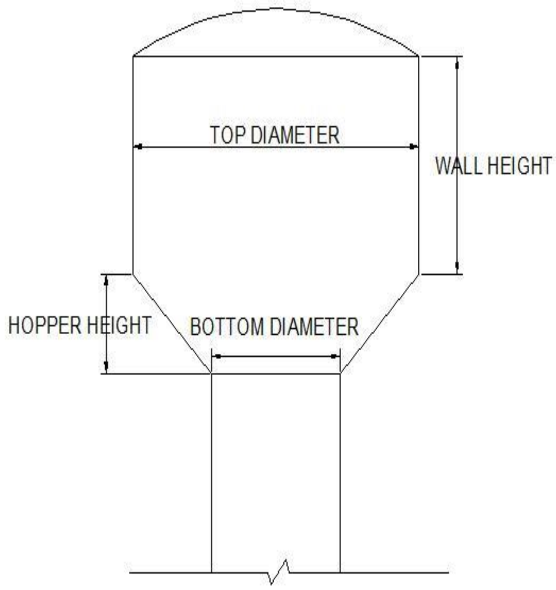

Figure 1: General diagram of Intze water tank

1.1. Objectives:

An attempt is made in this thesis seismic response and optimization of a high-water reservoir under different setup model with variations in tank volume. The main objectives of the relationship are

- To make a study about analysis and design of water tanks.
- To make a study about the guidelines for a design of liquid retaining structure according to IS code.
- To know about the design philosophy for the safe and economical design of water tank.
- To develop program for the design of water tank of flexible base and rigid base.
- In the end, the programs are validated with the results of manual calculation given in "concrete structure" book.

II. LITERATURE REVIEW

R.K.Prasad and Akshaya B. Kamdi[1] BIS has drawn out the modified variant of IS 3370 (section 1 and 2) after quite a while from its 1965 adaptation in year 2009. This re examined code is for the most part drafted for the fluid stockpiling tank. This paper gives in a nutshell, the hypothesis behind the configuration of roundabout water tank utilizing WSM and LSM. Outline of water tank by LSM is most practical as the amount of material required is less when contrasted with WSM. Water tank is the most vital compartment to store water in this manner, Crack width computation of water tank is additionally fundamental. Various literatures has presented in the form of technical papers till date on the Wind and Seismic analysis of Elevated Water Tanks. Various issues and the points are covered in that analysis. i.e. wind speed of various cities as per seismic zones, hydrodynamic pressure, and dynamic response of framed staging etc.

Pavan S. Ekbote and Dr. Jagdish G. Kori[2] during earthquake elevated water tanks were heavily damages or collapsed. This was might be due to the lack of knowledge regarding the behavior of supporting system of the water tanks again dynamic action and also due to improper geometrical selection of staging patterns of tank. Due to the fluid structure interactions, the seismic behavior of elevated water tanks has the characteristics of complex phenomena. The main aim of this study is to understand the behavior of supporting system (or staging) which is more effective under different response spectrum method with SAP 2000 software. In this paper different supporting systems such as cross and radial bracing studied. This chapter gives the background to the need of tank for possible used by the study; elevated water tank with different criteria and conditions. The available published literature on analysis of elevated water tank is also briefly reviewed.

Durgesh C. Rai and Bhumika Singh[3] (2004), studied Reinforced concrete pedestal (circular, hollow shaft type supports) are popular choice for elevated tanks for the ease of Construction and the more solid form it provides compared to framed construction. In the recent past Indian earthquakes, Gujarat (2001) and Jabalpur (1997), thin shells (150 to 200 mm) of concrete pedestals have performed unsatisfactorily when great many developed circumferential tension exural cracks in the pedestal near the base and a few collapsed.IITK-GSDMA Guidelines (For Seismic Design of Liquid Storage Tanks) says that, most elevated tanks are never filled completely with liquid. Hence a two-mass idealization of the tank is more appropriate as compared to a one-mass idealization, which was used in IS 1893: 1984. Two mass models for elevated tank were proposed by Housner (1963b) and are being commonly used in most of the international codes.

S.Deepika, Gugulothu.Swarna[4] ,"DESIGN AND ANALYSIS OF INTZE TYPE WATER TANK FOR DIFFERENT WIND SPEED AND SEISMIC ZONES AS PER INDIAN CODES ", International Journal of Advanced Technology in Engineering and science , This project deals with the design and analysis and comparison of intze type water tank for different wind speed and seismic zones as per Indian codes. Any design of Water Tanks is subjected to Dead Load + Live Load and Wind Load or Seismic Load as per IS codes of Practices. The seismic load is also called as unstable load.

Thalapathy.M, Vijaisarathi.R.P, Sudhakar.P, Sridharan.V, Satheesh.V.S, [5] "Analysis and Economical Design of Water Tanks ", IJISET - International Journal of Innovative Science, Engineering & Technology, A water tank is a container for storing liquid. The need for a water tank is as old as civilization, to provide storage of water for use in many applications, drinking water, irrigation, agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses. Water tank parameters include the general design of the tank, and choice of construction materials, linings. Reinforced Concrete Water tank design is based on IS 3370: 2009 (Parts I – IV).

Nitesh J Singh, Mohammad Ishtiyaque[6], has "DESIGN ANALYSIS & COMPARSION OF INTZE TYPE WATER TANK FOR DIFFERENT WIND SPEED AND SEISMIC ZONES AS PER INDIAN CODES." 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 will be 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. The effect of wind on the elevated structures is of prime importance as Wind flows relative to the surface of ground and generates loads on the structures standing on ground.

III. RESEARCH METHODOLOGY

The proposed work is planned to be carried out in the following manner.

- Study of Design of Intze Tank in Perspective of Revision of IS: 3370, IS 800:2002, IS 875: (Part I, Part II, Part III, Part IV), IS 1893 :2002,
- Study of Design parameters used in STAAD.
- Preparation of STAAD models for 2, 50,000 ltrs capacity Intze type tank .
- Analysis and Design of Intze tank for different seismic loads, wind loads.
- Optimization of design of ESR.

IV FORMULATION OF PRESENT WORK

Intze tank plan capacity of 250,000 lts

Height of the tank over the ground level 24 m

Safe bearing limit of the dirt 100kn/m^2

Wind weight 1200 N/m^2

Accepting M20 grade concrete

For which σcbe = 7N/mm^2, σcc = 5N/mm^2

Direct strain σt = 5N/mm^2

Strain in twisting = 1.70 N/mm^2

Particular proportion m = 13

For Steel stress,

Tractable anxiety in direct strain =115 N/mm^2

Tractable anxiety in twisting on fluid face =115 N/mm^2 for t < 225 mm

Furthermore, 125 N/mm^2 for> 225 mm

4.1 Design of Roof Dome

Considering an ascent of 1.50 m, sweep of the rooftop vault is given from

1.50(2R-1.50) = (3.75)2

R = 5.4375m.

Cos υ = (5.4375 – 1.50)/5.4375

= 0.7241

Also, υ= 43.602 < 51.8°

Likeness wind load inadvertent stacking and live load 2600 N/m^2

Meridian anxiety at of edge of arch

$N\upsilon$ = - wr/ (1+cosυ)

= -5000 (5.4375) /(1+0.7241)

=15769.10 N

Also, meridian anxiety = 15769.10/1000(100) = 1577 N/mm^2

Most extreme loop stress at crown = wr/2t= 5000(5.4375)/2(100)(1000)

= - 0.136 N/mm^2

Use typical fortification 0.3% = 300 mm^2 Utilize 8mm bars @ 160 mm c/c both ways

4.2 Design of Ring Beam at Top

Horizontal component Nυ= Nυcosυ

= 15769.10 (0.7241)

= 11418.41N

Hoop tension in ring = 11418 .41 (7.5/2)

= 42819.10N

Steel required for hoop tension = 42819.10/115

= 372.33mm^2

Use 4 Nos.12 mm bars at corners.

Area of cross section of ring beam considering concrete only

=42819.10/1.20

=35682.58mm^2

Use a ring beam 225mmX160mm

Area provided = 36000mm^2 > 35682.58mm^2

Use 6mm dia nominal stirrups @ 100mm c/c.

4.4 Design of Bottom Dome

Range of the arch = 4.70 m.

Ascent of the vault = 0.950 m.

Span of the vault from 0.950 (2R - 0.950) = (4.70/2)2

Thus R =3.3816m

Point subtended by the vault =2θ

Sinθ = (4.70/2)/3.3816 =0.695

What's more, θ = 44.02°; Cos θ = 0.71

Take thickness of vault as 200 mm Stacking

D.L. of vault = 0.200 (24000) = 4800 N/m^2

Wt. of water on vault = 10,000 [π/4(4.70)^2 (6.40) –π/6(0.950) (3x2.352 +0.9502)] = 1023465.44N

Territory of arch surface = 2 n (3.3816) (0.950) = 20.185 m^2 = 2 π (3.3816) (0.950) = 20.185

Load force = (1023465.44/20185) + 4800 =55504.26N/m^2

Meridian push at springing level = wR/(1+cosθ) = 55504.26(3.3816)/1.719 =109187.43N/m

Loop stress = wR/t [cosθ-(1/1+cosθ)]

Most extreme at θ=0, where

Max loop stress = 0.469N/mm^2

Hassles are low and give 0.30 % steel.

Utilize 8 mm Ø bars @ 80 mm c/c.

4.5 Total loads

Load from Top = 3843667.62 N

Self wt. of 6 segments = 529300.00 N

Wt. of Bracing = 60000.00N

All out = 4432967.62 N

Load on every segment because of W = 738828 N

Pushed on every segment = 739567.50 N

Vz =Vb k1 k2 k3 = 0.90Vb k2k3 taking k1 as 0.90 For 25 yrs. Life

Taking k2 and k3 both as solidarity

pz = 0.60 v^2 = 0.60 $(45)^2$ =1215 N/m^2

P1 = [7.5+0.450)(5.0(7.69)(2/3)(1.60)+(7.69+5.10)(1.60)/2](1215)(0.70) = 49915N

P2 = Due to segment, Bracing and roundabout Girder

=[(5.50) (0.600) + Vi (0.60) (4.0) (6.0)] (1215) (0.70) +(5.50) (0.300) (1215) (0.70)

=10333.58N at l2m above G.L.

P3 = on segment and Bracing

=[6 (0.600) (4) + (5.80) (0.300)] (1215) (0.70)

=13727 Nat 4 m. above G.L

P4 = [6(0.600) (4) + (6.20) (0.300)](1215) (0.70)

= 13829 N at 4 m above G.L.

4.6 Design of Bottom Slab

Utilize 400 mm thick chunk

Projection =1.60(0.450/2) = 1.375 m

Intended for variety of bearing weight considering impact of Moment Downward load from top due to Section and soil = 40 kN/m^2

Maximum = [(104.81-40)(1.375)2/2]+13.297[(1.375)2/3] =69.4556kNm

Saying. SF at separation d = 3 50 from face of bar

=[½(108.20 +118.107) - 40] (1.375 - 0.350)

=74.982 KN

τv = 1.5(74.962)(10)3/1000(350) = 0.321 N/mm^2

J = 0.948 and Ast =869.67mm^2

Utilize 12mmυ @125 c/c

4.7 Check for Stability

Sliding - Due to seismic stacking

V= 244237.52 N

W=4193494.15 + Wt. of base + Circular Bear

=4193494.15 + 617662.25 + 65144.06

=4876300.56 N

V.Modeling and Analysis

A. Area sections:

Member	Thickness
Thickness of top dome	100mm
Thickness of cylindrical wall	500mm
Thickness of conical wall	210mm
Thickness of bottom dome	200mm

Table : Area Sections of Water Tank

B. Material Properties: The material is used for analysis is reinforced concrete with M20 grade and Fe 415 reinforcing steel.

C. Loads considered in the analysis using STAAD- PRO.

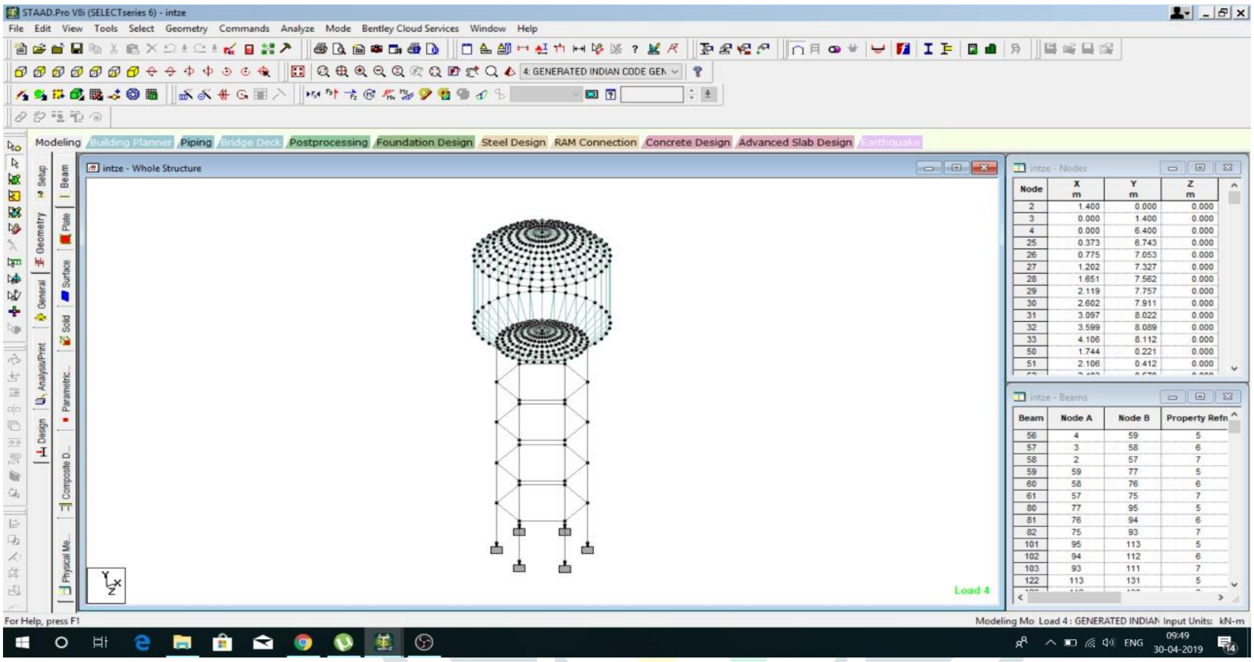

Fig: - Deformed shape of elevated water tank showing node beam structure STAAD PRO

The above node beam structure is located at each end of beam, and each corner of plates. Nodes considered the essence of the geometry of any structure in STAAD.Pro. Each node will hold node number and node coordinate in XYZ plane.

The design wind pressure at any height above suggests mean ground will be acquired by the following relationship among wind velocity and wind pressure. $Pz = 0.6Vz^2$

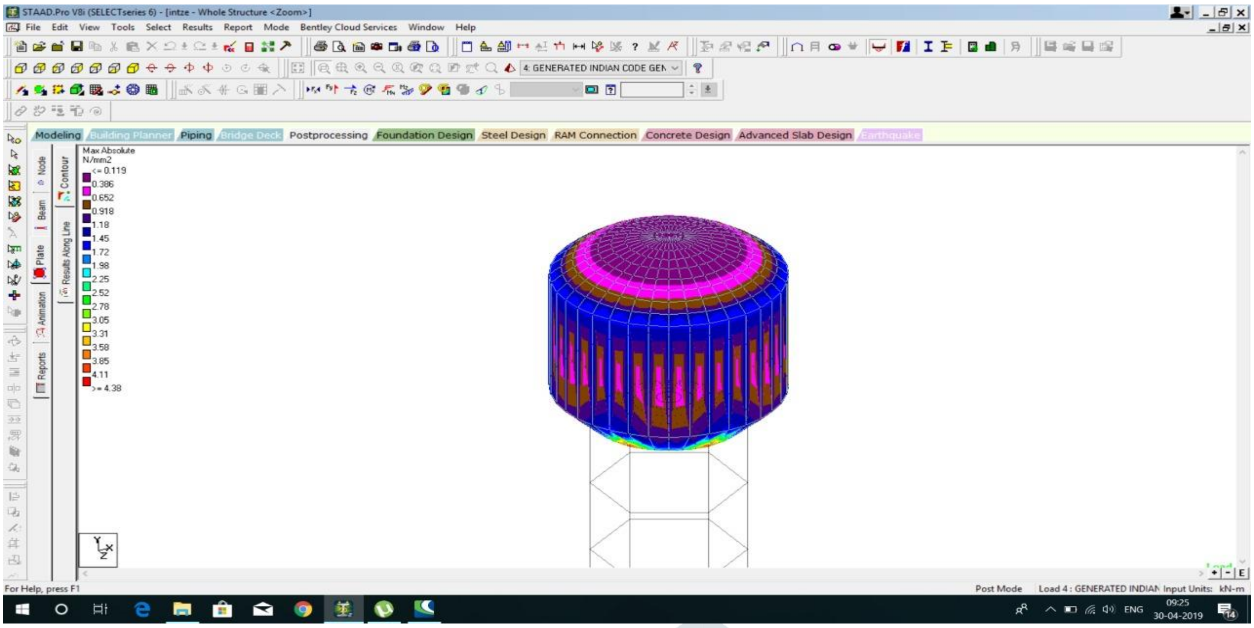

Fig: - Deformed shape of elevated water tank indicates plates stress diagram by STAAD PRO

The above fig shows that the plate stress diagram, plate in STAAD means a thin shell with multi-nodded shape starting from 3 nodes, and more. It can be anything of slab, wall, or raft foundation. Each plate will hold the plate number and node number at each corner of it.

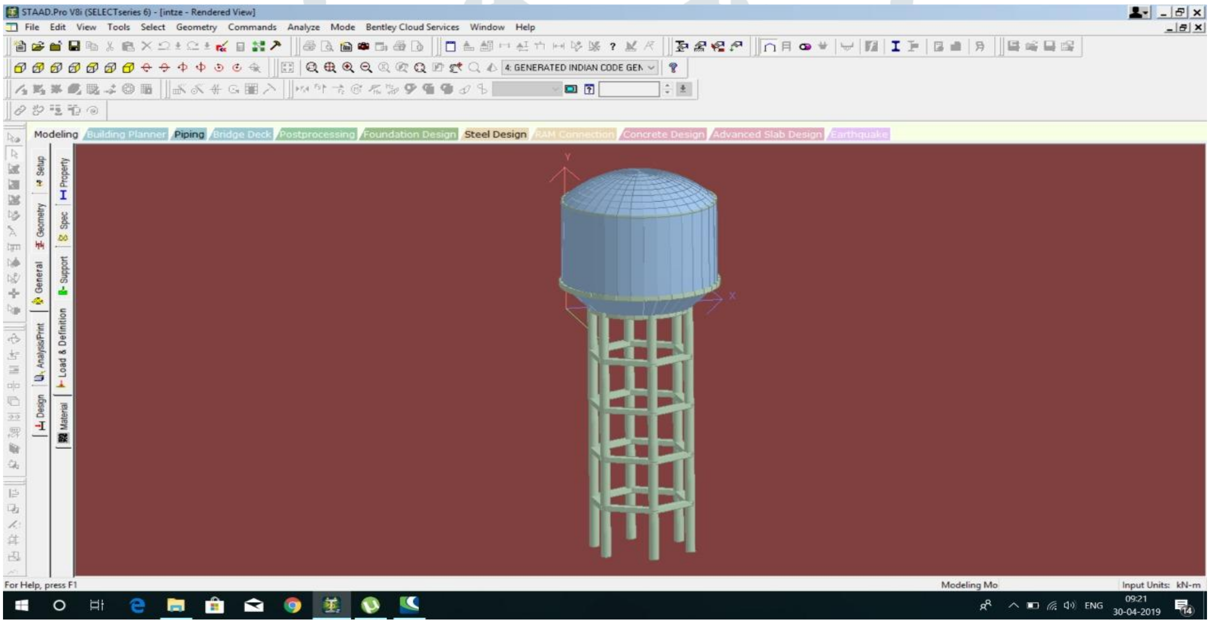

FIg: - Deformed shape of elevated water tank due to 3D rendered view in STAAD PRO

The above node rendered water tank view after applying all the forces in each particular direction. So, in above figure wind load has to be characterized by the analysis according to Indian standard. Wind force depends on expose area of the structure. The wind force will act mainly exterior frames and it may reduce to interior frames based on the type of structure. A structure having a higher mass will resist the wind load effectively. The wind force increases as height increases as the exposed area remains same. The wind force is generated at each node in exposed area. Wind load doesn't cause the torsion in a structure. Soil type also not affects the performance of structure during wind. When wind load act in a building, negative pressure act in it due to suction.

The wind load generation is a utility, which takes place as an input wind pressure and height ranges over which these pressure act and generates nodal point and member loads. As we said earlier, the intensity versus height of calculation by using formula. To calculate the wind intensity, use the following formula from IS 875-Part3.

$V_z = V_b\, k_1\, k_2\, k_3$ and $p_z = 0.6\, V_z^2$

Where, V_z = Design wind speed at any height

V_b= Base wind speed

K_1= Probability factor

K_2= terrain, height and structure size factor

K_3= Topography factor

P_z= Design wind pressure

VI. CONCLUSION

By carried out the study with help of the STAAD Pro Software, We made the conclusion as pointed below:

1) There is an increase in moment when the height of the structure increases.

2) When using fix joint at the base its remarkable reduction in base settlement.

3) This type tank is simplest form as compare to the circular tank.

4) We have given the inclination to the staging of water tank because as respected inclination the tank performs better than that type of straight one.

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