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Wind Force Analysis of Intze Type Water Tank in Various Wind Zones Using STAAD-PRO

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Abstract *: Overhead Intze type tank is a form of expanded water tank resting on staging. Bottom part of circular tank of Intze tank is abounding in flat structure, thus in flat bottom, the thickness and reinforcement is set up to be high. This work aims to study the performance of the Overhead water tank of Intze type under the action of basic wind loads in different terrain category. Commonly water tank is analysed as in step with the code IS 875 (element 3) and layout of water tank dome is executed as consistent with IS code 3370-1987 in working stress approach and the staging (column and beams) are designed as per IS code 456-2000 in limit state method. In addition the present work deals with the Wind analysis of elevated INTZE type water tank using STAAD-Pro Software package. Wind study of reinforced concrete Intze tank is finished at one of a kind staging heights of tank with the aid of assuming to be located in exclusive wind zones in India of different terrain categories. Different parameters like as Design wind forces, displacements because of wind forces at unique heights of water tank are in comparison in one of a kind wind zones.*

Keywords: *Intze type tank, wind forces, Lateral displacement, STAAD-PRO, Wind Zones.*

I. INTRODUCTION

A water tank is a container for storing liquid. The need for a water tank is as oldest as civilization, to offer storage of water for utilize in several operations, irrigation, agriculture, fire suppression, drinking water, agricultural gardening, together for plants and farm animals, chemical industries, food Product industry as well as different other uses. A water tank is utilized to store water to tide over the everyday need. Cost, shape, size and building materials used for constructing water tanks are influenced by the capacity of water tank. In common, for a given capability, circular shape is consider because stresses are homogeneous and lower compared to other shapes. Design of water reservoirs arrangement has to be depends on the escaping of cracks in the concrete wall of reservoir with respect to its tensile strength. In common, for a provide capability, round form is favoured due to the fact stresses are uniform and decrease compared to other structure. Construction of liquid reservoirs structure requires to be mostly based at the prevention from cracks within the concrete having regard to its tensile strength.

II. METHODS OF WIND ANALYSIS

A. **Code Based Wind Analysis:**

- Designed based on IS-875 part –III: It is very important to analyse reinforced cement concrete elevated water tank properly against horizontal forces. The present analysis at has been deliberate to find the severity of wind load with the top roof of the elevated water tank in various zones of India.

a) Computational Modelling:

It's very significant to examine reinforced cement concrete elevated water tank correctly against horizontal forces. The exiting analysis has been planned to test the severity of wind forces with height of the elevated water tank in distinct zones of India. The study is carried out utilizing sap 2000 software as in line with IS 875 (Part three): 1987. The wind magnitude pressure especially relies upon on following factors.

b) Classification ff Structure.

The Structures are divided into the subsequent three different parts depending upon their sizes;

- Class A - Structures or/and their element e.g. glazing, roofing, cladding, etc., having maximum dimension (greatest vertical or horizontal dimension) lesser than 20m.
- Class B - Structures or/and their element e.g. glazing, roofing, cladding, etc., having maximum dimension (greatest vertical or horizontal dimension) amid 20 and 50 m.
- Class C - Structures or/and their element e.g. glazing, roofing, cladding, etc., having maximum dimension (greatest vertical or horizontal dimension) larger than 50m.

c) Terrain Category

There are 4 terrain classes. Terrain wherein a particular structure stands will be assessed as being one of the following terrain groups:

- Category 1- Exposed open terrain with some or no difficulties and in which the average height of any object surrounding the structure is less than 1.5 m.

- Category 2- Open terrain with properly scattered difficulties having heights commonly amid 1.5 to 10 m.
- Category 3- Terrain with several nearly areas difficulties having the scale of structure up to 10 m in height with or without a few secluded tall structures.
- Category 4- Terrain with several massive excessive closely spaced difficulties.

B. Wind Speed:

Based on Normal wind speed, there are 6 zones, zone I to zone VI. Normal wind speed shall be modified to include following effects to get design wind velocity at height for the chosen structure;

There are four terrain categories as per the code depending on the obstruction to the wind. From the wind zone map of India shown in Figure 3.9.It's found that based totally on basic wind pace, India is split into six wind zones such as Zone I to zone VI.

Table 1: Risk Coefficient K1 for Structure

Zone	Basic wind speed (m/sec)	k1 factor
I	33	1.05
II	39	1.06
III	44	1.07
IV	47	1.07
V	50	1.08
VI	55	1.08

C. DESIGN WIND SPEED (Vz):

The primary wind speed (Vb) for any site will be changed to consist of the following effects to get design wind velocity at any height (Vz) for the select structure.

a) Local topography

b) Risk degree

c) Terrain roughness, height and length of structure

Risk Coefficient (k1 Factor) 6)

K1 component provide basic wind speeds for terrain class 2 as applicable at 6 m above ground level primarily based on 50 years mean return length. The recommended life period to be supposes in design and the corresponding k1 elements for the different class of structures for the motive of design.

Terrain, Height and Structure Size Factor (K2 Factor)

a) ***Terrain:*** choice of terrain classes will be made with because regard to the effect of obstructions which constitute the ground surface roughness. The terrain class utilized inside the Design of a shape may range relying on the route of wind below consideration. Wherever sufficient meteorological data is available about the nature of wind way, the orientation of any building or shape can be certainly deliberate. The terrain categories are mentioned above.

b) ***Topography (k3 Factor*)**: The general wind pace Vb takes account of the overall level of site above sea stage. This doesn't allow for local topographic characteristic which includes hills, cliffs, valleys, or ridges and escarpments that could significant have an effect on wind speed of their region. The impact of topography is to speed up wind near by the height of hills or crests of cliffs, ridges and slow down the wind in valleys or close to the steep escarpments, or ridges and foot of cliffs. The effect if topography could be significantly at a domain while the upward slope is more than approximately 30, and underneath that, the value of k3 may be taken to be identical to 1.0. The price of k3 is confined in the range of 1. 0 to 1.36 for slopes extra than 30. Approach of evaluating the value of k3 for values more than 1.0. It may be referred to that the value of k3 varies with height above floor level, at a most close to the ground, and decreasing to 1.0 at higher level.

c) ***Design wind pressure (Pz)****:* The design wind pressure at any height above suggests mean ground will be acquired via the following relationship among wind velocity and wind pressure.

$Pz = 0.6\ Vz^2$

8) Wind forces and pressures on buildings/structures Overall:

The wind will be compute for:

1) The building as a complete.

2) Separate structural factor as walls and roofs, and

3) Individual cladding units comprising glazing and their fixings.

III. MODELLING AND ANALYSIS

A. Frame Sections:

Table 2: Frame Sections of water tank

Member	Size (mm)
Column rectangular type	1000x500 mm
Bracings	400x400mm
Bottom ring Beam	500x500 mm

B. Area Sections:

Table 3: Area Sections of water tank

Member	Thickness (mm)
Thickness of top dome	200 mm
Thickness of cylindrical wall	1000
Thickness of conical wall	500
Thickness of bottom dome	300

C. Material Properties:
The material is used for analysis is Reinforced concrete with M-20 grade and Fe-415 reinforcing Steel.

D. Loads considered in the analysis using STAAD-PRO.
1. Dead load
2. Water pressure
3. Wind load

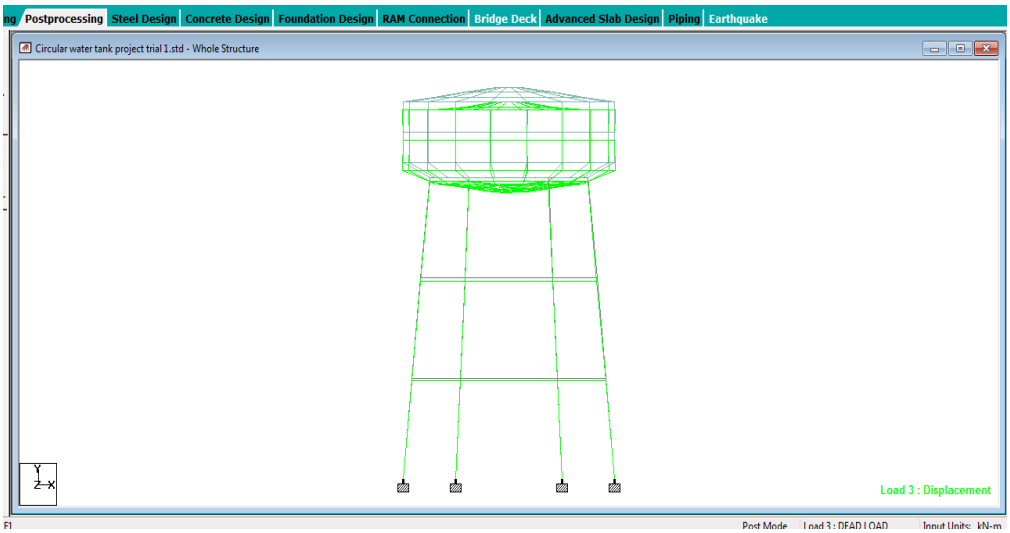


Figure 1: Deformed Shape of Elevated Water Tank Due To Dead Load in STAAD PRO

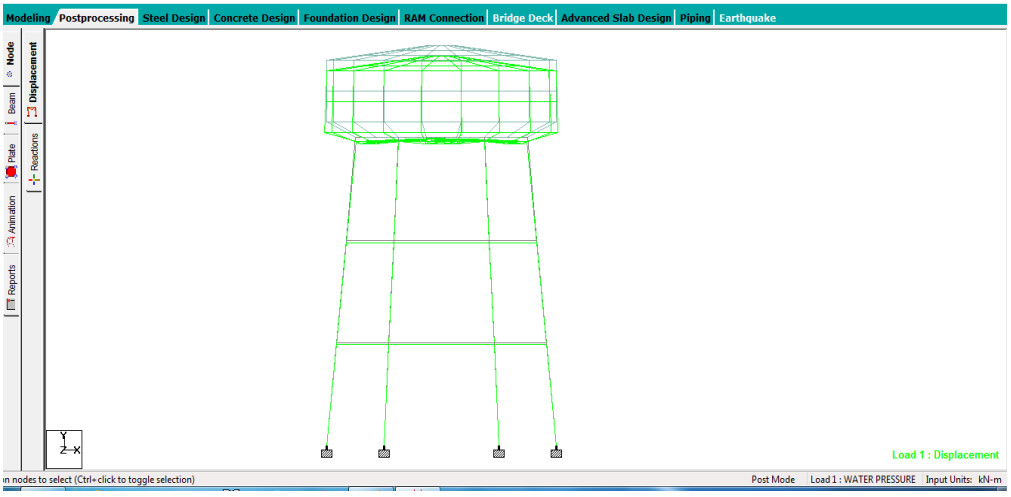


Figure 2: Deformed Shape of Water Tank Using STAAD-PRO Due To Water Load

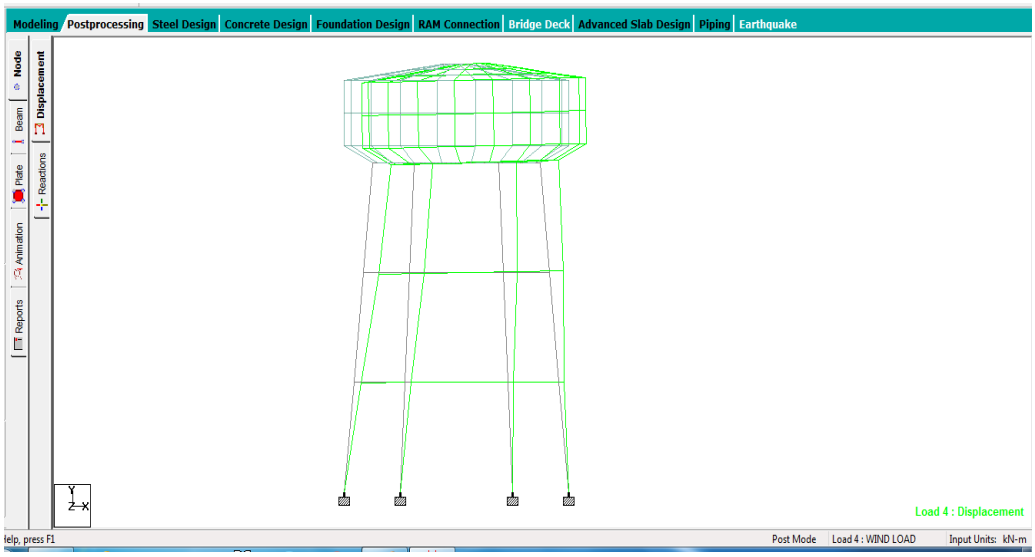


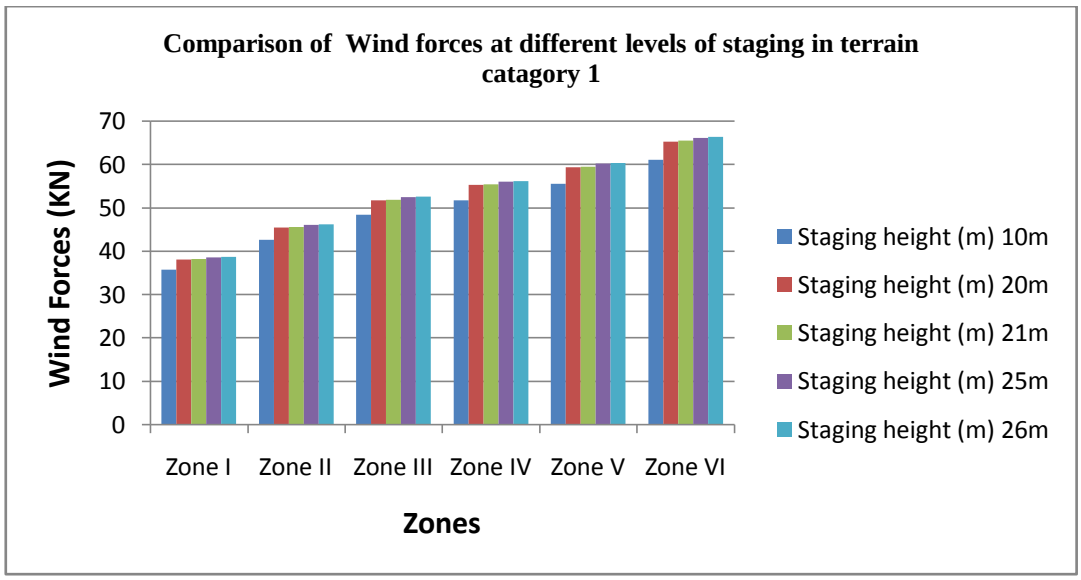
Figure 3: Deformed Shape of Elevated Water Tank Using STAAD-PRO Due To Wind Load in Zone6

IV. RESULTS AND DISCUSSIONS

Comparison of wind forces in different wind zones of India at different heights of staging

Table 4: Wind Forces (KN) for different wind Zones of terrain category 1

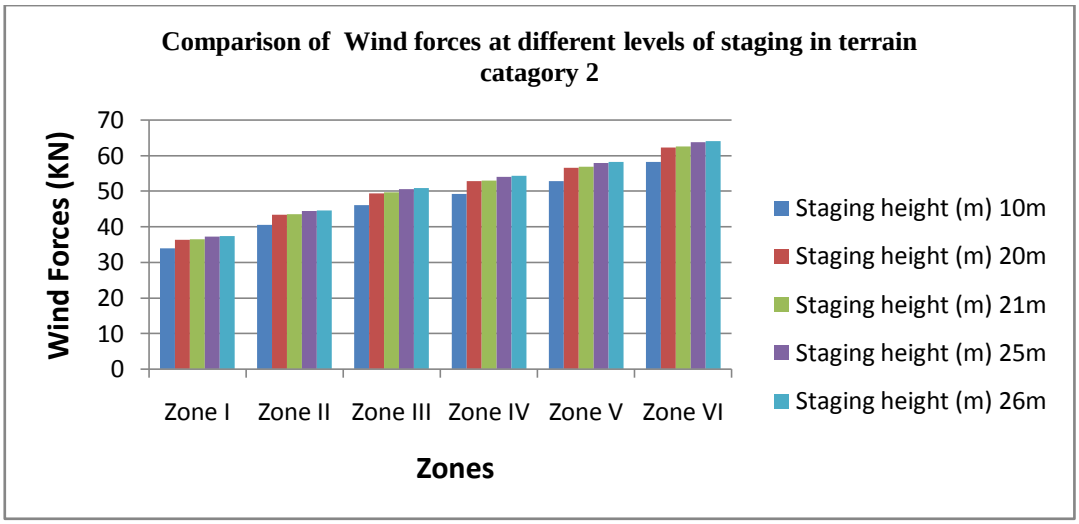
Staging height (m)	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI
Staging height (m) 10m	35.69	42.58	48.492	51.799	55.62	61.182
Staging height (m) 20m	38.115	45.474	51.788	55.319	59.4	65.34
Staging height (m) 21m	38.219	45.598	51.929	55.47	59.562	65.519
Staging height (m) 25m	38.635	46.094	52.494	56.073	60.21	66.231
Staging height (m) 26m	38.739	46.218	52.635	56.224	60.372	66.409



Graph 1: Variation of Wind Forces in Different Wind Zones of Terrain Category I

Table 5: Wind Forces (KN) For different wind Zones of terrain category 2

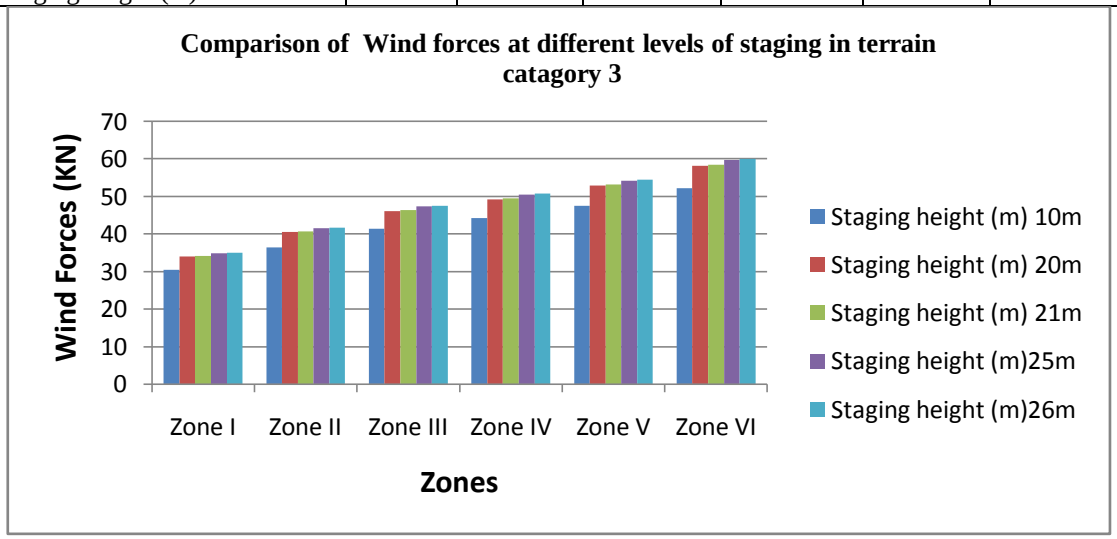
Staging height (m)	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI
Staging height (m) 10m	33.957	40.513	46.138	49.284	52.92	58.212
Staging height (m) 20m	36.382	43.407	49.434	52.805	56.7	62.37
Staging height (m) 21m	36.556	43.614	49.669	53.056	56.97	62.667
Staging height (m) 25m	37.249	44.441	50.611	54.062	58.05	63.855
Staging height (m) 26m	37.422	44.647	50.864	54.313	58.32	64.152



Graph 2: Variation of Wind Forces in Different Wind Zones of Terrain Category 2

Table 6: Wind Forces (KN) for different wind Zones of terrain category 3

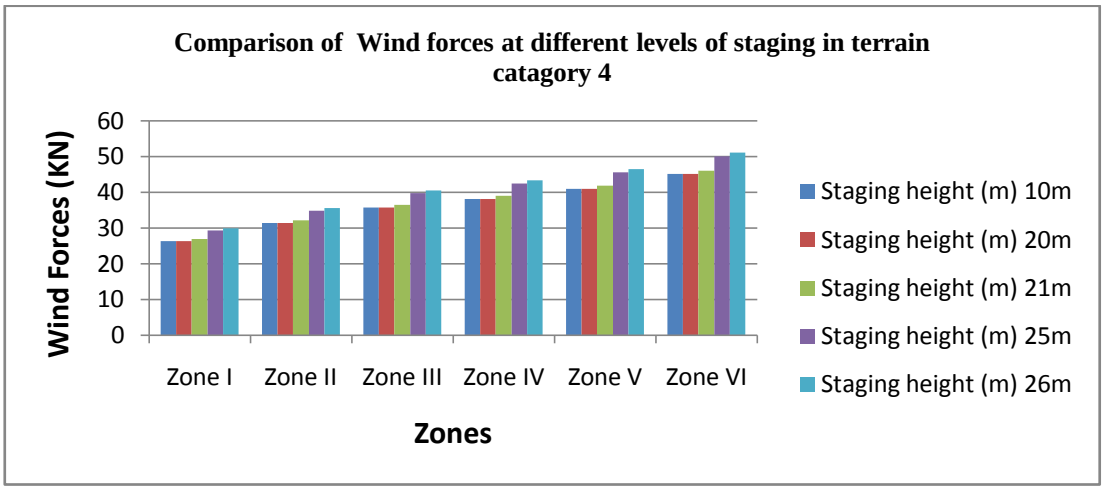
Staging height (m)	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI
Staging height (m) 10m	30.492	36.379	41.43	44.26	47.52	52.272
Staging height (m) 20m	33.957	40.513	46.138	49.29	52.92	58.212
Staging height (m) 21m	34.13	40.72	46.374	49.54	53.19	58.509
Staging height (m)25m	34.823	41.547	47.325	50.54	54.27	59.697
Staging height (m)26m	34.997	41.753	47.55	50.8	54.54	59.994



Graph 3: Variation of Wind Forces in Different Wind Zones of Terrain Category 3

Table 7: Wind Forces (KN) for different wind Zones of terrain category 4

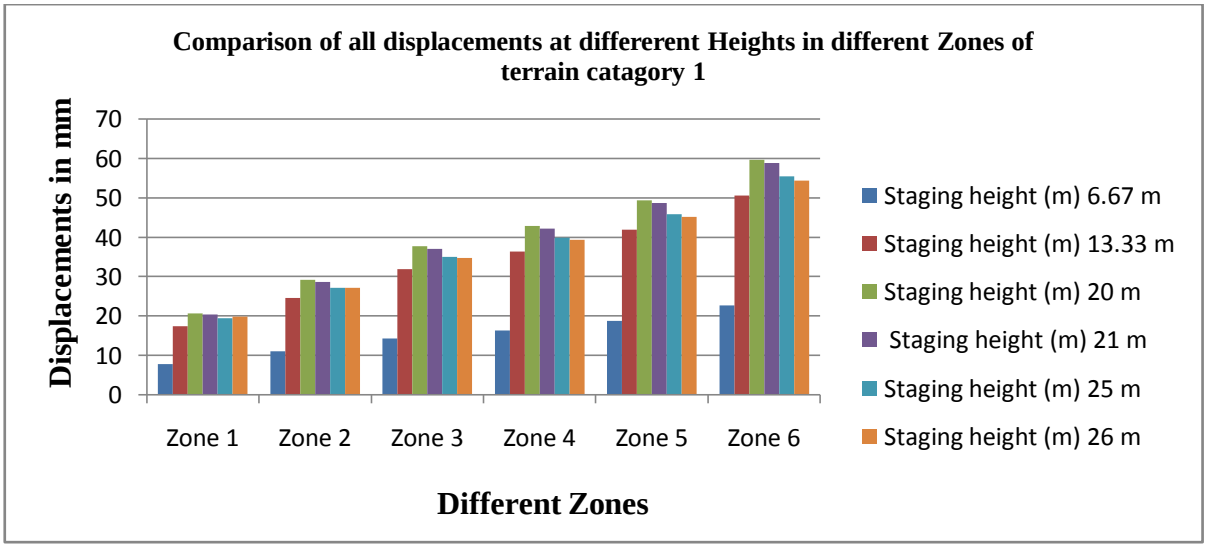
Staging height (m)	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI
Staging height (m) 10m	26.334	31.418	35.781	38.22	41.04	45.144
Staging height (m) 20m	26.334	31.418	35.781	38.22	41.04	45.144
Staging height (m) 21m	26.923	32.121	36.581	39.075	41.958	46.154
Staging height (m) 25m	29.279	34.932	39.783	42.495	45.63	50.193
Staging height (m) 26m	29.868	35.635	40.583	43.35	46.548	51.201



Graph 4: Variation of Wind Forces in Different Wind Zones of Terrain Category 4

Table 8: Lateral displacements at various heights of staging in various zone of India of terrain category 1

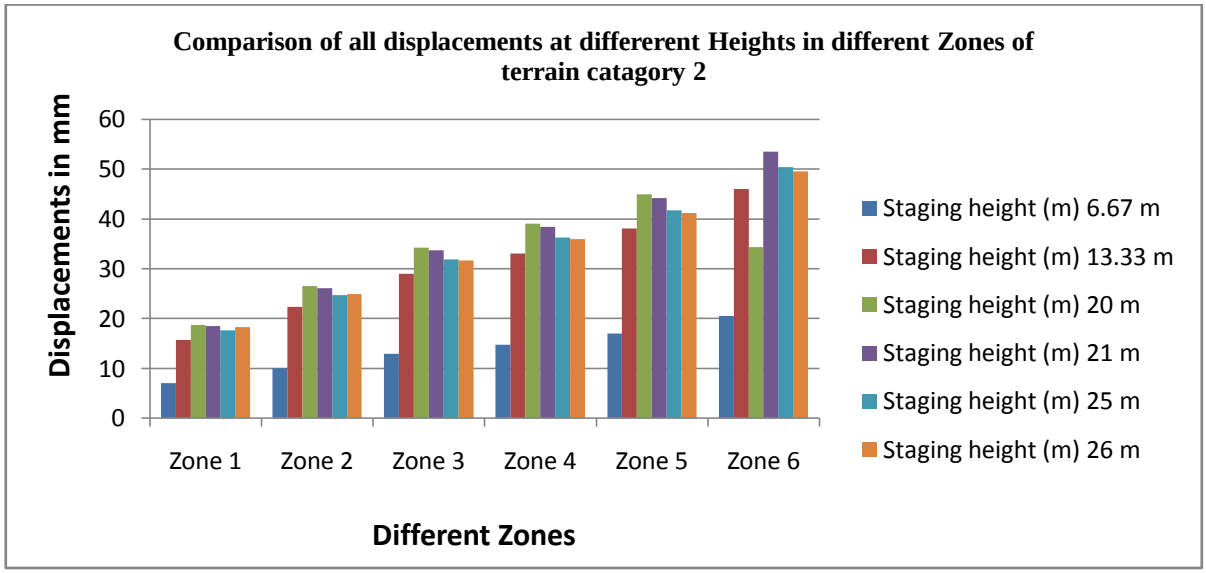
Height	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Staging height (m) 6.67 m	7.78	11.011	14.242	16.235	18.701	22.608
Staging height (m) 13.33 m	17.346	24.607	31.867	36.343	41.883	50.568
Staging height (m) 20 m	20.616	29.136	37.659	42.915	49.42	59.725
Staging height (m) 21 m	20.299	28.65	37.043	42.229	48.653	58.838
Staging height (m) 25 m	19.333	27.149	35.012	39.871	45.891	55.438
Staging height (m) 26 m	19.849	27.19	34.697	39.368	45.176	54.414



Graph 5: Comparison of displacements at different heights in different zones of terrain Category 1

Table 9: Lateral displacements at various heights of staging in various zone of India of terrain category 2

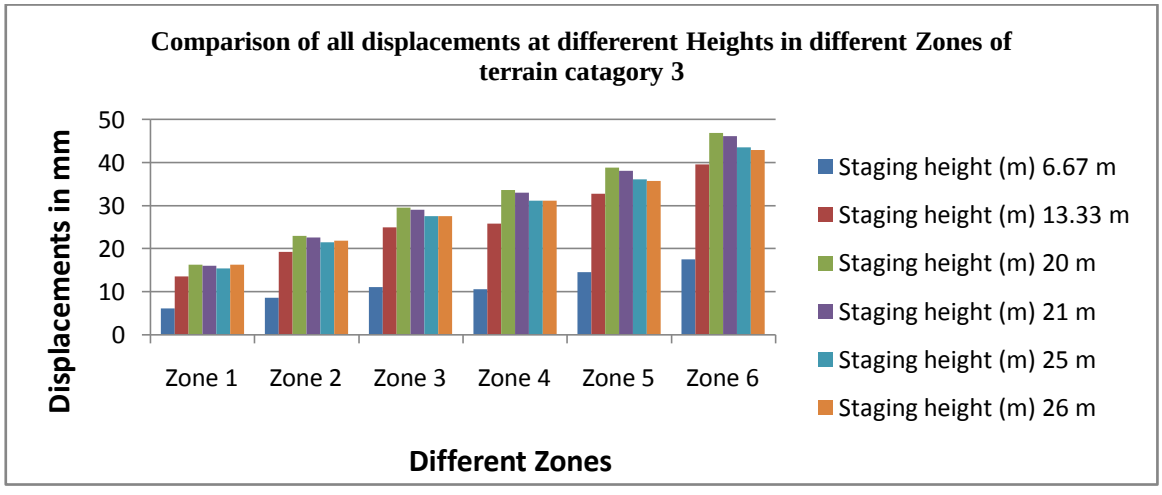
Height	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Staging height (m) 6.67 m	7.087	10.029	12.961	14.772	17.015	20.564
Staging height (m) 13.33 m	15.796	22.416	29.008	33.081	38.122	46.1
Staging height (m) 20 m	18.801	26.571	34.311	39.095	45.016	34.386
Staging height (m) 21 m	18.531	26.13	33.743	38.46	44.303	53.56
Staging height (m) 25 m	17.679	24.79	31.92	36.339	41.815	50.491
Staging height (m) 26 m	18.326	24.956	31.736	35.972	41.242	49.623



Graph 6: Comparison of displacements at different heights in different zones of terrain Category 2

Table 10: Lateral displacements at various heights of staging in various zone of India of terrain category 3

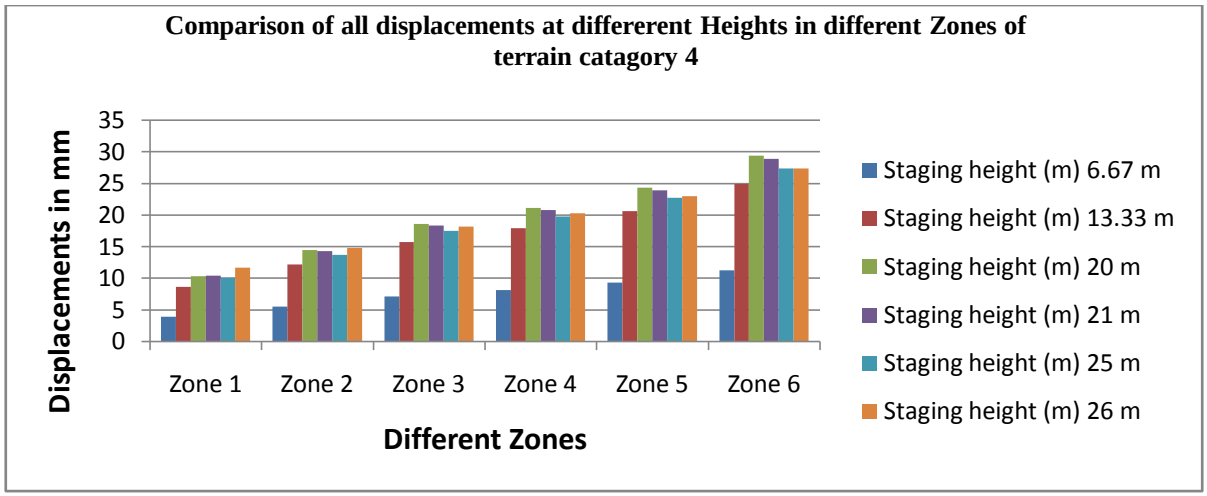
Height	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Staging height (m) 6.67 m	6.058	8.553	11.051	10.571	14.496	17.514
Staging height (m) 13.33 m	13.585	19.248	24.908	25.863	32.715	39.554
Staging height (m) 20 m	16.256	22.92	29.586	33.597	38.78	46.84
Staging height (m) 21 m	16.063	22.551	29.092	33.011	38.149	46.106
Staging height (m) 25 m	15.372	21.44	27.564	31.174	36.049	43.505
Staging height (m) 26 m	16.23	21.802	27.584	31.189	35.693	42.873



Graph 7: Comparison of displacements at different heights in different zones of terrain Category 3

Table 11: Lateral displacements at various heights of staging in various zone of India of terrain category 4

Height	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Staging height (m) 6.67 m	3.97	5.564	7.167	8.153	9.387	11.327
Staging height (m) 13.33 m	8.648	12.189	15.745	17.93	20.665	24.962
Staging height (m) 20 m	10.369	14.491	18.636	21.185	24.376	29.392
Staging height (m) 21 m	10.451	14.361	18.371	20.855	23.976	28.9
Staging height (m) 25 m	10.133	13.781	17.528	19.852	22.773	27.383
Staging height (m) 26 m	11.687	14.811	18.187	20.329	23.056	27.41



Graph 8: Comparison of displacements at different heights in different zones of terrain Category 4

V. CONCLUSIONS

Elevated Intze water tank are investigated in this study and compared with different zones of India for different terrain categories. The wind forces, lateral displacements are calculated for different zones and analyzed lateral displacement along tank height. Following are the conclusions drawn from the study.

A. *Designed Wind forces:*

Designed Wind forces for zone I is about 19 to 21% less than the that of zone II, about 35 to 37% less than that of zone III, about 45 to 47 % less than that of zone IV, about 55 to 57% less than that of zone V, about 71-73% less than that of zone VI. The wind forces increases from wind zone I to VI because of the increase in basic wind speed due to increase in risk coefficient k1.

As the wind force gradually increases from ground level up to the 10 meter height as per the recommendations of IS Code 875 part III. The Designed wind forces are compared for 10, 20, 21, 25 and 26 meter height of the tank it is observed that the designed wind forces increases with height in every zone. This is because exposed area terrain height and size factor k2 increases with increase in staging height.

It is also observed that of all the terrain categories 1,2,3,4 of wind zones, the terrain category1 is observed to be critical since it is open terrain with no obstructions.

B. Lateral Displacements:

Lateral displacements for zone I is about 29% less than that of zone II, about 45 to 46 % less than that of zone III, about 50 to 52% less than that of zone IV, about 56 to 58% less than that of zone V, about 63 to 65 % less than that of zone VI. There is an increase in lateral displacement from zone I to VI, there is also increase in lateral displacement with increase in height of staging because of increase in wind forces.

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