Comparative Analysis of Over head water tank of Intze type having Inclined Legs and Straight legs

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Abstract-*Wind load is a critical load component while analyzing and designing water tank as it results in lateral displacement. Lateral Displacement in water tank caused by wind load results in sloshing of water and additional vibrations. Hence it is a necessary to investigate different methods to reduce this lateral displacement .One method proposed in this direction is to adopt water tanks with inclined legs. That's why the intention of the work is to analyze the structural actions of water tank subjected to wind load with straight and inclined leg. The main objective of the work is to analyze different water tanks with straight and inclined legs for different wind zones in different terrain category using STAAD.PRO Software Package. 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

Intensity of the wind is the principal reason for wind caused disaster. Hence constructed structures must be prepared by constructor to fight the impending disaster due to wind by understanding the performance of the structure under wind load. In this study a computational analysis of water tank has been analyzed to find out the performance of overhead water tank under the action of wind forces. Since these types of tank have high mass concentrated at the top height of slender supporting structure and that's why these types of structures are mainly susceptible to horizontal forces induced by wind. Overhead water tanks have been investigated to analyze the performance of this structure due to wind force by changing different parameters such as capacity, height of stage, terrain category and wind zone. The results presented in this paper will be useful to the designer to understand the effect of various factors as mentioned above on the magnitude of wind force acting on the overhead water tank.

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 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 studyis carried out utilizing STAAD.PRO software package as in line with IS 875 (Part three): 1987. The wind magnitude pressure especially relies upon on following factors.

b) Classification of Structure.

The Structures aredivided 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 nearlyareas 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)

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 nearby 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. 0to 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

CASE 1

A overhead water tank of Intze type supported on inclined staging of 20m height. These 6 columns are inclined towards the centre at the top. The columns are rectangular columns having a dimension of 1000x500 mm. The other dimensions considered for water the tank are elaborated below.

Height of the water tank- 26m
Height of staging- 20m
Number of columns-6

The structure will be modelled and analyzed for wind loads using STAAD-Pro software package.

Case 2

A overhead water tank of Intze type supported on straight staging of 20m height. These 6 columns are straight from bottom to top. The columns are rectangular columns having a dimension of 1000x500 mm. The other dimensions considered for water the tank are elaborated below.

Height of the water tank- 26m
Height of staging- 20m
Number of columns-6

The structure will be modelled and analyzed for wind loads using STAAD-Pro software package.

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: case 1 Intze type tank with inclined legs

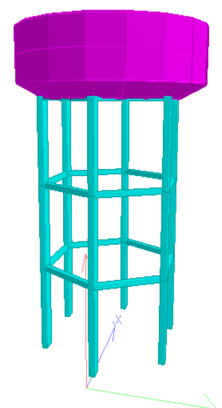


Figure 2: case 2 Intze type tank with straight legs

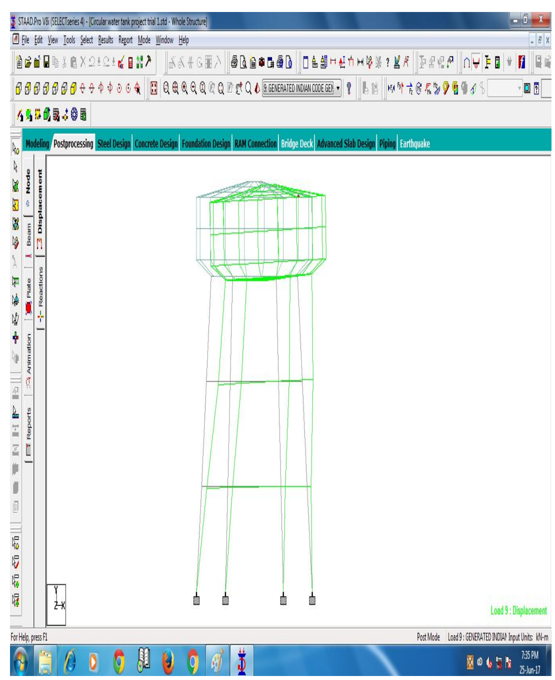


Figure 3: Deformed Shape of Overhead Water Tank having Inclined Legs due to wind load in Zone6

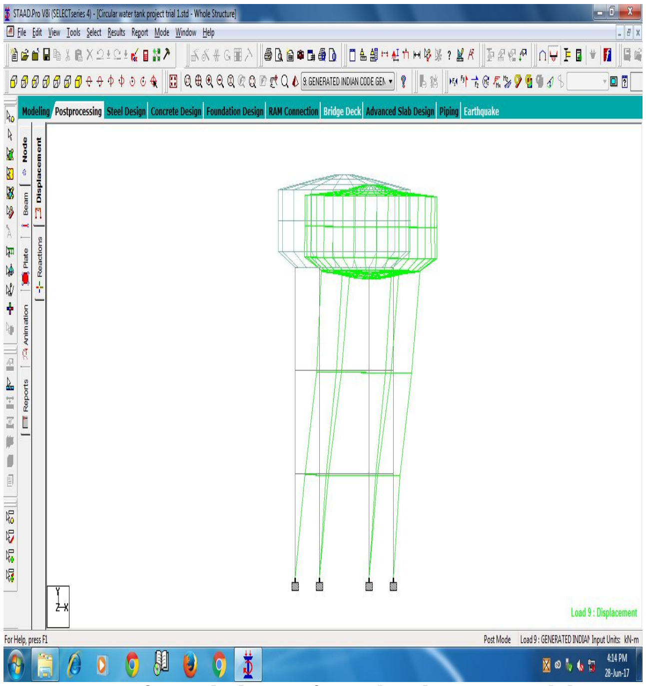
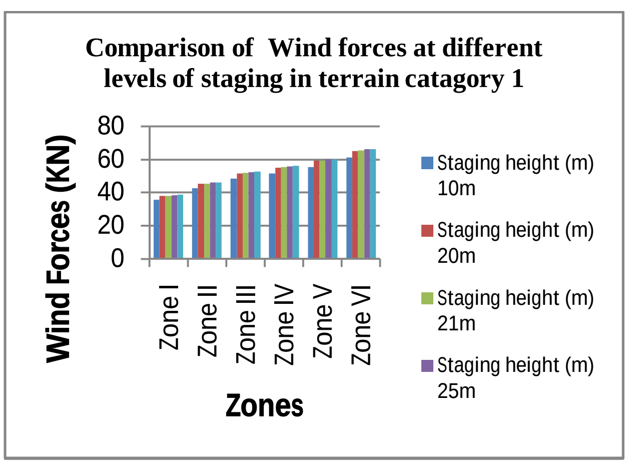


Figure 3: Deformed Shape of Overhead Water Tank having Straight Legs due to wind load in Zone6

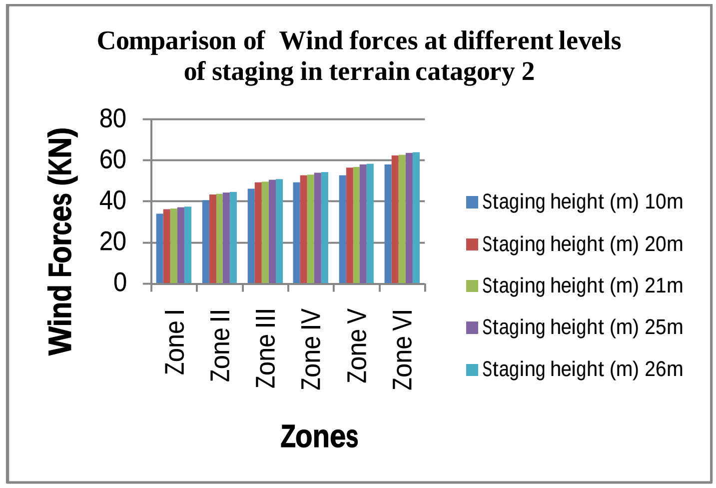
IV. RESULTS AND DISCUSSIONS

This chapter includes both analysis and Discussions. Water tank with straight and inclined legs analyzed and comparison of Different Parameters between these models was made to find out better performing of Water Tank i.e. either straight or inclined water tank as shown in Fig.1-2.

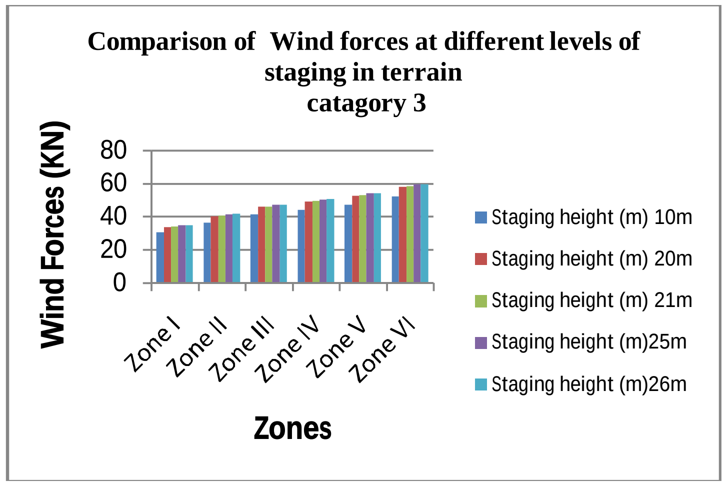
Comparison of wind forces in different wind zones of India at different heights of staging



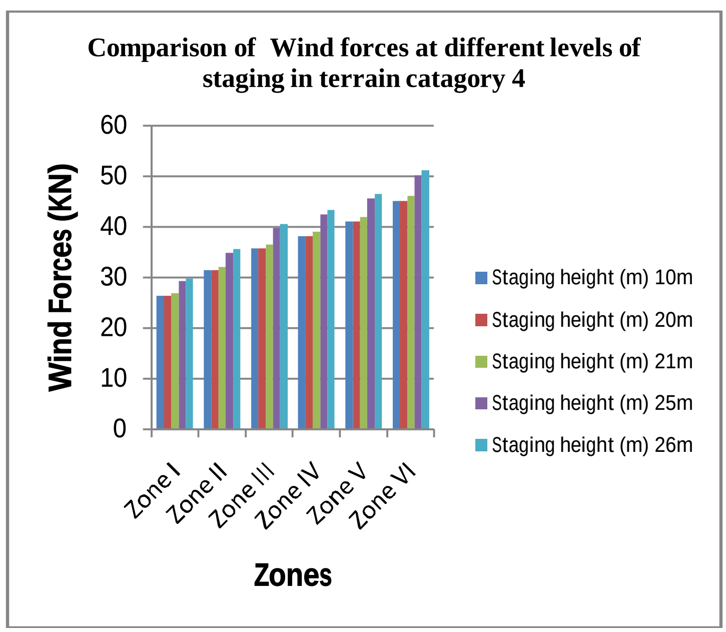
Graph 1: Variation of Wind Forces in Different Wind Zones of Terrain Category I



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

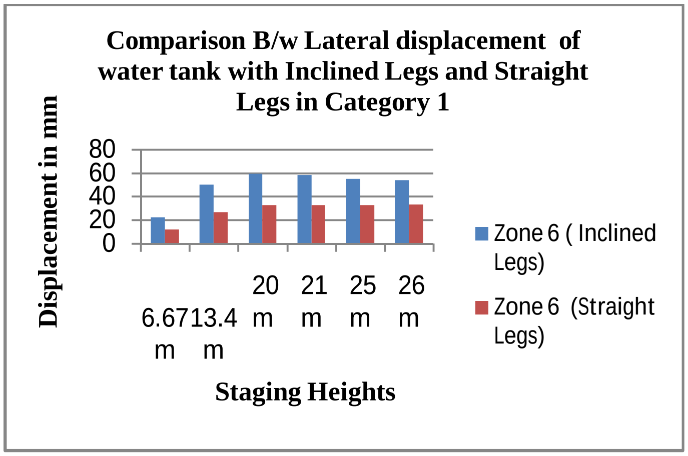


Graph 3: Variation of Wind Forces in Different Wind Zones of Terrain Category 3

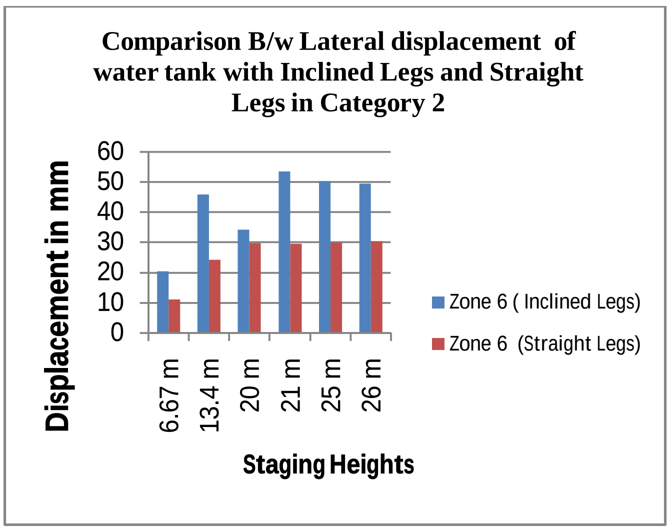


Graph 4: Variation of Wind Forces in Different Wind Zones of Terrain Category 4

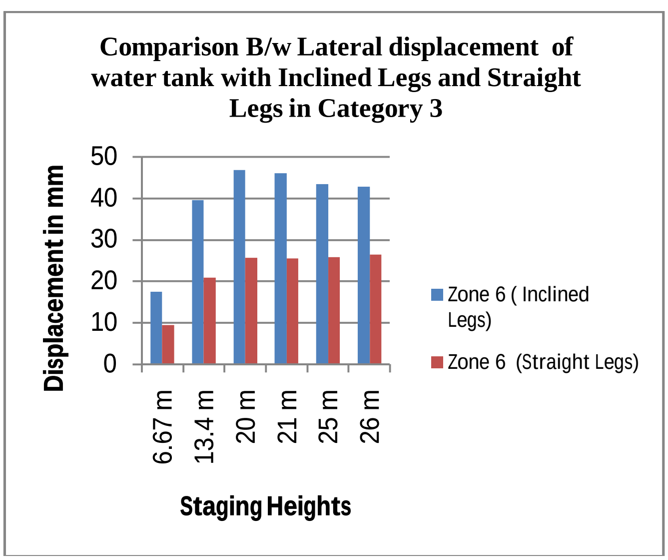
Lateral displacement b/w inclined legs and straight legs water tank



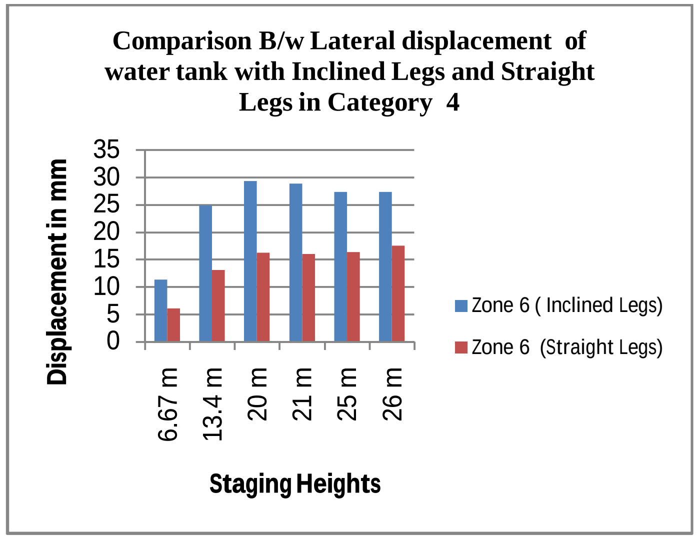
Graph: 5 Comparison of Lateral displacement of water tank with inclined legs and straight legs in category1



Graph: 6 Comparison of Lateral displacement of water tank with inclined legs and straight legs in category2



Graph: 7 Comparison of Lateral displacement of water tank with inclined legs and straight legs in category3



Graph: 8 Comparison of Lateral displacement of water tank with inclined legs and straight legs in category4

V. CONCLUSIONS

The structural actions of Intze tank with straight and inclined legs subjected to wind speeds was studied using STAAD-Pro. From the results it can be concluded that

Lateral Displacement for Inclined legs:

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.

Lateral Displacement for Straight legs:

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.

In conclusion water tanks with columns having suitable inclination are found to perform better than water tanks with straight columns however for the studies required to decide on the optimum inclination.

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