EFFECT OF WIND LOAD ON LOW, MEDIUM, HIGH RISE BUILDINGS IN DIFFERENT TERRAIN CATEGORY

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Abstract *Any Tall building can vibrate in both the directions of along wind and across wind caused by the flow of wind. Modern Tall buildings designed to satisfy lateral drift requirements, still may oscillate excessively during wind storm. These oscillations can cause some threats to the Tall building as buildings with more and more height becomes more vulnerable to oscillate at high speed winds. Sometimes these oscillations may even cause discomfort to the occupants even if it is not in a threatening position for the structural damage. So an accurate assessment of building motion is an essential prerequisite for serviceability. There are few approaches to find out the Response of the Tall buildings to the Wind loads.*

Wind is a perceptible natural motion of air relative to earth surface, especially in the form of air current blowing in a particular direction. The major harmful aspect which concern to civil engineering structures is that, it will load any and every object that comes in its way. Wind blows with less speed in rough terrain and higher speed in smooth terrain. This paper presents story drift, story shear, and support reactions accour in different storey Buildings (Low Rise Buildings, Medium Rise Buildings, and High Rise Buildings) due to wind in different terrain category. Totally 12 models for G+5, G+10, G+15 are analyzed using ETABS. Present works provides a good source of information about variation in drift, shear are compared as height of model changes and percentage change in drift, shear of same model in different terrain category.

KEY WORDS: *Tall Buildings, drift, story shear, ETABSv9.7.4, different terrain category*

1. Introduction

Wind has two aspects. The first beneficial one is that its energy can be utilized to generate power, sail boats and cool down the temperature on a hot day. The other a parasitic one is that it loads any and every object that comes in its way. The latter is the aspect an engineer is concerned with, since the load caused has to be sustained by a structure with the specified safety. All civil and industrial structures above ground have thus to be designed to resist wind loads. This introductory note is concerning the aspect of wind engineering dealing with civil engineering structures.

Wind induced response of a tall building is a function of many parameters. These include the geometric and dynamic characteristic of building as well as the turbulence characteristic of the approach flow. A few analytical approaches are available for the estimation of the wind induced response of the tall buildings in along and across wind direction.

1.1 Types of buildings used in the study

The following 3 buildings are generally considered for the design

Low rise buildings (1 to 6 stories)

Design principles:

1. Low rise housing typically involves residential townhouse/terrace housing or small scale residential apartment buildings

2. Low rise housing will be located typically around the outer edges (beyond 400 metres) of the town centers
3. Can be expected to be located close to heritage and conservation zones and at the interface to single dwelling areas to provide a transition zone from higher density areas
4. The typical height for low rise housing is 2-4 storey's

Medium rise buildings (7 to 12 stories)

Design principles:

1. Medium rise housing involves residential apartment buildings, sometimes with cafes or small shops at the ground level
2. Smaller town centres such as Hurlstone Park, Dulwich Hill will have medium rise housing immediately surrounding the main street area
3. Bankstown CBD and larger town centres will have medium rise housing typically be located within 400 metres of railway stations
4. Medium rise housing will range from 5-7 storeys
5. Medium rise housing will be limited to 5 storeys in sensitive locations such as interface areas

High rise buildings (13 stories and above)

Design principles:

1. High rise housing comprises both standalone apartment buildings and mixed use buildings that incorporate retail shops and / or commercial uses on the lower levels
2. High rise housing starts from 9 storeys and extends to 25 storeys
3. The upper end of this range will be accommodated mainly within the Bankstown CBD and larger town centres such as Campsie and Canterbury
4. The lower end of this range will accommodated mainly within the smaller town centres such as Marrickville, Belmore and Lakemba
5. High rise housing will be located close to the rail station – typically within 200-400m from the station

Objectives of the study

Following are the main objectives of the work:

1. The main objective of the present work is to study the effect and variation of wind pressure for three categories of buildings Low Rise Buildings, Medium Rise Buildings, and High Rise Buildings for different terrain categories.
2. In the present study the variations of the wind pressure on typical multi-storied Buildings was done by dynamic analysis method is given by the draft code IS-875 part 3 – is studied
3. In the present work, multistory buildings of 6 storey, 11 storey and 16 storey were modeled for different Terrain categories i.e. Terrain categories 1, Terrain categories 2, Terrain categories 3, Terrain categories 4.
4. The analysis of the building has been carried out using ETABSV9.7.4. And the dynamic analysis method.
5. The results from the models (story drift, story shear) are compared in different types of story buildings (low, medium, high rise buildings) for different terrain categories.

2. LITERATURE REVIEWS

Whitbread (1963) He has presented an account of various flow parameters required to be matched in the wind tunnels and concluded that

Jensen's (1958) model law provided satisfactory answers using floor roughening devices.

Davenport & Isyumov (1967) This paper discussed various available techniques to simulate the ABL in the long test section wind tunnels. They have emphasized that for correct modelling of flow complete turbulence characteristics including velocity profile, turbulence intensity profile, length scales and energy spectrum should be made available for natural wind. Flow characteristics in the new boundary layer wind tunnel at the University of Western Ontario are presented. `Power law' variation of velocity profile is used. Counihan (1969) evaluated the use of a system of `elliptic wedge' generators and a castellated barrier to produce a simulated rough wall boundary layer. Good agreement between the boundary layer flow so produced and neutral atmospheric boundary layer is obtained.

Fujimoto et al. (1975) In this research it was tested a 1:400 scaled aero elastic mod el of rectangular tall building (1:1.2:3.75) in smooth flow and two boundary layer flows. Values of along wind and across wind response are presented versus reduced velocity and a relationship is established. Experimental gust factors are compared with Davenport (1967). A four mass model was also tested in natural wind, and contribution of higher modes is reported to be negligible on displacements and about 10% on accelerations

3. EFFECT OF WIND LOAD ON BUILDINGS AND STRUCTURES

3.1 NATURE OF WIND IN ATMOSPHERE

In general, wind speed in the atmospheric boundary layer increases with height from zero at ground level to a maximum at a height called the gradient height. There is usually a slight change in direction (Ekman effect) but this is ignored in the Code. The variation with height depends primarily on the terrain conditions. However, the wind speed at any height never remains constant and it has been found convenient to resolve its instantaneous magnitude into an average or mean value and a fluctuating component around this average value. The average value depends on the averaging time employed in analyzing the meteorological data and this averaging time can be taken to be from a few seconds to several minutes. The magnitude of fluctuating component of the wind speed, which represents the gustiness of wind, depends on the averaging time. Smaller the averaging interval, greater is the magnitude of the wind speed.

3.2 BASIC WIND SPEED:

Figure 1 gives basic wind speed map of India, as applicable at 10 m height above mean ground level for different zones of the country. Basic wind speed is based on peak gust speed averaged over a short time interval of about 3 seconds and corresponds to 10m height above the mean ground level in an open terrain (Category 2). Basic wind speeds presented in Fig. 1 have been worked out for a 50-year return period. The basic wind speed for some important cities/towns is also given in Appendix A.

5.3 Design Wind Speed (Vz)

The basic wind speed for any site shall be obtained from Fig. 1 and shall be modified to include the following effects to get design wind speed, Vz at any height, Z for the chosen structure: (a) Risk level, (b) Terrain roughness and height of structure, (c) Local topography, and (d) Importance factor for the cyclonic region. It can be mathematically expressed as follows:

$$Vz = V_b K_1 K_2 K_3 K_4$$

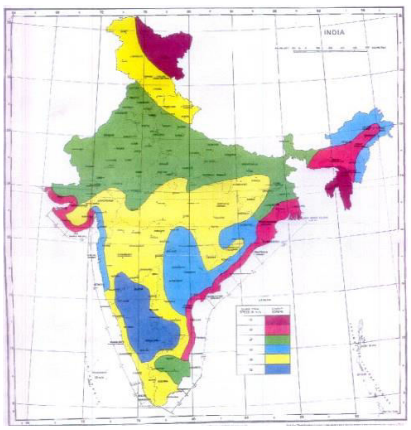
Where Vz = design wind speed at any height z in m/s,

k1 = probability factor (risk coefficient)

k2 = terrain roughness and height factor

k3 = topography factor

k4 = importance factor for the cyclonic region



Basic wind speed in m/s (based on 50 year return period)

TERRAIN

Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration. Wherever sufficient meteorological information is available about the wind direction, the orientation of any building or structure may be suitably planned.

Terrain in which a specific structure stands shall be assessed as being one of the following terrain categories:

Terrain category 1

Exposed open terrain with few or no obstructions and in which the average height of any object surrounding the structure is less than 1.5 m. Open terrain, open country or open ground is terrain which is mostly flat and free of obstructions such as trees and buildings. Examples include farmland, grassland and specially cleared areas such as an airport. Such terrain is significant in military manoeuvre and tactics as the lack of obstacles makes movement easy and engagements are possible at long range. Such terrain is preferred to close terrain for offensive action as rapid movement makes decisive battles possible. Wind loading tends to be high in open country as there are few obstacles providing a windbreak. This affects the design of tall structures such electricity pylons and windmills.

Open ground

Open area

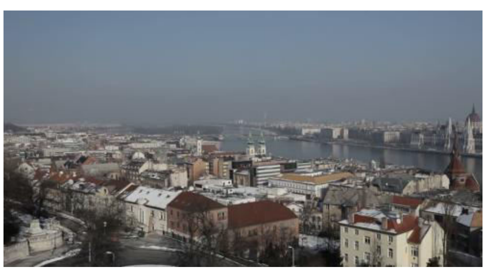
Terrain category 2

Open terrain with well scattered obstructions having heights generally between I.5 to 10 m

Forest terrain can be divided into three categories: sparse, medium, and dense. An immense forest could have all three categories within its borders, with more sparse terrain at the outer edge of the forest and dense forest at its heart. The table below describes in general terms how likely it is that a given square has a terrain element in it.

Terrain category 3

Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m in height with or without a few isolated tall structures.

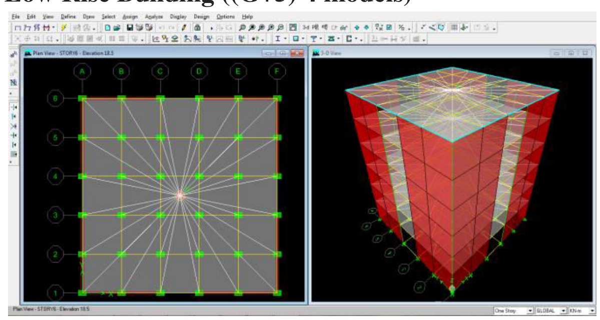


Terrain category 4

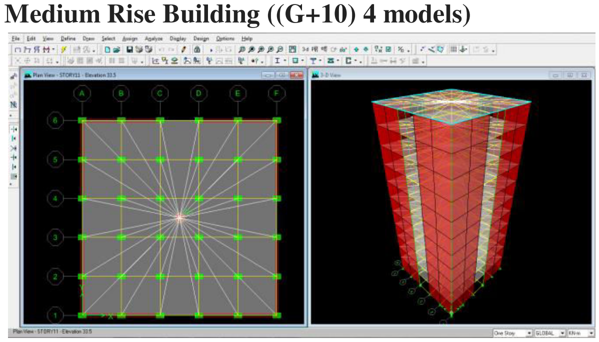
Terrain with numerous large high closely spaced obstructions.

Building models made in ETABS

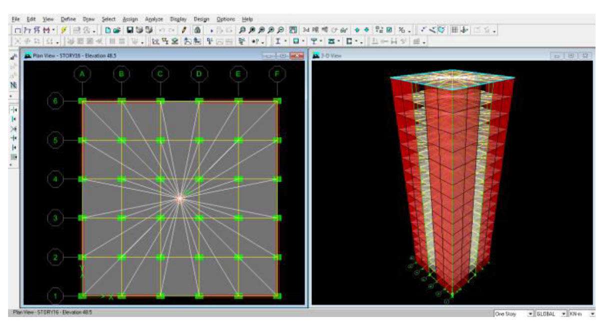
Low Rise Building ((G+5) 4 models)



Medium Rise Building ((G+10) 4 models)

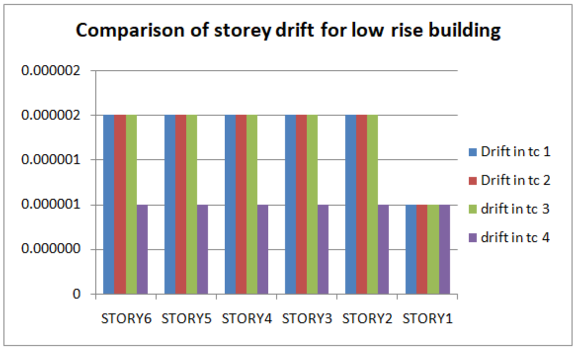


High Rise Building ((G+15) 4 models)

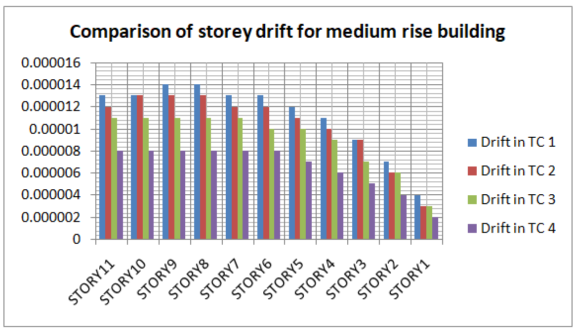


RESULTS AND ANALYSIS

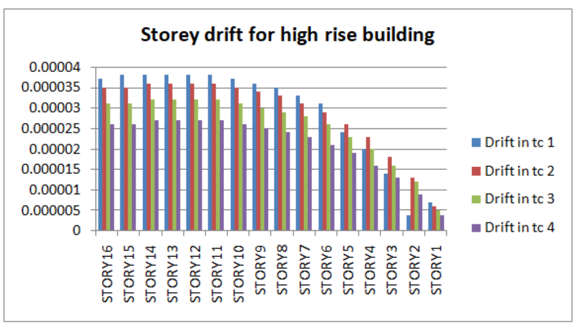
Comparison of storey drift



Storey drift for low rise building

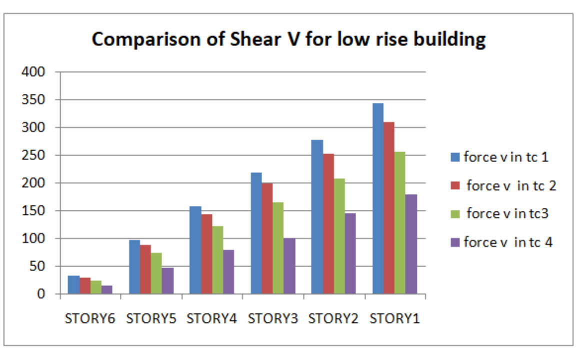


Storey drift for medium rise building

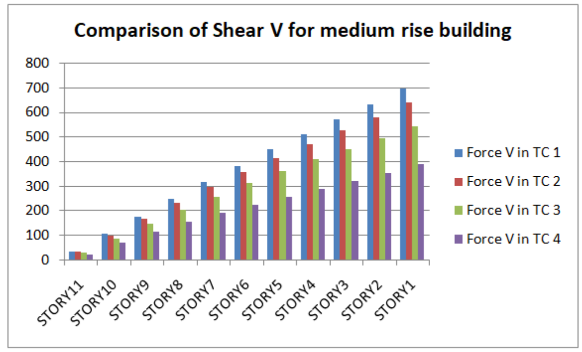


Storey drift for high rise building

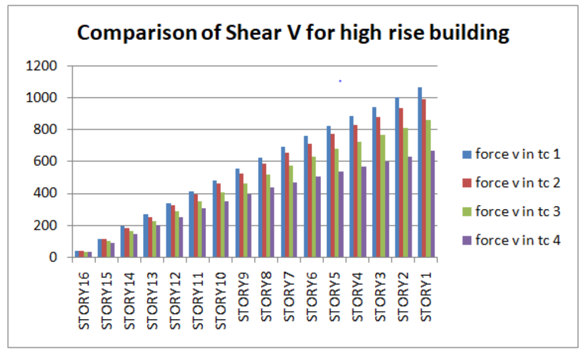
Comparison of Shear V Values



Comparison of shear V for low rise building

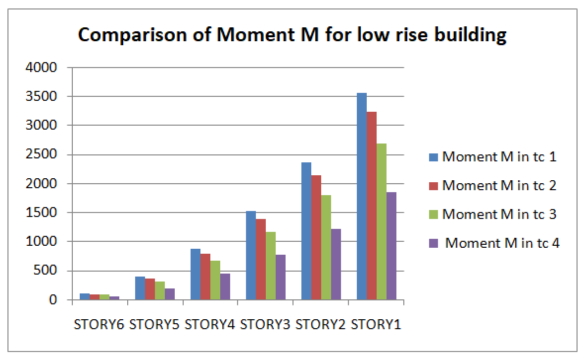


Comparison of shear V for medium rise building

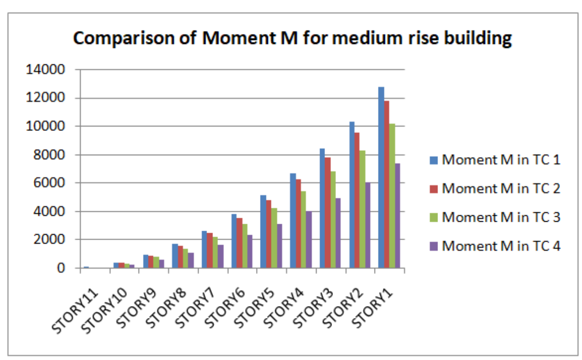


Comparison of shear V for high rise building

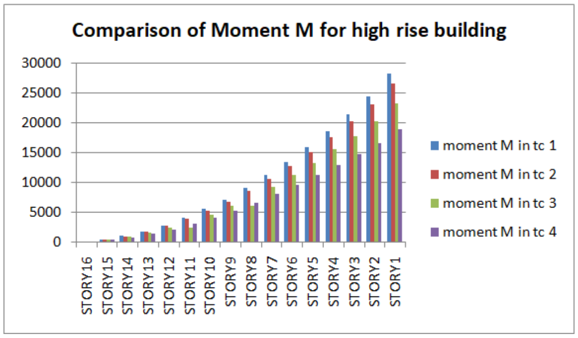
Comparison of Bending M Values



Comparison of bending M for low rise building

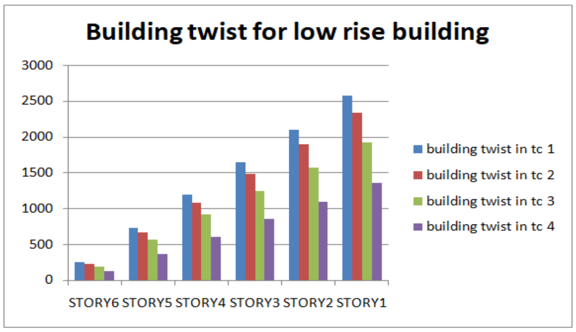


Comparison of bending M for medium rise building

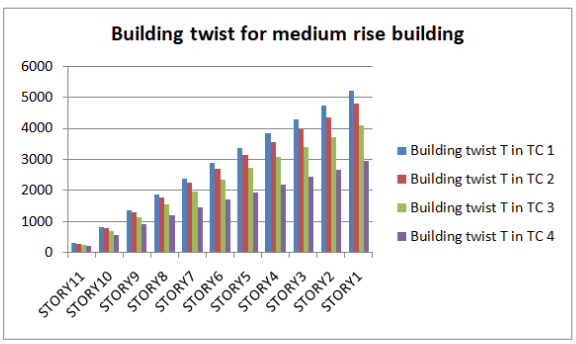


Comparison of bending M for high rise building

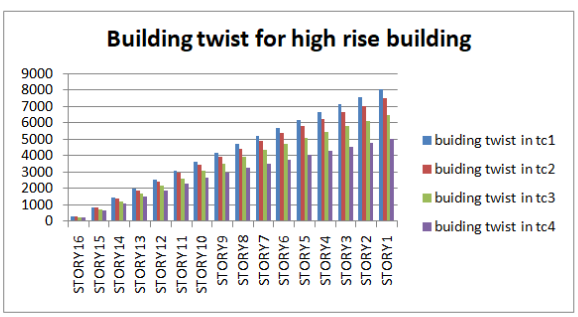
Comparison of twisting T Values



Comparison of twisting T for low rise building



Comparison of twisting T for medium rise building



Comparison of twisting T for high rise building

CONCLUSIONS

From the above study the following conclusions were made

1. The values of storey drifts are constant in G+5 building design in all terrain categories up to 2nd storey and is decreases to 1st storey this indicates there is less effect of wind in the low rise buildings

2. In case of medium rise and high rise buildings value of story drift is decreases from top story to bottom story (11th to 1st in medium rise buildings and 16th to 1st in High rise buildings). And the Higher drift values are obtained in terrain category 1 and lower drift values are obtained at terrain category 4.

3. The maximum values of building twist (T) was obtained terrain category 1 than remaining terrains. The value of building twist decreases from 6th storey ton 1st story.

4. The maximum values of forces and moments are obtained at terrain category 1. The forces and moments are decreases from top story to bottom storey (6th to 1st in case of low rise buildings, 11th to 1st in medium rise buildings and 16th to 1st in High rise buildings)

5. For the above conclusions the maximum values are obtained at terrain category 1 in all cases and minimum values are obtained in terrain category 4 from this it was

concluded that there is no wind effect on buildings which are in terrain category 4 than other terrain categories.

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