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A Comparative Study of Wind Load on Tall Building by Analytical and Experimental Method

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***Abstract*: Building are the most important structure used by the people to shelter for living and working. Today there is shortage of land for building and due to this more buildings at a faster growth in both residential and industrial areas the vertical construction is given, because of which tall buildings are built on a large quantity. Wind forces are studied on four main groups of building structures as Tall Buildings, Low Buildings, Equal-Sided Block Buildings Roofs and Cladding Almost no investigations are made in the first two categories, as the structure failures are rare, even the roofing and the cladding designs are not carefully designed, and localised wind pressures and suctions are receiving more attention. But as tall buildings are flexible and are susceptible to vibrate at high wind speeds in all the three directions (x,y,z,) and even the building codes do not incorporate the maximum wind speed of the life of the building and does not consider the high suctions which create damages. Due to all these reasons the wind load estimation for tall buildings are very much important.**

***Keywords*: Indian wind code, Tall building, Wind tunnel, Wind force and displacement.**

1. Introduction

The wind loading on structure is very complex phenomenon. It is multi-disciplinary field involving metrology, structural dynamics, statistical theory of turbulence and probabilistic methods. The wind induces highly fluctuating pressures on building surface. Today's most developers and Architects are coming up with unconventional building shapes with offsets, setback, various corner shapes, balconies. Etc. The building located in complex surrounding along with other structures. These conditions we are not covered or addressed in any of the international codes. Code analytical methods are helpful for preliminary design and for simple situation but provide conservative wind load in most cases. It is prudent to do the experimental tests for finding out the true wind loads and forces that acting upon a structure. As Building Height increases, the need for doing the actual experimental study increases, these are several factors, which can contribute to the inaccuracy of the analytical methods, such as geometry and elevation of structure.

2. Methodology and Problem Formation

Lateral load analysis and designing of building is done using standard practices as per the codal norms. For the earthquake IS: 1893:2002 and for wind IS: 875:1987 are used in order find out the lateral forces to be applied. But code also some places gives user defined permissions in order to derive at exact values of loads. Above study is to found the wind loads by analytical and experimental methods. Analytical method was carried out as per the codal norms and whereas the experimental method used in help of wind tunnel experiment. Static and dynamic analysis is done as per the IS: 875:1987 and wind tunnel observations are done in experimental laboratory. The Method is important to find the loads variation by various methods and reliability in order to achieve sound serviceable at the same time economical design. For this purpose, three similar structure are selected which are in from same location [i.e. Pune]. Structures vary in geometry & heights are tested for three methods.

A. Static method

The Static method used to find the force F acting in a specified direction of wind is given as follows,

F = Cf. Ae. Pd

Where, Ae = Effective front area of the structure or building.

Cf = Force Coefficient of the building and

Pd = Design wind force on the Building.

Design wind pressure Pd is given in clause of the wind code as follows

Pd = 0.6 x VZ2

$V_Z = V_b\, k_1\, k_2\, k_3$

Where, Vb = Design wind pressure at any height z in m/s

K1 = Probability factor (clause 5.3.1)

K2 = Terrain, height and structure size factor

K3 = topography factor (clause 5.3.3)

Values considered are considered form IS: 875:1987:

K1 = 1.0, refer Table 1.0

K2 = as per the height based on table 2. (Class C structure, category 3)

K3= 1.0, refer table 3 Vb = 39 m/s

B. Software Analysis

Model of Building Frame used in software to analyses wind load on structures and verify forces compare with static method and experimental method by wind tunnel.

The basic three activities, which are to be carried out in following

a) Model generation
b) The calculations to obtain the analytical results
c) Result verification are facilitated by tools contained in the programs graphical environment.

C. Experimental method [Wind tunnel]

Wind tunnel used to testing of building in which the flow of wind is duplicated at high altitudes. The tunnels for testing airplanes are designed to minimize the effects of turbulence, and they do not duplicate atmospheric boundary layer or wind turbulence. Due to this, most of airplane flights, except for brief periods of landing and take-off, occur at a height well above the boundary layer. In Building Case, it occurs precisely within this atmospheric boundary layer, characterized by a gradual retardation of wind speed and high turbulence near the surface of the earth. Therefore, for testing of buildings, aeronautical wind tunnels have been modified and entirely new facilities have been built to reproduce turbulence and natural flow of wind within the boundary layer.

3. Material and Geometric Properties

Following material properties used in modelling:
Density of RCC: 25 kN/m^3
Density of Masonry: 18.5 kN/m

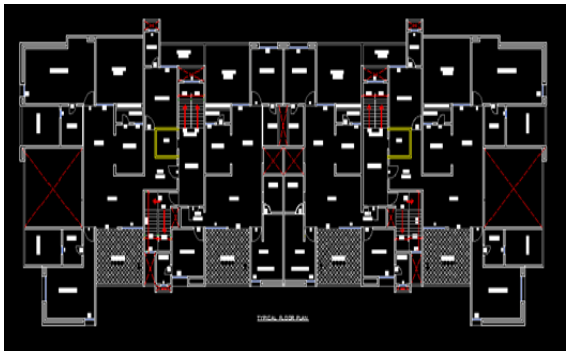

Fig. 1. Basic floor plan of building

Dead load-Self wt. of slab considering 125mm thick Slab =0.125*25 = 3.125 kN/m^2
Floor Finish load = 1 kN/m^2
Live Loads= Live Load on typical floors =2 kN/m^2
Wind load= Calculation of wind load as per is code IS-875.
Following Building properties has been taken in for modelling.

Following Modelling created in software to analyse building forces.

Table 1
Building properties

High Rise Building Details		
Max. Length in X direction	42	m
Max. Length in Y direction	22.25	m
No of floors	LP+UP+P+32flrs	
Floor height @ typical floor	3	m
Floor height @ typ.Podium floors	4.25	m
Floor height @ Ground level	4.33	m
Total height of the structure	105.54 m from ground floor	m
Foundation Type	Open	
Soil type	type1 (Hard)	
General Live load	2 kn/m^2	

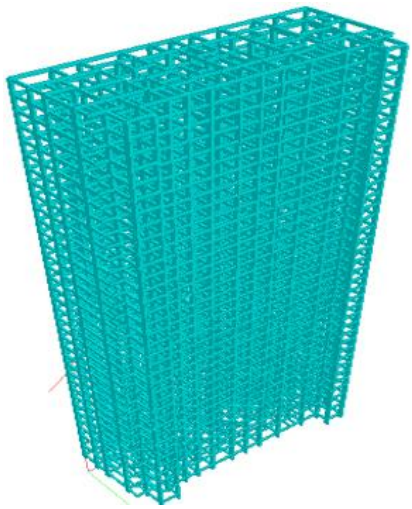

Fig. 2. Model plan of building in software

Following Modelling created in Wind Tunnel for analyse building forces.

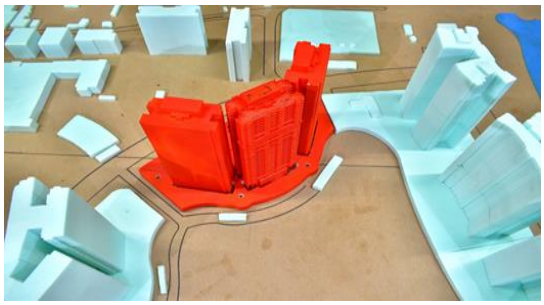

Fig. 3. Model of building in wind tunnel

4. Result and Discussions

a) From the building studies conducted in the project, we can conclude that to capture the true dynamic effects of wind, and one should conduct the experimental test. The Gust factor analysis is not effectively capture the dynamic load distribution along with the structure height. The displacement values reported by the Tunnel methods clearly indicate that the Gust factor methods clearly under estimate the true dynamic behaviour of the structures.
b) For the 33 storied structure (Rectangular building), Tunnel tests report about 40% decrease in the Y displacement

values than the Gust factor method. It also reports a decrease in the X- direction as well. But in the 33 storied Square building Tunnel displacements is about 6% less in y direction. It reports an increase the displacement values in the X direction than the Gust factor method.

c) A direct comparison of the acceleration values is difficult, as the Tunnel acceleration, outputs are based on 5 or 10-year return period of wind, but the codal method is based on 50 Year return period. It is obvious from the values reported by the code method, as the acceleration values are quite heavy for both the towers. For serviceability checking, one cannot take longer duration cycle, and so we have to rely on the experimental method only.

5. Conclusion

This paper presented a comparative study of wind load on tall building by analytical and experimental method.

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