Desirable Shapes of Building to Resist Wind Load in Cyclonic Region

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Abstract- *Cyclonic storms subject buildings to extreme winds which if the buildings are not able to withstand, they collapse leading to huge losses during cyclones. Hence the wind load codes of every country provide guidelines for the design of cyclone-resistant structures. For a building to be safe during wind induced disasters, the foundation, the walls as well as each connection have to be well-built. Hence in this paper the main area of concern will be to tackle the vulnerable areas and design of the elements in order to make them less vulnerable to the high-speed winds.*

Keywords- Cyclones; Wind; Pressure; Suction; Disaster

I. INTRODUCTION

1.1 General

Indian population is estimated at 1,282,390,303 as of 2015 and India has become second most populous country in the world. Vertical growth of built environment is unavoidable for providing shelter and workspace for them. Dynamic analysis of tall buildings with all considered safety factors has become a challenge for Civil Engineers. Earthquake resistant tall buildings behaving well in all type of soil conditions, especially in soft soils are necessary to be constructed. Wind analysis is also important in case of tall buildings.

1.2 Tall Buildings

The last two decades have seen a remarkable increase in construction of tall buildings in excess of 150m in height, and an almost exponential rate of growth. A significant number of these buildings have been constructed in the Middle East and Asia, and many more are either planned or already under construction. "Super-tall" buildings in excess of 300m in height are presenting new challenges to engineers, particularly in relation to structural and geotechnical design. Wind analysis is important in case of tall buildings. Figure 1 shows the significant growth in the number of such buildings either constructed.

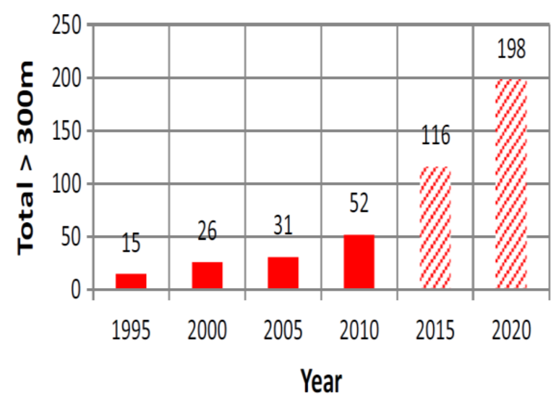

Fig 1.: Total number of buildings in excess of 300 m tall.

The investigations have been carried out by many researchers on the structural behaviour of tall buildings with SSI (Soil Structure Interaction) by considering many parameters like foundation type, soil conditions, lateral forces, ratio of flexural stiffness of beam and column etc.

1.3Effectsofwindonstructures

A typical wind force operates on a structure. This mean wind force is calculated using the mean wind speed and the fluctuating wind force generated by the fluctuating flow field. The influence of a fluctuating wind force on a building or part of a structure relies not only on the characteristics of the fluctuating wind force, but also on the size and vibration characteristics of the building or portion of the building. To estimate the design wind load, it is required to assess the features of varying wind forces and the building's dynamic properties.

1.3.1 Wind sensitive structures

Tall and slender buildings are elastic and display a dynamic wind response. Tall structures vibrate in the wind owing to the turbulence inherent to the wind as well as the turbulence caused by the structure itself as a result of flow separation. Thus, there is a mean and variable wind response.

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II. LITERATUREREVIEW

K. Vishnu Haritha, Dr.I. YaminiSrivalli [1] In this paper equivalent static method is used for analysis of wind loads on buildings with different aspect ratios. The aspect ratio can be varied by changing number of bays. Aspect ratio 1, 2, 3 were considered for present study. The analysis is carried out using ETAB.

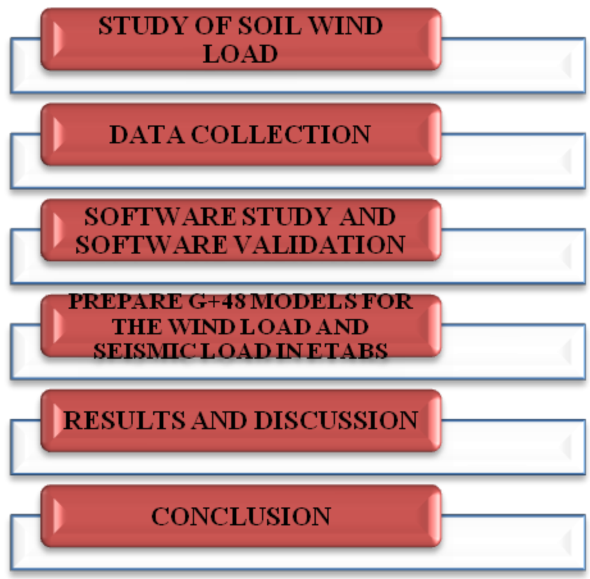
B. Dean Kumar and B.L.P. Swami [2] In this paper the present work, the Gust Effectiveness Factor Method is used, which is more realistic particularly for computing the wind loads on flexible tall slender structures and tall building towers. In this paper frames of different heights are analysed and studied.

Yin Zhou and Ahsan Kareem [3] In this paper "Gust loading factors for design applications" Wind loads on structures under the buffeting action of wind gusts have been treated traditionally by the "gust loading factor" (GLF) method in most major codes and standards around the world. The equivalent static wind loading used for design is equal to the mean wind force multiplied by the GLF. Although the traditional GLF method can ensure an accurate estimation of the displacement response, it fails to provide a reliable estimate of some other response components. In order to overcome this shortcoming, a more realistic procedure for design loads is proposed in this paper.

Wakchaure M. R., GawaliSayali [4] In this paper the gust effectiveness factor method takes into account the dynamic properties of the structure, the wind-structure interactions and then determines the wind loads as equivalent static loads. Wind loads are determined based on gust effectiveness factor method. The critical gust loads for design are determined. After the application of calculated wind loads to the building models prepared in finite element software package ETAB's 13.1.1v. Having different shapes are compared in various aspects such as storey displacements, storey drifts, storey shear, axial forces in column etc. Based on the results, conclusions are drawn showing the effectiveness of different shapes of the structure under the effect of wind loads.

Mohammed Asim Ahmed, Moid Amir, Savita Komur, VaijainathHalhalli [5] In this paper presents displacement occur in different storey due to wind in different terrain category. Three models are analysing using ETABS 2015 package. Present works provides a good source of information about variation in deflection as height of model changes and percentage change in deflection of same model in different terrain category.

III. METHODOLOGY



The methodology worked out to achieve the above-mentioned objectives is as follows:

1) Extensive literature survey by referring books, technical papers or research papers carried out to understand basic concept of topic.
2) Identification of need of research.
3) Formulation of stages in analytical work which is to be carried out.
4) Data collection.
5) 50 storey building is considered for the analysis.
6) The model has prepared on ETABS for the various shapes of the buildings.
7) Manual calculation of wind loads for the building according to IS 875(part3)-1987 has done by using the various parameters of the wind.
8) Application of calculated wind loads on the modeled buildings is to be done.
9) In similar way, another buildings is to be modeled of various shapes and by using Gust factor method, the wind loads is to calculated and applied to the modeled buildings.
10) Comparative studies done for axial loads on column, storey shear, lateral story displacement, story drift, wind intensity for the various shapes of

buildings and determination of structurally efficient shape of building is to be done.

11) Interpretation of results and conclusion.

3.1 Parameters considered for the study

A 50 storied building of different shapes- Square, Rectangular, Circular and Elliptical, having equal plan area and equal stiffness of the columns has been analyzed.

3.2 Design wind speed

Wind speed in the atmospheric boundary layer increases with height from at ground level to maximum at a height called the gradient height. The basic wind speed shall be modified to include risk level, terrain roughness, height of the structure and local topography to get the design wind velocity Vz and is given as:

$V_z = V_z.k_1.K_2.K_3$ 3.1

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

Vb = Basic wind speed for various zones K1 = Probability factor (risk coefficient) K2 = Terrain roughness and height factorK3 = Topography factor.

Risk coefficient (K1): suggested life period to be assumed and the corresponding K_1 factor for different class of structures as per IS: 875 (Part 3)

Terrain and height factor (K2): Selection of terrain categories shall be made with due regard to the effect of obstruction, which constitute the ground surface.

Topography Factor (k3): The effect of topography will be significant at a site when the upwind slope is greater than about 3, and below that, the value of k3 may be taken to be equal to 1.0. The value of k3 is confined in the range of 1.0 to 1.36 for slopes greater than 3º.

3.3 Need for the present study

- From various experimental investigations, it is observed that plan shape and dimensions of buildings significantly affects the wind pressure distributions on different faces of the buildings.
- This study shows that certain shapes are prone to wind phenomena which can generate high dynamic loads and govern the design.
- This study will ignite an interest on the use of aerodynamic shapes and the consideration of building shape in terms of wind performance, early in design process.
- This study will explore the sensitivity of various shapes to the static and dynamic properties of structure.

3.4 Scope of the present study

The scope of the present work included the study of the wind load estimation on tall buildings for the structural design purpose with the analytical approach given by Davenport's gust factor approach as well as equivalent static method in IS 875: part 3 1987 and the analysis of the buildings had been done by using ETABS 2013 software and the performance was analyzed by varying the shape of structure.

3.5 Objectives of the present study

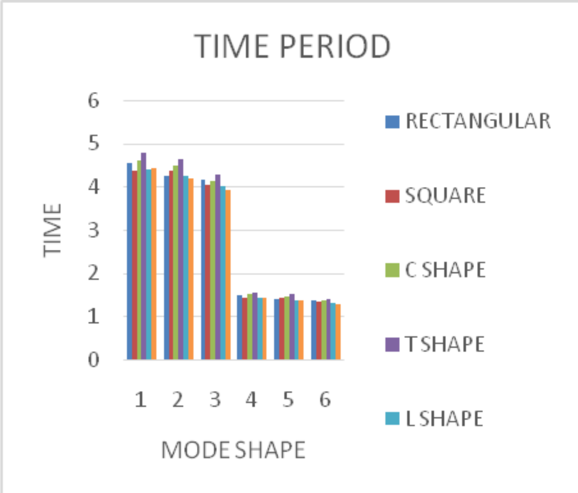
- To study the behavior of tall structures when subjected to along wind loads.
- To study the effect of shape of the building in plan on the behavior of the structure.
- To determine the effect of wind load on various parameters like storey drifts, lateral displacements in the building.

IV. RESULTS & DISCUSSION

Graph no- Displacement In X –Direction

Table no 1- Time Period

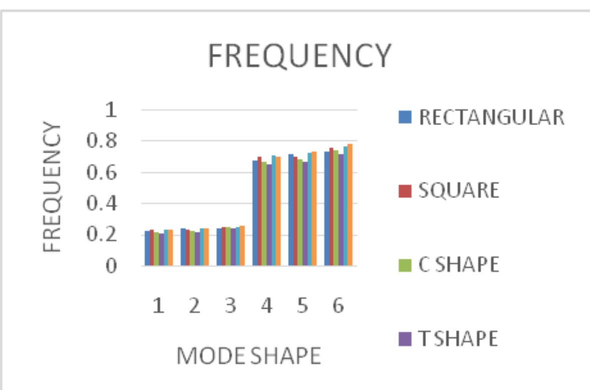
	TIME PERIOD					
MODE SHAPE	RECTANGULAR	SQUARE	C SHAPE	T SHAPE	L SHAPE	HOLLOW RECTANGULAR
1	4.542	4.372	4.615	4.797	4.39	4.426
2	4.251	4.372	4.472	4.63	4.233	4.187
3	4.17	4.042	4.119	4.276	4.004	3.912
4	1.488	1.438	1.503	1.548	1.421	1.428
5	1.401	1.438	1.464	1.508	1.38	1.366
6	1.374	1.334	1.358	1.405	1.316	1.288



Graph no 1- Time Period

Table no 2 – Frequency

	FREQUENCY					
MODE SHAPE	RECTANGULAR	SQUARE	C SHAPE	T SHAPE	L SHAPE	HOLLOW RECTANGULAR
1	0.22	0.229	0.217	0.208	0.228	0.226
2	0.235	0.229	0.224	0.216	0.236	0.239
3	0.24	0.247	0.243	0.234	0.25	0.256
4	0.672	0.695	0.666	0.646	0.704	0.7
5	0.714	0.695	0.683	0.663	0.725	0.732
6	0.728	0.75	0.737	0.712	0.76	0.776



Graph no 2- frequency

V. CONCLUSION

Each tall building is unique and based on many situations which influence the choice made in the design of high rise buildings. It was concluded that, before constructing tall buildings an alternate design method should be introduced by creating innovative computational workbench in order to design efficient high rise building to withstand wind load influences. High rise buildings are affected by wind load through deferent parameters such as storey drift, shear force, displacement, bending moment, axial force etc. The wind load affects increases with increasing the height of the building. Many researchers carried out papers to study the effect of lateral load on tall building and find a proper solution to avoid instability of structure. In order to reduce those effects the suitable structural system and the frontage of the building should be well chosen. Also, the appropriate choice of building shape and architectural modifications are frequently effective to reduce wind load by changing the flow pattern in surrounding of the building. In addition, the geometry and aerodynamic modification contribute to make the building having more stability and strength.

VI. SCOPE FOR FUTURE WORK

1. The proposed results need to be validated by further case studies. Further study could be on another aerodynamic shapes which can reduce the wind pressures.
2. Another field of wide study could be the addition of maximum openings to irregular shaped high rise buildings to reduce the effects of wind on the structures.
3. Another field of wide study could be the reduction in plan area after certain heightto evaluate the wind effects. Future study could be on the modifications in comer geometry of various shaped high rise buildings.

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