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Effects of Corner Geometry of Various Shaped on Wind Forces of High Rise Buildings

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Abstract:-The rapid increase of the urban population in developing countries such as India, has forced the revaluation of the importance of high rise buildings. The structural systems of high rise buildings are usually sensitive to the effects of wind. Gust is the most critical effect of the wind. 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. In this paper, same building with different corner geometry of various shaped is to be consider of height 180 m having equal stiffness of column are considered for wind load analysis. 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. 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 will be drawn.

Keywords:- Storey displacement, Storey drift, Storey shear, Wind load.

I. INTRODUCTION

In India, in recent decades, the application of wind engineering to civil engineering structures has become popular and the state-of-the-art has improved considerably. Wind engineering requires a multifaceted approach to provide solutions to various wind-sensitive problems. It involves various fields such as (i) Fluid dynamics (ii) Probability and statistics and (iii) Structural dynamics. Wind, in general, has two main effects on tall buildings: First, it exerts forces and moments on the structure and its cladding, and second, it distributes air in and around the building, mainly termed as wind pressure. Wind pressures on buildings are influenced by the building geometry, angle of wind incidence, surroundings and wind flow characteristics. There are many situations where available database, codes/standards and analytical methods cannot be used to estimates the wind pressure coefficients and wind loads on the claddings and supporting system of buildings, for example, the aerodynamic shape of the building is uncommon.

In view of the increasingly improved database on wind itself, a better understanding of the structure of wind, greater knowledge about the response of structure to wind, the wind loading standards have been in frequent revision. Interpretation of codes often throws up questions, not always easy to resolve. Hence it important for the designers to study adverse effects of wind and design the structures accordingly.

A. Objectives

- 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 study Same shapes of the building with different corner geometry.
- To determine the effect of wind load on various parameters like storey drifts, lateral displacements in the building.
- To define the most efficient corner geometry in high rise buildings which can provide sound wind loading by observing the comparative studies.

B. Scope of the 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 SAP software and the performance was analyzed by same building with different corner geometry of various shaped is to be consider.

- Height of the building considered was 180 m/60 storey
- Same shapes of the building with different corner geometry.

II. LITERATURE REVIEW

J.A. Amin and A.K. Ahuja (2011) has studied wind-induced pressures on buildings of various geometries. The experimental investigation of wind pressure distributions on models of typical plan shape buildings over an extended range of wind incidence angles of 0° to 180° at an interval of 15°. Two L-shaped and two T-shaped models of same plan area and height but having the different dimensions were tested in a closed circuit wind tunnel under boundary layer flow. The models were made from perspex sheets at a geometrical scale of 1:300. Fluctuating values of wind pressures are measured at pressure points on all the sides of the models and mean, maximum, minimum values of pressure coefficients were evaluated from pressure records. It is observed that plan shape and dimensions of models significantly affects the wind pressure distributions on different faces of the models. The location and magnitude of the measured peak pressure coefficient vary considerably with wind direction. The influence of shifting the upstream block from edge of the downstream block to center of it, which transforms the L-shape into T-shape model, is also noticeable on the pressure coefficient distribution.The results shows that, The wind orientation induces different pressure distributions on the walls of L- and T-shaped models from those of isolated rectangular/square models. The distribution and magnitude of wind pressure coefficients are significantly influenced by the interference/disturbance of the streamlines from the upwind block, plan-shape and dimension of models and wind orientations. The suction on side faces and leeward faces are also significantly affected by the plan-shape of the models and wind orientation.

Sarita Singla, Taranjeet Kaur, Megha Kalra and Sanket Sharma (2012) has studied Behavior of R.C.C. tall buildings having different shapes Subjected to Wind Load. This paper presents the results of analytical studies on various shapes of buildings. In this study a35 storeyed building of different shapes-Square, Hexagonal and Octagonal, having equal plan area and equal stiffness ofthe columns has been analysed. Based upon the study, it is concluded that shape of the structure plays an important role in resisting wind loads. Octagonal shaped building performed the best followed by hexagonal shaped and square shaped building.The results shows that, With the change in shape of building from square to octagonal the storey drifts and the lateral displacements of the building decreased. Shape of the structure plays an important role in resisting wind loads. Octagonal shaped building has lesser storey drifts, lesser lateral displacements at the joints as compared to hexagonal and square shaped building.

P. Harikrishna, A. Abraham, S. Arunachalam, S. Selvi Rajan, G. Ramesh Babuand N. Lakshmanan (2009) has studied Pressure measurement studies on a model of a tall building with different plan shapes along the height. This paper describes the experimental details of a wind tunnel study conducted on a 1:300 scale model of a 327 m tall building with different plan shapes along the height. Pressures have been measured on the model at 5 different levels and for various wind angles. Based on the evaluated mean force and torsion coefficients, critical wind angles have been identified. Results shown that, All force coefficients are influenced by wind angles, α. For the design of the building, the following critical wind angles of 0, 35, 90, 200, 255, 270 and 315 have been identified. Dynamic analysis shall be carried out to compute the gust response factor, *G*, in order to evaluate the dynamic response of the building.

Hemil M. Chauhan, Manish M. Pomal and Gyayak N. Bhuta (2011) has studied a comparative study of wind forces on high-rise buildings as per Is 875-iii (1987) and proposed draft code (2011).In this paper, the influence of static & dynamic velocity fluctuations on the along wind loads for these structures are determined using force coefficient method & Gust factor method respectively. In this Paper 60 m & 120 m buildings is analyzed using both the codes using ETABS Software v9.6 is done with variations in four terrain categories & six basic wind speeds. Both codes are used for analysis and results (calculations of S.F, B.M & Displacements) obtained are compared and discussed.

Results shown that,

- In static analysis, give almost same values of shear forces & bending moments for various terrain categories, IS draft code gives higher values of shear force & bending moment.
- In dynamic analysis, IS draft code gives less values of shear forces & bending moments for various terrain categories.
- In general, IS draft code-2011 is more accurate and more direct than present code for estimating response parameters such as acceleration and forces.

P. Mendis, T. Ngo, N. Haritos, A. Hira, B. Samali and J. Cheung (2007) [5] has studied wind loading on tall buildings simple static treatment of wind loading, which is universally applied to design of typical low to medium-rise structures, can be unacceptably conservative for design of very tall buildings. This paper provides an outline of advanced levels of wind design, in the context of the Australian Wind Code, and illustrates the exceptional benefits it offers over simplified approaches. This paper has considered a number of key factors associated with the design of tall buildings to the effects of wind loading. Results shows that dynamic response levels also play an important role in the detailed design of façade systems.

Jonas Thor Snaebjornsson (2012) [6] has studied wind effects on a medium rise building in a built up area. The objective of the study is, in a way, to attempt to provide a sound wind loading chain a la Davenport in the form of data that would facilitate the study of the links connecting the main parameters i.e. Wind – Load – Response. This entails the definition of the relevant wind parameters, the description of the aerodynamic loading process, such as the time-dependent variations of pressure fluctuations on the building surface, and an investigation of the wind induced response of a medium-rise building.

Prof. M.R.Wakchaure, Anantwad Shirish and Rohit Nikam(2007) has studied plan irregularity on high-rise structures analytical method during seismic events. Analyses have been done to estimate the seismic performance of high rise buildings and the effects of structural irregularities in stiffness, strength, mass and combination of these factors are to be going to be considere. The work describes to the irregular plan geometric forms. These irregular plans were modeled. to determine the effect of the plan geometric form on the seismic behavior of structures with elastic analyses. Also, effects of the gust factor are considering in T-shape and Oval Shape plans. Although these affects mainly on the architectural plan configuration, plan irregularity find better structural system solution such as dual system has been use for structural analysis. Result shows that ,From the study of plan geometry for both the T-Shape and Oval shape models, it is found that staircase, lift duct, service duct and service lift ducts are weak parts, which are strengthen by providing core (i.e. ductile shear wall) with coupling beam. Due to this modal combination effects are going below 33 Hz, which ultimately results in the nullifying the torsion in the structures. From this study it is proved that the dual system offered more economic construction along with the iconic architectural image

A state of the art literature review is carried out as part of the present study. The extensive literature review was carried out by referring standard journals, reference books and conference proceedings. The major work carried out by different researchers is summarized in this chapter. It deals with the previous work carried out on behavior of tall buildings having different shapes subjected to wind loads and the gust effectiveness factor approach for estimating dynamic effect on high-rise structures

III. METHODOLOGY

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

- Extensive literature survey by referring books, technical papers or research papers carried out to understand basic concept of topic.
- Identification of need of research.
- Formulation of stages in analytical work which is to be carried out.
- Data collection.
- 60 storey building is considered for the analysis.
- The model has prepared on ETAB for the various shapes of the buildings.
- Application of calculated wind loads on the modeled buildings is to be done.
- 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.

A) Plan of model

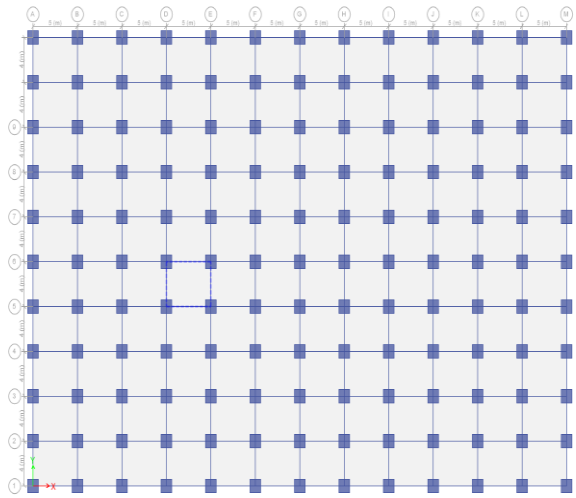


Fig 1 :- Plan of Model

B) 3D view

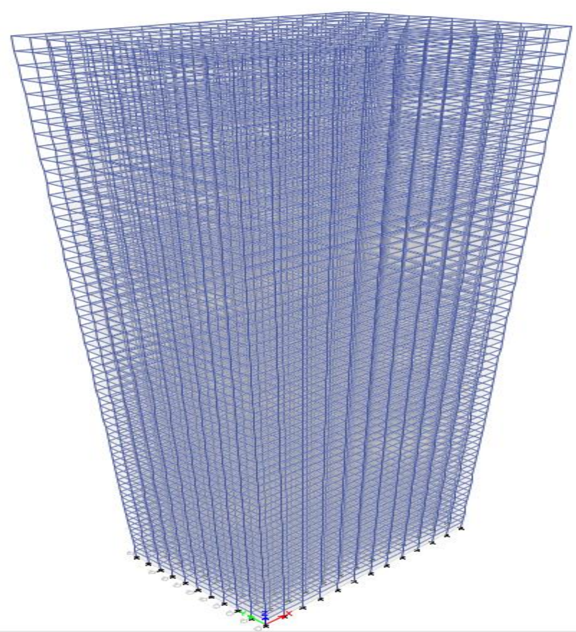


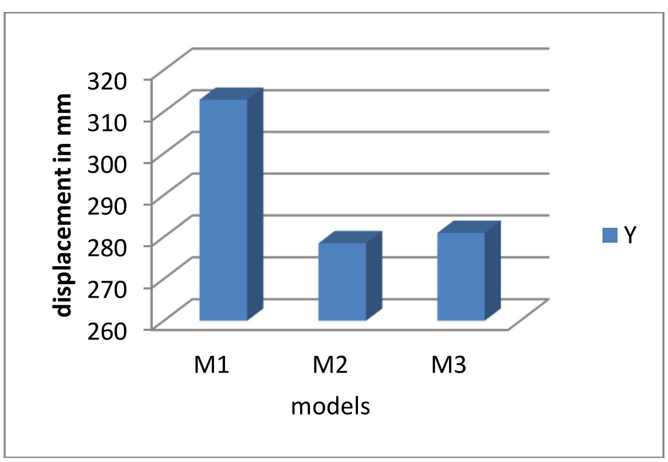
Fig 2 :- 3D View

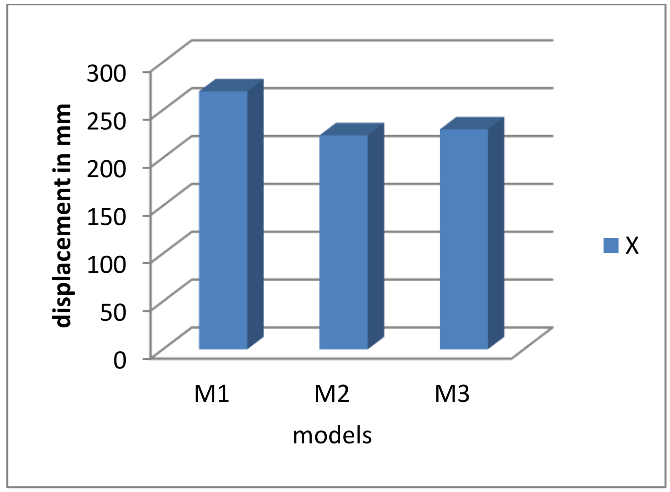
IV. RESULTS

Name of parameter	Value	Unit
No. of storey	40	Nos.
Bottom storey height	3	m
Storey height	3	m
Soil type	Medium	
Wind zone	I	
Design wind speed	33	m/sec
Shape of buildings	Rectangular	
Plan area	2400	m^2
Grid size	4 x5	m
Thickness of slab	125	mm
Size of beam	230 x 600	mm
Size of column	1200 x 1200	mm
Material properties		
Grade of concrete	M40	N/mm^2
Grade of steel	Fe500	N/mm^2
Dead load intensities		
FF on floors	1.75	kN/m^2
FF on roof	2	kN/m^2
Live load intensities		
LL on floors	2	kN/m^2
LL on roof	1	kN/m^2

Model description

M1 Base model
M2 Model with rectangular corner
M3 Model with Squire corner
M4 Model with Circular
M5 Model with Elliptical





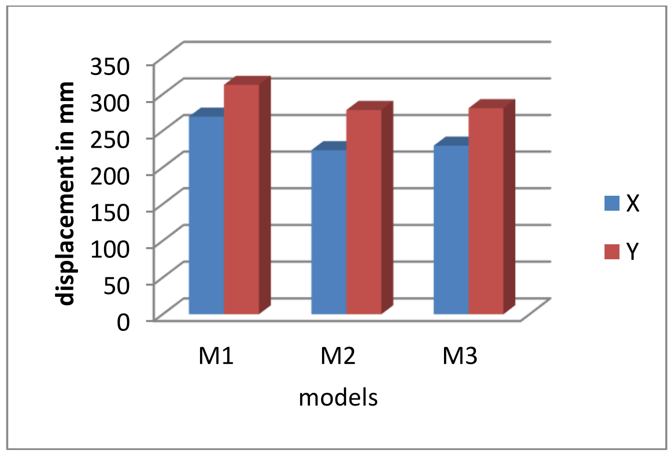
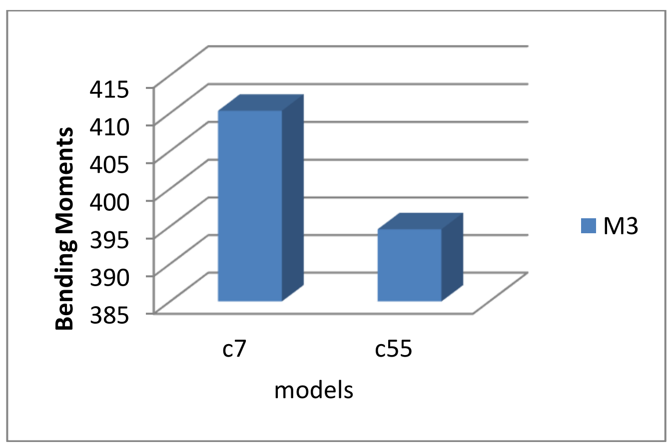
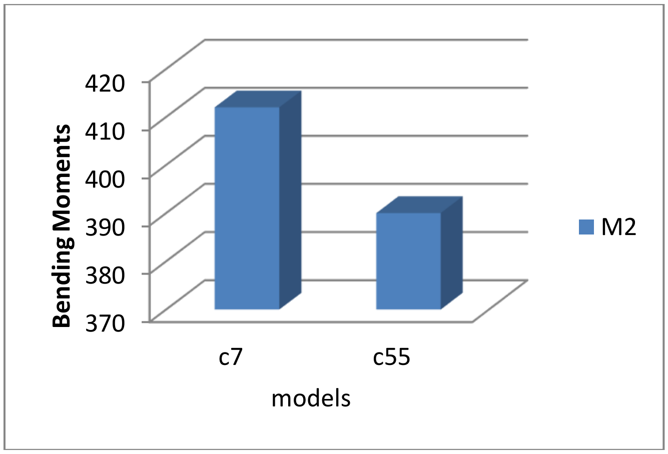
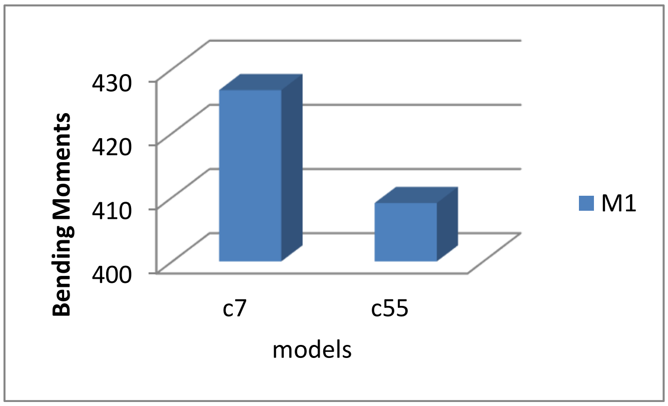


Fig 3:- Lateral displacement(for M1,M2 and M3)







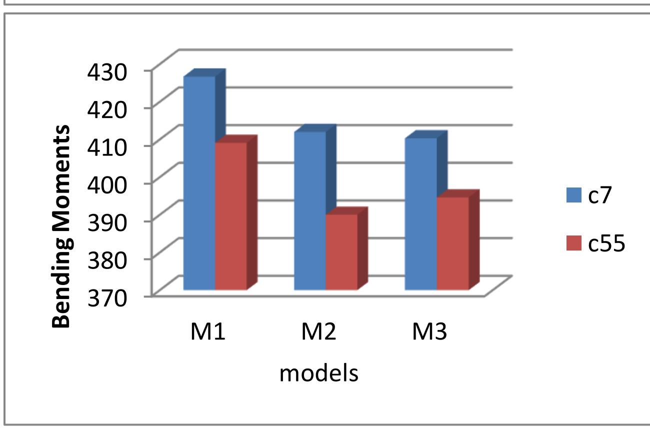
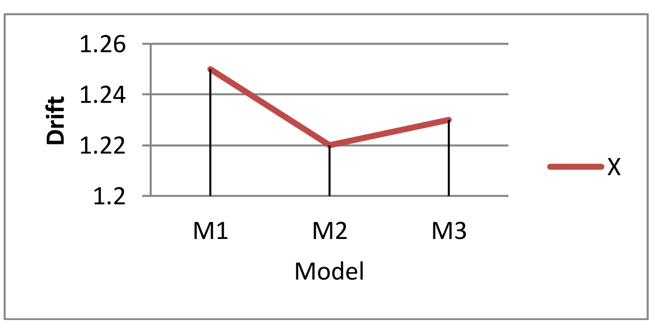
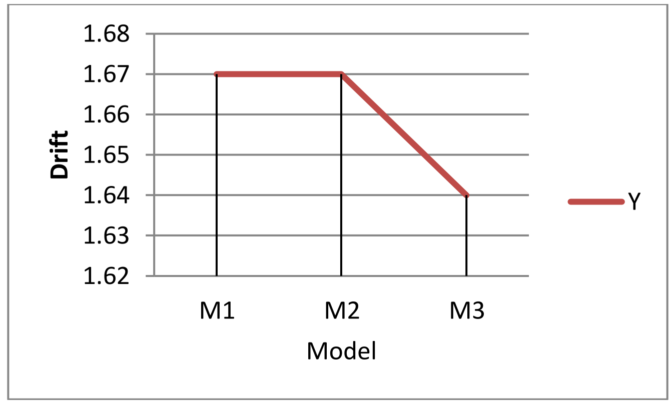


Fig 4 :- Bending Moment (for M1,M2 and M3)





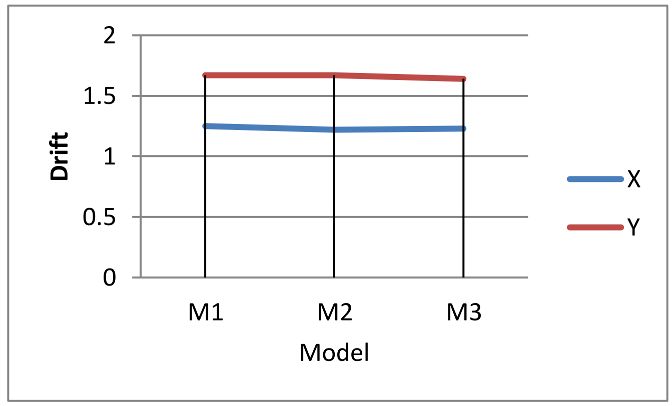


Fig 5 :- Drift of building in X and Y Direction

V. CONCLUSION

After changing of corners Geametri of building there is Following change has be Obtaine

- Reduction in lateral Displacement in X and Y Direction.
- Also decresed in Drift in X and Y Direction.
- there is reduction in axial and Bending of coolumn (C7 and C55).
- building with circular Corner geometri is found to be most suitable to reduced wind effect high resed structure .

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