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Effect of Wind Forces on Various Types of Structural Plan Configurations in Case of RCC Building Structures – A Comparative Study

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Abstract— Earlier in 19th century, there were no structures as tall buildings but with the technological advancement and rise in urbanization, there was a need for vertical expansion of cities. During that era, for design purpose, only vertical/gravity loads on buildings were to be considered but with increase in slenderness/height of buildings, lateral loads on structures i.e. wind loads and earthquake loads came into pictures which are more predominant. In 1930's many high rise buildings were constructed across the world. It was a period of great prosperity for high rise buildings as extensive research work was carried out on wind induced effects on high rise buildings. Unlike the mean flow of wind, which can be considered as static, wind loads associated with gustiness or turbulence rapidly and even abruptly, creating effects much larger than if the same loads were applied gradually. Wind loads, therefore, need to be studied as if they were dynamic in nature. This project work mainly concentrates on wind induced pressures which would be arises due to wind intensity and how pressure varies according to different shapes of buildings, finding out the wind response by using the dynamic analysis method provided in IS code.

Keywords— Tall buildings, Wind Engineering, Gust, Dynamic Analysis, Storey Displacement.

I. INTRODUCTION

It is difficult to distinguish the characteristics of building which categorize it as tall. Building cannot be defined as tall using the term of height or number of floors only. A building is an enclosed structure that has walls, floors, a roof and usually windows. "A tall building" is a multi-storey structure in which most occupants depend on elevators to reach their destinations. The most prominent buildings are called high-rise buildings in most countries. There is no absolute definition of what contributes a tall building. From the structural design point of view, it is simpler to consider a building as tall when its structural analysis and design are in some way affected by the lateral loads, particularly the sway caused by such loads. As the height increases, the wind forces begin to dominate. Therefore, structural framework for super-tall buildings is developed around concepts associated entirely with resistance to turbulent wind.

Indian cities are witnessing immense demographic expansion due to migration from surroundings from villages, leading to urban sprawl, housing demand, rise in cost of land. Housing has emerged as an economy generating industry. Because of this grate demand, economic growth, technological advancement, desire for aesthetics in urban areas, restriction of random expansion in major cities adjacent to agricultural land; high rise residential structures have become a solution in the metropolitan cities.

Fifty years ago-during the 1950's-structures were, by present standards, relatively massive. Structural members themselves were heavier due to the relatively weak materials and dead loads were higher. For example, to the heavy masonry and stone facades on buildings and the use of heavy reinforced concrete deck systems on bridges. These massive structures were frequently much stiffer than they were predicted to be due to the participation of the non-structural components, the contribution of which was difficult to estimate. The massiveness of these structures did little to emphasize the importance of wind forces.

In tracing the further developments of wind loading from 1930's to the present, there appear to have been several forces at work. First there have been some radical changes in structural properties-mass, stiffness and damping. The average densities of tall buildings and long span bridges, for example, have fallen to roughly a factor of 2 from around 20 to 10 lb/ft3 in case of buildings and from 200 to 100 lb/ft3 of roadway in case of long span bridges. In parallel, the substantial increase in material strengths (by factor of 2 and 3 in case of structural steel and concrete) has led to reduction in member sizes and consequently stiffness. This has been exaggerated further by the omission of heavy masonry cladding and frame infill and therefore the loss of their contribution to stiffness. To this, we can add the significant improvements in analysis such as plastic analysis and the contribution of the digital computer. Lastly, there have been significant reductions in damping due to extensive use of welding, pre-stressing and the omission of heavy masonry

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elements. All of these changes in structural form directly increase their susceptibility to wind and hence the need for better models of wind loading.

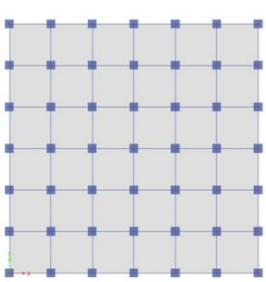
II. METHODOLOGY

This study includes comparative study of behaviour of high rise building frames considering different geometrical plan configurations but with constant plan area under the effect of wind forces. In the absence of the computational fluid dynamics study and wind tunnel study, how can we make the best use of the codal provisions given in our wind code for computing the wind load on a structure. A comparative study has been made by finding out the response using new IS: 875 (part-3) – 2015 for the displacement, wind force and base bending moment.

Step 1: Review of various technical papers presented by different researchers.
Step 2: Selection of the various plan configurations of the building suitable for the present study. The Plan configurations used for the study are as follows;

A. Square Shape
B. Rectangular Shape
C. Circular Shape
D. Diamond Shape
E. Plus Shape
F. Capsule Shape
G. 12-Sided Polygonal Shape
H. Octagonal Shape
I. Hexagonal Shape
J. Elliptical Shape

Step 3: Modelling of the above selected plan configurations in ETABS 16 software.
Step 4: Analysis of the various models using the dynamic method given in IS 875 (Part 3): 2015.
Step 5: Interpretation of the various results due to wind response.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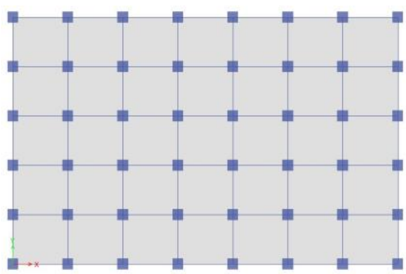
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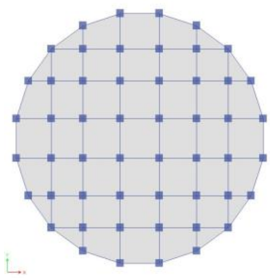
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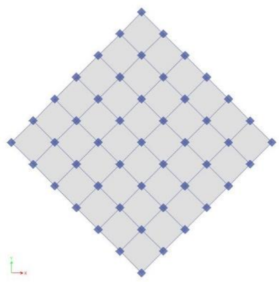
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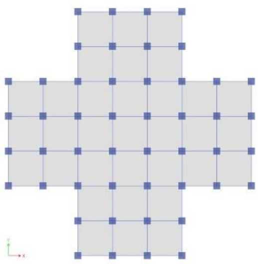
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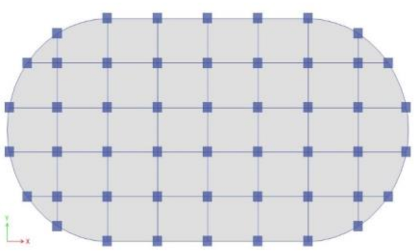
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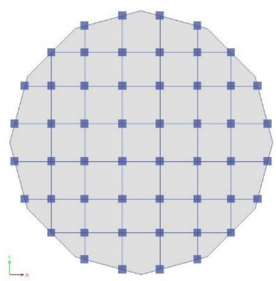
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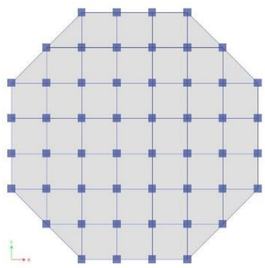
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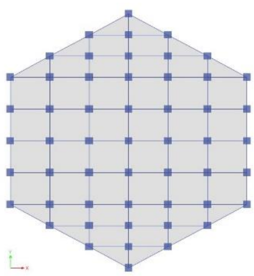
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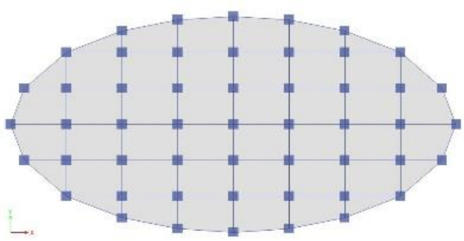
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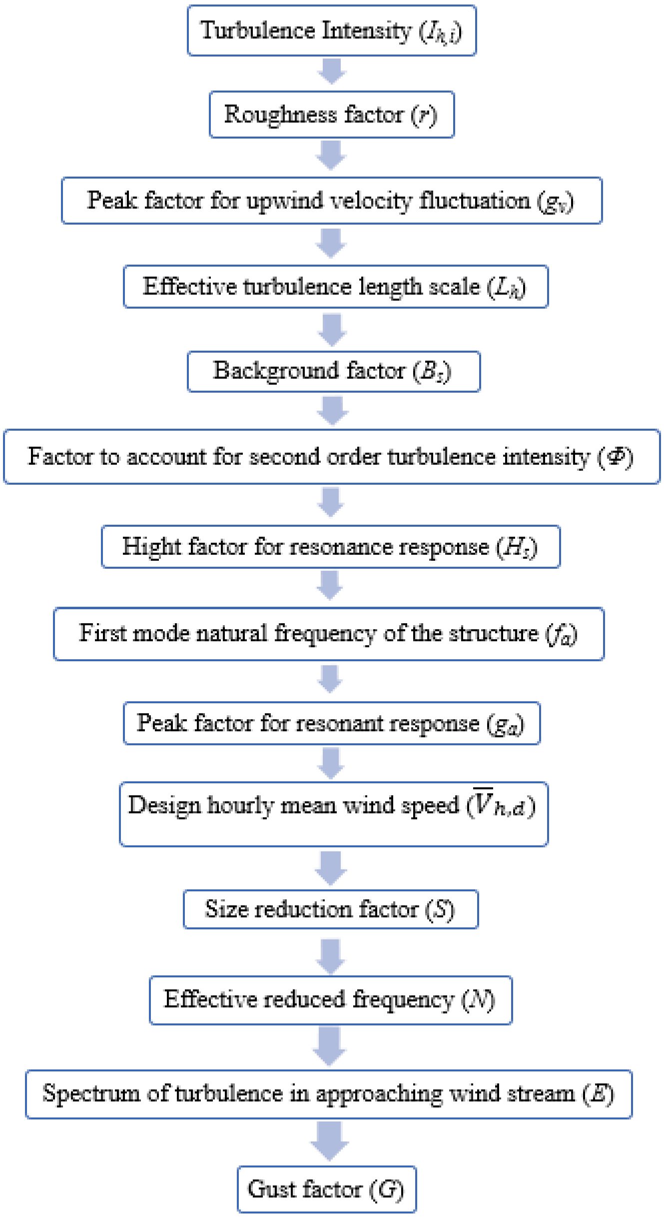
III. FLOW CHART FOR CALCULATING THE GUST FACTOR



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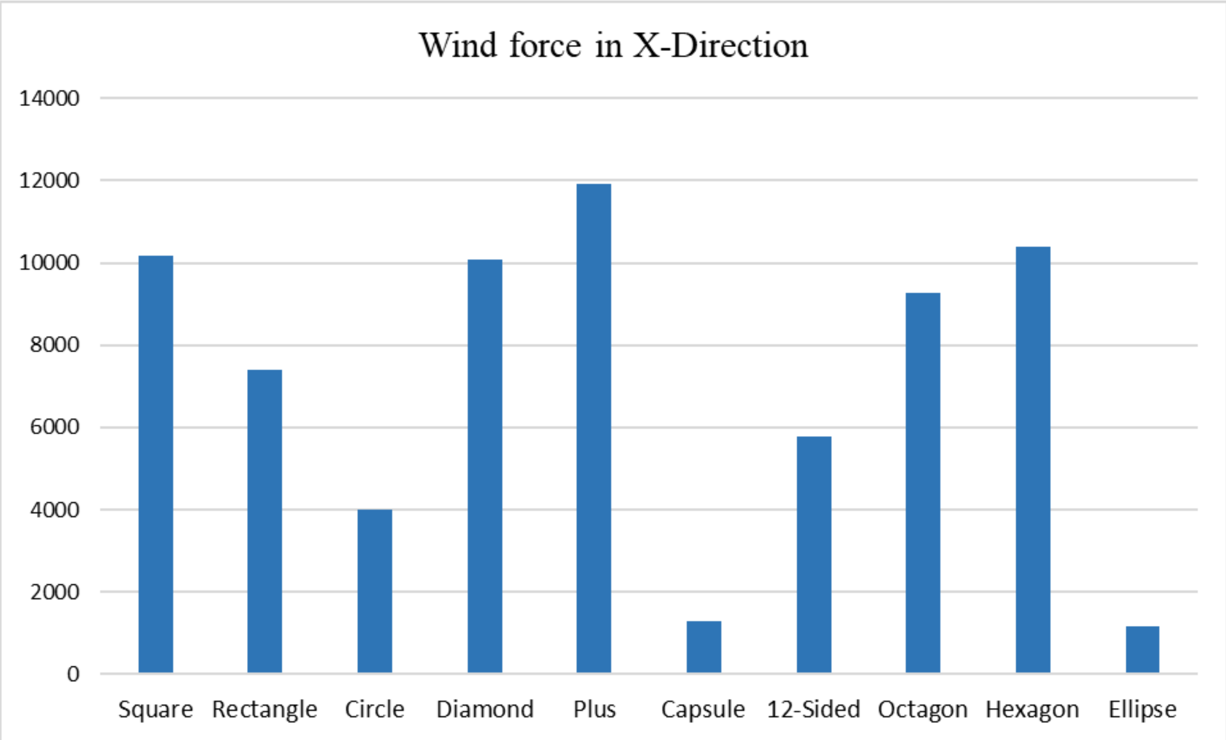
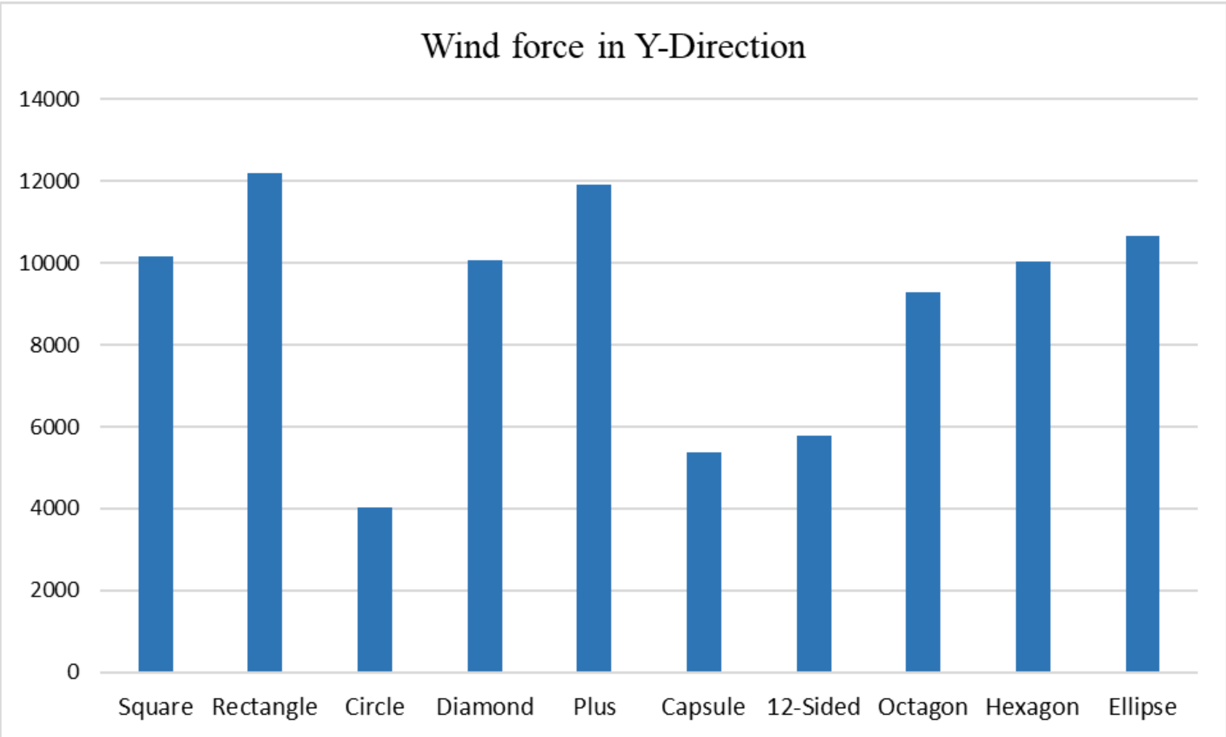
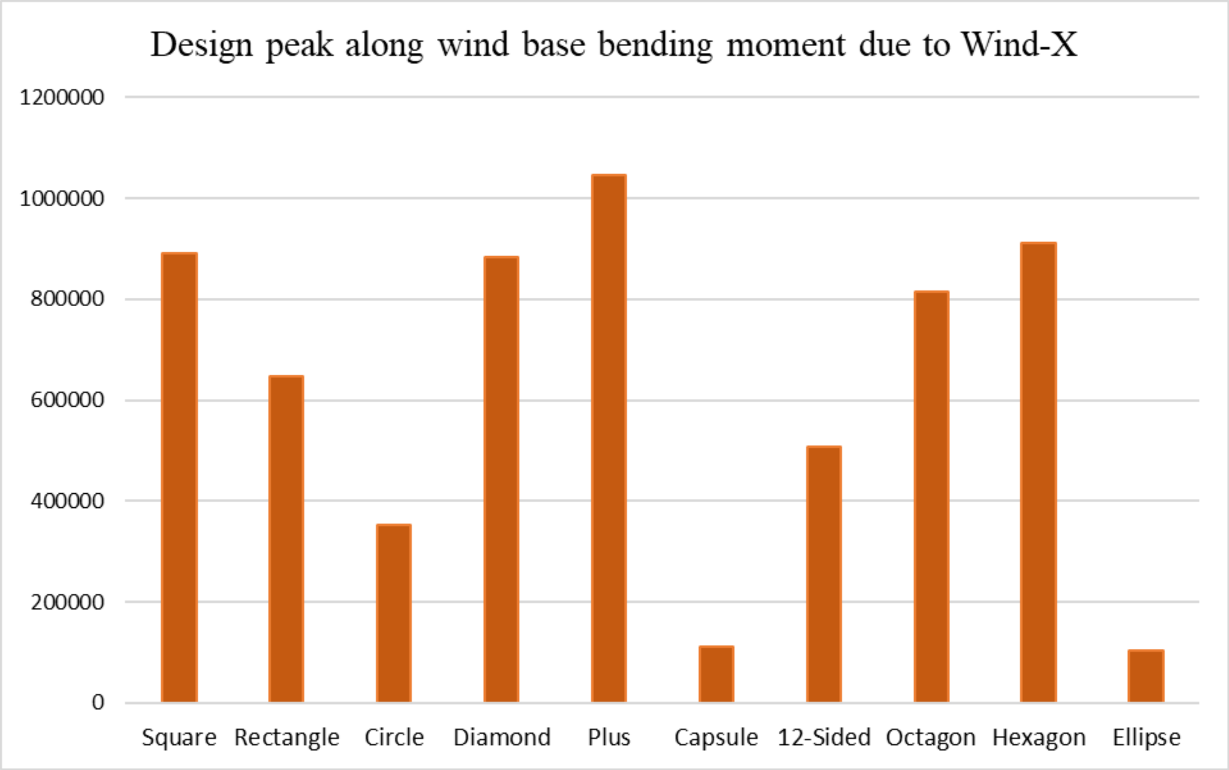
IV. RESULTS



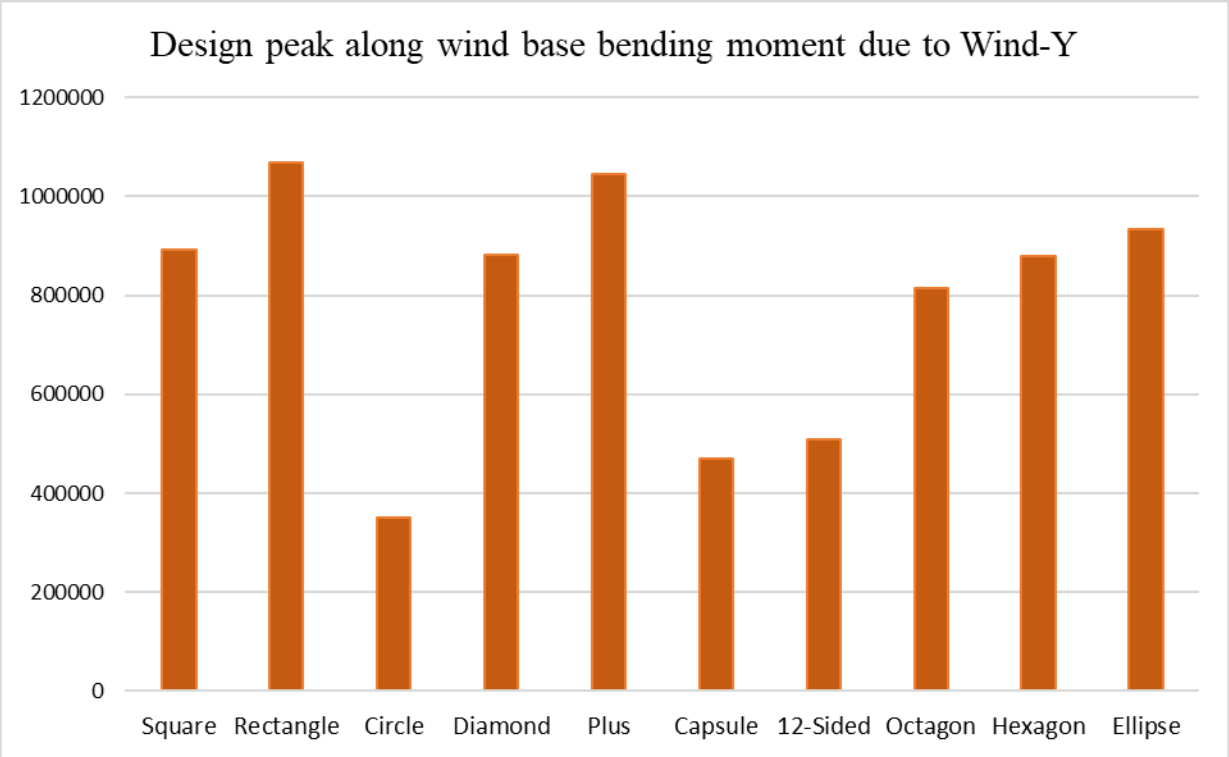
Graph 4.1 Comparison of wind force for all shapes in (X-direction)



Graph 4.2 Comparison of wind force for all shapes in (Y-direction)



Graph 4.3 Comparison of design peak along wind base bending moment for all shapes due to Wind-X



Graph 4.4 Comparison of design peak along wind base bending moment for all shapes due to Wind-Y

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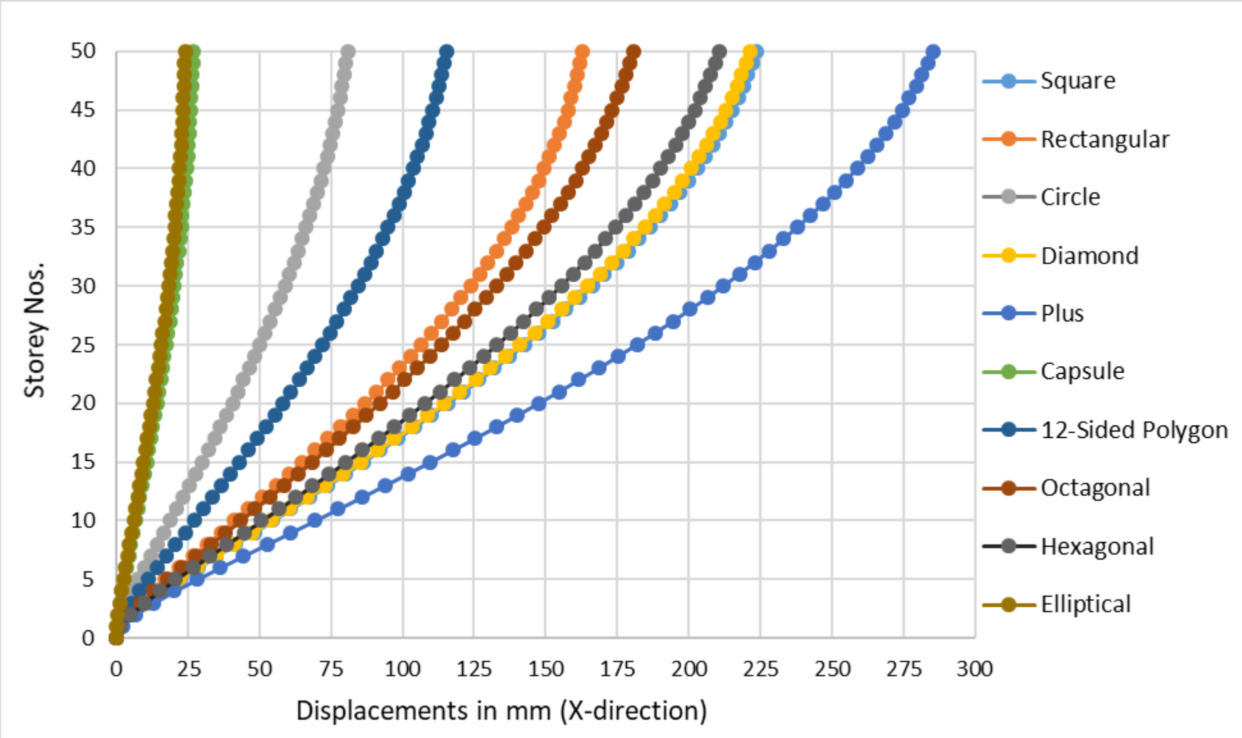
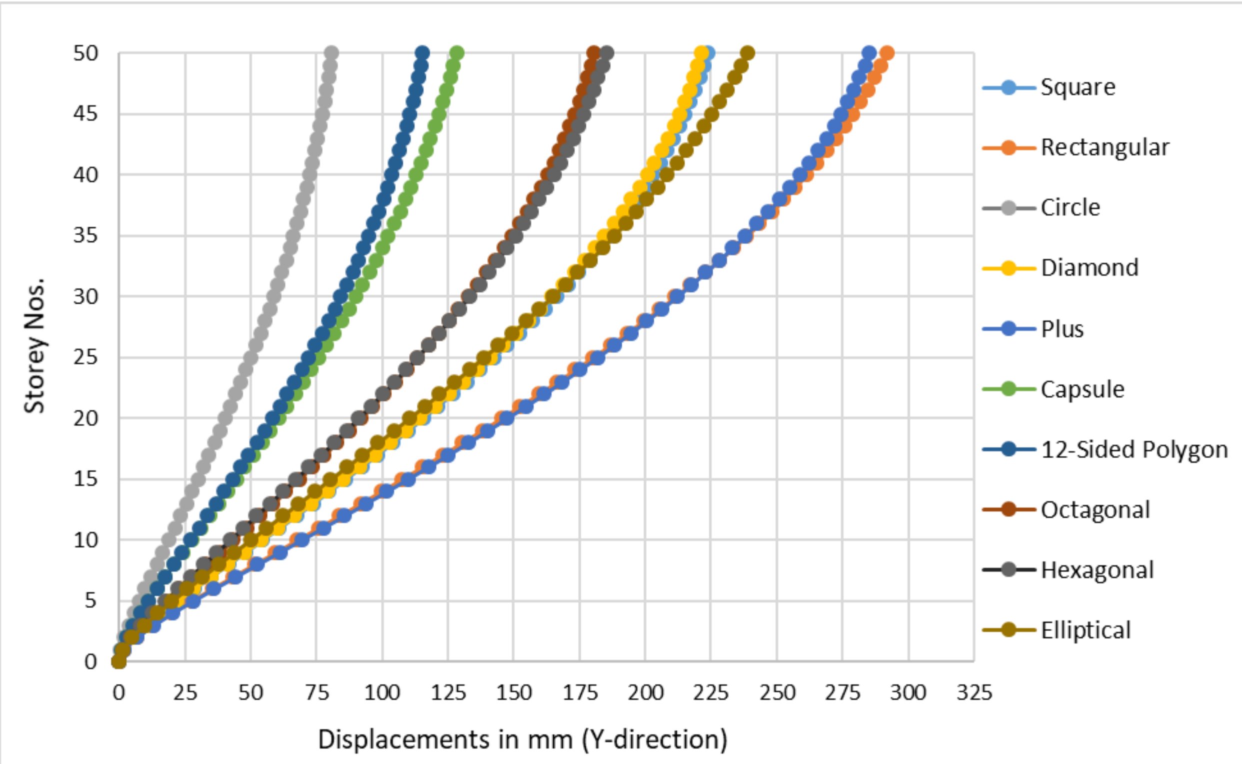


Graph 4.5 Comparison of maximum storey displacement for all shapes in (X-direction)



Graph 4.6 Comparison of maximum storey displacement for all shapes in (Y-direction)

V. CONCLUSION

1. If we consider wind force in X-direction then Elliptical shape is having the minimum value and the Plus shape is having the maximum value.
2. If we consider wind force in Y-direction then Circular shape is having the minimum value and the Rectangular shape is having the maximum value.
3. If we consider design peak along wind base bending moment due to Wind-X then Elliptical shape is having the minimum value and the Plus shape is having the maximum value.
4. If we consider design peak along wind base bending moment due to Wind-Y then Circular shape is having the minimum value and the Rectangular shape is having the maximum value.
5. If we consider maximum storey displacement in X-direction then Elliptical shape is having the minimum value and the Plus shape is having the maximum value.
6. If we consider maximum storey displacement in Y-direction then Circular shape is having the minimum value and the Rectangular shape is having the maximum value.
7. Other parameters used for calculation of Gust Factor like, Background Factor, Phi, Natural frequency, Peak factor for resonant response, Size reduction factor, Effective reduced frequency, Spectrum of turbulence, and Gust factor varies randomly.

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