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Structural Response of the Tall Building Under Dynamic Wind Loading

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Abstract- The tall buildings are designed primarily to serve the needs of the occupancy, and, in addition to satisfying structural safety, one of the dominant design requirements is to meet the necessary, standards for the comfort of the building users and the serviceability. The present work aims to demonstrate the performance of buildings at three different level steel structure are considered with V_b= 44 m/s, and The building studied in this work is a G+26, 42, 59, stories steel moment-resisting frame designed for gravity, and wind using IS 875-2005, and is studied using two different methods namely Gust factor method, and Rayleigh factor method. , and is studied using Etabs 2016 structural analysis software. In the study, the storey displacement, Storey, axial load, shear force, and bending moment of the structure were studied, and the results obtained were compared with those obtained from others

Keywords: Tall Building, Skyscraper, Wind, Wind Excitation, gust factor method, Rayleigh factor method

INTRODUCTION

The development of modern materials and construction techniques has resulted in the emergence of a new generation of structures that are often, to a degree unknown in the past, remarkably flexible, low in damping, and light in weight. Such structures generally exhibit increased susceptibility to the action of wind. Accordingly, it has become necessary to develop tools enabling the designer to estimate wind effects with a higher degree of confidence than was previously required. Wind engineering is the discipline that has developed, primarily during the last few decades, from effects aimed at developing such tools. It is the task of the engineer to ensure that the performance of structures subjected to the action of wind will be adequate during their anticipated life from the point of both structural safety, and serviceability. Under the action of wind flow, structures experience aerodynamic forces that include the drag (along-wind) force acting in the direction of the mean wind, and the lift (across-wind) force acting perpendicular to the direction.

- Study of Response of regular steel buildings using the dynamic wind analysis.
- Present a thorough investigation of the gust factor method, and the Rayleigh factor method in Terms of lateral displacement at the top, moments, shear, and axial loads.
- Study the response of steel building in terms of different height, (G+ 26, 42, and 59) and to evaluate the response of dynamic-wind.

LITERATURE REVIEW

Ankit Panjwani (International Journal of Creative Research Thoughts (IJCRT)): This is the approach taken by most Codes and Standards. The present Indian Standard for wind loads IS 875 (Part 3) 2015 is also based on Static method. In this paper the effect on buildings with change in terrain category considering category 2 & 4 is also studied using the parameters like Base shear, Overturning moment, Maximum story displacement & Maximum story drift and the best suitable approach corresponding to the terrain category is suggested.

Amit K. Mali Turkish Journal of Computer and Mathematics Education (2023): The main objective of the paper was to investigate the effect of the gust factor on a 100m tall structure, while keeping the B/H ratio between 0.2 and 1.2 and the L/B ratio of the building varying from 0 to 50. The height of the structure was varied from 50m to 450m to analyze the shear force and bending moment multipliers. Furthermore, the study aimed to examine the effect of the fundamental frequency of the building structure on the gust factor and to prepare elastic spectra accordingly. As the slenderness ratio increases, the gust factor also increases. The gust factor for flexible structures was higher than that for stiff buildings

Sakshi Kirar Research gate(2024): Tall buildings are being developed due to rapid urbanization, as land availability decreases and population growth increases. High-rise buildings are more susceptible to wind forces, making their structures dynamically sensitive at greater elevations. The gust factor, a pseudo-static constant, is provided by several nations to compute dynamic wind forces. This study compares the structural response of tall steel buildings with V-bracing, X-bracing, and Chevron bracing under dynamic wind loading, using four different codes and standards: India (IS 875:2015 part-3), America (ASCE 7-16), Australia/New Zealand (AZ/NZS 1170.2:2011), and Canada (NBCC 2015) for varying structure heights and exposure conditions (Open and Rough).

1. Module And Building Configuration

The Plan configuration consists of

Models considering with wind speed Vb = 44 by gust analysis, and Rayleigh analysis G+26, H=81m

A model considering with wind speed Vb =44 by gust analysis, and Rayleigh analysis G+42, H=129m

A model considering with wind speed Vb = 44 by gust analysis, and Rayleigh analysis G+59, H=180m

The plan and 3D view of the building used for the modelling is as below:

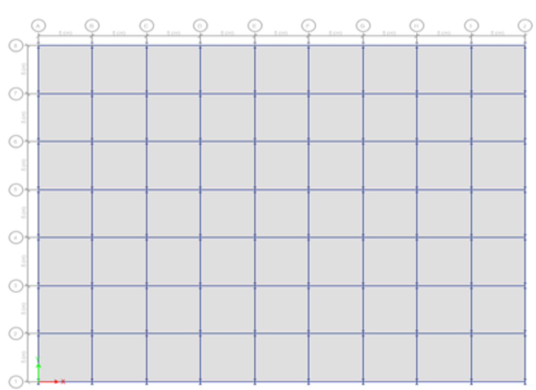

Figure 1: Plan view of G+26 storey building

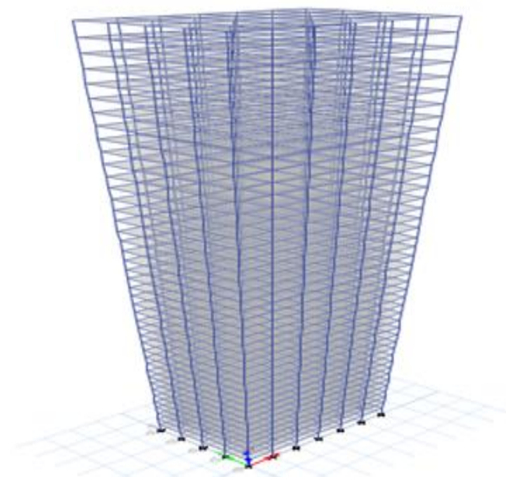

Figure 2: Isometric view of G+26 building

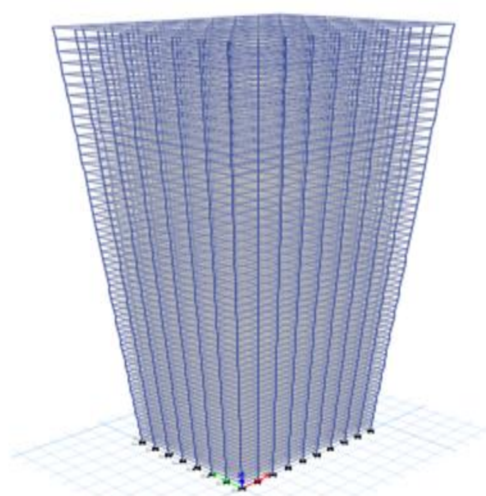

Figure 3: Isometric view of G+42 building

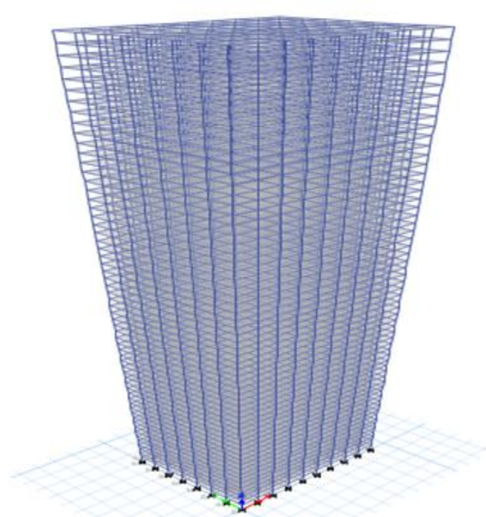

Figure 4: Isometric view of G+59 building

2. RESULTS FOR MODELS

STORY DISPLACEMENT G+26

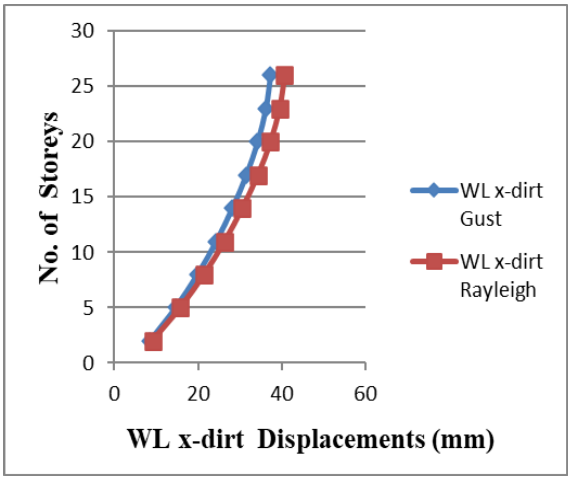

Figure 6: story displacement G+26 in the X direction

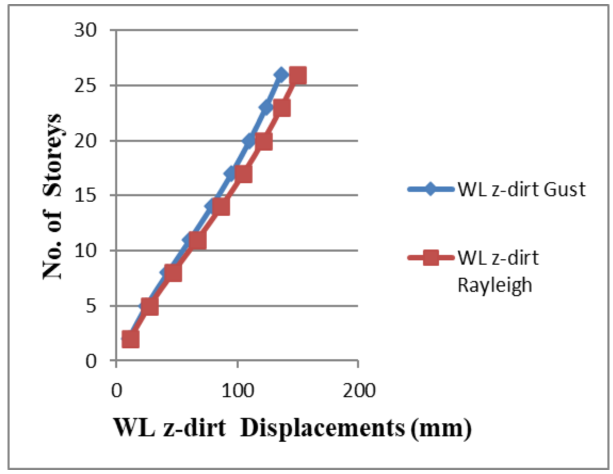

Figure 7: story displacement G+26 in Y direction

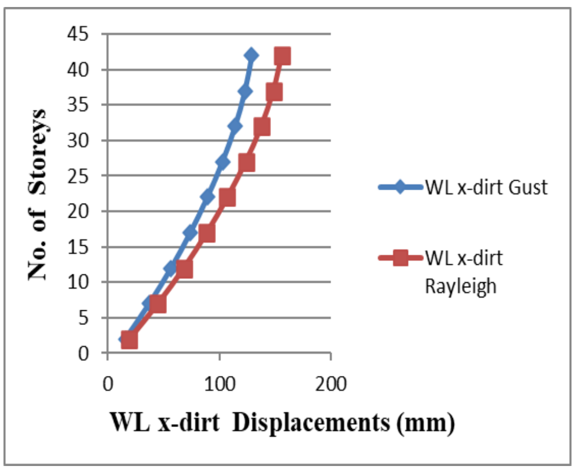

Figure 8: story displacement G+42 in the X direction

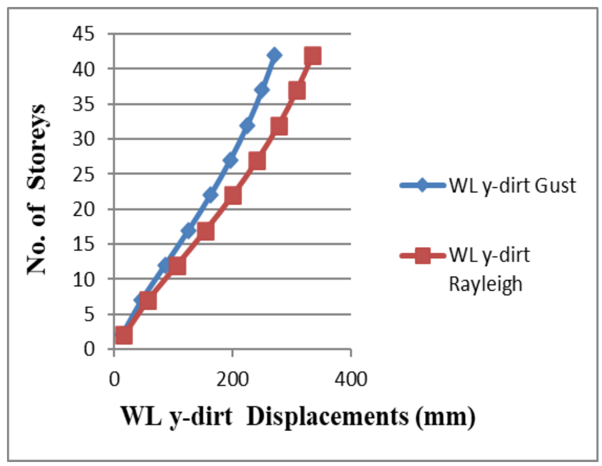

Figure 9: story displacement G+42 in Y direction

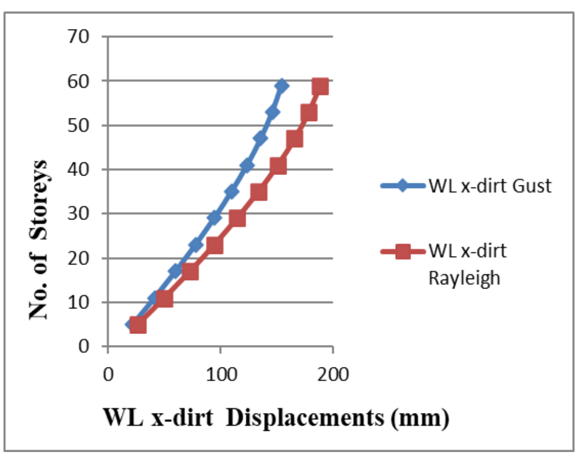

Figure 10: story displacement G+59 in the X direction

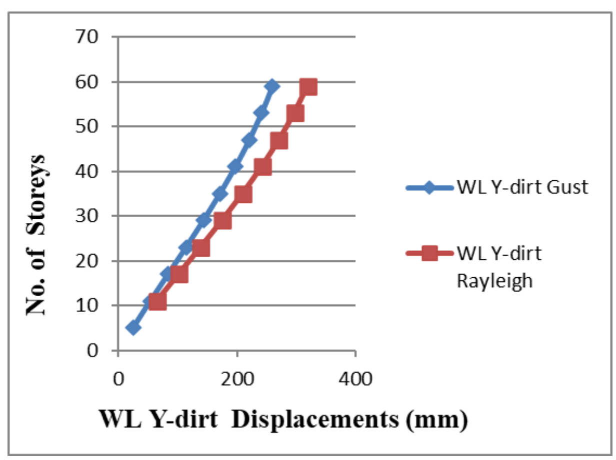

Figure 11: story displacement G+59 in Y direction

Comparison of Axial forces on columns (a, b,c) in X-direction by Gust factor method and Rayleigh factor method

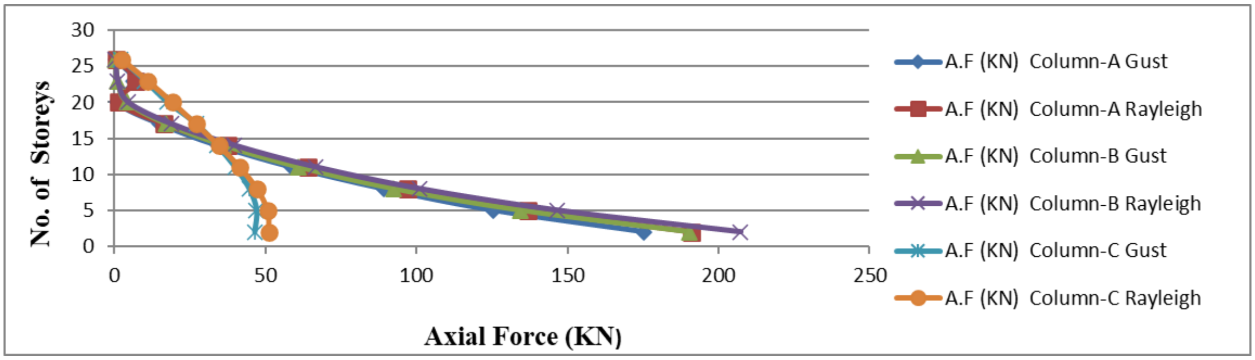

Figure 12: Axial forces for G+26

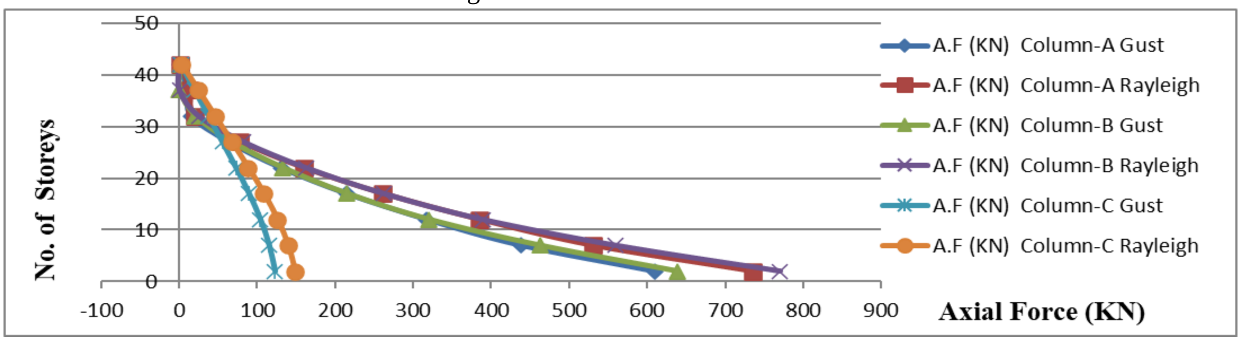

Figure 13: Axial forces for G+42

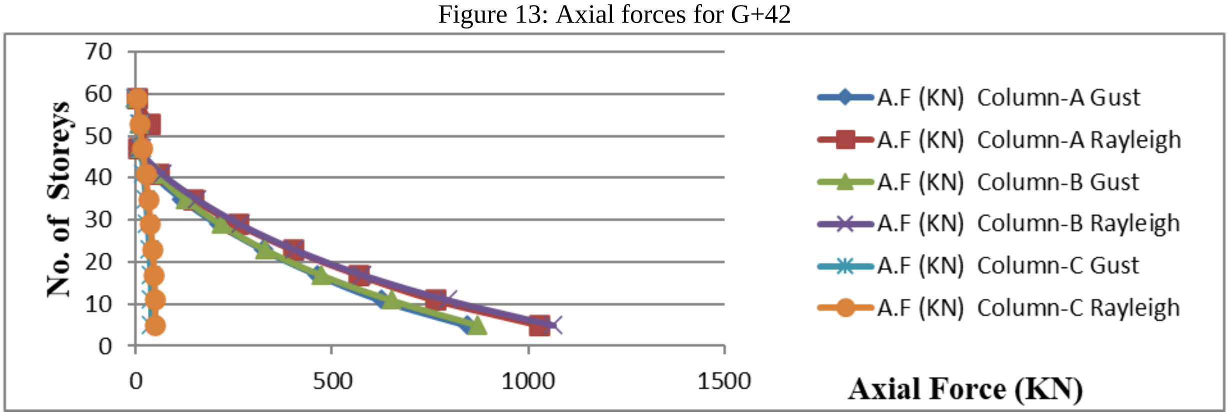

Figure 14: Axial forces for G+59

SHEAR FORCE RESULTS

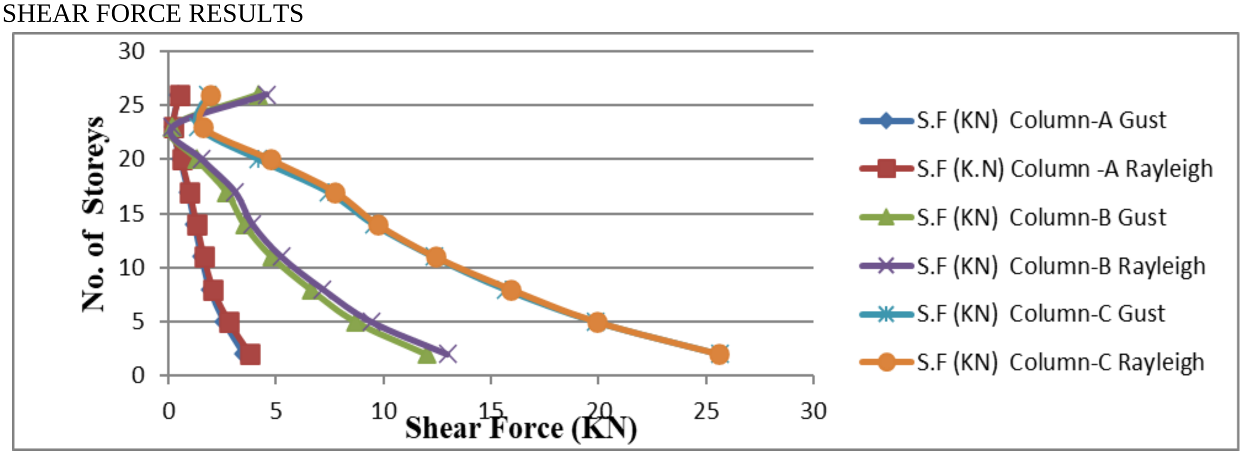

Figure 15: Shear forces for G+26

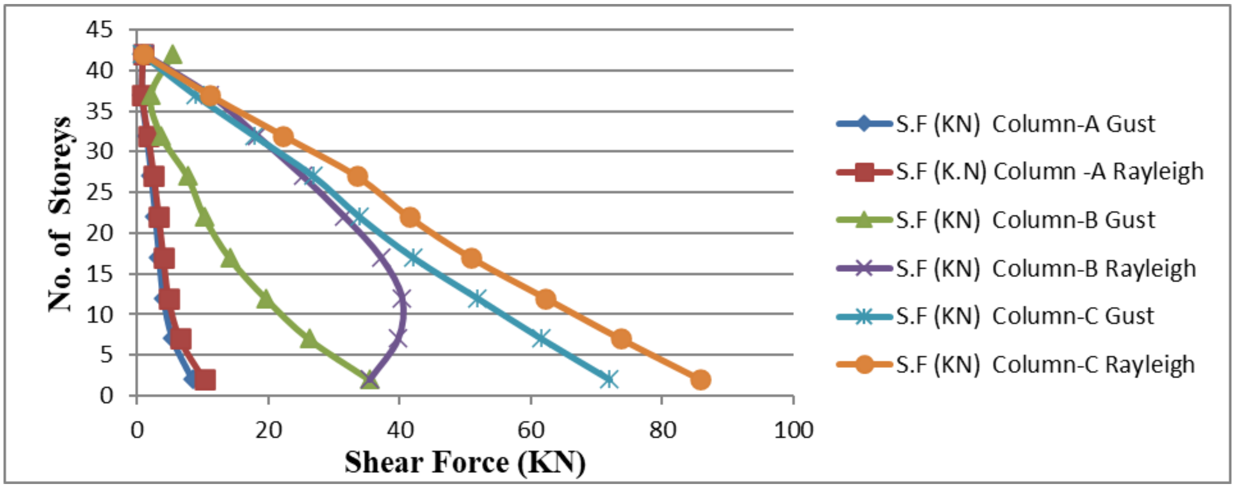

Figure 16: Shear forces for G+42

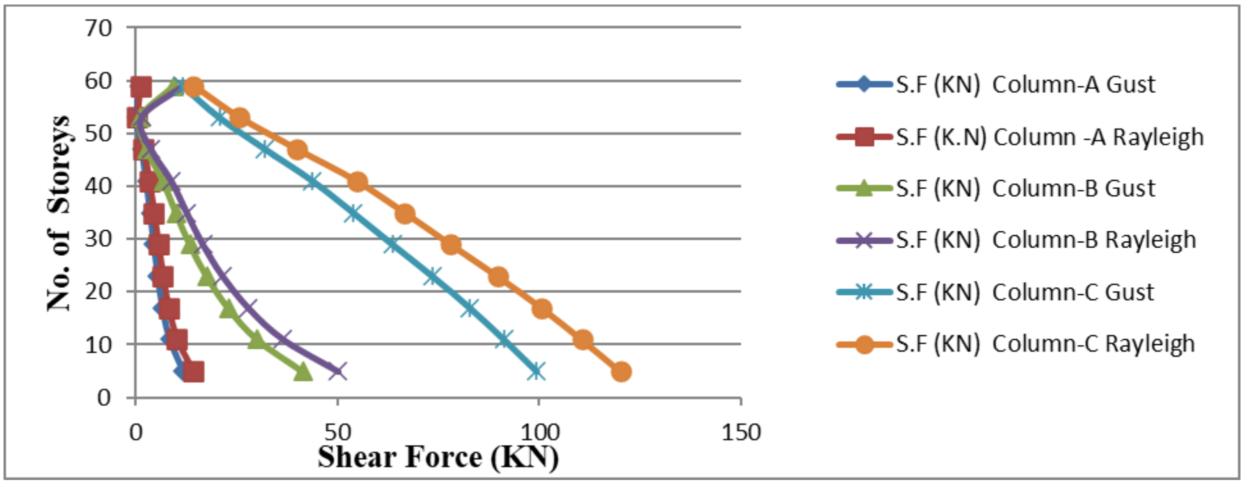

Figure 17: Shear forces for G+59

3. CONCLUSION

- From maximum displacement, it is observed that the displacement value is higher in Rayleigh factor method when compare it to the value of displacement obtain by analyzing it by gust factor method, and the result is same in both direction, i.e., in X – direction, and in Y – direction.
- Moreover, from the above mention tabular forms, it is also observed that the displacement values for the gust factor method are within the criteria, i.e., it is lesser than H/500.
- By comparing it is observed that the values of Axial load, shear force, and bending moment is higher in the Rayleigh factor method when compared to the gust factor method in X-direction and Y-direction of steel frame building.
- Displacement on building due to wind load in x direction starts at 7.455% at lowest storey i.e on 2 storey and reaches a value of 7.868% at 14 storey and further it increases at 8.056% at 17 storey and reaches the maximum value of 8.303% at top floor i.e on 26 storey.
- Displacement on steel frame building G+42 in x direction increases floor wise due to wind load starting with a value of 15.886 mm at 2 storey and reaching maximum value 129.226 mm at 40 storey in gust factor method and in Rayleigh factor method the displacement is lowest on 2 storey i.e 18.95 mm and reaching a maximum value of 156.26 mm at top level. The percentage increases of displacement for Rayleigh factor model is 20.91% when compared to gust factor method.

- Displacement on steel frame building G+59 in x direction increases floor wise due to wind load starting with a value of 21.587 mm at 5 storey and reaching maximum value 153.99 mm at 60 storey in gust factor method and in Rayleigh factor method the displacement is lowest on 5 storey i.e 26.1 mm and reaching a maximum value of 188.22 mm at top level. The percentage increases of displacement for Rayleigh factor model is 22.22% when compared to gust factor method.

5. SCOPE OF FURTHER STUDY

- To study the dynamic Wind effects on tall building frames-influence of dynamic parameters.
- Seismic behavior of a reinforced concrete framed structures under different soil interaction.
- For study the effect of shear lag on a high structure, there is a significant degree of shear lag with a consequent reduction in structural efficiency.
- To research the dynamic wind impact of dynamic parameters on high building frames.
- Effect of geometric plan configuration of tall building can also be studied.

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