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Dynamic Wind Analysis of Different Shapes Tall Building

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Abstract: Tall buildings are increasingly becoming a norm in urban landscapes, and their design and construction require careful consideration of various factors, including wind loads. This study investigates the dynamic wind analysis of different shape tall buildings, with a focus on understanding the effects of wind loads on building stability and safety. analyse the wind load effects on different shape tall buildings. The results show that wind load effects vary significantly depending on building shape, size, and orientation.

The study provides valuable insights into the design of tall buildings, highlighting the importance of considering wind load effects in the design process.

In this we are study G+50 stories tall building with different shapes, Shapes can influence wind interacts with the structure. By different studies we already know buildings with sharp edges or irregular geometries tend to create more turbulence and, thus, experience higher dynamic loads than those with streamlined, cylindrical, or uniform shapes. Wind loads are modelled based on wind speed, direction, turbulence intensity, and other atmospheric conditions. These factors are combined to predict the wind's impact on a building at various heights.

Different building shapes have different responses to wind. Tall buildings with tapered or rounded shapes generally experience lower wind loads due to better airflow around them, while those with sharp angles or corners may lead to vortex shedding and higher wind-induced forces.

Dynamic wind analysis of tall buildings is essential for ensuring structural integrity, occupant comfort, and safety. It requires an understanding wind effect to predict and mitigate the effects of wind on various building shapes.

Keywords: Gust Factor Method, ETABS Software, Dynamic Response, IS 875: (Part-3): 2015, Effects of Building Shape, Tall buildings, Along wind, across wind

I. INTRODUCTION

Tall buildings have become an integral part of modern urban landscapes, and their design and construction require careful consideration of various factors, including wind loads. Wind load theory is an essential part of structural engineering, particularly for the design of tall buildings and structures in windy areas. By understanding how wind interacts with a structure's shape, height, and environment, engineers can design buildings that withstand wind forces safely. The calculation of wind loads requires knowledge of dynamic forces, local wind patterns, and the structure's ability to resist or absorb those forces through appropriate design and materials. Wind loads have a significant impact on the stability and safety of tall buildings, and their effects vary depending on the building's shape, size, and orientation. Wind loads one of the critical factors in the design and safety of buildings. In recent years, advances in computational fluid dynamics (CFD) and wind tunnel testing have enabled researchers to study the effects of wind loads on tall buildings in greater detail. Dynamic wind analysis, which involves simulating the dynamic behaviour of wind flows around buildings, has emerged as a powerful tool for evaluating the wind load effects on tall buildings. This study investigates the dynamic wind analysis of different shape tall buildings, with a focus on understanding the effects of wind loads on building stability and safety.

The study employs ETABS Software analyse the wind load effects on different shape tall buildings When tall buildings are geometrically irregular it is become more essential to calculate and analysis wind effect. In this study also we are going to calculate wind load dynamically by Gust Factor Method. Gust Factor Method which is given in IS 875 Part 3:2015 in detail give all formulas and criteria to understand and calculate wind load.

Dynamic wind analysis of tall buildings involves the study of the wind-induced behaviour of structures under varying wind conditions. This analysis is critical for understanding the structural performance and safety of tall buildings, as they are more susceptible to dynamic forces caused by wind.

II. LITERATURE REVIEW

There are some literature reviews of preview years where engineers have studies on different points about dynamic wind analysis –

1) Verma, D., & Gupta, R. (2018) explored the wind-induced vibrations of tall buildings in tropical climates, specifically in India. Their study looked at the impact of building shape, height, and location on the dynamic behavior under monsoon and seasonal wind conditions. They highlighted that building shape significantly affects the wind load distribution, with irregular and slender shapes being more susceptible to high-frequency vibrations and requiring additional damping measures.
2) Kumar, A., & Singh, V. (2019) utilized CFD simulations to study the effects of building geometry on wind load distribution. Their study, which focused on urban regions of India, analyzed how various building shapes—particularly tall and slender forms—respond to wind forces. They found that angular shapes, such as square buildings, tend to induce stronger vortex shedding and torsional motions, while cylindrical and tapered shapes mitigate these effects.
3) Tamura, Y., & Yoshida, A. (2019) provided a detailed review of the factors influencing wind-induced vibrations in tall buildings. They focused on how building shape influences the dynamic response, particularly the effects of vortex shedding on square, cylindrical, and tapered buildings. Their study demonstrated that cylindrical buildings offer better wind resistance compared to angular shapes, which are more prone to oscillations due to vortex-induced forces.
4) Kareem, A., & Kijewski, T. (2020) reviewed the impact of building geometry on wind-induced vibrations, particularly focusing on resonance effects caused by vortex shedding. Their research covered a range of building shapes, including square, cylindrical, and tapered forms, and emphasized the importance of aerodynamic features in mitigating these effects. They noted that angular shapes and taller buildings are particularly vulnerable to wind-induced resonance, while more streamlined, cylindrical forms show improved resistance to wind-induced oscillations.
5) Sharma, P., & Joshi, A. (2020) analyzed the dynamic behavior of tall buildings under wind loading in India, particularly the influence of building shape on wind-induced vibrations in Indian cities. They examined several different building shapes—rectangular, tapered, and irregular—using both CFD simulations and empirical formulas for wind load calculations. Their study concluded that slender and irregular buildings need additional damping systems, such as tuned mass dampers (TMDs), to reduce wind-induced oscillations and improve structural stability.
6) Ghosh, S., & Ray, S. (2021) conducted studies focused on buildings in Indian urban environments, where high-rise construction is on the rise. Their research analyzed the wind-induced vibrations in buildings of various shapes, with a focus on traditional rectangular forms, cylindrical shapes, and modern faceted designs. They used both CFD simulations and wind tunnel testing to analyze how these shapes interact with wind forces in the unique climatic conditions of Indian cities. Their study found that slender, irregular buildings, common in high-rise developments in India, tend to experience higher torsional motion compared to more aerodynamically shaped structures.
7) Stathopoulos, T., & Karava, P. (2021) explored the effect of irregular building shapes on wind-induced forces using CFD analysis. Their work showed that buildings with complex geometries (such as asymmetrical shapes or faceted designs) can experience more severe dynamic wind forces due to unsteady flow patterns and vortex shedding. They emphasized the importance of using computational methods to predict these effects accurately, especially in cities with high wind velocities.
8) Zhang, S., & Zhang, H. (2022) explored the dynamic response of tall buildings under wind loading, specifically considering the impact of shape and flexibility. By combining wind tunnel tests with CFD simulations, they assessed the behavior of cylindrical, rectangular, and irregular building shapes. They noted that flexible buildings with rectangular or angular geometries are more prone to torsional vibrations, while cylindrical buildings experience more stable wind responses.
9) Kawai, S., & Wakamatsu, K. (2023) conducted research on the influence of building shape on wind-induced vibrations, specifically focusing on optimizing shapes to mitigate vortex shedding. Their study used advanced CFD techniques and wind tunnel testing to analyze the behavior of angular and slender structures under different wind conditions. They found that tapered and curved shapes reduce wind load impacts by creating more uniform pressure distributions, which lower the risk of dynamic resonance.
10) Lee, J., & Cho, M. (2023): This study examined how building height and shape influence wind-induced vibrations, particularly in metropolitan environments. They proposed that adaptive dampers and smart materials could be used in angular high-rise structures to reduce resonant vibrations, especially during monsoon seasons in wind-prone regions.
11) Nguyen, H., & Tan, L. (2024): This study combined theoretical models and CFD simulations to analyze the impact of wind tunnel effects on the dynamic responses of tall buildings with complex shapes. They found that wind loads in urban canyons create more complicated aerodynamic interactions, which exacerbate wind-induced vibrations in irregularly shaped buildings.

12) Feng, X., & Wu, H. (2024): This research focused on wind-induced vibrations in tropical storm-prone regions. By simulating the effects of different building forms (cylindrical, rectangular, and stepped), they found that stepped or tapering shapes perform best under extreme wind loading, as these forms dissipate wind energy more effectively.
13) Hassan, A., & Ahmad, S. (2025): This study analyzed wind-induced vibrations in high-rise buildings in coastal and arid regions. Using CFD simulations with real-world data, they demonstrated that while faceted buildings offered better performance in coastal areas, these forms showed higher vulnerability to torsional oscillations in arid regions. The study stressed the need for climate-specific design solutions.
14) Li, X., & Zhang, Q. (2025): This paper reviewed the effectiveness of damping systems in mitigating wind-induced vibrations. They found that while tuned mass dampers (TMDs) effectively reduce vibrations in rectangular and angular buildings, cylindrical forms require smaller or no damping systems due to their aerodynamic shape.
15) Wang, Y., & Liu, D. (2025): This study explored the correlation between building flexibility and wind-induced vibrations. They found that flexible buildings with irregular geometries, such as cantilevered or asymmetrical designs, exhibited increased resonance effects, particularly in regions with variable wind velocities. They recommended hybrid damping systems that combine passive and active strategies.

VI. CONCLUSION

The dynamic wind analysis of tall buildings demonstrates that building shape significantly impacts wind-induced vibrations and structural stability. Various studies have shown that buildings with angular, slender, or irregular shapes are more prone to wind-induced oscillations, especially due to vortex shedding. These effects can lead to resonance phenomena, increasing the risk of structural damage, which could result in higher maintenance costs or, in severe cases, pose a safety threat. To mitigate such risks, more aerodynamic shapes, such as cylindrical and tapered forms, offer better wind resistance, as they help reduce vortex shedding and maintain more stable wind responses.

Research highlights the importance of tailored design approaches, especially in urban and tropical environments like India, where local wind conditions and building flexibility play crucial roles in a building's performance under wind loading. The combination of local environmental factors, such as monsoon winds, and global phenomena like climate change, can drastically affect the wind load distribution on buildings. Understanding these influences is vital for designing structures that are not only safe but also energy-efficient. In this context, the incorporation of advanced computational techniques, such as CFD simulations and wind tunnel testing, is vital for optimizing building shapes and accurately predicting wind load effects. These tools enable engineers to test various design parameters without the need for extensive physical prototypes, leading to cost savings and a faster design process.

Furthermore, innovations in structural damping technologies, such as tuned mass dampers (TMDs), are becoming increasingly crucial for mitigating wind-induced vibrations, particularly in slender and irregularly shaped buildings. While TMDs have proven effective, future developments in damping technologies, including active and semi-active systems, may further enhance a building’s ability to resist dynamic forces. The integration of smart materials and sensors that respond to wind forces in real-time could also become a critical aspect of next-generation building designs, allowing for adaptive damping systems that adjust to changing conditions.

Another key point is the growing need to focus on building flexibility. As buildings increase in height, their ability to flex and sway in response to wind forces becomes more important. Research has shown that flexibility can help distribute the wind load more evenly, reducing the risk of resonance. However, excessive flexibility can also be a concern, leading to more significant sway, which can be uncomfortable for occupants. Therefore, there must be a balance between rigidity and flexibility in the design of tall buildings to ensure occupant comfort while maintaining structural integrity.

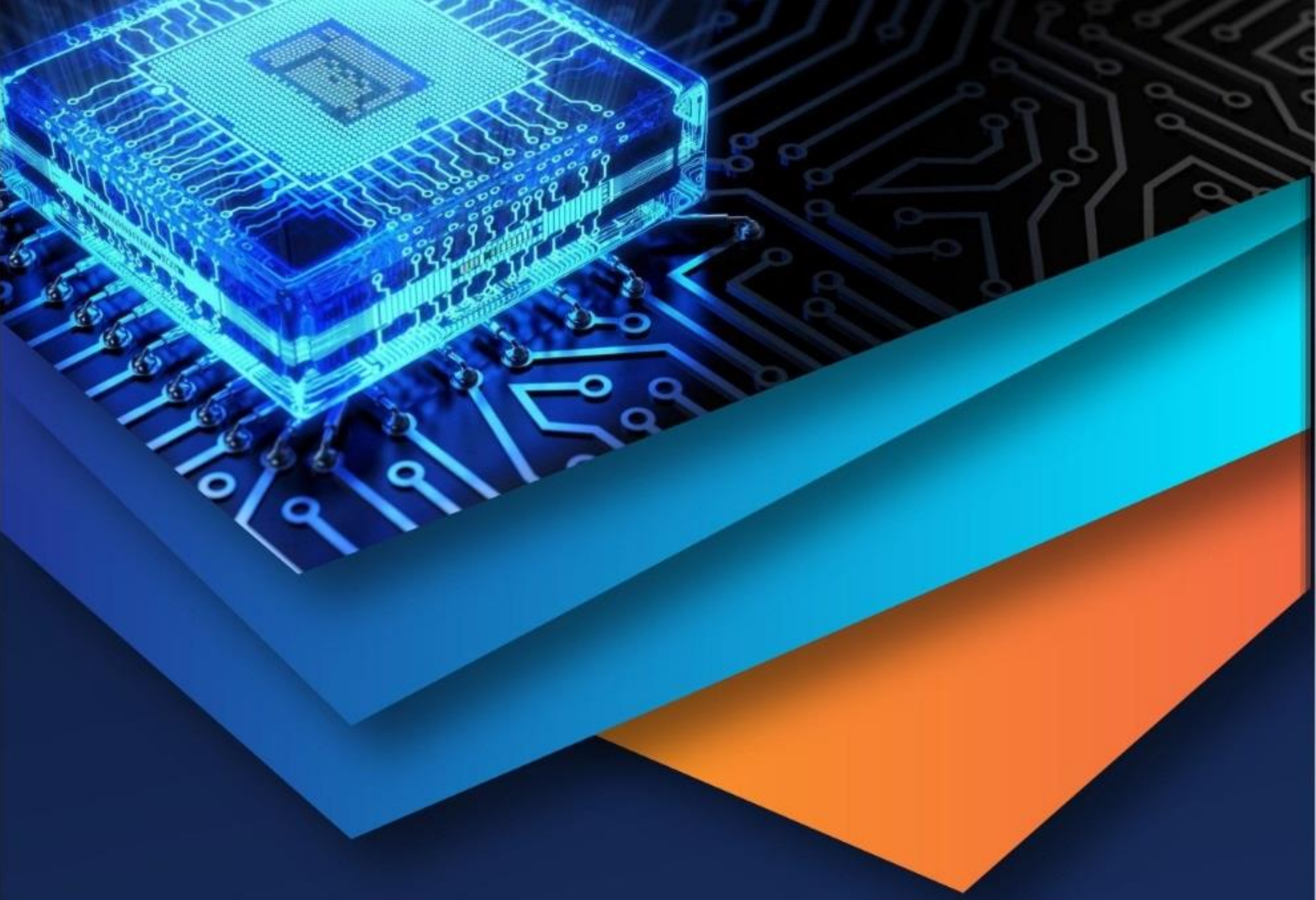
In conclusion, the selection of building geometry should carefully consider wind-induced vibration characteristics, with streamlined shapes offering improved stability. Furthermore, advanced engineering methods should be employed to minimize dynamic wind forces, ensuring the safety and resilience of tall buildings in high-wind regions. The combination of computational techniques and experimental data has enhanced our ability to predict wind forces and develop more resilient buildings. As high-rise constructions continue to rise, particularly in urban environments like those in India, it is imperative to consider both aerodynamic factors and damping solutions to ensure the structural stability of these buildings under dynamic wind loading conditions.

Future studies should focus on further improving the integration of climate-specific design solutions and advanced damping technologies to address the increasingly complex challenges posed by dynamic wind forces. Additionally, with the rapid urbanization in many parts of the world, especially in regions prone to extreme weather conditions, urban planning and zoning regulations should incorporate guidelines for wind-induced vibration mitigation to safeguard public health and structural safety.

It is essential for engineers and architects to work together, with a holistic view that integrates wind engineering, architectural design, and sustainability goals to create resilient, safe, and energy-efficient high-rise buildings for the future.

REFERENCES

[1] IS 875 (Part 1) : 1987 - Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures: Dead Loads
[2] IS 875 (Part 2) : 1987 - Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures: Imposed Loads
[3] IS 875 (Part 3) : 2015 - Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures: Wind Loads (Third Revision)
[4] IS 456 : 2000 - Code of Practice for Plain and Reinforced Concrete
[5] Abhay Guleria (2014) - "Structural analysis of a multi-storeyed building using ETABS for different plan configurations," International Journal of Engineering Research & Technology, Vol. 3 Issue 5, May 2014.
[6] Aiswaria G. R and Dr. Jisha S. V (2018) - "Along and Across Wind Loads Acting on Tall Buildings," 92 Second International Conference on Architecture Materials and Construction Engineering – AMCE 2018.
[7] Anupam Rajmani (2015) - "Analysis of Wind & Earthquake Load for Different Shapes of High Rise Building," IJCIET.
[8] Bhumika Pashine, V. D. Vaidya, Dr. D. P. Singh (2016) - "Wind analysis of multistoried structure with T shape and L shaped geometry," International Journal of Engineering Development and Research.
[9] K. Vishnu Haritha, Dr. I. Yamini Srivalli (2013) - "Effect of Wind on Tall Building Frames - Influence of Aspect Ratio," International Journal of Research in Civil Engineering, Architecture & Design, Volume 1, Issue 1, July-September, 2013.
[10] K. R. Kumar, M.I. Shreef, Nagesh R. Iyer, S. Gopalakrishnan (2013) - "Analysis and Design of Tall Building Subjected to Wind and Earthquake Loads," The Eighth India Pacific Conference on Wind Engineering, December 10-14, 2013.
[11] Lone, B. A., & Chand, J. (2019) - "Comparative Study on Seismic and Wind Performance of Multi-Storeyed Building with Plan and Vertical Irregularities-A Review," International Research Journal of Engineering and Technology.
[12] M. R. Wakchaure, Sayali Gawali (2015) - "Effects of shape on the wind-instigate response of high rise buildings," IJRET: International Journal of Research in Engineering and Technology, Volume: 04 Issue: 09, September 2015.
[13] Mohammed Asim Ahmed, Moid Amir, Savita Komur, Vaijainath Halhalli (2015) - "Effect of wind load on tall buildings in different terrain category," IJRET: International Journal of Research in Engineering and Technology.
[14] Ravindra Ahlawat, Ashok Kumar Ahuja (2015) - "Wind loads on 'Y' plan shape tall building," International Journal of Engineering and Applied Sciences, April 2015.
[15] Ranjitha KP, Khan KN, Kumar NS, Raza SA (2014) - "Effect of Wind Pressure on R.C. Tall Buildings using Gust Factor Method," International Journal of Engineering Research and Technology, Volume 3, Issue 07, July 2014.



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