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REVIEW ARTICLE

WIND LOAD MITIGATION ON HIGH RISE BUILDINGS WITH DIFFERENT CONFIGURATIONS: REVIEW

***Roshan Singh Dhami and Astha Verma**

Department of Civil Engineering, College of Technology, GBPUA&T, India

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ABSTRACT

In modern architecture, people want to create impressive and intricate buildings. However, due to limited land and a growing population, especially in countries like India, it has become necessary to build taller structures. As buildings go higher, they face challenges from strong winds. This can be risky, especially if the building's shape is irregular, as it can lead to twisting forces and wind induced vibrations that pose a threat to the structure, human lives, and resources. Therefore, it's crucial to carefully study and understand these forces during the design process. In this study we tried to sum up all the conclusion made till date to mitigate the wind forces on high rise buildings. Adding openings or openings in a building is one method to reduce the impact of wind-induced vibrations and the force of strong winds, especially when constructing tall buildings. These openings allow the wind to pass through, decreasing the pressure on the building and minimizing the vibrations and potential damage caused by powerful winds as the building goes higher.

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INTRODUCTION

The design of tall buildings is influenced by the increasing wind loads that become more severe as the height of the building increases. Standard values are available for structures with regular shapes, as outlined in international standards such as AS/NZS 1170.2 (2011), ASCE 7-16 (2017), and IS 875 (2015). However, when it comes to buildings with irregular shapes, it is necessary to conduct specific research to understand the impact of wind on the structure. Irregularly shaped structures may experience unique challenges that require a more in-depth analysis to ensure their stability and safety. Wind tunnel testing and computational fluid dynamics (CFD) are both widely used methods for studying the effects of wind on tall buildings. Because the impacts of wind on a building vary depending on its design, several researchers have used wind tunnel experiments to study these effects and to evaluate the effects of isolated circumstances, computational research has been done utilizing the k-epsilon turbulence model in ANSYS CFX. The fundamental advantage of wind tunnel testing is that it enables for controlled physical testing of an accurate model of the building. This more effectively represents real experimental wind conditions and their effects on the building. Compared to CFD models, wind tunnel testing is essential for gaining a deeper understanding of the wind flow characteristics and provides a more realistic picture of pressure distribution. For instance, the wind tunnel test considers both pressure and suction when calculating the pressure on the margins of a building from upstream to downstream wind, yielding a more accurate amount of pressure on the edges. Alternatively, CFD models may reduce the magnitude. To investigate wind effects on high-rise structures in the boundary layer flow of the atmosphere, numerous wind tunnel setups are utilized in experiments. It should be noted, however, that this necessitates a proper setup, which can be more expensive than CFD simulations. CFD also allows for greater freedom in terms of building model size and shape, as well as wind speeds and other variables that may be investigated. CFD simulations, on the other hand, are restricted by the quality of the computer models and the assumptions used in the simulation.

LITERATURE REVIEW

Y. Li *et al*, 2023. They analyze the tapered tall building with 0%, 5%, 10%, 15%, 20%, the results showed that aerodynamic performance of the tapered tall buildings has been improved effectively, especially for a cross-wind effects. This study aims to provide reference for aerodynamic optimization design of tapered tall buildings. R. Kumar *et al*, 2023. In this study, the wind effects on building models with square, rectangular, pentagonal, hexagonal, heptagonal, octagonal, and nonagonal shapes were investigated, with different wind incident angle. From square to nonagonal plan there is decrease in suction pressure at leeward faces. Y. Abu-Zidan *et al*, 2022. The researcher investigated the behavior of square tall buildings with openings on service floors. His findings indicated that a greater number of openings led to improved performance. The most effective configuration involved a single opening positioned at 70% of the building's height. The study considered a maximum of seven façade openings, which resulted in a 76% reduction in resonant acceleration and a 43% reduction at the comfort threshold. R. Raj *et al*, 2022.In their study, Computational Fluid Dynamics technique is utilized to analyze a square building plan with having (+) shape in upper portion of tall building. The results are interpreted in terms of the pressure coefficient values (from pressure contours) and velocity streamlines obtained, compared these results with square tall building. P.Sanyal *et al*, 2020. The flow patterns, wind-induced force and distribution of pressure over the surfaces of diferent types of Y-shaped buildings are represented graphically to interpret the limit of alteration due to the modifcations of shape. Diferent types of helical, tapered, setback and corner-modifed models were analysed, and their pros and cons were discussed. Setback building model with rounded corner shape is proved out to be most efcient among the studied models, but there is a problem of a huge increase in the suction on the corner regions. Meena *et al,* 2022. Studied the comparative study in Octagonal and hexagonal structure by computational method (ANSYS CFX, concluded that octagonal tall structure experiences almost symmetrical pressure distribution. The octagonal and hexagonal plan cross-sectional shape has more or less the same nature of pressure distribution on the windward surface in the case of symmetrical wind incidence angle. Y. Li *et al*, 2019. The purpose of their study was to investigate the effects of voids in tall buildings on the surrounding wind environment. Greater no of voids can disperse the surrounding heat with more efficiency and weaken the wind velocity in the lowest level. Therefore, in high-rise buildings, the number and distribution of the openings will have different effects on the wind environment around the buildings.

B.S. Chauhan *et al*, 2017. Presents the effect on wind pressure distribution on rectangular plan tall buildings due to the presence of two other closely spaced tall buildings having similar plan shape. Models of three rectangular plan buildings are arranged in a straight line, keeping the principal building model at the center. The effect of height variation of the interfering buildings is studied, by varying the heights of the interfering building in two different manner: (1) Height of both the interfering building models is varied simultaneously, (2) Height of only one of the interfering building model is varied. As the height of the interfering buildings is decreased the effect of interference decreases. An increase of about 25 percent is noted in drag force compared to isolated condition. The torsional moment in the principal building model is observed to increase as the height difference of the two interfering building models increase. A. K. Roy *et al*, 2017.They studied the various research paper and concluded various wind mitigation methods for tall buildings. For the maximum mean overturning moment coefficients, tapered models such as Tapered and Setback Models show better aerodynamic behaviors in the along-wind direction and Corner modification models, shows better aerodynamic behaviors in the across-wind direction. The aerodynamic characteristics of the composite models with multiple modifications are mostly superior to those of the models with single modification. However, the advantages of corner modification seem to be eliminated somewhat by the helical shape.

It was found that Wind Pressure Coefficient is maximum in case of square plan shape and it is minimum in case of circular plan shape of tall building. The swastika plan shape is effective in reducing the wind pressure coefficient on surfaces of tall building in comparison with square plan shape of building, but the total drag force will be more in case of swastika plan shape building compared to square plan shape of building. M.A. Mooneghi *et al*, 2016. Author concluded the various research done on the modifications in building to mitigate wind impact by following some major modifications like varying floor plan, cross sectional shape, twisting, tapering, setback and openings. Mladen Bošnjaković, 2016. The paper analyzes different turbine design suitable for the urban environment. They discussed various options for setting up wind turbines in relation to the building. Introduction of wind turbines on top of building having orifices. Making modern tall building energy efficient and sustainable. S.K. Verma*et al*, 2015. They studied the CFD Simulation for Wind Load on Octagonal Tall Buildings and the effect of varying wind incident angles namely 0º, 15º and 30º on wind pressure distribution. They found the symmetric pressure distribution on both side faces, octagonal plan building is more aerodynamic as compared to square plan.

CONCLUSION & RESEARCH GAP

As openings in square and regular plan tall buildings are becoming very efficient in mitigating wind load , we can further reduce movement on building due to wind by introducing helical, tapered, setback, hexagonal ,octagonal tall buiding with openings on its service floors. Orifices on tall building at various height can also helps in dispersion of surrounding heat very efficiently and also introduction of wind turbine on these orifices makes these high rise structures more stable, energy efficient and environmental friendly.

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