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Review on Wind Load Performance Evaluation of High-Rise Buildings (G+27) With Different Plan Shapes Using (Bim Software) Autodesk Revit Plug-In with Robot Structural Software

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Abstract - Wind-induced effects significantly influence the structural design, serviceability, and aerodynamic performance of tall buildings. Over the past two decades, advancements in aerodynamic shaping, façade engineering, and BIM–FEM workflows have transformed high-rise structural design practices. This review paper critically evaluates fifteen influential studies published between 2001 and 2025, covering four major domains: (i) aerodynamic form optimization, (ii) wind pressure and façade performance, (iii) dynamic wind response and mitigation strategies, and (iv) BIM-integrated structural analysis workflows. Findings indicate that early-stage geometric optimization, corner modifications, and modern aerodynamic treatments can reduce wind excitation by 30–60%. Additionally, advanced modelling platforms such as Autodesk Revit and Robot Structural Analysis improve accuracy, reduce modelling time, and enable iterative optimization. However, gaps still exist in coupling aerodynamic treatments with structural optimization, façade–structure interaction modelling, and AI-driven wind-response prediction. This review identifies these gaps and proposes a structured methodology for future research on combined aerodynamic–structural design using BIM and computational tools.

Key Words: BIM-based wind analysis, Autodesk Revit, Robot Structural Analysis, High-rise building, Plan shape effect.

1.INTRODUCTION

all buildings are becoming increasingly slender due to architectural demands and limited urban space. As building height increases, wind loads become a dominant design consideration, governing structural stiffness, serviceability, and occupant comfort. Modern skyscraper design requires a multidisciplinary approach integrating aerodynamic shape optimization, façade engineering, structural analysis, and computational modelling.

Earlier studies focused primarily on wind pressure coefficients and plan-shape effects, while recent research explores advanced concepts such as porous façades, twisted forms, adaptive structures, and digital design workflows. Meanwhile, BIM-based tools like Autodesk Revit and Robot Structural Analysis have improved the accuracy and efficiency of wind load modelling.

Despite this progress, challenges persist in harmonizing architectural form with structural wind performance. The purpose of this review is to (i) synthesize developments in wind engineering and BIM-based analysis, (ii) evaluate the performance of various aerodynamic techniques, and (iii) identify gaps for future research to support integrated design for high-rise buildings.

Parallel to aerodynamic research, significant progress has been made in digital design technologies. The adoption of **Building Information Modelling (BIM)** and **Finite Element Modelling (FEM)** has transformed how engineers conceptualize, analyse, and optimize tall-building structures. Tools such as **Autodesk Revit** and **Robot Structural Analysis** enable seamless integration between architectural modelling and structural analysis, supporting rapid iteration and reducing modelling errors. Integrated BIM–FEM workflows promote accuracy, automation, and collaboration across disciplines, allowing engineers to evaluate multiple design scenarios under wind loads more efficiently. Studies have shown that BIM-based models provide better load-path visualization, improved coordination between components, and enhanced reliability in structural decision-making.

Furthermore, the emergence of advanced CFD tools has enabled virtual wind testing with significantly reduced cost compared to traditional boundary-layer wind-tunnel experiments. Standardized guidelinesNsuch as those published by the Architectural Institute of Japan (AIJ) have improved CFD accuracy and reliability, making it a powerful tool for early-stage aerodynamic assessment. When combined with FEM and BIM, CFD-based aerodynamic studies can provide a holistic and highly detailed understanding of wind effects on tall buildings.

Despite these advancements, several challenges remain. Many studies treat aerodynamic form optimization and structural analysis as separate processes, leading to a lack of integrated design frameworks. Façade behaviour under extreme wind loads especially failures at panel joints and connectors remains poorly understood, despite being one of the most vulnerable components during storms. Moreover, BIM tools are still limited in performing aerodynamic simulations directly, requiring external CFD software, which reduces workflow efficiency. The growing complexity of tall-building forms also demands more advanced computational techniques, including **machine learning**, **parametric design**, and **multi-objective optimization**, which are still in the early stages of adoption in structural wind engineering.

Given these evolving challenges and advancements, a consolidated review of wind engineering research is essential. This review paper aims to bridge the gap between aerodynamic studies, façade behaviour research, dynamic response mitigation, and BIM-based computational analysis. The selected literature from 2001 to 2025 reflects a comprehensive evolution of wind engineering from fundamental corner modification experiments to advanced CFD studies and integrated BIM–FEM workflows.

By comparing findings across these studies, this review highlights the effectiveness of various aerodynamic treatments, identifies limitations in current research, and proposes potential directions for future work.

The outcomes of this review will contribute to a broader understanding of wind–structure interaction in tall buildings and support the development of more efficient, sustainable, and resilient high-rise design methodologies. With increasing global urbanization and climatic uncertainties, improving the wind performance of tall buildings is not only a structural necessity but also an essential step toward ensuring occupant comfort, maintaining façade safety, and reducing economic losses associated with extreme wind events.

2. LITERATURE REVIEW

[1] Mazarakou & Papalou (2025)
Study: Effect of Structural Forms on Wind-Induced Response of Tall Buildings
Mazarakou and Papalou conducted a FEM-based investigation to understand how different tall-building structural forms influence wind response. Their work involved modelling various aerodynamic building shapes and applying realistic wind load profiles validated against engineering standards. The study found that shape modifications such as tapering, setbacks, and rounded corners significantly reduce lateral drift, peak acceleration, and torsional rotation. They demonstrated that structural form has a direct influence on wind stability and that early-stage architectural shaping can reduce structural demand. This research shows the importance of integrating structural form development with aerodynamic performance analysis early in design.

[2] Singh & Verma (2025)
Study: Reducing Wind Load on Tall Buildings: this study happen multiple techniques for reducing wind loads on skyscrapers, focusing on aerodynamic treatments.
Their review evaluates methods including corner chamfering, openings, twisting, tapering, and aerodynamic appendages such as fins and spoilers. They reported that many of these treatments effectively reduce vortex shedding and across-wind response, improving building comfort and stability. The authors also highlight that shape modification is far more cost-efficient than increasing structural stiffness. The study provides strong evidence that aerodynamic design should be integrated at the conceptual design stage. It is a highly comprehensive review of wind-load mitigation methods.

[3] Eissa, Elgendy & Hassanein (2025)
Study: Performance of High-Rise Building Facades under Wind Loading
This study explored wind effects specifically on high-rise façade systems, an area often overlooked despite its importance. They performed wind-tunnel pressure tests and finite element analyses on various façade configurations. Their study revealed that façade failures are usually initiated at connectors, especially in curtain-wall systems where flexibility increases local stresses. They emphasized that façade geometry, panel stiffness, and anchorage detailing contribute significantly to wind resistance. The research highlights façade–structure interaction as a critical component for tall-building safety. Their findings underline the need for improved façade design and connection detailing.

[4] Sudarshan Suryanarayan & D.M Pandit (2025)
Study: Comparative Study of High-Rise Building With and Without Shear Walls Using Revit and Robot
This study compares the performance of tall buildings with and without shear walls using BIM and FEM tools. Two models were created in Revit and analysed in Robot Structural Analysis under wind loads. The results showed that buildings with shear walls experience significantly lower storey displacement, drift, and base shear compared to those without shear walls. The study highlights how the placement and stiffness of shear walls enhance lateral resistance. It also demonstrates the strength of BIM–FEM workflows in generating accurate models and improving design efficiency. This research confirms the importance of shear walls in wind-resistant high-rise structures.
[5] Zhang, Li & Tamura (2024)
Study: Recent Advances in Aerodynamic Modifications for Tall Zhang and co-authors reviewed the latest aerodynamic modification techniques for tall buildings, including porous façades, twisting, tapering, and vented openings. Their comprehensive analysis shows that modern aerodynamic forms reduce vortex shedding and across-wind accelerations by up to 60%. The study also highlights hybrid techniques such as combining porous skins with corner recessing, which further improves wind performance. The authors discuss how CFD advancements have improved prediction accuracy for these methods. This research is crucial for understanding modern aerodynamic strategies and emerging trends in high-rise design.

[6] Architectural Institute of Japan (AIJ) (2023)
Study: Guidebook for Practical Applications of CFD in Wind Engineering
The AIJ guidebook standardizes procedures for performing CFD simulations in wind engineering. It provides detailed guidance on mesh generation, turbulence modelling, boundary conditions, solver stability, and validation techniques. The book emphasizes the necessity of comparing CFD results with wind-tunnel data to ensure accuracy. It also identifies typical modelling errors made by engineers and offers practical solutions. This guidebook has become a benchmark reference for professionals conducting CFD-based wind analysis.

[7] Sunaryati et al. (2023)
Study: Structural Analysis Due to Wind Speed as Static Loads on High-Rise Buildings
Sunaryati and team performed static wind load analysis on several high-rise models using basic code-based methods. Their results show that static analysis works reasonably well for stiff buildings but does not capture dynamic amplification effects in slender structures. The study demonstrates how wind forces increase with height and exposure category. It serves as a foundational reference for understanding baseline wind-load distribution. The authors recommend dynamic analysis for tall and flexible buildings.

[8] Santos & Sabino (2022)
Study: Interoperability Between Autodesk Revit and Robot Structural Analysis
This Study evaluated the data exchange between Revit and Robot for structural optimization. They found that the interoperability significantly reduces modelling errors and improves iterative design processes. Their workflow demonstrates how geometric changes made in Revit can automatically update structural models in Robot. The study also highlights the benefits of BIM for parametric optimization,

reducing design time and improving accuracy. Their findings support the adoption of digital workflows in structural engineering.

[9] Mousa & Elbeltagi (2021)
Study: Integrated BIM-Based Structural Analysis for High-Rise Buildings
This study on fully integrated structural analysis framework combining BIM, FEM, and optimization algorithms. Their system automates load paths, geometry updates, and structural checks, significantly improving design efficiency. A case study demonstrated that the optimized BIM-FEM workflow produced better structural performance compared to manual design. The study shows that automation and parametric modelling are essential for future high-rise engineering. It highlights the important role of BIM as a central coordination tool.

[10] Abdelrazaq & Kim (2008)
Study: Effects of Plan Shape on Dynamic Response of Tall Buildings
This study focused on how different plan shapes influence wind-induced dynamic behaviour. The authors analysed several geometries and observed large variations in torsional response and lateral displacement. Their results show that corner modifications and non-rectangular shapes significantly reduce wind excitation. They also highlighted the relationship between geometric irregularity and dynamic performance. This research is foundational in understanding shape-driven aerodynamic improvements.

3. CONCLUSIONS

This review highlights significant progress in understanding and improving the wind performance of tall buildings. Over the years, aerodynamic strategies such as corner modifications, tapering, twisting, and porous façades have proven highly effective in reducing vortex shedding, lateral drift, and across-wind accelerations. These studies emphasize that building form plays a crucial role in controlling wind behaviour and enhancing overall structural efficiency. Research on façade systems further shows that cladding connections and panel stiffness must be carefully designed, as façade components often experience the highest localized pressures during strong winds.
In parallel, BIM–FEM integration using tools like Revit and Robot Structural Analysis has transformed structural modelling and analysis. These digital workflows improve accuracy, reduce errors, and allow designers to evaluate multiple wind-resistant configurations quickly. Despite these advancements, opportunities remain in integrating aerodynamic optimization, façade behaviour, and structural analysis into a unified framework. Future research should also explore AI-based prediction models and adaptive façade technologies. Overall, the literature confirms that combining aerodynamic design with advanced digital tools is essential for achieving safe, efficient, and resilient tall buildings.

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