A REVIEW OF HEIGHT-DEPENDENT WIND RESPONSE CHARACTERIZATION OF REINFORCED CONCRETE VERTICAL BUILDING SYSTEMS

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Abstract - *Rapid vertical urbanization has led to the proliferation of reinforced concrete (RC) high-rise buildings, making accurate characterization of height-dependent wind response a critical concern in structural engineering. Wind loading on tall buildings varies significantly with elevation due to changes in mean wind speed profile, turbulence intensity, and aerodynamic interaction effects. These variations induce complex static and dynamic responses, including base shear amplification, overturning moments, inter-story drift, and occupant-level acceleration. This review synthesizes existing research on the characterization of wind-induced responses in RC vertical building systems with specific emphasis on height-dependent behavior. The paper critically examines analytical formulations, code-based procedures, numerical simulations, wind tunnel experiments, and full-scale monitoring studies. Particular attention is given to the evolution of dynamic analysis methods, the influence of stiffness and mass distribution along height, and discrepancies between code predictions and measured performance. Comparative assessments reveal limitations in simplified gust factor approaches and highlight the growing role of computational fluid dynamics and performance-based design frameworks. Furthermore, the review identifies research gaps related to aeroelastic coupling, nonlinearity in RC systems, and the need for long-term field data for calibration of design provisions. The study provides an integrated understanding of current knowledge and outlines future directions for improving wind-resilient design of tall RC structures.*

Key Words: **Height-dependent wind response; Reinforced concrete high-rise buildings; Wind–structure interaction; Dynamic amplification; Atmospheric boundary layer; Structural drift and acceleration.**

1. INTRODUCTION

1.1 Overview and Importance

1.1.1 Wind Loading and Structural Safety of Tall RC Buildings

The rapid expansion of vertical urban infrastructure has significantly increased the construction of reinforced concrete (RC) high-rise buildings. As building height increases, wind effects often govern structural design due to amplified lateral forces and dynamic excitations. Unlike low-rise buildings where wind loads may be treated predominantly as static actions, tall RC buildings exhibit pronounced dynamic sensitivity, particularly in the along-wind and across-wind directions. The atmospheric boundary layer causes wind speed to increase with height, producing non-uniform pressure distributions and elevated overturning moments at upper levels (Davenport, 1967). Additionally, the flexibility of tall RC systems, especially moment-resisting frames and shear wall–frame interactions, increases susceptibility to vibration-induced serviceability issues such as excessive drift and occupant discomfort (Kareem, 1982). Current international standards such as ASCE 7 and IS 875 Part 3 incorporate height-dependent wind profiles; however, these provisions rely on simplified assumptions that may not fully capture complex aeroelastic behavior.

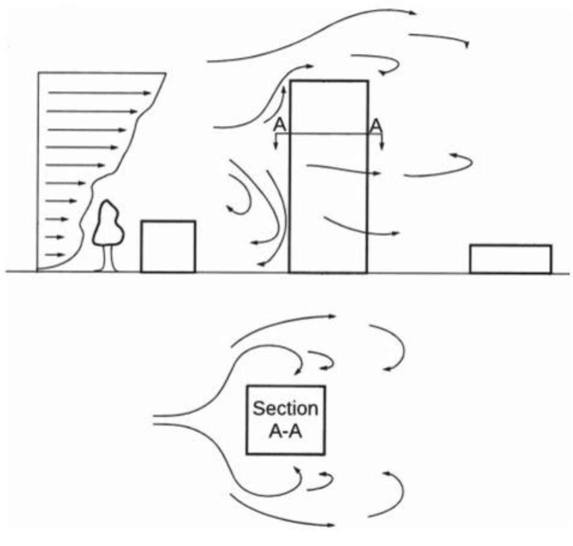

Figure-1: Wind Flow Around a Tall Building

1.1.2 Societal and Engineering Impacts

Wind-induced responses influence not only structural safety but also economic and societal resilience. Excessive lateral displacements can lead to non-structural damage, façade failures, and service interruptions. More critically, occupant comfort criteria related to acceleration thresholds have become decisive in high-rise residential and office towers (Melbourne, 1980). Failures or serviceability deficiencies in tall buildings can undermine public confidence in urban infrastructure. Therefore, accurate wind response characterization is integral to sustainable and resilient city development, particularly in rapidly urbanizing regions.

1.2 Challenges in Wind Response Characterization

1.2.1 Height Effects and Atmospheric Turbulence

One of the primary complexities in wind engineering is the vertical variation of wind characteristics. Mean wind speed typically follows a logarithmic or power-law profile with height, while turbulence intensity decreases with elevation. These gradients significantly affect aerodynamic loading and dynamic excitation (Simiu and Scanlan, 1996). In tall RC buildings, the upper stories experience higher wind velocities and fluctuating pressures, intensifying bending moments and drift demands. Furthermore, terrain roughness, topography, and urban interference modify boundary layer characteristics, complicating generalized modeling approaches.

1.2.2 Dynamic Amplification and Aeroelastic Interaction

Dynamic amplification arises when the frequency content of wind turbulence approaches the natural frequencies of the structure. Flexible RC systems with long fundamental periods are particularly vulnerable to resonant amplification effects. The gust factor method, widely adopted in design codes, attempts to account for this phenomenon but often underestimates cross-wind and torsional responses in slender configurations (Kijewski and Kareem, 1998). Additionally, aeroelastic coupling—where structural motion alters aerodynamic forces—introduces nonlinear feedback mechanisms that are difficult to represent in simplified analytical frameworks.

1.3 Objective of the Review

This review aims to systematically synthesize existing knowledge on height-dependent wind response characterization of RC vertical building systems. Specifically, it traces the evolution of analytical formulations, numerical modeling strategies, experimental investigations, and code-based procedures. By integrating theoretical developments with empirical observations, the review seeks to identify prevailing trends, methodological strengths and limitations, and areas requiring further investigation. Emphasis is placed on understanding how structural configuration, stiffness distribution, and height influence wind-induced demand parameters.

1.4 Organization of the Paper

The paper is structured to provide a coherent progression from fundamental concepts to advanced research developments. Following this introduction, Section 4 outlines theoretical foundations of atmospheric boundary layer wind and RC structural systems. Section 5 reviews relevant international wind design standards and their height-dependent provisions. Section 6 discusses analytical, numerical, and experimental methodologies for wind response characterization. Section 7 presents a comprehensive thematic literature review. Section 8 synthesizes major findings and contrasts competing models, while Section 9 discusses practical implications and limitations. Finally, Section 10 outlines future research directions, followed by concluding remarks.

2. BACKGROUND FUNDAMENTALS

2.1 Wind Characteristics Relevant to Structures

2.1.1 Wind Profile Variation with Height

Wind flow within the atmospheric boundary layer exhibits a systematic increase in mean velocity with elevation due to reduced surface friction effects. This vertical variation is typically represented using logarithmic or power-law expressions, which relate wind speed to terrain roughness and reference height. The logarithmic profile model is grounded in boundary layer theory, while the power-law approximation is commonly adopted in structural design practice due to its simplicity (Simiu and Scanlan, 1996). As building height increases, the upper portions of tall structures are subjected to significantly higher mean wind speeds, resulting in amplified lateral pressures and bending demands. This height-dependent gradient is explicitly incorporated in design provisions such as ASCE 7 and Eurocode 1, where exposure categories define terrain-dependent velocity variation. However, real atmospheric flows are influenced by topography, urban interference, and thermal stratification, introducing deviations from idealized profiles.

2.1.2 Turbulence Intensity and Spectral Characteristics

In addition to mean wind speed, fluctuating wind components play a critical role in structural excitation. Turbulence intensity, defined as the ratio of standard deviation of wind speed fluctuations to mean velocity, generally decreases with height but remains significant in urban terrains. These fluctuations contain energy distributed across a range of frequencies described by turbulence spectra, such as the Kaimal or von Kármán models (Kaimal et al., 1972). When the dominant frequencies of wind turbulence align with a structure's natural frequencies, resonant amplification may occur. Therefore, accurate spectral representation is essential in dynamic wind analysis, particularly for flexible tall buildings where response is highly sensitive to low-frequency turbulence components.

2.2 Reinforced Concrete Vertical Building Systems

2.2.1 Typical RC High-Rise Structural Configurations

Reinforced concrete high-rise buildings employ various lateral load–resisting systems to control wind-induced effects. Common configurations include moment-resisting frames, shear wall systems, coupled shear walls, tube-in-tube systems, and core–outrigger arrangements. Shear wall and core systems provide substantial lateral stiffness and are widely used in residential towers, while outrigger systems enhance overturning resistance by mobilizing perimeter columns (Taranath, 2016). The selection of structural system significantly influences dynamic properties such as fundamental period, mode shapes, and damping ratios. As height increases, structural slenderness becomes a governing parameter, requiring optimized structural layouts to balance stiffness and material efficiency.

2.2.2 Stiffness, Mass Distribution, and Wind Performance

The distribution of stiffness and mass along the height of an RC building critically affects its wind-induced response. Uniform stiffness distribution may not be optimal for controlling inter-story drift at upper levels, where wind demands are higher. Variations in floor mass, stiffness degradation due to cracking, and nonlinear material behavior further complicate response prediction. Research indicates that higher mode effects become increasingly important in tall RC systems, influencing acceleration and drift patterns (Chopra, 2017). Moreover, inherent damping in RC structures—arising from material hysteresis and non-structural components—plays a significant role in limiting dynamic amplification.

2.3 Key Response Metrics

2.3.1 Base Shear and Overturning Moment

Base shear and overturning moment are primary global response parameters used in wind-resistant design. Base shear represents the cumulative lateral force transferred to the foundation, while overturning moment reflects the rotational demand generated by height-dependent pressure distribution. These forces increase nonlinearly with building height due to the combined effect of elevated wind speeds and larger lever arms. Accurate estimation of these parameters is essential for foundation design and overall structural stability (Holmes, 2015).

2.3.2 Drift and Acceleration

Inter-story drift and peak acceleration are critical serviceability criteria in tall buildings. Excessive drift can cause damage to cladding, partitions, and glazing systems, while high accelerations may lead to occupant discomfort. International guidelines, including International Organization for Standardization standards on human exposure to vibration, provide threshold limits for acceptable acceleration levels. Unlike base shear, acceleration response is strongly influenced by dynamic characteristics such as damping ratio and natural frequency. Consequently, performance-based wind design increasingly emphasizes acceleration control in addition to strength requirements.

3. WIND LOAD CODES & STANDARDS

3.1 International and Regional Standards

3.1.1 Overview of Key Wind Load Standards

Wind-resistant design of tall buildings is guided by internationally recognized codes and standards that provide methodologies for estimating design wind forces and dynamic responses. Prominent standards include ASCE 7, which is widely used in the United States, and Eurocode 1, which governs structural design across Europe. In India, the relevant provision is IS 875 Part 3

4. METHODOLOGIES FOR WIND RESPONSE CHARACTERIZATION

4.1 Analytical / Deterministic Approaches

4.1.1 Simplified Formulas and Closed-Form Solutions

Analytical or deterministic methods have historically provided the first means to estimate wind-induced responses in tall buildings. Simplified formulas, often derived from static wind pressure equations combined with empirical gust factors, allow for rapid assessment of base shear, overturning moments, and story drift. For example, slope–drift relations correlate wind speed at a given height to the corresponding lateral displacement, providing an approximate measure of inter-story drift (Simiu and Scanlan, 1996). Closed-form solutions, based on beam or cantilever models of the building, incorporate fundamental mode shapes and effective height-dependent stiffness to predict lateral response. These approaches are computationally efficient and provide initial design guidance.

4.1.2 Strengths and Limitations

The main strength of analytical approaches lies in their simplicity and ease of implementation in early design stages. They are particularly useful for parametric studies and code-checking calculations. However, they have inherent limitations: they often assume linear elastic behavior, neglect higher-mode effects, and oversimplify complex aerodynamic interactions such as torsion or vortex shedding. As a result, deterministic formulas may underestimate dynamic amplification in flexible or irregular RC high-rise buildings (Holmes, 2015).

4.2 Numerical Simulation Strategies

4.2.1 Computational Fluid Dynamics (CFD)

CFD techniques provide detailed simulation of wind flow around structures, allowing the prediction of local pressure distributions and turbulence effects. Large eddy simulation (LES) models capture time-dependent, three-dimensional eddies, which are crucial for representing gustiness and turbulent fluctuations in the atmospheric boundary layer. By coupling CFD-generated wind pressures with structural models, engineers can study the dynamic response of RC buildings under realistic wind conditions (Blocken, 2014).

4.2.2 Finite Element Structural Models

Finite element analysis (FEA) enables detailed modeling of structural behavior, including material nonlinearity, stiffness variations, and modal interactions. Modal analysis can identify the building's natural frequencies and mode shapes, while coupled wind–structure interaction studies incorporate feedback effects between structural motion and aerodynamic forces. This approach is particularly important for tall, flexible RC structures where higher modes significantly influence acceleration and drift response (Chopra, 2017).

4.3 Experimental Techniques

4.3.1 Wind Tunnel Testing

Wind tunnel experiments remain a cornerstone of wind engineering research. Scaled models of buildings are tested under controlled atmospheric boundary layer conditions to replicate real-world wind profiles. Measurement techniques include pressure taps, force balances, and motion sensors, enabling determination of base shear, overturning moments, and local pressures (Melbourne, 1980). Wind tunnels are essential for validating analytical and numerical models and for assessing aerodynamic phenomena such as vortex shedding and interference effects in urban environments.

4.3.2 Field Measurements

Full-scale instrumentation provides invaluable data for calibrating and validating design methods. Modern high-rise buildings are often equipped with anemometers, accelerometers, and displacement sensors at multiple elevations. These measurements capture wind speed, dynamic pressures, and structural accelerations, offering insights into actual building performance under natural wind conditions. Field data complement experimental and numerical methods and highlight discrepancies between predicted and observed responses, particularly for irregular RC systems in complex urban settings (Simiu and Scanlan, 1996).

5 LITERATURE REVIEW

5.1 Early Studies

5.1.1 Pioneering Work on Wind Effects on Tall Buildings

Early research on wind effects focused on understanding the fundamental behavior of tall structures under lateral loading. Davenport (1967) introduced the concept of gust loading factors, which formed the basis for estimating wind-induced forces and base shear in tall buildings. These pioneering studies primarily employed simplified linear models, treating the building as a cantilevered beam subjected to uniform or quasi-static wind pressures. Experimental data from scale models in boundary layer wind tunnels provided initial validation for these formulas, although turbulence effects and higher-mode contributions were often neglected (Melbourne, 1980). Despite their simplicity, these studies laid the groundwork for systematic assessment of wind loads and influenced the development of national and international wind codes.

5.1.2 Simplistic Models and Early Measured Data

Simplistic models, such as single-degree-of-freedom (SDOF) representations, were widely used to approximate inter-story drift and acceleration. These models assumed uniform mass and stiffness distribution along building height and often ignored torsional or coupled modes. Early wind tunnel measurements offered valuable insight into the relationship between mean wind profiles, pressure distributions, and lateral displacements, albeit with limited spatial resolution and scale effects (Simiu and Scanlan, 1996). These initial investigations highlighted the need for more refined methods that could capture height-dependent wind effects and dynamic amplification in tall RC buildings.

5.2 Height-Dependent Wind Profiles

5.2.1 Vertical Wind Gradient Effects

Height-dependent wind behavior arises from the atmospheric boundary layer, where mean wind speed increases logarithmically or according to a power law with elevation. Several studies emphasized that neglecting this gradient leads to underestimation of top-level pressures and base shear, particularly for buildings over 50 meters in height (Holmes, 2015). Researchers demonstrated that incorporating height-specific wind speeds into structural models significantly improves the accuracy of predicted lateral forces and overturning moments.

5.2.2 Turbulence Intensity Variation with Height

In addition to mean speed, turbulence intensity decreases with height but remains a critical factor for dynamic response. High-frequency turbulence near the lower stories affects fatigue and serviceability, while low-frequency turbulence at upper stories excites fundamental modes, amplifying drift and acceleration (Blocken, 2014). Studies employing Kaimal and von Kármán spectra provided a realistic representation of turbulent wind forces along the building height, improving dynamic load predictions.

5.3 Dynamic Response of RC Vertical Systems

5.3.1 Modal Characteristics versus Height

The dynamic response of RC high-rise buildings is strongly influenced by their height-dependent modal properties. Fundamental periods increase with building height, while higher modes contribute increasingly to acceleration and drift in flexible structures (Chopra, 2017). Mode shapes are affected by stiffness distribution, material properties, and architectural irregularities, necessitating multi-degree-of-freedom (MDOF) analyses to capture realistic behavior.

5.3.2 Coupling Between Structural Dynamics and Wind Forces

Dynamic wind analysis highlights the interaction between structural motion and fluctuating aerodynamic loads. Aeroelastic coupling can result in vortex shedding or along-wind resonance, particularly in slender RC towers. Research using coupled wind–structure simulations and wind tunnel tests confirmed that ignoring these interactions underestimates critical responses at the upper levels (Holmes, 2015; Blocken, 2014).

5.4 Code Versus Research Observations

5.4.1 Discrepancies Between Code Predictions and Research Findings

Comparisons of code-based gust factor methods with research data reveal systematic discrepancies. Simplified assumptions, such as uniform exposure or linear gust factors, often underestimate accelerations and higher-mode contributions, especially in tall or irregular RC buildings (IS 875 Part 3, 2015). Studies demonstrated that dynamic amplification and torsional effects are inadequately addressed in prescriptive code formulas.

5.4.2 Empirical Evidence from Full-Scale Monitoring

Field measurements from instrumented high-rise RC buildings provide direct evidence of height-dependent wind responses. Data collected from accelerometers and anemometers show significant variation in inter-story drift and acceleration along height, often exceeding code predictions. Such empirical findings emphasize the importance of performance-based design approaches that integrate experimental and numerical insights (Simiu and Scanlan, 1996).

5.5 Comparative Studies

5.5.1 Influence of Structural Systems and Geographic Wind Climates

Comparative analyses highlight that RC, steel, and composite structures respond differently to wind depending on height, stiffness, and mass distribution. RC buildings, due to higher damping and stiffness, generally exhibit lower accelerations than equivalent steel towers but may experience larger inter-story drifts at mid-heights (Taranath, 2016). Geographic variations in wind climate, including monsoon regions or coastal zones, further influence design considerations, necessitating location-specific studies.

5.5.2 RC versus Steel/Infill Systems

Studies indicate that RC shear wall systems demonstrate superior lateral stiffness compared with steel frames or infill wall systems, leading to reduced drift. However, complex infill or core–outrigger systems can introduce higher mode participation and torsion, especially at taller heights. Comparative research underlines that structural configuration significantly affects the height-dependent wind response profile.

5.6 Critical Themes from Literature

5.6.1 Influence of Stiffness Distribution with Height

Uniform versus non-uniform stiffness distribution alters modal participation and drift patterns. Literature shows that strategically varying stiffness can reduce peak acceleration and upper-story drift while maintaining structural efficiency (Chopra, 2017).

5.6.2 Aeroelastic Effects in Tall RC Buildings

Height-dependent wind response is strongly influenced by aeroelastic phenomena, including vortex shedding and dynamic coupling between structure and wind. Accounting for these effects is critical for accurate prediction of serviceability and safety margins (Blocken, 2014).

5.6.3 Height-Based Amplification of Wind Effects

Overall, research consistently demonstrates that wind-induced forces, drift, and acceleration are amplified with height due to increasing wind velocity, reduced damping influence, and higher modal participation. This amplification necessitates refined modeling, experimental validation, and performance-based design strategies to ensure tall RC buildings maintain both safety and occupant comfort (Holmes, 2015).

6. CONCLUSION

This review systematically analyzed the height-dependent wind response of reinforced concrete (RC) vertical building systems, integrating insights from analytical, numerical, and experimental studies. It is evident that wind characteristics, including mean velocity profiles, turbulence intensity, and spectral distribution, vary significantly with height, profoundly influencing lateral forces, inter-story drift, overturning moments, and structural accelerations. Analytical approaches, such as simplified formulas and closed-form solutions, provide efficient preliminary design guidance but are limited in capturing higher-mode effects, torsion, and aeroelastic coupling. Numerical simulations, particularly computational fluid dynamics (CFD) and finite element-based modal analyses, enable detailed investigation of complex wind–structure interactions, while wind tunnel and full-scale field studies validate these models and highlight discrepancies with code-based predictions. Comparative studies demonstrate that RC systems generally exhibit higher damping and lower acceleration than steel structures, yet stiffness distribution, building configuration, and geographic wind climate play critical roles in height-dependent response. Literature consistently shows that wind effects amplify with height due to increased wind velocities, reduced damping influence, and significant modal participation. Overall, the review emphasizes the necessity of integrating height-specific wind profiles, dynamic amplification, and aeroelastic effects into performance-based design frameworks. By synthesizing existing knowledge, this study identifies gaps in modeling, experimental validation, and code provisions, providing a foundation for improving the wind resilience, safety, and serviceability of tall RC buildings.

7. LIMITATIONS OF THE REVIEW

This review is constrained by several factors. First, it primarily focuses on reinforced concrete high-rise structures, excluding detailed analysis of steel, composite, or hybrid systems, which limits generalizability. Second, the synthesis relies on published literature and experimental data, which may be uneven in coverage across geographic regions and wind climates. Third, while it discusses numerical and experimental methodologies, the review does not provide quantitative meta-analysis due to heterogeneity in study parameters, modeling assumptions, and scale effects. Finally, rapidly evolving computational and measurement techniques, such as real-time structural monitoring and high-fidelity CFD simulations, may not be fully represented, potentially omitting cutting-edge research developments.

REFERENCES

1. Blocken, B. (2014) '50 years of Computational Wind Engineering: Past, present and future', Journal of Wind Engineering and Industrial Aerodynamics, 129, pp. 69–102.
2. Chopra, A.K. (2017) Dynamics of Structures: Theory and Applications to Earthquake Engineering. 5th edn. Boston: Pearson.
3. Davenport, A.G. (1967) 'Gust loading factors', Journal of the Structural Division, ASCE, 93(ST3), pp. 11–34.
4. Holmes, J.D. (2015) Wind Loading of Structures. 3rd edn. Boca Raton: CRC Press.
5. IS 875 Part 3 (2015) Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures – Part 3: Wind Loads. New Delhi: Bureau of Indian Standards.
6. Kaimal, J.C., Wyngaard, J.C., Izumi, Y. and Coté, O.R. (1972) 'Spectral characteristics of surface-layer turbulence', Quarterly Journal of the Royal Meteorological Society, 98(417), pp. 563–589.
7. Melbourne, W.H. (1980) 'Comparison of measurements on the CAARC standard tall building model in simulated model wind flows', Journal of Wind Engineering and Industrial Aerodynamics, 6(1–2), pp. 73–88.
8. Simiu, E. and Scanlan, R.H. (1996) Wind Effects on Structures: Fundamentals and Applications to Design. 3rd edn. New York: Wiley.
9. Taranath, B.S. (2016) Structural Analysis and Design of Tall Buildings: Steel and Composite Construction. Boca Raton: CRC Press.
10. Hou, F. (2020) 'Investigation approaches to quantify wind‐induced load and response of tall buildings: A review', Sustainable Cities and Society, 62, 102376.
11. Singh, A., Kontoni, D.P.N. and Mandal, S. (2024) 'Wind‐induced torsional loads and responses of tall buildings', Research in Engineering Structures and Materials, 10(3), pp. 1281–1300.
12. Shanthi, S., Vidjeapriya, R. and Jaya, K.P. (2024) 'Influence of across‐wind on rectangular tall buildings', Buildings, 14(12), 3902.
13. Yadav, H. and Roy, A.K. (2024) 'Wind‐induced aerodynamic responses of triangular high‐rise buildings with varying cross‐section area', Buildings, 14(9), 2722.

14. Xu, Z. and Yin, J. (2023) 'The influence of aeroelastic effects on wind load and wind-induced response of a super-tall building: An experimental study', Buildings, 13(7), 1871.

15. Ricci, M. (2018) 'Wind loads assessment on a high-rise building', Journal of Wind Engineering and Industrial Aerodynamics.

16. Park, S. et al. (2019) 'Wind effects on a tall building with square cross-section and mid-side base columns: Database-assisted design approach', Journal of Structural Engineering.

17. Hickey, J. et al. (2022) 'Mitigation of wind induced accelerations in tall modular buildings', Structures, (17), pp. 21–32.

18. (2021) 'Analysis of wind-induced response of tall reinforced concrete building based on GPS and inclination sensor data', IOP Conference Series: Materials Science and Engineering, 1025(1):012030.

19. Mrkonja, I. et al. (2025) 'Evaluation of wind and seismic load modelling in high-rise concrete structures: A literature review', Inżynieria Mineralna, 2(2).

20. Pagare, P.N. and Kute, S.Y. (2023) 'Review of studies on the effects of various wind load parameters on tall buildings with irregular geometries', Journal of Harbin Engineering University.

21. Mazarakou, P. and Papalou, A. (2025) 'Effect of structural forms on wind-induced response of tall buildings: A finite element approach', Eng, 6(6):131.

22. Zhang, X., Zheng, X.Y. and Lin, K. (2024) 'Structural response analysis and comfort evaluation of residential buildings: A combined wind tunnel and FEM approach', Buildings, 14(9), 3025.

23. Fadi Alkhatib et al. (2022) 'Wind-resistant structural optimization of irregular tall buildings using CFD and genetic algorithms', Frontiers in Energy Research.

24. Tschanz, U. and Davenport, A.G. (1983) 'High-Frequency Force Balance method for wind load measurements', Journal of Wind Engineering and Industrial Aerodynamics.

25. Kwok, K.C.S. et al. (2013) 'Wind-induced motion of tall buildings – designing for habitability', (PDF).

26. Bezabeh, M. (2020) 'Performance-based wind design of tall buildings', UBC Open Collections Thesis.

27. Wind and tall buildings, IAWE Proceedings (historical overview).

28. Research topic compilation: Wind-induced responses of tall buildings (topic page).

29. Abdo, A. (2025) Comparative study on reinforced concrete, steel and composite tall building wind effects (cited within Eng paper).

30. Ali, A.S. and Moon, K.S. (2012) Evolution of tall building structural systems (cited within Eng paper).

31. Meena, A.K. et al. (2024) CFD for regular vs irregular tall building aerodynamic response (cited within Eng paper).

32. Htun, T. (2016) Simplified dynamic wind response approach for tall buildings (cited within Eng paper).

33. 4. Code, Case History & Foundational Engineering Sources

34. Irwin, P.A. (2009) Wind engineering challenges of the new generation of super-tall buildings, Journal of Wind Engineering and Industrial Aerodynamics (historical review).

35. Park, S. et al. (2019) Structural response to wind direction and forces in tall buildings, Journal of Structural Engineering.