

Wind Analysis in Skyscraper Design Using STAAD Pro

Akshay Mistry^{1*}; Sakshi Bane²; Rutika Nakhate³; Sakshi Desai⁴

Department of Civil Engineering, VIVA Institute of Technology / University of Mumbai, India

*Corresponding Author

Abstract— Wind resistance is a critical factor in designing high-rise buildings, as strong winds can cause significant structural damage and impact occupant comfort. STAAD Pro is a powerful software tool used for analyzing and designing buildings to resist wind loads. This study presents a comprehensive review of wind resistance analysis and design of high-rise buildings using STAAD Pro. The software's capabilities in simulating wind loads, calculating wind pressures, and designing structural elements are discussed. Case studies of G+40 buildings are presented, highlighting the importance of wind resistance in skyscraper design. The results demonstrate the effectiveness of STAAD Pro in ensuring the structural integrity and safety of high-rise buildings under various wind conditions, providing a comprehensive understanding of wind resistance analysis and design using STAAD Pro.

Keywords— STAAD Pro, Skyscraper Design, High-Rise Building, Wind Analysis.

I. INTRODUCTION

Wind resistance refers to a building's ability to withstand lateral forces caused by wind pressure. In skyscraper design, wind becomes one of the primary loads influencing the structure's safety, serviceability, and occupant comfort. When wind flows around a tall building, it creates positive pressure (on the windward face), negative suction (on the leeward and side faces), and vortices that cause oscillations or vibrations (especially for slender structures). These effects can cause lateral displacement (side sway), story drift (relative movement between floors), vibration or resonance problems, and fatigue in structural elements.

Tall structures are more exposed to wind pressure because wind speed increases with height. Wind generates lateral forces, which can bend or twist the structure. If not properly designed, it can cause structural failures, excessive sway, or occupant discomfort. Proper wind resistance design:

- Prevents structural damage and excessive deflection
- Improves comfort by limiting sway at top floors
- Allows efficient design, reducing material use by optimizing shape and damping

STAAD Pro (Structural Analysis and Design Professional) is a computer-aided software developed by Bentley Systems. It is used for modeling, analyzing, and designing structures subjected to various loads, including wind. The contribution of this study lies in demonstrating the feasibility of wind analysis in skyscraper design using STAAD Pro. The organization of this paper is as follows: Section II describes the methodology; Section III discusses the results and observations; and Section IV provides the conclusions.

II. MATERIAL AND METHODS

Wind analysis is essential in the design of skyscrapers because wind loads have a significant impact on structural stability and serviceability. This study adopted a systematic approach to examine the effects of wind on a high-rise building using STAAD Pro software. The methodology emphasizes accurate modeling, proper load application, and result evaluation in accordance with standard codes (IS 875 Part 3: 2015).

2.1 Materials

The materials and tools required for the wind analysis include:

Component	Description
Primary Software	STAAD Pro for modeling and analysis
Structural Elements	Beams, columns, slabs, and shear walls (RC and structural steel)
Material Properties	Modulus of elasticity, density, Poisson's ratio (per IS codes)
Wind Load Data	IS 875 (Part 3): 2015 guidelines
Wind Parameters	Basic wind speed, terrain category, height factor, pressure coefficients
Hardware	Computer system with adequate processing capacity

2.2 Wind Analysis Methodology

The wind analysis methodology consists of 13 sequential stages:

Sr. No.	Stage	Key Activities	Purpose/Output
1	Preliminary Data Collection	Gather architectural drawings, structural usage, geotechnical report, site data (seismic zone, wind speed, terrain), design codes (IS 456, IS 1893, IS 875)	Determines structural system, load assumptions, material grade
2	Selection of Structural System	Choose lateral load resisting system (Shear wall + RC frame, Core + outrigger, Tube-in-tube) based on height, slenderness, wind/seismic demand	Controls lateral stability and drift
3	Preliminary Member Sizing	Columns: 900–1200 mm (base) → 400–600 mm (top); Beams: 300–600 mm depth; Shear walls: 250–600 mm; Drift target $\approx H/500$	Provides initial model stiffness
4	Modeling in STAAD Pro	Define grids and storey nodes, beam elements (beams/columns), plate elements (slabs/walls), translational repeat for storeys	3D structural model ready for loading
5	Material & Section Assignment	Concrete: M40, Steel: Fe500; Cracked section modifiers: Beams 0.35EI, Columns 0.7EI	Realistic stiffness representation
6	Supports	Define boundary conditions (fixed or pinned base, spring supports for soil flexibility)	Transfers loads to foundation
7	Load Definition	Apply loads: Gravity (DL, LL), Wind (height dependent), Seismic (response spectrum)	Simulates real-world forces
8	Load Combinations	1.5 DL; 1.2 DL + 1.5 LL + 1.0 EQX; 0.9 DL \pm EQZ	Ultimate and service limit states
9	Analysis	P-Delta (2nd order effects), Modal analysis (≥ 90 –95% mass participation), Response spectrum, Buckling checks	Drift, displacement, base shear
10	Serviceability Checks	Story drift $\leq H/500$, inter-story drift check, deflection limits, torsional irregularity check	Performance validation
11	Member Design	Beam/column/wall design per IS 456; Interaction ratio ≤ 1 ; Foundation design (mat or pile)	Safe member sizing
12	Optimization	Taper upper columns, adjust core thickness, utilization target 0.8–0.95	Material efficiency
13	Documentation & Verification	Drift and base shear report, reinforcement detailing, peer review	Final approved design

2.3 Importance of Wind Analysis

Wind analysis ensures the safety, stability, and serviceability of buildings under varying environmental conditions. Without proper analysis, structures may experience excessive sway, occupant discomfort, or even structural failure in extreme cases.

3.2 Discussion

The distribution of wind pressure along the height of the skyscraper shows a gradual increase with elevation, leading to higher lateral forces at the top levels. Maximum displacement occurs at the top of the structure, consistent with theoretical expectations for high-rise buildings subjected to wind loads. However, all values obtained are within permissible limits specified by relevant design codes.

Bending moments and shear forces generated due to wind loads are significant in columns and beams at lower levels, as they carry the cumulative effect of loads from upper floors. This emphasizes the need for stronger structural members at the building base. Load combinations involving wind loads produce more critical results compared to gravity loads alone, indicating the importance of considering wind effects in skyscraper design.

Storey drift is observed to be higher in middle levels, highlighting the importance of proper stiffness distribution throughout the structure. Proper design of shear walls and bracing systems helps control excessive drift and improve overall performance.

Overall, the results confirm that STAAD Pro provides an efficient and accurate platform for analyzing wind effects on tall structures. The findings highlight the importance of proper modeling, load application, and design optimization to ensure safety, stability, and occupant comfort.

IV. CONCLUSION

Wind analysis plays an important role in the safe and efficient design of skyscrapers, as wind loads often govern the structural behavior of tall and slender buildings. This study demonstrated the effective use of STAAD Pro for performing wind analysis in skyscraper design in accordance with relevant Indian Standard codes.

Key Conclusions:

Aspect	Finding
Wind Load Impact	Significantly influences stability and serviceability, especially at higher elevations
Occupant Comfort	Excessive lateral movement and acceleration must be controlled
Structural Systems	Proper stiffness and damping mechanisms are essential
STAAD Pro Utility	Streamlines design process, provides reliable outputs, facilitates code compliance

The study confirms that wind analysis using STAAD Pro is a practical and reliable approach for skyscraper design, contributing to enhanced structural safety, occupant comfort, and optimized material usage in modern high-rise construction.

ACKNOWLEDGMENT

The authors extend their deepest gratitude to the project guide for invaluable guidance, continuous support, and insightful feedback throughout the course of this project. Technical expertise and constructive suggestions were crucial in directing the research and refining the final outcomes of this work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research paper. This work has been carried out solely for academic purposes, and all results and observations presented are based on unbiased analysis and standard engineering practices. The software, data, and design codes used in this study have been applied in accordance with accepted guidelines, without any external influence from commercial organizations or third parties.

REFERENCES

- [1] Sathe, K. K., Patil, A. D., & Jadhav, V. S., "Wind Load Analysis of Tall Building – Review," International Journal of Research in Engineering, Science and Management, Vol. 7, No. 6, 2024, pp. 221–225.

- [2] Yadav, H., & Roy, A. K., Wind-Induced Aerodynamic Responses of Triangular High-Rise Buildings with Varying Cross-Section Areas, *Buildings*, Vol. 14, Issue 9, 2024.
- [3] Khanche, A. A. & Salunke, P. J., "Comparative Study of Pre-Engineered Building with Varying Wind Speed," *IJRASET*, 2024
- [4] Parametric study of wind-induced vibration control of tall buildings using TMD and TLCD systems, *Structures*, Vol. 57, 2023.
- [5] Srivastava, K. N., & Raj, R., "Aerodynamic Study of Tall Buildings under Wind Load," *International Journal of Health Sciences*, Vol. 6, No. S3, 2022, pp. 2620–2641.
- [6] Rajendran, V., Swaminathan, A. N., & Aparna, K., "Comparative Analysis of Wind Effects on High-Rise Structures Across Diverse Terrain Categories Using STAAD Pro," *Journal for Educators, Teachers and Trainers*, Vol. 12, No. 4, 2021.
- [7] Jagtap, S., & Shrivastava, H., "Analysis of High Rise building under Static and Dynamic Wind Conditions Considering Various Aspects," *International Research Journal of Engineering and Technology (IRJET)*, Vol. 08, Issue 11, 2021.
- [8] Venkata Sai, K. B., Pavan Kumar, M., & Madhu Veena, N., "Wind Load Analysis on a Multistoreyed Building Curved in Plan," *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol. 10, Issue 3, 2021.
- [9] Ritu Raj, Shubhangi Jha, Shreyansh Singh & Siddhant Choudhary, Response Analysis of Plus Shaped Tall Building with Different Bracing Systems Under Wind Load, *International Journal of Advanced Research in Engineering and Technology (IJARET)*, Vol. 11, Issue 3, Mar. 2020.
- [10] Javed, M., & Kumar, S., Enhancement of Tall Buildings Under the Wind Load, *International Journal of Engineering Research & Technology (IJERT)*, Vol. 9, Issue 06, Jun. 2020.
- [11] Prajapati, S., & Soni, K., "Analysis of A Tall Structure Using Staad.Pro Providing Different Wind Intensities as Per 875 Part-III," *International Journal of Scientific Research in Civil Engineering*, Vol. 3, No. 2, 2019, pp. 72–76.
- [12] Kumar, T. D., Ibrahim, M., Quadri, M. I. P., Ali, M. S., Rahman, S. A., & Khan, M. A., "Design and Analysis of High-Rise Building using STAAD Pro," *SSRG International Journal of Civil Engineering*, Vol. 6, Issue 6, 2019.
- [13] Shinde, V. R., & Shingade, V. S., A Review on Computational Evaluation of Wind Pressure on Tall Buildings using CFD and Sd, *International Journal of Engineering Research & Technology (IJERT)*, Vol. 7, Issue 03, Mar. 2018.
- [14] Susheel, S. M., Sanjith, J., Vidyashree, B. S., & Ranjith, A., Analysis of Tall Building in Chikkamagaluru Region, *International Research Journal of Engineering and Technology (IRJET)*, Vol. 03, Issue 06, Jun. 2016.