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EFFECT OF WIND ON TALL BUILDING SUBJECTED TO DIFFERENT TERRAIN CATEGORIES USING STAAD.PRO

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Abstract

The project "Effect of Wind on Tall Building Subjected to Different Terrain Categories Using STAAD.Pro" focuses on studying the structural behavior of a tall building under wind loading conditions for different terrain categories. Tall buildings are highly sensitive to lateral wind forces, making proper wind-load analysis essential for ensuring structural safety and stability. A three-dimensional structural model of the tall building is developed using STAAD.Pro by defining the building geometry, structural members, material properties, supports, and loading conditions. Wind loads are applied according to the relevant design provisions, considering variations in terrain characteristics that influence wind pressure and velocity. The building is analyzed under different terrain categories to evaluate changes in wind pressure, lateral displacement, bending moments, shear forces, axial forces, and support reactions. The analysis results are compared to identify the critical terrain condition and its effect on the overall structural response. Particular attention is given to storey-wise displacement and member forces because these parameters are important for assessing the performance of tall buildings. STAAD.Pro helps automate structural calculations and provides graphical visualization of the analysis results. The study demonstrates the importance of considering terrain conditions while estimating wind effects on tall structures. Overall, the project provides a systematic approach for evaluating wind-induced structural behavior and developing a safer and more reliable tall-building design.

I. Introduction

The Effect of Wind on Tall Building Subjected to Different Terrain Categories Using STAAD.Pro project focuses on evaluating the structural behavior of a tall building under different wind conditions. As building height increases, wind becomes an important lateral load that can significantly influence the stability, strength, and serviceability of the structure. The effect of wind on a building depends on several factors, including building height, shape, location, surrounding environment, and terrain characteristics. Different terrain categories produce different wind-flow patterns and wind pressures around a structure. Therefore, considering suitable terrain conditions is important during the structural analysis and design of tall buildings. In this project, a three-dimensional model of the tall building is developed using STAAD.Pro. The structural members, material properties, supports, and dimensions are defined according to the proposed building configuration. Wind loads are applied for different terrain categories along with relevant gravity loads and load combinations. The building is analyzed to determine parameters such as wind pressure, lateral displacement, bending moment, shear force, axial force, and support

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reactions. The results obtained for different terrain categories are compared to understand their influence on structural response. Critical beams, columns, and storeys can be identified from the analysis results. The study helps demonstrate the importance of wind-load assessment in the safe and efficient design of tall buildings. Overall, STAAD.Pro provides an effective computer-aided approach for analyzing and evaluating the wind-induced behavior of tall structures.

II. Literature Survey

Several studies have investigated the influence of wind loading on tall and high-rise buildings because wind-induced lateral forces can significantly affect structural strength, stability, serviceability, and occupant comfort. Research on tall buildings has shown that wind response depends on parameters such as building height, geometry, wind speed, aspect ratio, and surrounding terrain. Parametric studies have particularly examined how changes in terrain category influence along-wind response, including shear force and bending moment. These studies demonstrate the importance of considering terrain characteristics during the design and analysis of tall structures.

The Indian Standard IS 875 (Part 3) provides procedures for evaluating wind loads on structures and considers terrain roughness and height through the relevant wind-load parameters. The standard recognizes four terrain categories based on the degree of obstruction around a structure. Research reviewing the Indian wind-loading provisions has highlighted that the 2015 revision introduced important changes for tall buildings, including improved treatment of terrain roughness, height variation, along-wind gust response, and across-wind response. These provisions provide a basis for evaluating how environmental conditions influence wind loading on tall buildings.

Recent research has specifically examined tall-building wind-load analysis using STAAD.Pro. A 2026 study analyzed a tall reinforced-concrete building under Terrain Categories 1, 2, 3, and 4 and compared parameters such as storey displacement, storey drift, base shear, overturning moment, bending moment, shear force, axial force, and support reactions. The study reported that changes in terrain characteristics can significantly influence wind pressure and the resulting structural response. This demonstrates the usefulness of computer-aided structural analysis for comparing different terrain conditions.

Other investigations have used three-dimensional structural models to study the response of tall buildings under different wind directions and loading conditions. Recent STAAD.Pro-based research has evaluated axial forces, bending moments, twisting moments, and lateral displacements along the height of tall reinforced-concrete buildings. Such studies indicate that wind direction and building geometry can influence the distribution of structural forces and lateral movement, making it important to examine more than a single simplified wind-loading condition.

Overall, the literature indicates that terrain category is an important factor in estimating wind effects on tall buildings. Previous research has mainly focused on wind pressure, member forces, storey displacement, drift, and overall structural response under different terrain and wind conditions. Building on these studies, the present project uses STAAD.Pro to develop a three-dimensional tall-building model

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and compare its structural response under different terrain categories. The study focuses on parameters such as bending moment, shear force, axial force, support reaction, and lateral displacement to identify the critical wind-loading condition and support a safer structural design.

III. System Analysis

System analysis is an important stage for evaluating the behavior of a tall building subjected to wind loads under different terrain categories. The project focuses on studying how changes in terrain conditions influence the wind forces acting on the structure. The building geometry, storey height, structural members, supports, and material properties are defined before performing the analysis. A three-dimensional structural model is developed using STAAD.Pro to represent the building accurately. Dead load and live load are considered along with wind loads for the required loading conditions. Different terrain categories are considered to represent variations in the surrounding environment and wind exposure. The software calculates important structural responses such as bending moments, shear forces, axial forces, support reactions, and lateral displacements. Storey-wise displacement is evaluated to understand the lateral movement of the building under wind action. The analysis results for different terrain categories are compared to identify the critical loading condition. Critical beams, columns, and storeys are identified based on the obtained structural forces and displacement values. Appropriate load combinations are considered to evaluate the governing design condition. Overall, the system analysis helps in understanding the influence of terrain characteristics on the structural performance of tall buildings.

Existing System

In the conventional system, wind effects on buildings are often evaluated using manual calculations, simplified assumptions, spreadsheets, or basic structural analysis procedures. Engineers need to determine wind parameters and calculate the corresponding wind pressure acting on different portions of the building. For tall buildings, these calculations become more complicated because wind effects vary with building height and exposure conditions. Different terrain categories require separate calculations to determine the corresponding wind pressures and structural responses. Performing repeated calculations manually can consume considerable time and effort. Manual methods may also increase the possibility of arithmetic, data-entry, and modeling errors. It can be difficult to visualize the three-dimensional behavior of a tall building using conventional calculation methods. Changes in building dimensions or wind parameters may require the calculations to be repeated. Comparing structural responses for multiple terrain categories can also become difficult without a computerized system. Preparation of detailed analysis results and structural reports may require additional effort. Therefore, a computer-aided approach is useful for efficiently analyzing tall buildings subjected to different wind conditions. STAAD.Pro provides an integrated environment for structural modeling, loading, analysis, and design.

Disadvantages of Existing System

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- Requires extensive manual calculations.
- Time-consuming for tall-building analysis.
- Higher possibility of calculation and data-entry errors.
- Difficult to evaluate complex three-dimensional structural behavior.
- Separate calculations are required for different terrain categories.
- Difficult to compare multiple wind-loading conditions efficiently.
- Repeated calculations are required when building parameters change.
- Limited graphical visualization of structural response.
- Less efficient for large and complex structural models.

Proposed System

The proposed system focuses on analyzing the effect of wind on a tall building under different terrain categories using STAAD.Pro. A detailed three-dimensional structural model is created by defining beams, columns, supports, storey heights, material properties, and member sections. The required concrete and steel properties are assigned to the structural members according to the design requirements. Dead loads and live loads are applied to represent the gravity loading conditions of the building. Wind-load parameters are defined for different terrain categories to evaluate variations in wind pressure and structural demand. Appropriate load cases and load combinations are generated for the structural analysis. STAAD.Pro processes the complete model and calculates member forces and structural responses under the applied loading conditions. Important results such as bending moments, shear forces, axial forces, support reactions, and lateral displacements are obtained. Storey-wise displacement is examined to understand the wind-induced movement of the building. The analysis results obtained for different terrain categories are compared to identify the most critical condition. Critical beams, columns, and storeys are evaluated based on the governing structural responses. The proposed approach reduces repetitive manual calculations and improves the efficiency of wind-load analysis. Overall, the system provides a systematic method for evaluating the safety and performance of tall buildings under varying terrain conditions.

Advantages of Proposed System

- Provides computer-aided structural analysis.
- Reduces manual calculation effort.
- Supports three-dimensional tall-building modeling.
- Allows wind analysis for different terrain categories.
- Provides detailed member force results.
- Helps evaluate storey-wise lateral displacement.
- Makes comparison between terrain conditions easier.
- Helps identify critical beams and columns.
- Improves efficiency of structural analysis and reporting.

IV. Methodology

The methodology begins with collecting the required architectural and structural information of the proposed tall building. The building plan, number of storeys, storey height, member dimensions, material properties, and support conditions are defined.

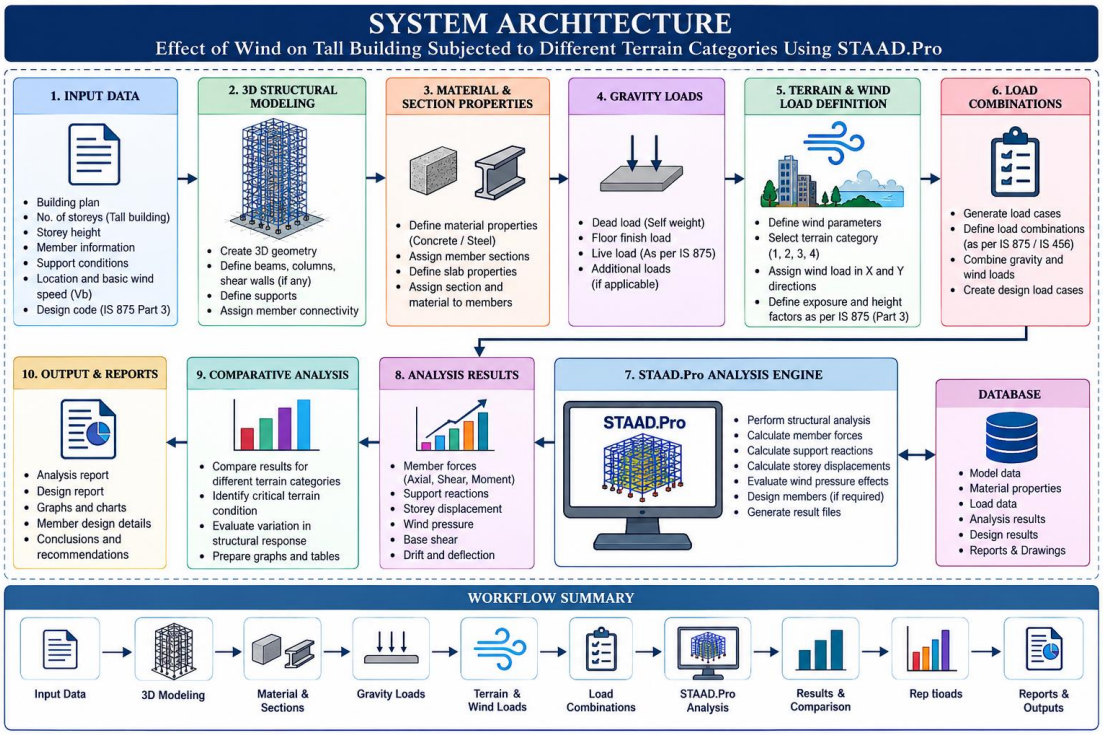
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A three-dimensional structural model is then developed in STAAD.Pro using beams, columns, supports, and other required structural components. Material properties and suitable member sections are assigned to the model. Dead loads and live loads are calculated and applied according to the building requirements. Wind-load parameters are then defined by considering the selected terrain categories and relevant design provisions. Separate wind-load cases are generated to represent the effect of different terrain conditions on the building. Appropriate load combinations are created by combining gravity and wind loads for structural evaluation. The complete model is analyzed to obtain bending moments, shear forces, axial forces, support reactions, and lateral displacements. Storey-wise structural responses are evaluated to identify the critical levels of the building. Results obtained from different terrain categories are compared to understand variations in wind-induced structural demand.

System Architecture

The system architecture represents the complete workflow used for analyzing the effect of wind on a tall building under different terrain categories using STAAD.Pro. The process begins with Building Input Data, which includes building geometry, storey dimensions, member information, and structural requirements. This information is used to create the 3D Structural Model consisting of beams, columns, supports, and other required components. The Material and Section Module assigns material properties and member sections to the structural model. The Gravity Load Module defines dead loads and live loads acting on the building. The Terrain and Wind Load Module defines wind parameters for the selected terrain categories. The Load Combination Module generates appropriate combinations of gravity and wind loads. The complete structural model is then processed through the STAAD.Pro Analysis Engine. The analysis produces member forces, support reactions, wind pressures, and storey displacements. Finally, the Output and Reporting Module generates analysis tables, displacement results, force diagrams, comparisons, and structural reports. Overall, the architecture follows the workflow **Building Data → 3D Modeling → Material & Sections → Gravity Loads → Terrain & Wind Loads → Load Combinations → STAAD.Pro Analysis → Structural Response → Terrain Comparison → Critical Member Evaluation → Results & Reports**.

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V. Result and Output

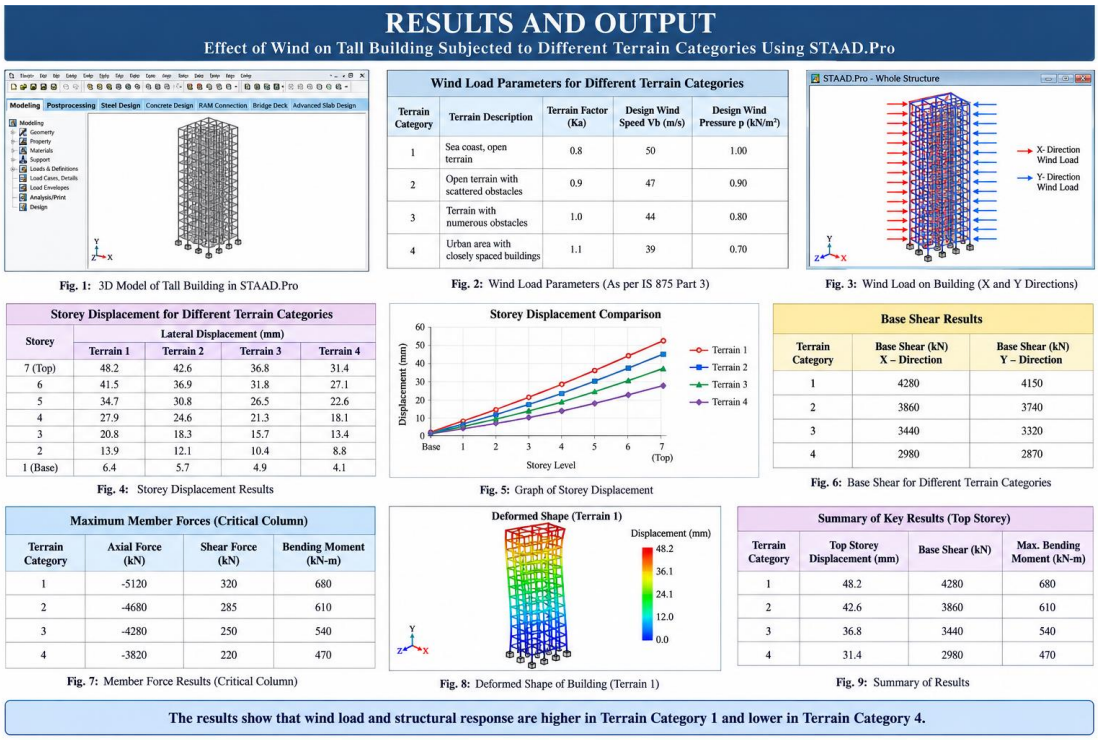


Fig. 1: 3D Model of Tall Building in STAAD.Pro

Wind Load Parameters for Different Terrain Categories

Terrain Category	Terrain Description	Terrain Factor (Ka)	Design Wind Speed Vb (m/s)	Design Wind Pressure p (kN/m²)
1	Sea coast, open terrain	0.8	50	1.00
2	Open terrain with scattered obstacles	0.9	47	0.90
3	Terrain with numerous obstacles	1.0	44	0.80
4	Urban area with closely spaced buildings	1.1	39	0.70

Fig. 2: Wind Load Parameters (As per IS 875 Part 3)

Fig. 3: Wind Load on Building (X and Y Directions)

Storey Displacement for Different Terrain Categories

Storey	Lateral Displacement (mm)			
	Terrain 1	Terrain 2	Terrain 3	Terrain 4
7 (Top)	48.2	42.6	36.8	31.4
6	41.5	36.9	31.8	27.1
5	34.7	30.8	26.5	22.6
4	27.9	24.6	21.3	18.1
3	20.8	18.3	15.7	13.4
2	13.9	12.1	10.4	8.8
1 (Base)	6.4	5.7	4.9	4.1

Fig. 4: Storey Displacement Results

Fig. 5: Graph of Storey Displacement

Base Shear Results

Terrain Category	Base Shear (kN) X – Direction	Base Shear (kN) Y – Direction
1	4280	4150
2	3860	3740
3	3440	3320
4	2980	2870

Fig. 6: Base Shear for Different Terrain Categories

Maximum Member Forces (Critical Column)

Terrain Category	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN-m)
1	-5120	320	680
2	-4680	285	610
3	-4280	250	540
4	-3820	220	470

Fig. 7: Member Force Results (Critical Column)

Fig. 8: Deformed Shape of Building (Terrain 1)

Summary of Key Results (Top Storey)

Terrain Category	Top Storey Displacement (mm)	Base Shear (kN)	Max. Bending Moment (kN-m)
1	48.2	4280	680
2	42.6	3860	610
3	36.8	3440	540
4	31.4	2980	470

Fig. 9: Summary of Results

The results show that wind load and structural response are higher in Terrain Category 1 and lower in Terrain Category 4.

VI. Conclusion

The project successfully analyzed the effect of wind on a tall building subjected to different terrain categories using STAAD.Pro. A three-dimensional structural model was developed by defining the building geometry, structural members, material properties, supports, and loading conditions. Wind loads were applied for different

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terrain categories along with the required dead and live loads. The analysis provided important structural parameters such as wind pressure, storey displacement, bending moments, shear forces, axial forces, and support reactions. The results showed that changes in terrain conditions significantly influence the wind load and overall structural response of the building. The comparison of different terrain categories helped identify the critical wind-loading condition and the corresponding structural response. Storey-wise displacement and member forces were evaluated to understand the behavior of the tall building under lateral wind action. STAAD.Pro provided an efficient platform for structural modeling, analysis, visualization, and comparison of results. The study demonstrates that proper consideration of terrain characteristics is essential for the safe and economical design of tall buildings. Overall, the project provides a systematic approach for evaluating wind-induced effects and improving the structural stability and reliability of tall buildings.

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