JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Seismic and Wind Analysis of Multi-Storey Structure with T and L Shape

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Abstract : Analyzing the seismic and wind performance of multi storey structures with T-shape and L-shape geometries is a complex but essential task in structural engineering. Both seismic and wind loads can have a significant impact on the stability and safety of such structures. Performing seismic and wind analyses for multi storey structures with T-shape and L-shape geometries involves a comprehensive engineering approach. In both cases, it is crucial to start by defining the geometric characteristics and material properties of the structure. Performing seismic and wind analyses for multi storey structures with T-shape and L-shape geometries involves a comprehensive engineering approach. In both cases, it is crucial to start by defining the geometric characteristics and material properties of the structure. In this study, seismic and wind analysis of multi-storey structure with T and L shape has been done**.**

***Keywords* - Seismic, Wind Analysis, Multi-Storey Structure, T And L Shape.**

I. INTRODUCTION

Analysing the seismic and wind performance of multi storey structures with T-shape and L-shape geometries is a complex but essential task in structural engineering. Both seismic and wind loads can have a significant impact on the stability and safety of such structures. Performing seismic and wind analyses for multi storey structures with T-shape and L-shape geometries involves a comprehensive engineering approach. In both cases, it is crucial to start by defining the geometric characteristics and material properties of the structure.

Performing seismic and wind analyses for multi storey structures with T-shape and L-shape geometries involves a comprehensive engineering approach. In both cases, it is crucial to start by defining the geometric characteristics and material properties of the structure. Following this, the application of relevant design codes, such as ASCE 7 or Eurocode 8, is essential to ensure compliance with seismic and wind standards. Structural modeling using finite element analysis software is then employed to create an accurate representation of the building's behavior under seismic and wind loads. For seismic analysis, dynamic analysis methods, such as response spectrum analysis or time history analysis, are utilized to assess the structure's response to ground motion. Wind analysis, on the other hand, involves determining wind loads based on factors like wind speed and directionality, followed by static or dynamic structural analysis. The results from both analyses must be thoroughly examined to verify that the structure meets safety and performance criteria, considering factors like member forces, inter-story drift, and foundation design. The iterative refinement of the design, compliance with building codes, and detailed documentation of the analysis and design decisions contribute to a robust and resilient multistory structure with T-shape or L-shape geometry. The complexity of seismic analysis for multistory buildings with T- and L-shaped geometries stems from the requirement to take the structure's dynamic reaction to ground motion into consideration. In order to effectively depict the behavior of both vertical and lateral load-resisting parts, the structural model must capture the distribution of mass and stiffness across the structure. Based on the region's seismic threat, historical or synthetic ground motion recordings are chosen. The dynamic analysis aims to predict the structure's displacements, accelerations, and internal forces over time. The outcomes are then scrutinized to ensure that the structure satisfies performance objectives, such as limiting inter-story drifts and avoiding excessive displacements. Foundation design considerations become critical, as the analysis informs the selection of appropriate foundation types and dimensions to mitigate seismic forces effectively. On the other hand, wind analysis for T-shape and L-shape structures requires a meticulous consideration of wind loads and their distribution. The structure's geometry significantly influences the wind pressures on its surfaces, demanding detailed modeling. Wind speed, wind directionality, and other meteorological factors are crucial inputs for determining these loads. Structural engineers employ static or dynamic analysis methods to evaluate the impact of wind forces on the structure. This involves assessing the distribution of loads on various structural elements and analyzing their effects on the overall stability and performance of the building. The results are carefully examined to ensure that the structure can withstand wind-induced forces without experiencing excessive deflections or structural damage.

A holistic approach is vital when considering both seismic and wind analyses, as these forces can act simultaneously and interact with each other. The combined effects must be thoroughly evaluated to guarantee the structural integrity of the building under all relevant loading conditions. Iterative design processes may be necessary to refine the structural elements and ensure compliance with building codes. The documentation of the entire analysis and design process is of paramount importance, providing a basis for reviews, future modifications, and, most importantly, ensuring the safety and resilience of multistory structures with T-shape or L-shape geometries.

II. LITERATURE SURVEY

Bharatbhai, N. K., Dubey, P., & Hardiya, (2022) present the position of these tall buildings having plan of L – shape20 storey building under a basic wind speed of 39 m/s. Using Staad pro software, a total of 4 cases have been analyzed. Dimension of the plan is different from both the projection on which wind is applied in all four directions. A comparison of result parameters like displacements, drift, axial forces in column, shear in beam in both longitudinal and transverse direction are made for all the models and suggestions are made to choose which position is the best of all.

Li, Y., Deng, Y., Li, A., & Xu, T. (2023)demonstrate that using Revit to simulate the pagoda's CFD geometry and the Realizable k-ε turbulence model to forecast wind pressure are both reasonable and practical. CFD findings are better in line with the wind tunnel test results when the LoD model is greater, particularly on the pagoda's leeward side. The wind field is greatly influenced by the structural elements that shape the building, such as the columns, ridges, and railings. Instead, the architectural shape's concealed elements—like Dougong, for example—barely alter the wind field. The purpose of this research is to improve our understanding of the CFD simulation while using multi-LoD geometric models to analyze wind impacts and structural safety on a tall wooden pagoda.

Patidar, G., & Pandey, A. (2022)provides an overview of previous research on the seismic and wind analysis of multi-story structures with various complicated and irregular plan forms. Along with it, the impact of shear walls, variations in seismic zones, and wind speed are taken into consideration. Techniques employed by various scholars to analyze wind and seismic data for variously shaped structures are examined. This study examines how plan form affects storey drift, lateral displacement, base shear, storey shear, soft storey, axial force, moments, and other factors.

Kumawat, K., Gupta, T., Shekhawat, R. S., & Agrawal, Y. (2024)examined the ground floor stiffness and seismic response of non-uniform reinforced concrete buildings with and without shear walls. By raising the ground level, a ten-story regular frame is altered to provide vertical irregularity in elevation. The program ETABS 2020 is utilized for doing the structural analysis and modelling in its entirety. The Time History method is applied, and the study is focused on seismic zones V in India. The performance of structures is compared based on criteria such as storey displacement, storey drift, storey shear and overturning moment. The findings suggest that a building structure with uneven stiffness is more likely to experience instability, as seen by increased displacement and drift values. Shear walled buildings have proven to be more stable than non-shear walled structures because they have higher base shear values and have seen a decrease in lateral displacement of over 40%. Additionally, the inclusion of shear walls has increased the structure's strength and stability, demonstrating a linear reaction during significant earthquakes.

Malge, A., & Belvekar, A. (2024) understand the behaviour of the wind booster at different frequencies. ANSYS-SAMCEFsoftware is used for entire numerical analysis. Von Mises stress model is used to estimate the maximum and minimum stress. The maximum stress induced in vertical deflectors is 4.64 MPa, wherein the maximum defection is 9.75×10^{-3}. Analytical and numerical analysis of wind booster deflectors has been done for Von Mises stress and it is found to be in close agreement with others.

Sadh, A., & Pal, A. (2018)examine how tall buildings behave in the second wind zone when subjected to wind force; the L shape is examined and evaluated at different altitudes. The direction of the wind also has a significant impact on how the structure behaves.

Singh, D., & Tiwari, S. (2018)examined the impact of wind load on tall R.C.C. structures with varying forms in accordance with IS: 875-1987 (part-3) norms of practice, focusing on the most and least structurally stable building types. In accordance with IS 875(Part3):1987 norms, a 40-story RCC high rise building is analyzed using the wind load analysis using force coefficient technique. The STAAD.ProV8i program is used to create a 3D representation of the building. One important factor influencing a high-rise building's ability to withstand wind is its geometrical layout. STAAD.ProV8i was used in this work to simulate seven distinct geometrical configurations with 40 stores and a total height of 120 meters that were constructed using RCC. According to IS: 875, all of the models have dead, live, and wind loads.

Ansari, S. J., & Bhole, S. (2016) Nowadays, the majority of buildings are frequently built with irregularities such torsional irregularity, soft story, asymmetrical in-fill wall layouts, vertical and plan abnormalities, etc. Previous research on earthquakes reveals that the majority of RC structures with these kinds of flaws sustained significant damage from ground motion caused by earthquakes. A summary of the structural integrity of symmetric and asymmetric, or torsionally balancing and unbalanced, buildings that are exposed to seismic study is provided in this work. Three L-shaped and T-shaped architectural models, one symmetrical and three asymmetrical in stiffening distribution, are studied. These buildings are built on medium soil in India's seismic zone II (per IS: 1893-2002[9]). Static analysis (concerning earthquake and gravitational stresses). It is determined that when compared to models in which the sturdiness of plan size is neglected, the outcome of the simulations in which it is taken into consideration is found to be superior.

Bhattacharya, S., & Dalui, S. K. (2022) considering different local modifications like corner chamfered and corner rounded of 'V' plan shaped building model. The angle between the limbs is 90° which remains unchanged. For both chamfered and rounded corners, the proportion is progressively raised from 5% to 20% of the overall plan area in increments of 5% every time. For every scenario, the wind incidence angle is raised from 0° to 90° at regular intervals of 30°. The numerical modeling of a "V"-shaped structure with local alterations, like corner chamfered or center rounded corners, which mimic urban terrain's wind environment, is based on the use of computational fluid dynamics, or CFD.A research on grid convergence is conducted in order to increase the accuracy of the results by using a much smaller computationally domain the meshing process. Through numerical analysis, the pressure coefficient on every single face, force coefficient, velocity variation, and pressure variations on each face are derived. In order to examine the impact of aerodynamics modification on the wind-induced response of a "V" plan shaped designing exposed to varying wind incidence angles, a comparison with a basic "V" plan shaped towering structure model that has not undergone any modifications has also been made. According to the simulation result, evaluations have been made regarding the suitability of aerodynamic modification.

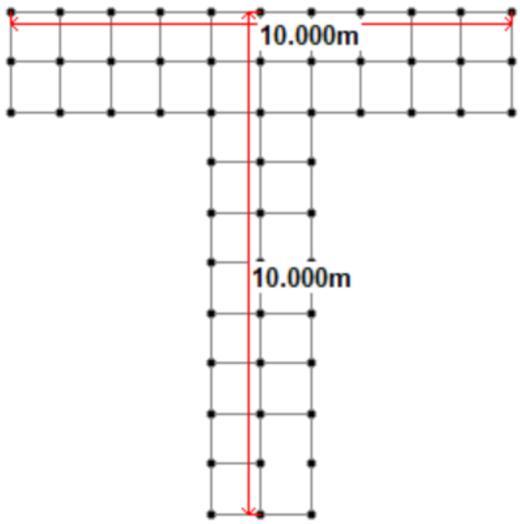
III. METHODOLOGY

A. General

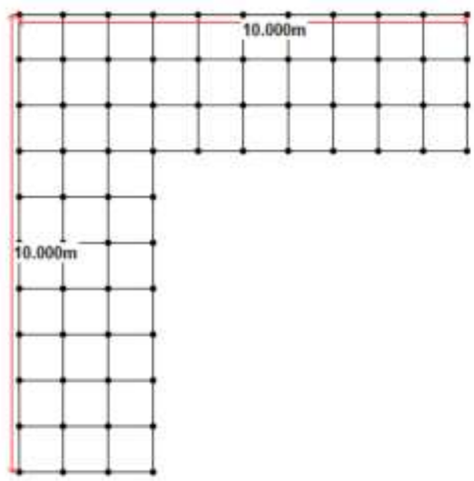
This research is focused towards presenting the comparative analysis of a G+10, 15 and 25 story structure to understand the effect of wind and seismic load on RCC structure of L and T shape. The modelling and analysis are performed using Staad Pro software

B. Structure

The G+10, 15 and 25 RCC multi storey framed buildings of L and T shape are considered for analysis to know the realistic behavior during an earthquake with the general plan and elevation is shown in figure 1. The RCC multi-storey framed building is modeled in Staad Pro software. Plan dimensions in X and Y direction are 10m and 10m respectively. The buildings consist of columns with dimension 500x300mm for all stories and beams with dimension 400x300mm. The floor slabs are 150mm thick. The height of all floors is 3.5m. Modal damping 5% is assumed with SMRF and I=1. The columns are assumed to be fixed at the base. Material concrete grade is M30



(a) T-shape



(b)

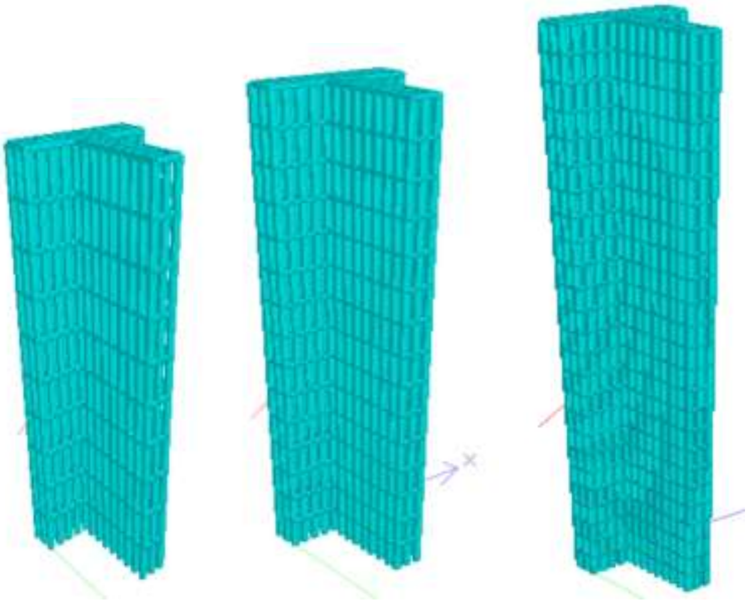


Fig. 1: Plan of building for T-shape structure

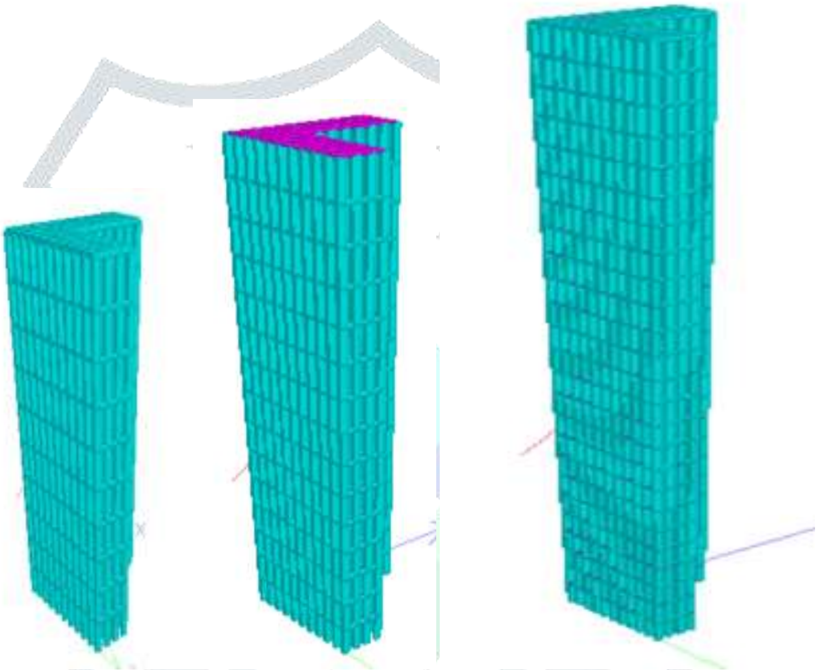


Fig. 2: Plan of building for L-shape structure

3.I Geometrical Specifications

Table 1: Geometrical Specifications of the L-Shape Structure

Geometrical Specification			
Particulars of Item	Properties for L-shape		
Number of Storey	G+10	G+15	G+25
Total height of Structure	35m	52.5m	87.5m
Typical Storey height	3.5m	3.5m	3.5m
Bottom Storey Height	3.5m	3.5m	3.5m
Floor Diaphragm	Rigid	Rigid	Rigid
Beam Size	400x300mm	400x300mm	400x300mm
Beam Shape	Rectangular	Rectangular	Rectangular
Column Size	500x300mm	500x300mm	500x300mm
Column Shape	Rectangular	Rectangular	Rectangular

Slab Depth	150mm	150mm	150mm
Slab Type	Thin Shell	Thin Shell	Thin Shell
Seismic zone	3	3	3
Zone factor	0.16	0.16	0.16

Table 2: Geometrical Specifications of the T-Shape Structure

Geometrical Specification			
Particulars of Item	Properties for T-shape		
Number of Storey	G+10	G+15	G+25
Total height of Structure	35m	52.5m	87.5m
Typical Storey height	3.5m	3.5m	3.5m
Bottom Storey Height	3.5m	3.5m	3.5m
Floor Diaphragm	Rigid	Rigid	Rigid
Beam Size	400x300mm	400x300mm	400x300mm
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Slab Depth	150mm	150mm	150mm
Slab Type	Thin Shell	Thin Shell	Thin Shell
Seismic zone	3	3	3
Zone factor	0.16	0.16	0.16

IV. RESULT AND DISCUSSION

4.1 Overall Comparison of Seismic load analysis

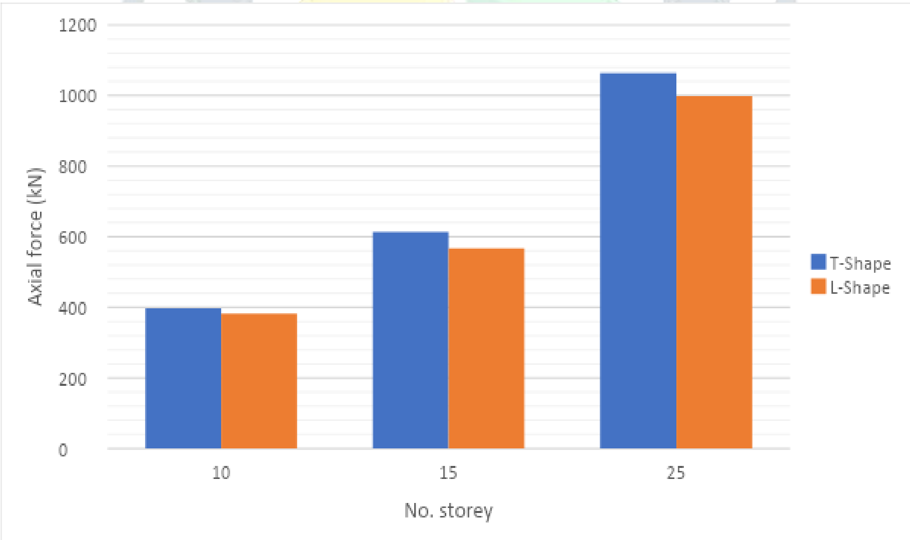

Fig. 3: Comparison of axial force under seismic loading condition

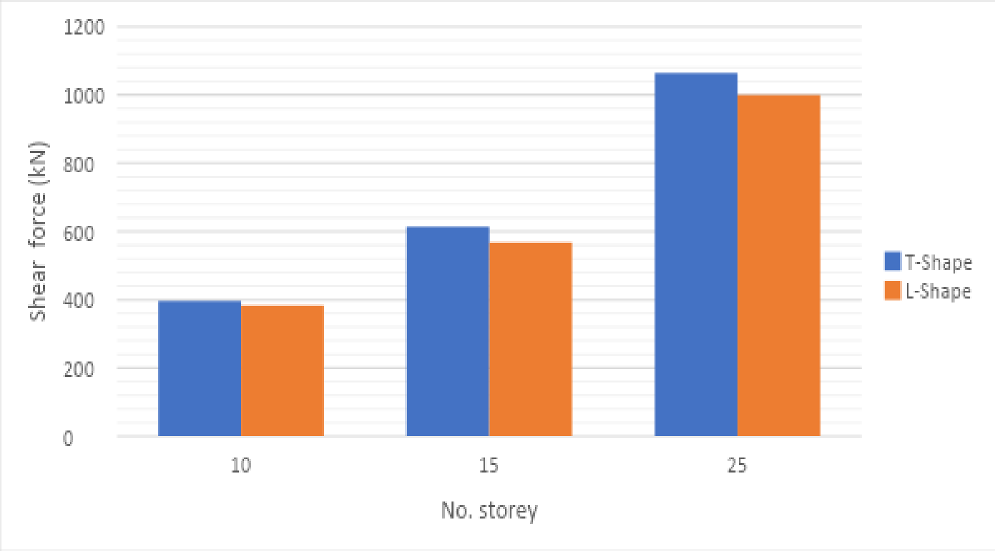

Fig. 4.: Comparison of shear force under seismic loading condition

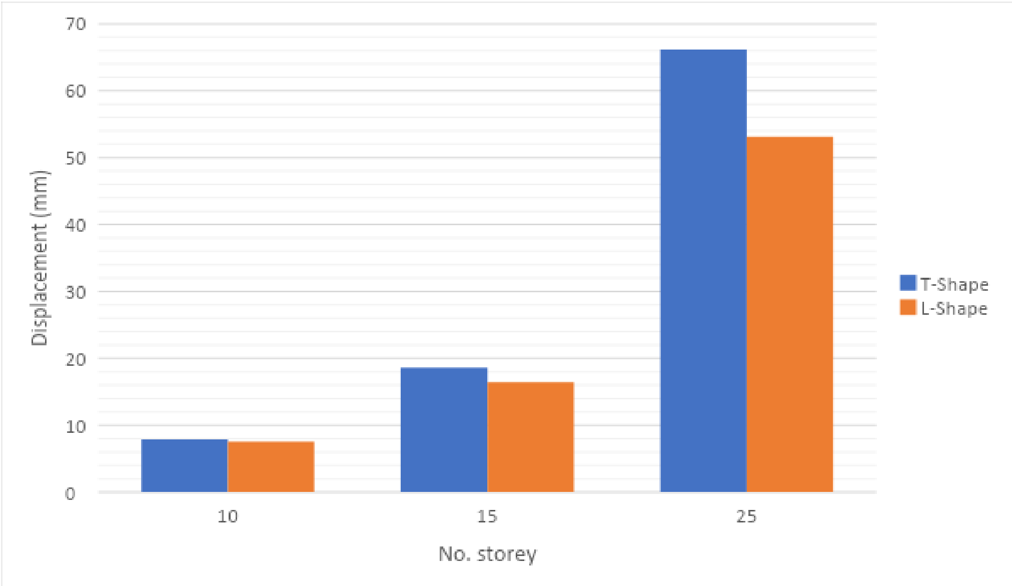

Fig. 5.: Comparison of displacement under seismic loading condition

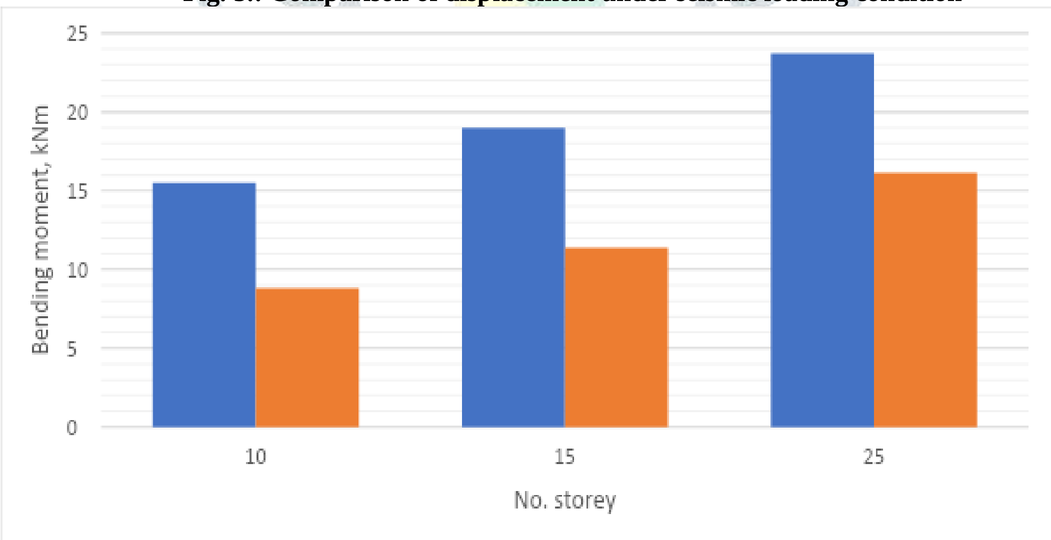

Fig. 6: Comparison of bending moment under seismic loading condition

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Max. Axial force is observed in T-shape building when no. storey is 25 and min. axial force is shown in L-shape building under seismic loading conditions.

Max. Shear force is observed in T-shape building when no. storey is 25 and min. Shear force is shown in L-shape buildings under seismic loading conditions.

Max. Displacement is observed in T-shape building when no. storey is 25 and min. displacement is shown in L-shape buildings under seismic loading conditions.

Max. Bending moment is observed in T-shape building when no. storey is 25 and min. The bending moment is shown in an L-shape building under seismic loading conditions

4.2 Overall Comparison of wind load analysis

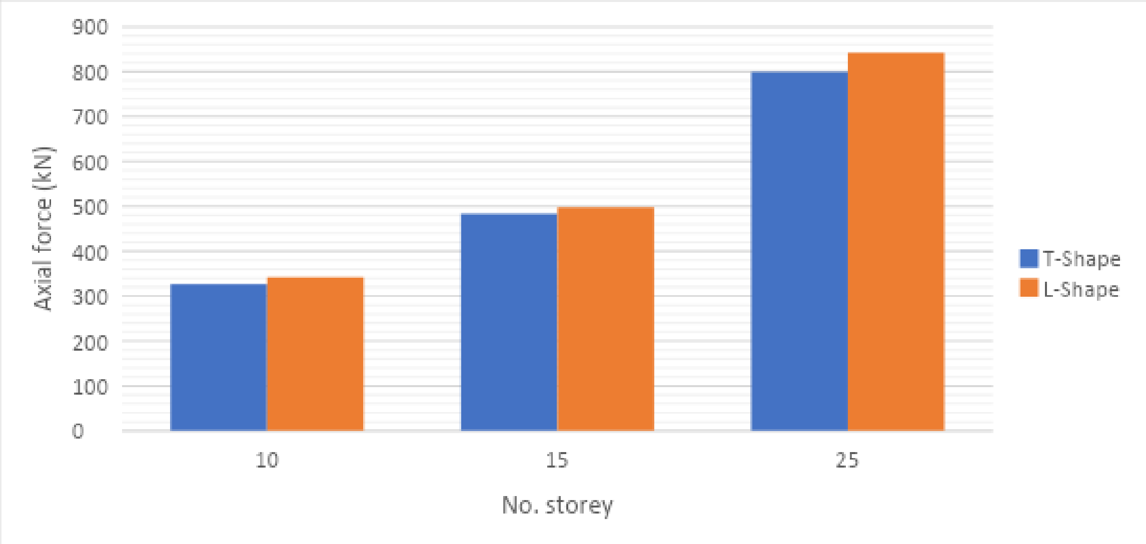

Fig. 7: Comparison of axial force under wind loading condition

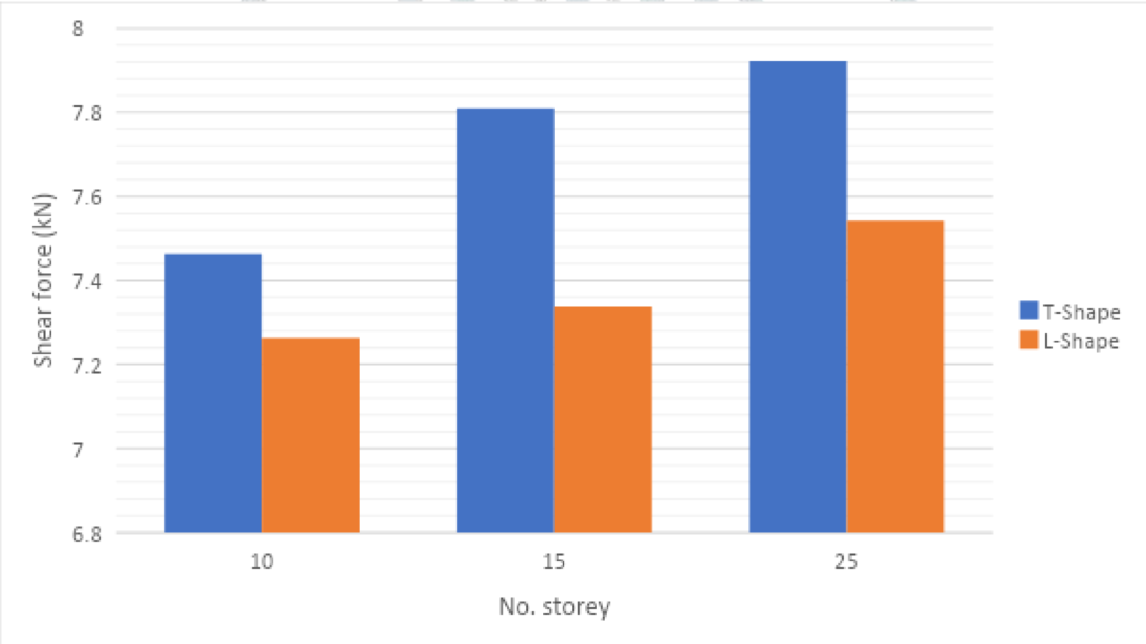

Fig. 8: Comparison of shear force under wind loading condition

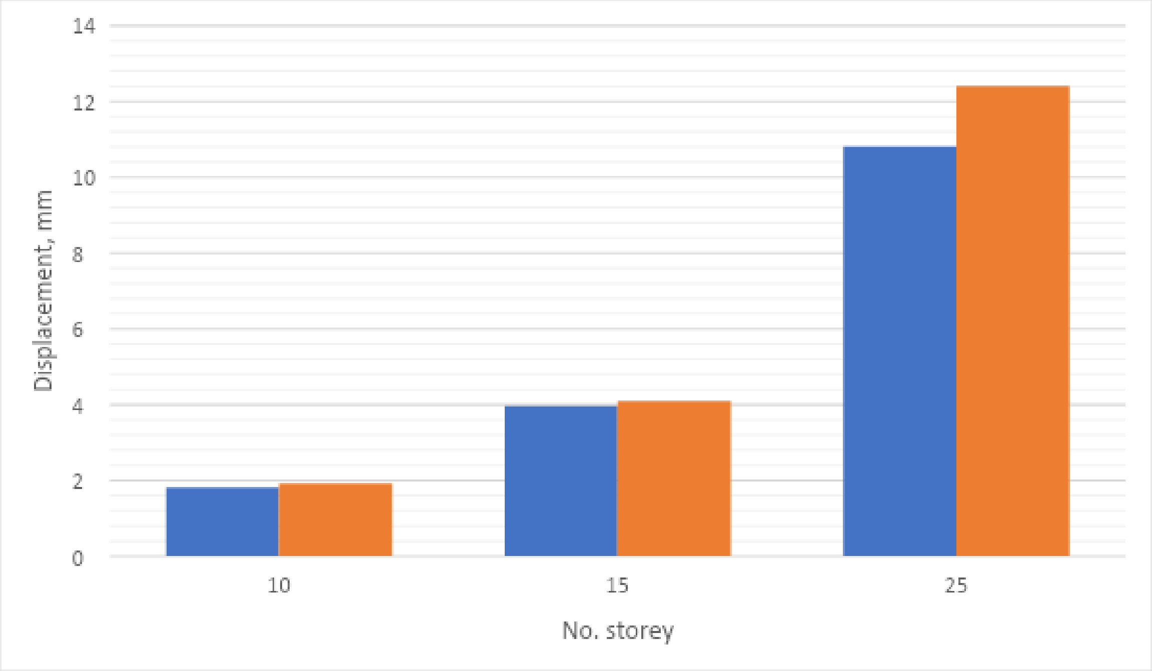

Fig. 9: Comparison of displacement under wind loading condition

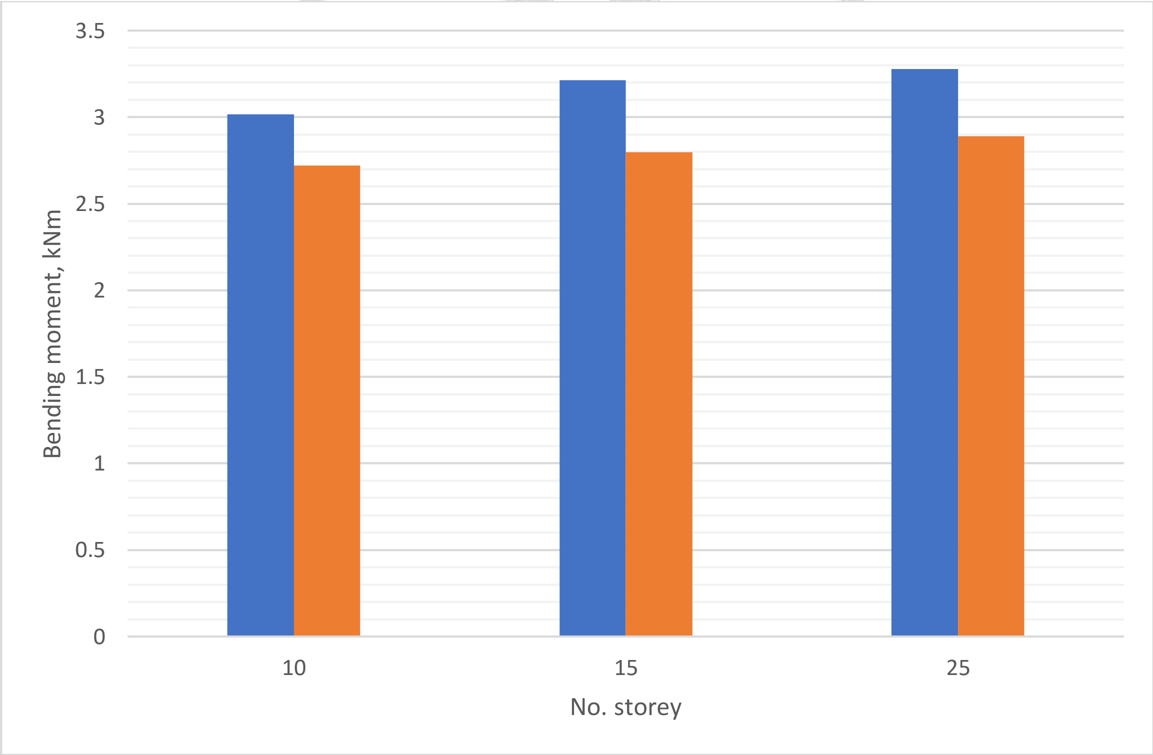

Fig. 10: Comparison of bending moment under wind loading condition

Under wind load conditions, the effects are opposite, for axial, and displacement. Max. axial, and displacement values are observed in L-shape while in case of shear force and bending moment, T-shape buildings showed higher values.

V. CONCLUSION

1. Under wind load conditions, the effects are opposite, for axial and displacement. Max. axial and displacement values are observed in L-shape while in case of V bending moment, T-shape buildings showed higher values.
2. Max. axial force is observed in T-shape building when no. storey is 25 and min. axial force is shown in L-shape building under seismic loading conditions.
3. Max. Shear force is observed in T-shape building when no. storey is 25 and min. Shear force is shown in L-shape buildings under seismic loading conditions.
4. Max. Displacement is observed in T-shape building when no. storey is 25 and min. displacement is shown in L-shape buildings under seismic loading conditions.
5. Max. Bending moment is observed in T-shape building when no. storey is 25 and min. The bending moment is shown in an L-shape building under seismic loading conditions.

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