International Journal of Scientific Research & Engineering Trends
Volume 10, Issue 1, Jan-Feb-2024, ISSN (Online): 2395-566X

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

M.Tech Scholar Sahil Netam, Associate Professor R.K. Grover
Department of Civil Engineering, JEC Jabalpur

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.

Index Terms- Seismic, wind analysis, multi-storey structure, T and L shape

I. INTRODUCTION

In the seismic analysis of multi storey structures with T-shape and L-shape geometries, the complexities arise from the need to account for the dynamic response of the structure to ground motion. The structural model must accurately represent the distribution of mass and stiffness throughout the building, capturing the behavior of vertical and lateral load-resisting elements. Ground motion records, either historical or synthetic, are selected based on the seismic hazard of the region. 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 multi storey structures with T-shape or L-shape geometries.

II. EFFECT OF SEISMIC LOAD ON STRUCTURE

The effect of seismic loads on a structure is a critical consideration in the field of structural engineering, given the potential for destructive forces associated with earthquakes. Seismic loads result from the ground motion caused by the sudden release of energy in the Earth's crust. When seismic waves travel through a structure, they induce dynamic forces that can lead to significant deformations and, in extreme cases, structural failure. These forces are particularly impactful on multi story structures due to their susceptibility to lateral displacements. The primary concern is the interplay between the structure's mass, stiffness, and the ground motion's frequency content. Seismic analysis involves evaluating the structure's response to various ground motion scenarios, using methods such as response spectrum analysis or time history analysis. Engineers assess factors like inter-story drift, acceleration, and shear forces to ensure that the structure can withstand the seismic forces without compromising safety or functionality. Mitigation strategies, such as the use of seismic-resistant materials, base isolators, and appropriate foundation design, are employed to enhance the structure's resilience to seismic loads and reduce potential damage during seismic events. The goal is to design structures that can not only withstand seismic forces within acceptable limits but also provide a level of ductility and energy dissipation to safeguard occupants and minimize damage in the event of an earthquake. Seismic loads introduce complex and dynamic challenges to structural systems, influencing various aspects of a building's behavior. The impact of seismic forces extends beyond merely causing lateral displacements; it affects the integrity of individual structural components and the overall stability of the system. One critical consideration is the distribution of forces throughout the structure, leading to the development of internal forces, stresses, and deformations.

Moreover, the frequency content of seismic waves is a crucial factor influencing the structure's response. Resonance, where the natural frequency of the building aligns with that of the seismic waves, can amplify displacements and forces. Structural engineers employ sophisticated analysis techniques to assess the resonance potential and adjust the design accordingly.

The vulnerability of certain structural configurations, such as tall or irregularly shaped buildings, becomes pronounced under seismic loads. Torsional effects, where the structure twists about its vertical axis, can lead to uneven distribution of forces and amplify the potential for damage. To address these challenges, engineers often incorporate stiffness irregularity mitigation strategies and distribute mass and stiffness appropriately within the structure.

Seismic-resistant design practices aim not only to prevent immediate collapse but also to provide a level of ductility, allowing the structure to undergo controlled deformation without catastrophic failure. This is achieved through the use of materials with enhanced ductile properties, strategic detailing of connections, and the incorporation of energy dissipation devices.

III. EFFECT OF WIND LOAD ON STRUCTURE

The effect of wind loads on a structure is a crucial consideration in structural engineering, as wind forces can exert substantial pressures on buildings, particularly tall or exposed structures. Wind loads result from the dynamic interaction between the structure and the surrounding wind flow. The impact of wind on a building is characterized by both static and dynamic forces, leading to various structural responses. These forces can induce lateral and uplift pressures on the building envelope, causing deformations, vibrations, and potential structural damage. Engineers employ rigorous modeling and analysis techniques to evaluate wind-induced loads, factoring in parameters such as wind speed, directionality, and turbulence effects. The structural design must account for the wind profile around the building, considering its shape, height, and surrounding terrain. Strategies to mitigate the effects of wind loads include the use of wind-resistant materials, aerodynamic shaping of the building, and the incorporation of damping devices to dissipate wind-induced vibrations. Additionally, structural elements such as bracings and shear walls are strategically placed to resist lateral forces. Ensuring the structural integrity of a building under wind loads is vital not only for immediate safety but also for preventing long-term fatigue and potential structural degradation. Overall, wind load analysis and design are essential components of creating resilient structures that can withstand the challenges posed by dynamic wind forces.

Wind loads on structures have a significant impact not only on the overall stability but also on the serviceability and occupant comfort of a building. The distribution of wind forces across the structure creates complex load patterns, influencing both the lateral and torsional responses. Tall or slender structures, such as high-rise buildings, are particularly susceptible to wind-induced effects, leading to considerations beyond simple static equilibrium. Dynamic effects, such as vortex shedding and galloping, can occur, potentially causing fatigue in structural components.

In addition to structural considerations, wind loads can affect the functionality of a building. Wind-induced vibrations, if not properly addressed, can lead to discomfort for occupants and may impact the functionality of sensitive equipment or machinery within the structure. This is especially critical in structures such as bridges, long-span roofs, and slender towers. Structural engineers employ various design strategies to counteract the effects of wind loads. Wind tunnel testing and computational fluid dynamics analyses are commonly used to simulate the wind's interaction with the structure and refine the design. The incorporation of damping systems, such as tuned mass dampers or viscous dampers, helps mitigate excessive vibrations induced by wind.

Furthermore, the choice of building materials and the configuration of architectural elements play a crucial role in resisting wind forces. The design of cladding and façade systems must account for the wind pressures and ensure water tightness, preventing infiltration and protecting the building envelope.

Overall, the effect of wind loads on a structure involves a holistic approach that considers not only the structural stability but also the functional and aesthetic aspects. Wind load analysis and design, when integrated into the overall structural engineering process, contribute to the creation of resilient and efficient structures capable of withstanding the dynamic forces imposed by wind.

IV. LITERATURE REVIEW

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) reveal that it is sensible and feasible to model the pagoda CFD geometric model by Revit and predict the wind pressure by the Realizable k-ε turbulence model. The higher LoD model makes CFD results more consistent with those in the wind tunnel test, especially on the leeward side of the pagoda. The components that affect the shape of the structure (e.g., the railings, ridges, and columns) have a great influence on the wind field. Rather, the components hidden in the architectural shape (e.g., Dougong) hardly affect the wind field. This paper aims to further understand the CFD simulation with multi-LoD geometric models in evaluating the wind effects and assessing structural safety on a high-rise wooden pagoda. It also provides a basis for the modeling and CFD analysis of ancient wooden architecture.

Patidar, G., & Pandey, A. (2022) presents a summary of research work already done in the seismic & wind analysis of multi-storied buildings with different irregular and complex plan shapes. The effect of shear wall, variation of seismic zone & wind speed also considered along with it. Methods used in the analysis of the seismic & wind analysis for different shaped buildings by different researchers are studied. The Effect of plan shape is studied in this paper in terms of storey drift, lateral displacement, base shear, storey shear, soft storey, axial force, moments, etc.

Kumawat, K., Gupta, T., Shekhawat, R. S., & Agrawal, Y. (2024) investigated the seismic response of irregular reinforced concrete structures possessing stiffness at ground floor with and without shear walls. A ten-storey regular frame is modified by incorporating vertical irregularity in elevation by increasing the height of the ground floor. The complete structural analysis and modeling are carried out by using the software ETABS 2020. The Time History method is applied, and the study is focused on seismic zones V in India. The performance of structures are compared based on criteria such as storey displacement, storey drift, storey shear and overturning moment. The results lead to the conclusion that a building structure exhibiting stiffness irregularity is prone to instability which is indicated by higher displacement and drift values. Structures incorporating shear walls have demonstrated greater stability compared to structures without shear wall as they exhibited higher base shear values and experienced a reduction in lateral displacement by more than 40%. The presence of shear walls also has enhanced the stability and strength of the structure, showing a linear response during critical earthquakes.

Malge, A., & Belvekar, A. (2024) understand the behavior of the wind booster at different frequencies. ANSYS-SAMCEF software 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) study the behavior of high rise building against the wind force in wind zone 2nd, L shape is studied and analyzed for specific heights.Also direction of wind plays a very vital role in behavior of structure.

Singh, D., & Tiwari, S. (2018) studied the influence of wind load on R.C.C. tall buildings of different shapes as per IS: 875-1987 (part-3) codes of practice are studied most and least structurally stable shape of building. Wind load analysis with force coefficient method is used for analysis of a 40-storey RCC high rise building as per IS 875(Part3):1987 codes respectively. The building is modelled in 3D using STAAD.ProV8i software. The geometrical configuration of a high rise building is a vital parameter that affects the wind response of the structure. In this study, seven different geometrical configurations having 40 floors with a total height of 120m built with RCC were modelled using STAAD.ProV8i. All the models are loaded with the Dead load, Live load and Wind Load as per IS: 875 (part I to III).

Ansari, S. J., & Bhole, S. (2016) In present scenario, most of the buildings are often constructed with irregularities such as soft storey, torsional irregularity, asymmetrical layout of in-fill walls, vertical and plan irregularity, etc. Past earthquake studies show that most of the RC buildings having such irregularities were severely damaged under the seismic ground motion. This paper presents an overview of performance of the torsion ally balanced and unbalanced buildings also called as symmetric and asymmetric buildings subjecting to seismic analysis. Three building models for L-shaped and T-shaped building are considered for study, which are constructed on medium soil in seismic zone III of India (as per IS: 1893-2002[9]), one symmetric and 3 asymmetric in stiffness distribution. Static analysis (for gravity and seismic loads). It is concluded that the performance of the models in which the stiffness of plan size is considered is found better when compared with the models in which the stiffness of plan size is ignored.

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. The percentage is gradually increased from 5% to 20% of the total plan area with 5% regular increment for both chamfered and rounded corners. Wind incident angle is increased from 0° to 90° with a 30° regular interval for each case. Computational Fluid Dynamics (CFD) is the basis of method to perform the numerical simulation of 'V' plan shaped building with local modifications such as corner chamfered, corner rounded which is similar wind environment as in urban terrain. Grid convergence study is performed to improve the accuracy of result by adopting very finer meshing of Computational Domain. Pressure coefficient of each face, force coefficient, velocity variation, pressure variation on each face is obtained by numerical analysis. Further, a comparison has been made with basic 'V' plan shaped tall building model without any modification to study the effectiveness of aerodynamic modification on wind-induced response of 'V' plan shaped building exposed to different wind incidence angle and observations have been made on the suitability of aerodynamic modification based on the numerical result.

V. CONCLUSION

A literature review on the analysis of T-shaped and L-shaped buildings under seismic and wind loads reveals a significant body of research focused on understanding the structural behavior, vulnerabilities, and design considerations for these building configurations. Researchers have extensively investigated the seismic response of T-shaped and L-shaped buildings, recognizing their distinctive behavior compared to regular rectangular structures.

The irregular geometry of T and L shapes can lead to complex torsional effects during seismic events, influencing lateral drift, inter-story drift, and floor accelerations. Different seismic codes and guidelines are reviewed to understand the design requirements and provisions for mitigating seismic vulnerabilities in these building types.

Wind load analysis on T-shaped and L-shaped buildings involves studying the aerodynamic forces and structural response to wind-induced pressures.

The building's geometry, including protruding wings or extensions, affects wind-induced responses, such as vortex shedding and wind-induced vibrations.

Design strategies and wind load provisions from various building codes are explored to address the challenges posed by wind forces on T and L-shaped structures.

Some studies focus on the combined effects of seismic and wind loads, recognizing the importance of considering these forces simultaneously in certain geographical regions.
Interaction effects between seismic and wind loads on structural components and their implications for building safety are investigated.

REFERENCES

1. Bharatbhai, N. K., Dubey, P., & Hardiya, (2022) A. Response Of Multistory Irregular L Shape Building Under Basic Wind Speed Of 39 M/S.
2. Sadh, A., Jamle, S., & Palł, A. (2018). Response of Multistory Irregular L Shape Building under Basic Wind Speed of 39 m/s.
3. Li, Y., Deng, Y., Li, A., & Xu, T. (2023). Comparative Studies of Computational Fluid Dynamic Geometric Models at Multiple Levels of Details in Evaluating Wind Action on Asian Ancient Wooden Tower. International Journal of Architectural Heritage, 17(6), 970-987.
4. Patidar, G., & Pandey, A. (2022) Dynamic Analysis of Multi-Storey Buildings of Different Shapes. International Journal for Research in Applied Science & Engineering Technology (IJRASET), ISSN, 2321-9653.
5. Kumawat, K., Gupta, T., Shekhawat, R. S., & Agrawal, Y. (2024). Seismic Response of Stiffness Irregularity at Ground Floor with and without Shear Walls. Journal of Scientific Research and Reports, 30(1), 12-24.
6. Malge, A., & Belvekar, A. (2024). Structural analysis of wind booster for multi storey vertical axis wind turbine. International Journal of Ambient Energy, 45(1), 2268082.
7. de Salles, H. B., Miguel, L. F. F., Lenzi, M. S., & Lopez, R. H. (2024). Reduced-order model for RBDO of multiple TMDs on eccentric L-shaped buildings subjected to seismic excitations. Mechanical Systems and Signal Processing, 206, 110906.
8. Sadh, A., & Pal, A. (2018). A Literature Study of Wind Analysis on High Rise Building. Int 'l J. of Advanced Engineering Research and Science, 5(11), 263-265.
9. Singh, D., & Tiwari, S. (2018). Influence of Wind Load on Multi-Storey Tall RCC Building of Different Shapes.
10. Jafari, M., & Alipour, A. (2021). Aerodynamic shape optimization of rectangular and elliptical double-skin façades to mitigate wind-induced effects on tall buildings. Journal of Wind Engineering and Industrial Aerodynamics, 213, 104586.
11. Ansari, S. J., & Bhole, S. (2016). Comparative Study of Symmetric & Asymmetric L-Shaped & T-Shaped Multi-Storey Frame Building Subjected to Gravity & Seismic Loads with Varying Stiffness. International Journal of Science Technology & Engineering, 2(10), 734-742.
12. Bhattacharya, S., & Dalui, S. K. (2022, December). Effect of Aerodynamic Modification on 'Vplan Shaped Tall

Building under Wind Excitation. In ASPS Conference Proceedings (Vol. 1, No. 5, pp. 1479-1485).

13. Lone, B. A., & Chand, J. (2019). Comparative Study on Seismic and Wind Performance of Multi-Storeyed Building with Plan and Vertical Irregularities-A Review. International Research Journal of Engineering and Technology, e-ISSN, 2395-0056.
14. Mattias, L. W. A., & Abdalla Filho, J. E. (2023). Dynamic behavior of H-shape tall buildings subjected to wind loading computed by stochastic and CFD methodologies. Wind and Structures, 37(3), 229-243.
15. Tapubhai, V. R., & Solanki, H. (2022) PARAMETRIC STUDY OF G+ 15 BUILDING MODEL WITH PLUS, L, T-SHAPE HAVE DIFFERENT POSITION OF BELT WALL.
16. Tomer, S., & Bhandari, M. (2023, February). Evaluation of Seismic Response of Irregular Buildings: A Review. In IOP Conference Series: Earth and Environmental Science (Vol. 1110, No. 1, p. 012012). IOP Publishing.
17. Al-sabaeei, M. S., Dabhekar, K. R., & Khedikar, I. (2023). State of art on seismic comparison of different types (V, diagonal and X) of bracings on different shapes of buildings (L, H, T and rectangular) with response spectrum method. Materials Today: Proceedings.
18. Gudainiyan, J., & Gupta, P. K. (2023). A comparative study on the response of the L-shaped base isolated multi-storey building to near and far field earthquake ground motion. Forces in Mechanics, 11, 100191.