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A Review on Comparative Seismic Analysis of Multistrorey Building for Different Shapes

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Abstract - *Seismic analysis of multistorey buildings is crucial in ensuring their safety and stability during earthquakes. The shape of a building significantly influences its seismic performance, as it affects the distribution of mass, stiffness, and the way lateral forces are resisted. This paper presents a comparative seismic analysis of multistorey buildings with different geometric configurations, including rectangular, L-shaped, I-shaped, and C-shaped plan layouts. The study explores how these various shapes respond to seismic loads, focusing on factors such as Base shear, Storey displacement and Storey drift. Seismic analysis techniques, such as linear static, dynamic response spectrum, and time history analysis, are reviewed for each building shape. The findings reveal that regular shapes like rectangular and square buildings generally exhibit more predictable and stable responses to seismic forces, while irregular shapes (such as L-shaped I-shaped structures) experience more complex dynamic behaviors, often requiring additional reinforcement and specialized design strategies. Overall, this review underscores the importance of selecting appropriate building shapes and utilizing advanced seismic analysis methods to ensure the safety of multistorey buildings in earthquake-prone regions.*

Key Words: Multistorey Buildings, Seismic analysis, Response spectrum Analysis, Building Shapes, Structural Performance, ETABS, etc.

1. INTRODUCTION

Seismic performance is a critical consideration in the design of multistorey buildings, especially in regions prone to earthquakes. The ability of a structure to withstand seismic forces largely depends on its geometric configuration, as different shapes exhibit varying responses to lateral forces induced by ground motion. Building shapes not only influence the distribution of mass and stiffness but also play a significant role in the torsional behavior of the structure. For multistorey buildings, ensuring stability during seismic events is paramount, as excessive vibrations and uneven force distribution can lead to structural damage or failure.

Traditionally, rectangular and square buildings have been the most common configurations in seismic design due to their symmetry and predictable performance under lateral loads. However, with urbanization and architectural innovation, irregularly shaped buildings, such as L-shaped, I-shaped, and C-shaped structures, have become more prevalent. These irregular shapes, while aesthetically appealing or functionally advantageous, present unique challenges in seismic analysis. The non-uniform distribution of mass and stiffness in these buildings can result in torsional effects, which complicate the prediction of seismic response and require more advanced design strategies.

The objective of this paper is to conduct a comparative seismic analysis of multistorey buildings with different shapes, including regular and irregular configurations. By evaluating the dynamic response of various building geometries under seismic loading, this study aims to highlight the key factors influencing seismic performance. Furthermore, the paper discusses the role of modern seismic design techniques, including base isolation and damping systems, in improving the resilience of irregular buildings. The findings from this review will offer valuable insights into how building shape affects seismic behavior and provide recommendations for optimizing structural design to ensure safety and performance in earthquake-prone regions.

1.1 Shapes

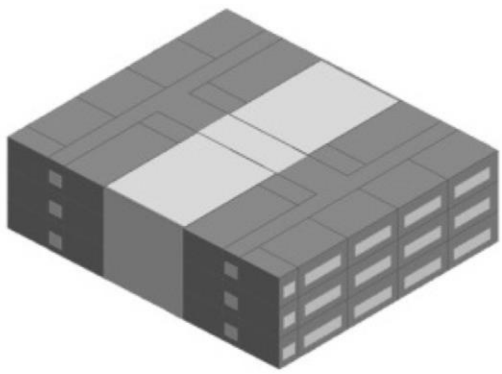

Fig.1.1 rectangle shape (https://www.mdpi.com/sustainability/sustainability-09-01708/article_deploy/html/images/sustainability-09-01708-g001.png)

Rectangle shaped Buildings Rectangular buildings exhibit a relatively uniform distribution of mass and stiffness along their axes, which typically results in more predictable seismic performance compared to irregularly shaped structures. However, the rectangular configuration is not immune to seismic issues.

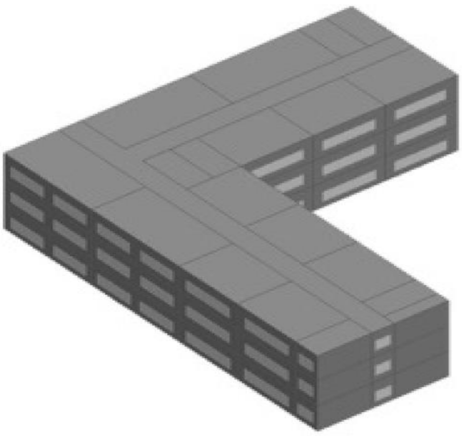

Fig.1.2 L-shape
(https://www.mdpi.com/sustainability/sustainability-09-01708/article_deploy/html/images/sustainability-09-01708-g001.png)

L-Shaped Buildings L-shaped buildings are increasingly popular in architectural design due to their ability to provide a greater variety of floor plans and functional spaces. However, the irregularity of the L-shape can result in significant seismic concerns, such as torsional coupling and uneven distribution of seismic forces.

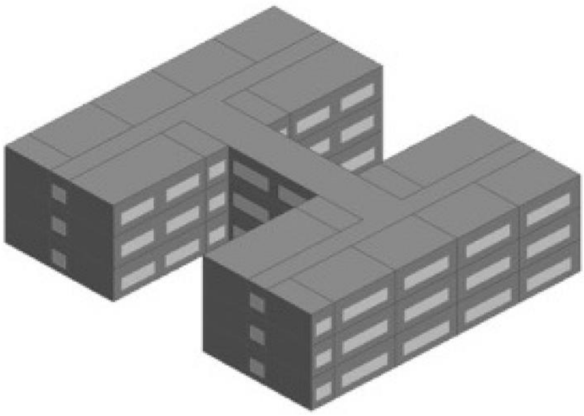

Fig.1.3 I-shape
(https://www.mdpi.com/sustainability/sustainability-09-01708/article_deploy/html/images/sustainability-09-01708-g001.png)

I-Shaped Buildings I-shaped buildings, with their long, linear form and uniform mass distribution, are commonly seen in high-rise commercial or institutional structures. Though these buildings are generally more straightforward to analyze compared to irregular configurations, their elongated shape can still introduce vulnerabilities. The length of the structure can lead to higher bending moments and increased sway during seismic events, which may affect building stability.

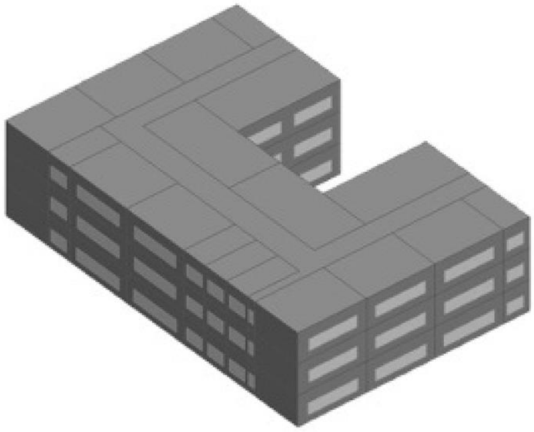

Fig.1.4 C-shape
(https://www.mdpi.com/sustainability/sustainability-09-01708/article_deploy/html/images/sustainability-09-01708-g001.png)

C-Shaped Buildings C-shaped buildings offer distinct architectural and functional advantages, especially in providing open courtyards or maximizing views. Like L-shaped buildings, C-shaped structures exhibit a degree of asymmetry that can make them more prone to torsional effects during seismic activity. The open core in the middle of the building can create challenges in terms of load distribution, and the structure may experience differential movement between the outer arms of the "C" shape.

2. LITERATURE REVIEW

Kiran devi (2023), A Comparative Study on Seismic Analysis of Multistorey Buildings in Different Seismic Zones."

Kiran Devi explores the seismic performance of multistorey buildings across different seismic zones, focusing on critical parameters like base shear, lateral displacement, and inter-storey drift. The study emphasizes the varying structural demands in high-risk zones, such as enhanced ductility and stronger foundations, compared to lower-risk zones, where design requirements are less stringent. By using computational models, the research highlights the importance of region-specific structural designs adhering to seismic codes like IS 1893. This comparative analysis provides valuable insights for optimizing building safety and cost-efficiency, contributing to the development of seismic-resilient structures tailored to local hazard levels.

Snehal Mevada (2022), "Effect of Irregularities on Seismic Performance of Building."

Snehal Mevada examines how structural irregularities affect the seismic performance of buildings. The study focuses on vertical and plan irregularities, such as uneven mass distribution, setbacks, and asymmetry, which can cause uneven force distribution and amplify torsional effects during earthquakes. Using computational analysis, Mevada evaluates parameters like base shear, lateral displacement, and inter-storey drift to assess the vulnerability of irregular buildings.

The research emphasizes the need for careful design considerations and adherence to seismic codes, such as IS 1893, to mitigate risks. The findings highlight the importance of addressing irregularities to enhance structural stability and seismic resilience.

Nurulla Shaik (2022), "Analysis of Multi-Storey Building in Different Seismic Zones of India."

Nurulla Shaik explores the seismic performance of multi-storey buildings in various seismic zones of India. The study focuses on comparing the structural behavior of buildings located in high, moderate, and low seismicity zones, evaluating parameters such as base shear, lateral displacement, and storey drift. Using dynamic analysis methods like response spectrum analysis, Shaik investigates the impact of different seismic forces on building stability. The research emphasizes the need for region-specific design considerations, with stronger reinforcement and advanced seismic-resistant features required for buildings in high-risk zones. The findings underscore the importance of adhering to seismic codes to ensure structural safety.

Gaurav Patidar (2022), "Dynamic Analysis of Multi-Storey Buildings of Different Shapes."

In this paper, the author investigates the dynamic behavior of multi-storey buildings with varying shapes under seismic forces. The study analyzes how geometric configurations, such as rectangular, L-shaped, and T-shaped designs, influence parameters like natural frequency, mode shapes, base shear, and lateral displacement. Using dynamic analysis methods, including response spectrum analysis, the research highlights that irregular shapes experience higher stress concentrations and uneven force distributions compared to regular shapes. Patidar emphasizes the importance of optimizing building geometry and adhering to seismic codes to ensure stability. The study provides critical insights into the relationship between structural shape and seismic performance, enhancing design strategies.

Tejaswini Wagh (2021), "Seismic analysis of multistorey building by using STAAD PRO."

The study investigates the seismic performance of multistorey buildings using STAAD PRO, a widely used structural analysis software. The study focuses on evaluating the building's response to seismic forces, examining parameters like base shear, displacement, and inter-storey drift under various seismic conditions. Wagh employs response spectrum and time history analysis to simulate earthquake effects and assess structural behavior. The research highlights how STAAD PRO helps engineers optimize designs by providing detailed insights into stress distribution, stability, and potential failure points. The findings emphasize the software's utility in enhancing the seismic resilience of buildings, ensuring compliance with seismic design codes.

T.Jayakrishna, (2018), "Seismic analysis of regular and irregular multi storey buildings by using STAAD PRO."

T. Jayakrishna analyzes the seismic performance of regular and irregular multistorey buildings using STAAD PRO, focusing on their response to seismic forces. The study compares the structural behavior of buildings with different configurations, such as rectangular and irregular shapes, under dynamic loading. By performing response spectrum and time history analysis, Jayakrishna evaluates key parameters like base shear, displacement, and inter-storey drift. The research highlights the increased vulnerability of irregular buildings to torsional effects and uneven force distribution. The study emphasizes the importance of using advanced software tools like STAAD PRO for accurate seismic analysis and optimizing building design for enhanced safety.

Brajesh Kumar Tondon, (2018), "Seismic analysis of milti storied building in different zones."

Brajesh Kumar Tondon investigates the seismic behavior of multi-storey buildings located in different seismic zones. The study focuses on the impact of varying seismic forces on structural performance, analyzing parameters such as base shear, lateral displacement, and storey drift. Using dynamic analysis methods like response spectrum and time history analysis, Tondon evaluates how buildings in high, moderate, and low seismicity zones respond to different earthquake intensities. The research emphasizes the importance of tailoring building designs to specific seismic zones, ensuring safety and structural integrity. Tondon's findings underscore the need for zone-specific seismic design strategies to enhance building resilience.

Ms. Payal K.Jayswal, (2018), "Seismic Analysis of Multistorey Building with Floating Column and Regular Column

Ms. Payal K. Jayswal explores the seismic performance of multistorey buildings with floating columns compared to regular column configurations. The study evaluates how the presence of floating columns, which create discontinuities in the structure, affects the building's response to seismic forces. Using dynamic analysis methods, the research focuses on key parameters like base shear, lateral displacement, and inter-storey drift under seismic loading. Jayswal highlights that buildings with floating columns tend to experience greater torsional effects and irregular behavior compared to regular column structures. The study emphasizes the need for careful design considerations to mitigate the risks associated with floating columns in seismic-prone areas.

Sanisha Santhosh, (2017), "Seismic Analysis of Multi Storied Building with Shear Walls of Different Shapes."

Sanisha Santhosh investigates the seismic performance of multi-storey buildings incorporating shear walls of different shapes. The study examines how the geometry and placement of shear walls influence the building's ability to resist seismic forces. By performing dynamic analysis, Santhosh evaluates parameters such as base shear, lateral displacement, and inter-storey drift for buildings with various shear wall configurations, including rectangular, circular, and L-shaped walls. The research highlights that shear walls significantly improve the building's stability by reducing lateral displacement and enhancing load-bearing capacity. The study emphasizes the importance of selecting optimal shear wall shapes to enhance seismic resilience.

Pushkar Rathod, (2017), "Seismic analysis of multistoried building for different plans using ETAB."

Pushkar Rathod explores the seismic performance of multistoried buildings with different floor plans using ETABS, a structural analysis software. The study focuses on comparing buildings with various layouts, such as rectangular, L-shaped, and irregular configurations, to assess their response to seismic forces. Rathod utilizes response spectrum and time history analysis to evaluate parameters such as base shear, displacement, and torsional effects. The research highlights that irregular plans tend to exhibit uneven load distribution and increased torsional vibrations, leading to higher seismic risks. The study emphasizes the effectiveness of ETABS in optimizing building design to improve earthquake resilience.

Mohammed Rizwan Sultan, (2015), "Dynamic analysis of multistorey building for different shapes."

Mohammed Rizwan Sultan investigates the dynamic behavior of multistorey buildings with different geometric shapes under seismic loading. The study compares the seismic performance of buildings with rectangular, L-shaped, and T-shaped configurations, analyzing key parameters like base shear, lateral displacement, and natural frequencies. Sultan uses dynamic analysis methods, including response spectrum and time history analysis, to evaluate the influence of building shape on its structural response. The research finds that irregular shapes, particularly L- and T-shaped buildings, experience higher torsional effects and irregular force distribution compared to regular shapes. The study underscores the importance of geometric optimization for improved seismic

Amin Alavi, (2013), "Effect of Plan Irregular RC Buildings In High Seismic Zone."

Amin Alavi examines the seismic performance of plan-irregular reinforced concrete (RC) buildings in high seismic zones. The study focuses on how irregularities in building layouts, such as asymmetric plans and discontinuities, impact the structure's ability to withstand seismic forces. Alavi evaluates key parameters like base shear, lateral displacement, and torsional behavior using dynamic analysis methods. The research finds that plan irregularities lead to uneven force distribution, increased torsional effects, and potential structural instability during earthquakes. Alavi emphasizes the need for special design considerations, such as enhanced reinforcement and stiffness, to mitigate the risks associated with irregular buildings in high seismic areas.

Raul Gonzalez Herrera, (2008), "Influence of plan irregularity of buildings."

Raul Gonzalez Herrera explores the influence of plan irregularity on the seismic behavior of buildings. The study focuses on how different types of plan irregularities, such as asymmetry, setbacks, and discontinuities, affect the building's response to earthquake forces. Herrera uses dynamic analysis to assess key parameters, including base shear, displacement, and torsional motion, in buildings with irregular plans. The research highlights that such irregularities lead to uneven load distribution, higher torsional effects, and potential structural weaknesses during seismic events. Herrera stresses the importance of incorporating design modifications to mitigate these effects and enhance the seismic resilience of irregular buildings.

3. SUMMARY OF LITERATURE AND GAP

The research papers collectively explore the seismic analysis of multi-storey buildings across various seismic zones, focusing on the effects of building shape, irregularities, and structural elements. Several studies emphasize the impact of plan irregularity, floating columns, shear walls, and dynamic responses using tools like STAAD PRO and ETABS. The research highlights the seismic performance of both regular and irregular buildings, with varying results based on location, building shape, and structural configuration. Analyses include dynamic effects, response spectrum analysis, and the comparison of buildings across different seismic zones, providing valuable insights for improving earthquake-resistant design in multi-storey buildings.

Despite the extensive research on seismic analysis of multi-storey buildings, there remains a gap in addressing the combined effects of irregularities in both plan and elevation on seismic performance, especially in buildings with mixed structural elements like floating columns, shear walls, and irregular shapes. Most studies focus on isolated factors, leaving a need for comprehensive analyses that consider multiple irregularities simultaneously. Furthermore, there is limited research on the long-term performance of buildings in varying seismic zones under real earthquake conditions. More studies are also needed on the integration of advanced software tools, like ETABS and STAAD PRO, with real-time seismic data for better prediction accuracy.

4. CONCLUSIONS

In conclusion, seismic analysis of multi-storey buildings remains a critical area of research, as it directly impacts the safety and resilience of structures in earthquake-prone regions. The studies reviewed highlight the significance of building shape, irregularities, and the inclusion of advanced structural elements like shear walls and floating columns in determining seismic performance. However, there is a need for more comprehensive models that consider the combined effects of multiple irregularities, as well as the long-term performance of buildings under real seismic conditions. Future research should focus on the integration of machine learning, AI, and real-time seismic data into structural analysis tools to improve prediction accuracy and dynamic response assessments. Additionally, retrofitting techniques and sustainable materials should be explored to enhance the earthquake resistance of both new and existing buildings. Overall, advancing seismic analysis techniques will lead to more resilient buildings and safer urban environments in seismic zones.

5. FUTURE SCOPE

The future scope of seismic analysis of multi-storey buildings offers numerous avenues for enhancing structural resilience and improving earthquake safety. One promising area is the development of more sophisticated simulation models that integrate various irregularities in both plan and elevation. Current studies often focus on isolated factors like shape, shear walls, or floating columns, but the real-world performance of buildings under seismic forces depends on the complex interaction of multiple irregularities. Future research should aim at modeling these combined effects more comprehensively to provide more reliable design solutions.

Another area for exploration is the use of advanced computational methods, such as machine learning and artificial intelligence, to predict seismic behavior. These technologies can process large datasets and uncover patterns that traditional methods might overlook, offering a more nuanced understanding of a building's response to earthquakes. Integrating AI with structural analysis tools like STAAD PRO and ETABS could lead to real-time performance monitoring and optimization of building designs, adapting them to dynamic seismic conditions.

Further research is needed to improve the understanding of retrofitting techniques for buildings, especially older structures in high seismic zones. Retrofitting methods can enhance the performance of existing buildings and reduce damage during earthquakes. Exploring cost-effective and efficient retrofitting solutions that work across diverse building types and seismic zones is crucial.

Finally, incorporating real-time seismic data into seismic analysis software could significantly improve the accuracy of predictions. This integration would allow for dynamic, real-time assessment of a building's performance during an earthquake, offering the potential for immediate structural adjustments or evacuation measures. Additionally, the role of green building materials and sustainable practices in seismic performance could be a valuable area for future research, ensuring that buildings not only resist earthquakes but also contribute to environmental goals.

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