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Comparison of Analysis and Design of Regular and Irregular Configuration of Multi Story Building in Various Seismic Zones- A Review

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Abstract: - In this review paper, a comprehensive and detailed study of previously published research works related to seismic analysis of regular and irregular buildings has been carried out. The study focuses on understanding the effect of various parameters such as plan irregularity, vertical irregularity, soil conditions, seismic zones, short column effect, and different analysis methods on the structural performance of buildings. From the detailed literature review, it is observed that regular buildings perform better under seismic loads due to uniform distribution of mass and stiffness, whereas irregular buildings show complex behavior due to discontinuity in geometry, resulting in higher displacement, storey drift, and torsional effects. It is also found that soil conditions play a very important role in seismic response, where soft soil increases displacement and amplification of vibrations compared to hard soil. The study also highlights that dynamic analysis methods such as response spectrum analysis and time history analysis provide more accurate and realistic results compared to static analysis methods. Additionally, the presence of short columns in buildings, especially in sloping ground conditions, leads to higher stiffness and attracts larger forces, making them more vulnerable to failure. The main objective of this review is to identify important parameters affecting the seismic behavior of buildings and to highlight the research gaps in existing studies. This paper will help researchers, engineers, and designers in understanding the complex behavior of structures and adopting suitable design techniques for safe, economical, and sustainable construction in earthquake-prone areas.

Keywords: - Seismic Analysis, Regular and Irregular Buildings, Storey Drift, Displacement, Short Column Effect, Soil Type, Dynamic Analysis, Earthquake Engineering.

I. INTRODUCTION

Earthquake is one of the most destructive natural disasters which causes severe damage to life and property. In India, a large area falls under different seismic zones, making it necessary to consider earthquake forces in the design of structures. Multi-storey buildings are widely constructed due to increasing population and limited land availability. These buildings are subjected to lateral forces such as earthquake and wind loads, which significantly affect their stability and performance. The behavior of a building during an earthquake mainly depends on its configuration, mass distribution, stiffness, height, and soil condition. Buildings can be classified as regular and irregular based on their geometry and structural arrangement. Regular buildings have uniform distribution of mass and stiffness, whereas irregular buildings have discontinuity in shape, mass, or stiffness, which leads to complex structural behavior. Studies have shown that irregular buildings are more vulnerable to seismic forces due to torsional effects and uneven load distribution [9], [10].

Plan irregularities such as L-shape, T-shape, and buildings with re-entrant corners create stress concentration and increase displacement and drift during earthquakes. Research indicates that irregular buildings experience higher storey drift and displacement compared to regular buildings [5], [8]. In addition, torsional effects due to asymmetry between center of mass and center of stiffness can lead to severe damage in structural elements [10]. Therefore, understanding the behavior of irregular structures is very important for safe design.

Another important factor affecting seismic performance is soil condition. The type of soil (hard, medium, or soft) influences the response of the building during earthquake. Studies have shown that buildings on soft or medium soil experience higher displacement and drift compared to those on hard soil [2], [8]. Soil-structure interaction also plays a significant role in determining the overall response of the structure. Short column effect is another major issue observed in buildings, especially those constructed on sloping ground or with partial infill walls. Short columns have higher stiffness and attract larger shear forces, which may lead to sudden failure during earthquakes [6], [15]. Proper design and strengthening measures are required to reduce the impact of short column behavior. For seismic analysis, both static and dynamic methods are used. Equivalent static analysis is simple but may not provide accurate results for complex structures. Dynamic analysis methods such as response spectrum and time history analysis give more realistic results by considering inertia and time-dependent forces [3], [12]. Hence, modern design practices prefer dynamic analysis for better safety and performance.

Recent studies also highlight that in tall buildings, wind load may dominate over earthquake load beyond certain heights, depending on soil condition and location [1]. Therefore, it is important to consider both wind and seismic forces during design of high-rise structures. From the above discussion, it is clear that various factors such as building configuration, soil type, short column effect, and analysis method play a crucial role in determining the seismic performance of multi-storey buildings. This review paper focuses on comparing the behavior of regular and irregular buildings in different seismic zones based on various research studies. The aim is to understand the key parameters affecting structural performance and to provide useful insights for safe and economical design of buildings in earthquake-prone areas.

II. LITERATURE REVIEW

[1] Digvijay S. Hada et al. (2025) conducted a study titled "Comparative Analysis of a Square Tall Building for Dominating Effect of Earthquake or Wind". The study analyzed tall buildings of heights ranging from 26 m to 104 m under different seismic zones (IV and V), soil conditions (hard and loose), and varying wind speeds. The objective was to identify whether wind load or earthquake load governs the design at different building heights. The results showed that wind forces become dominant over seismic forces beyond certain building heights, especially in loose soil conditions and higher wind speeds. It was observed that in seismic Zone V with loose soil, wind loads dominate for buildings taller than 64 m and above, while in Zone IV, wind dominance occurs at comparatively lower heights. Additionally, it was found that soil conditions have a greater influence than seismic zones for buildings below 64 m. The study concluded that both wind and earthquake loads must be carefully considered in tall building design, and identifying the dominant load helps in optimizing design and reducing time and resources.

[2] Gunjan Pradiprao Dihiye et al. (2025) conducted a study titled "Analysis and Design of Multistoried Building by Using Software for Different Earthquake Zones: A Review". The study summarized various research works related to seismic analysis of multi-story buildings using software tools like ETABS and STAAD-Pro. The review highlighted that the use of shear walls significantly improves seismic performance by reducing storey drift and increasing base shear resistance in both regular and irregular structures. It was observed that irregular buildings are more prone to higher deformation and torsional effects during earthquakes. The study also emphasized the importance of dynamic analysis methods such as response spectrum and time history analysis. It concluded that proper adherence to seismic codes and use of advanced analysis methods are essential for safe design.

[3] Akash Prasad Rauniyar et al. (2024) conducted a study titled "Comparative Study of Static and Dynamic Analysis of Multistoried Building". In this study, G+10 and G+25 RCC buildings were analyzed in seismic Zone IV using ETABS software. Both static and response spectrum methods were used to evaluate displacement, drift, and support reactions. The results showed that static analysis alone is not sufficient, while dynamic analysis provides more realistic structural behavior. The study concluded that response spectrum analysis is more reliable for seismic design.

[4] Aditya Kumar et al. (2023) conducted a study titled "Comparison of Analysis and Design of Regular and Irregular Configuration of Multi-Story Building in Various Seismic Zones and Short Column Effect through Various Types of Soils using STAAD". The study analyzed a G+4 RCC building on flat and sloping ground. The results showed that short columns attract higher shear forces and bending moments due to increased stiffness. It was also observed that sloping ground buildings experience higher displacement and torsional effects. The study suggested shear walls to improve performance.

[5] Hemant Singh Rathore et al. (2022) conducted a study titled "Seismic Analysis of Irregular Buildings with Re-Entrant Corners and AAC Blocks". The study analyzed L-shaped buildings with different configurations using ETABS. The results showed that irregular buildings have higher drift and displacement. Use of AAC blocks reduced seismic weight, and shear walls significantly improved stability.

[6] Aditya Kumar et al. (2022) conducted a study titled "Comparison of Analysis and Design of Regular and Irregular Configuration of Multi-Story Building in Various Seismic Zones and Short Column Effect". The study showed that short columns attract higher forces and are more prone to failure, especially in sloping ground conditions. Strengthening methods were recommended.

[7] Umesh Tumbahang et al. (2022) conducted a study titled "Seismic Study of RCC Building with Regular and Irregular Plan Using NBC 105:2020". The study analyzed G+9 buildings using ETABS. The results showed that irregular buildings have higher displacement, drift, and torsion. The study concluded that regular buildings perform better under seismic loading.

[8] Shaikh Shoaib Akthersalim et al. (2021) conducted a study titled "Comparison of Analysis and Design of Regular and Irregular Configuration of Multi-Story Building". The study analyzed G+11 buildings in Zones III and IV. The results showed that irregular buildings exhibit higher displacement and drift, especially in medium soil conditions.

[9] Mohd Abdul Aqib Farhan et al. (2019) conducted a study titled "Seismic Analysis of Multistoried RCC Buildings Regular and Irregular in Plan". The study found that irregular buildings have higher displacement due to torsional effects, while regular buildings show higher storey shear.

[10] Mohammad Aslam Faqueer Mohammad et al. (2019) conducted a study titled "Seismic Performance Assessment of Irregular RC Building". The study showed that plan irregularity leads to torsional effects and higher damage. It was also concluded that standard response reduction factor may not be suitable for irregular buildings.

[11] Albert Philip et al. (2017) conducted a study titled "Seismic Analysis of High Rise Buildings with Plan Irregularity". The study found that displacement increases with height and irregular buildings show higher drift and variation in stiffness.

[12] Imranullah Khan et al. (2017) conducted a study titled "Seismic Analysis of Irregular L-Shape Building in Various Zones". The study concluded that L-shaped buildings are more vulnerable due to uneven mass and stiffness distribution.

[13] B. S. Yashaswini et al. (2017) conducted a study titled "Comparative Study on Static and Dynamic Analysis of Multistoried Building Using ETABS". The study concluded that dynamic analysis gives more accurate results compared to static analysis.

[14] S. Mahesh et al. (2014) conducted a study titled "Comparison of Analysis and Design of Regular and Irregular Configuration of Multi Story Building". The study showed that irregular buildings have higher drift and displacement, and soft soil leads to maximum response.

[15] Keyvan Ramin et al. (2014) conducted a study titled "Study of Short Column Behavior Originated from the Level Difference on Sloping Lots during Earthquake". The study focused on the behavior of short columns formed due to level differences in buildings constructed on sloping ground. A four-storey reinforced concrete building was analyzed using STAAD Pro and SAP2000 software through both numerical and nonlinear static (pushover) analysis. The results showed that short columns develop higher shear forces and bending moments due to their increased stiffness, making them more vulnerable during earthquakes. It was also observed that sloping ground structures experience higher internal forces, while flat ground structures show greater displacement. The study concluded that short columns require stronger sections, increased reinforcement (especially stirrups), and retrofitting methods such as FRP or steel jacketing to improve their seismic performance and safety.

III. RESEARCH GAP

From the above literature review, it is observed that many researchers have studied the seismic behavior of regular and irregular buildings under different seismic zones and soil conditions. Most of the studies focus on parameters like storey drift, displacement, base shear, and torsional effects using software such as ETABS and STAAD. Also, some studies have considered the short column effect and use of shear walls to improve structural performance. However, there are still some gaps in the existing research. Very few studies have combined all important factors like plan irregularity, short column effect, soil type, and both static and dynamic analysis in a single study. Also, limited research is available on comparison of building performance considering both earthquake and wind effects together, especially for medium-rise buildings. Most of the studies are based on standard models and do not consider real site conditions or practical construction issues. In addition, there is less focus on optimizing structural design for both safety and economy. Therefore, there is a need to carry out a comprehensive study which includes all these factors together to better understand the actual behavior of buildings and to improve seismic design for safe and economical construction.

CONCLUSION

From the present review study, it can be concluded that the seismic behavior of multi-storey buildings is highly influenced by their structural configuration, soil condition, and analysis method used. Regular buildings show better performance due to uniform distribution of mass and stiffness, while irregular buildings are more vulnerable to earthquake forces due to torsional effects and uneven load distribution. It is also concluded that soil condition plays a very important role, as buildings on soft soil experience higher displacement and drift compared to hard soil. The short column effect is identified as one of the major causes of structural failure, especially in sloping ground buildings. Dynamic analysis methods such as response spectrum and time history analysis provide more accurate results compared to static methods and should be preferred for seismic design. The use of shear walls, proper reinforcement detailing, and adherence to IS codes significantly improves structural performance.

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