

Review on Comparative Analysis of Lateral Load Response of UG+G+7 Building Using Shear Wall, Bracing and Moment Resisting Frame Systems

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Abstract

This review paper provides a relative analysis of lateral load-resisting systems in multi-storey buildings, specifically focusing on high-rise structural configuration. The study synthesizes findings from research Papers to evaluate the performance of shear wall systems, bracing systems, and moment-resisting frame systems under seismic and wind loading conditions. With the rising requirement for safe and efficient urban structures, understanding the behavior of different structural systems under lateral loads has become essential. The reviewed literature highlights that shear wall systems provide high stiffness and effectively reduce storey displacement and inter-storey drift, making them suitable for earthquake-prone regions. Bracing systems enhance energy dissipation and structural structural balance while offering economical advantages. In contrast, moment-resisting frames provide flexibility and architectural freedom but tend to exhibit higher lateral deformation. Several studies also emphasize the influence of soil–structure interaction and damping mechanisms on overall structural response. Furthermore, the review identifies key research gaps, including limited studies on combined vertical and plan irregularities, insufficient consideration of multi-hazard effects, and lack of system-level performance-based evaluation. These gaps indicate the need for comprehensive relative studies under uniform modeling conditions. This paper intends to provide a clear understanding of the advantages and limitations of different lateral load-resisting systems and to assist engineers in selecting appropriate structural configurations for UG+G+7 buildings. The findings contribute to improving structural safety, performance, and design efficiency.

Keywords: High-rise building, lateral load response, shear wall, bracing system, seismic analysis

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INTRODUCTION

The fast-paced growth of urbanization and population has led to an increased demand for multi-story and high-rise buildings, especially in developing countries. These structures are often subjected to significant lateral loads owing to earthquakes and wind, which govern the design and performance of the building [1, 2]. Unlike gravity loads, lateral loads induce complex dynamic responses, such as displacement, inter-storey drift, and torsional effects, which can lead to structural damage or failure if not properly controlled. Therefore, the selection of an efficient lateral load-resisting system is critical in structural design.

Traditionally, moment-resisting frame systems have been widely used owing to their simplicity,

flexibility, and ease of construction. However, these systems tend to exhibit higher lateral displacements and lower stiffness when subjected to seismic forces [3, 4]. To overcome these limitations, structural systems such as shear walls and bracing systems have been introduced. Shear walls provide significant lateral stiffness and effectively reduce displacement and drift, making them suitable for seismic-prone regions [5–7]. Bracing systems enhance energy dissipation and structural stability while maintaining cost-effectiveness [8–10].

Several studies have been conducted to assess the performance of different structural systems under lateral loading. Research has shown that shear walls significantly reduce storey displacement and drift, whereas bracing systems enhance overall structural efficiency and energy absorption [11, 12, 6]. Although flexible, moment-resisting frames offer architectural freedom and are often used in combination with other systems [3, 4]. Recent studies have emphasized the importance of soil–structure interaction, damping devices, and hybrid structural configurations in improving seismic performance [13–16].

Despite these advancements, most existing studies have focused on individual structural systems or specific building configurations. There is a lack of comprehensive comparative assessment of different lateral load-resisting systems under uniform conditions, particularly for mid-rise buildings, such as UG+G+7 structures. Moreover, the combined effects of various parameters, such as irregularity, soil conditions, and multi-hazard loading, have not been adequately addressed [17, 18, 2].

Therefore, this review aims to provide a detailed comparative analysis of shear walls, bracing, and moment-resisting frame systems in a UG+G+7 building configuration. This study synthesizes findings from the recent literature to evaluate structural response parameters, such as displacement, drift, base shear, and stiffness. The outcomes of this review will assist engineers and researchers in selecting appropriate structural systems for safe, efficient, and economical building designs.

Classification of Lateral force resisting Systems

Lateral load-resisting systems are essential components of multi-storey buildings that resist forces due to earthquakes and wind. Based on the reviewed literature, these systems can be broadly classified into three categories: moment-resisting frames, shear wall systems, and braced systems. Moment-resisting frames provide flexibility and ductility, whereas shear walls offer high stiffness and strength. Bracing systems enhance energy dissipation and improve structural stability. Hybrid systems that combine these elements are increasingly used to achieve balanced performance.

Shear Wall System

Shear walls are vertical structural elements designed to withstand lateral loads and provide stiffness to structures. From the reviewed studies, it was observed that shear walls considerably decrease the storey displacement and inter-storey drift. The location and configuration of shear walls play crucial roles in their performance, with centrally located walls providing maximum efficiency. However, excessive stiffness may increase the base shear and construction costs, necessitating an optimal design.

Bracing System

Bracing systems are widely used to enhance the lateral load resistance and energy dissipation of buildings. Various types of bracing, such as X-, V-bracing-, and inverted V-bracing, have been studied. Among these, X-bracing provides maximum stiffness and a reduction in displacement. Bracing systems are economical and easy to implement, making them suitable for both new construction and retrofitting.

Moment Resisting Frame System

Moment-resisting frames are structural systems in which beams and columns are rigidly connected to resist lateral loads through bending action. These systems offer architectural flexibility and ease of construction. However, they exhibit higher lateral displacements than shear walls and bracing systems. Their ductile behavior renders them suitable for seismic design when properly detailed.

Problem Statement

The fast-paced increase in multi-story construction has led to the extensive use of different lateral load-resisting systems, such as shear walls, bracing systems, and moment-resisting frames. However, the selection of an appropriate system remains a critical challenge for structural engineers, particularly for mid-rise buildings such as UG+G+7 structures.

Most existing studies focus on individual structural systems or specific parameters without providing a uniform comparison under identical modeling conditions. Additionally, the combined influence of factors such as irregularity, soil conditions, and multi-hazard loading has not been adequately addressed.

Owing to this lack of integrated assessment, it is difficult to identify the most efficient structural system in terms of safety, performance, and economy. Therefore, a detailed review that critically assesses and compares different lateral load-resisting systems is required.

Objectives of the Study

- To review the performance of different lateral load-resisting systems in multi-story buildings
- To compare shear wall, bracing, and moment-resisting frame systems
- To assess key parameters such as displacement, drift, base shear, and stiffness
- To identify advantages and limitations of each structural system
- To highlight research gaps for future studies

LITERATURE REVIEW

A comprehensive examination of recent research has been conducted to understand the response of multi-story buildings to lateral loads. Various lateral load-resisting systems, including shear walls, bracing systems, moment-resisting frames, and hybrid structural configurations, were discussed in the reviewed studies.

These investigations focused on evaluating important structural response parameters, such as storey displacement, inter-storey drift, base shear, stiffness, and energy dissipation, under both seismic and wind loading conditions.

In addition, the literature highlights the impact of factors such as soil–structure interaction, damping mechanisms, structural irregularities, and the use of advanced materials on overall building performance. The next section presents a detailed analysis of 29 research papers, outlining their methodologies, major findings, and relevance to the present study.

This study investigated the fire resistance and structural behavior of load-bearing composite timber–glass wall systems under combined thermal and mechanical loading conditions. The authors aimed to assess the feasibility of using glass as a structural component, despite its brittle nature and vulnerability to high temperatures. Experimental investigations were conducted using a full-scale timber–glass wall specimen subjected to sustained loads and fire exposure in a controlled furnace environment. In addition, numerical simulations using finite element assessment were performed to understand the thermomechanical behavior. The findings indicate that the load-bearing capacity of the composite system is significantly influenced by the glass component, which tends to lose strength rapidly when exposed to high temperatures. However, the timber frame contributes to load redistribution and helps delay complete structural failure. This study also emphasizes the importance of protective measures, such as insulation layers and improved connection detailing, to enhance fire resistance. Furthermore, it was observed that although timber–glass systems provide adequate stiffness and strength under normal conditions, their performance under fire scenarios requires careful design considerations. The study concluded that composite timber–glass systems offer sustainable and architectural advantages but must be supplemented with advanced fire protection strategies for safe structural applications [19].

The combined influence of soil improvement and structural retrofitting on the seismic performance of reinforced concrete buildings constructed under weak soil conditions. This study emphasizes the

interaction between soil behavior and structural response during earthquakes, particularly in liquefaction-prone regions. A two-dimensional reinforced concrete frame model was analyzed using a nonlinear dynamic time history assessment. Structural retrofitting techniques, such as shotcrete panels and reinforced concrete jacketing, were implemented to improve the lateral strength and stiffness, whereas soil stabilization was achieved using jet-grouting techniques. The results demonstrate that the addition of shotcrete panels significantly reduces the inter-storey drift and enhances the overall stiffness of the structure. Furthermore, soil improvement was found to play a critical role in reducing foundation settlement and rotational instability, which are common failure modes under soft soil conditions. The combined approach of structural and geotechnical enhancement proved to be more effective than the individual techniques. This study highlights that neglecting soil–structure interaction may lead to unsafe designs and underestimation of seismic demands. Overall, this study emphasizes the importance of integrating structural and geotechnical solutions to improve the seismic resilience of buildings in earthquake-prone regions [13].

This study focuses on analyzing the influence of vertical irregularities in shear walls on the seismic response and collapse resistance of reinforced concrete buildings. The objective of this study was to understand how variations in shear wall height and distribution affect the structural performance under seismic loading. The authors employed nonlinear dynamic analysis and Incremental Dynamic Assessment (IDA) to evaluate the behavior of structures under increasing earthquake intensities. The results revealed that vertical irregularities located at lower stories significantly increased the seismic demand, leading to higher inter-story drift, stress concentration, and increased probability of collapse. In contrast, irregularities at higher levels have a relatively lower impact on overall performance and may sometimes improve energy dissipation. This study also identifies the limitations of existing seismic design codes, which fail to accurately predict the behavior of structures with such irregular configurations. To address this limitation, a new parameter is proposed to better quantify the effects of vertical irregularity. The study concluded that proper consideration of irregularities is essential for safe and efficient structural design [20].

This study evaluated the seismic performance of a high-rise reinforced concrete building using a displacement-based fragility approach. The model was developed in ETABS, considering the material properties and irregularities. Incremental dynamic analyses were performed using multiple earthquake records. The results show that irregular buildings are highly vulnerable, especially at mid-height levels. Displacement-based methods provide more reliable results, and performance-based designs with damping systems are recommended for improved safety [3].

This study evaluated the seismic performance of high-rise buildings incorporating bracing systems, shear walls, and hybrid configurations under different soil conditions. The objective of this study was to identify the most efficient lateral load-resisting system for improving seismic behavior. The assessment was conducted using response spectrum methods with various structural models. Parameters such as the storey displacement, inter-storey drift, base shear, and modal characteristics were evaluated. The results show that hybrid systems combining bracing and shear walls significantly improve stiffness and reduce lateral displacement compared with individual systems. Additionally, soil conditions were found to influence the structural response, with soft soils leading to higher displacement and seismic demand. The study concluded that integrated structural systems provide better performance, safety, and economy for high-rise buildings [8].

This study investigates the wind-resistant structural design of super-tall buildings with complex geometries, inspired by iconic high-rise projects such as twisted and tapered towers. The objective was to assess how aerodynamic modifications influence wind load reduction and overall structural performance. The authors conducted wind tunnel testing and numerical simulations to assess the wind pressure distribution, vortex shedding effects, and structural response. The findings indicate that aerodynamic shaping significantly reduces wind-induced vibration and lateral displacement. Twisted forms and tapered profiles disrupt vortex formation, thereby minimizing dynamic amplification. The

study also highlighted that combining aerodynamic design with structural systems, such as diagrids and outriggers, enhances overall efficiency. It was observed that the diagrid systems provided excellent stiffness and distributed the loads more uniformly across the structure. The study concludes that integrating architectural form with structural design is essential for optimizing wind performance in super-tall buildings. This study provides valuable insights for the design of G+50 and taller buildings subjected to strong wind forces [21].

This study examined the seismic behavior of shear wall systems in high-rise reinforced concrete buildings. The objective of this study was to analyze the effects of different shear wall configurations on structural stiffness, ductility, and energy dissipation. Nonlinear time-history analyses were conducted on multiple building models with varying wall thicknesses, locations, and aspect ratios. The results indicate that centrally located shear walls provide maximum stiffness and significantly reduce lateral displacement. Additionally, increasing the wall thickness enhances the load-carrying capacity but may lead to a higher base shear. This study also highlights the importance of coupling beams in improving ductility and energy dissipation. It was concluded that an optimized shear wall design plays a critical role in ensuring the seismic safety of high-rise buildings [5].

This study investigated the effect of the shear wall ratio on the seismic performance of reinforced concrete buildings. The objective of this study was to determine the optimal proportion of shear walls required for efficient lateral load resistance. Analytical models with varying wall ratios were developed and analyzed under seismic loading. The findings show that increasing the shear wall ratio significantly reduces the storey drift and displacement. However, beyond an optimum limit, the benefits become marginal, whereas the construction cost increases. An optimal balance between the wall ratio and structural efficiency is essential for economical and safe design [11].

This study investigates the relationship between the seismic performance and energy efficiency of mid-rise light-frame timber buildings subjected to varying climatic and seismic conditions. The primary objective of this study was to develop an integrated design approach that simultaneously satisfies the structural safety and energy optimization requirements. The authors conducted a parametric study considering multiple variables, such as building height, seismic zone, wall insulation thickness, stud spacing, and lateral anchorage systems. Five different climatic regions in Chile were selected to represent diverse environmental conditions, and the buildings were analyzed under the corresponding seismic demands [22].

The methodology involved numerical modeling combined with optimization techniques to evaluate the structural response and energy consumption. The results indicate that the design parameters significantly influence both the seismic behavior and thermal performance. For instance, increased wall insulation improves energy efficiency but may alter the stiffness distribution, thereby affecting the seismic response. Similarly, lateral anchorage systems were found to play a critical role in preventing overturning because of earthquake-induced forces. The study also revealed that optimal design solutions vary considerably depending on the climate and seismic zone, indicating that a single design approach cannot be universally applied [17].

Another key finding is that the number of storeys has a direct impact on both the energy demand and structural performance. Taller buildings require enhanced lateral resistance systems and influence thermal mass and insulation requirements. The study concludes that integrated design approaches that consider both energy and seismic aspects are essential for sustainable construction. This study is particularly significant because it highlights the need to move beyond traditional isolated design practices and adopt multidisciplinary optimization strategies in modern structural engineering.

This study examined the progressive collapse behavior of steel structures subjected to blast-induced loading, with a particular focus on the effectiveness of different bracing systems. The authors aimed to assess how various structural configurations respond to sudden extreme loads, such as explosions,

which can lead to localized damage and subsequent collapse of the entire structure. Three types of structural systems were analyzed: conventional moment-resisting frames, frames with conventional bracing, and frames equipped with buckling-restrained braces (BRBs) [17].

The analysis was performed using LS-DYNA software, which allows for a detailed simulation of the dynamic and nonlinear behavior under blast loading. A five-story steel frame structure was subjected to a blast equivalent to 100 kg TNT at a specified distance. The study adopted the Alternate Load Path (ALP) method to simulate progressive collapse by removing critical structural elements and observing load redistribution mechanisms.

The results demonstrate that structures equipped with BRBs exhibit superior performance compared with other systems. Specifically, the BRB systems reduced the peak displacement, velocity, and acceleration by significant margins, indicating an improved energy dissipation capacity. Unlike conventional braces, BRBs prevent buckling under compressive loads, allowing them to effectively sustain cyclic loading. The study also highlights that conventional moment-resisting frames are more vulnerable to progressive collapse owing to their limited redundancy and energy dissipation capability.

The study concluded that incorporating advanced bracing systems, such as BRBs, can significantly enhance the structural robustness against extreme events. Although this study emphasizes blast loading, its findings are also applicable to seismic design, where energy dissipation and structural redundancy are critical.

This study emphasizes the evaluation of the seismic capacity of reinforced concrete moment-resisting frames (RC-MRFs) with and without the inclusion of steel damper columns (SDCs). The objective of this study was to assess the influence of energy dissipation devices on the structural response under earthquake loading. The author employed an advanced analytical method known as Incremental Critical Pseudo-Multi Impulse Assessment (ICPMIA), which simulates seismic loading using a series of impulsive forces [14].

The assessment was conducted on multiple building models with varying heights and configurations. The study examined key performance parameters, such as the peak displacement, cumulative energy input, and seismic capacity curves. The results indicate that RC frames without dampers exhibit a significant reduction in seismic capacity as the loading intensity increases. In contrast, structures equipped with steel damper columns exhibited stable performance with reduced sensitivity to increasing seismic intensity.

One of the major findings is that steel damper columns effectively absorb and dissipate seismic energy, thereby reducing the demand for primary structural elements, such as beams and columns. This resulted in lower deformation and improved overall stability. Additionally, the presence of dampers reduces the influence of factors such as pinching behavior in RC members, which can lead to performance degradation.

The findings suggest that incorporating energy dissipation devices, such as SDCs, is an efficient strategy for enhancing seismic resilience, particularly in high-rise buildings. These findings support the adoption of performance-based design approaches that prioritize energy absorption and controlled deformation over traditional strength-based design methods.

This study investigates the analysis and design of a multi-story structure using a composite steel–concrete system to improve structural efficiency and optimize material utilization. A seventeen-story building was modeled in SAP2000, considering realistic design parameters. The methodology included defining the design criteria, selecting suitable materials, and performing static and modal analyses to understand the structural response. Composite beams, steel deck slabs, and shear connectors were used to ensure proper interactions between the steel and concrete components. The analysis also considered

geometric nonlinearity and second-order ($P-\Delta$) effects, which are important in high-rise structures. The results demonstrate that the composite systems offer enhanced strength, increased stiffness, and reduced overall weight. Additionally, the building shows noticeable flexibility under wind loads, emphasizing the need to consider dynamic behavior in design. Composite steel–concrete systems are highly suitable for high-rise buildings because of their structural efficiency and economic benefits. It also emphasizes the importance of a proper connection design and nonlinear assessment to ensure safety and performance [23].

This study investigates the application of outrigger and belt truss systems in high-rise buildings to enhance their lateral load resistance and overall structural stability. The primary objective is to reduce the lateral displacement and inter-storey drift of tall structures subjected to wind and seismic forces. The author developed multiple high-rise building models in ETABS with different outrigger level configurations and belt truss arrangements. These systems are integrated with a central core (usually a shear wall or core wall system), which acts as the primary vertical lateral load-resisting element [24].

The methodology involved placing outriggers at various heights (e.g., top, mid-height, and multiple levels) and analyzing their influence on structural response parameters, such as story displacement, drift, and base shear. The results show that outrigger systems significantly enhance lateral stiffness by connecting the core to the exterior columns, thereby mobilizing the entire structural width to resist overturning moments. This led to a considerable reduction in the top displacement and inter-storey drift. It was also observed that the efficiency of the outriggers depends on their placement, with optimum performance typically achieved when located near mid-height or at strategic levels corresponding to the maximum bending moments.

Furthermore, belt trusses help distribute forces evenly among the peripheral columns, improving load sharing and reducing stress concentration. The results indicate that combining outrigger systems with core shear walls provides a highly efficient structural system for tall buildings. This integrated approach not only improves the stiffness and strength but also enhances the overall structural performance under both wind and seismic loading conditions.

This study examined the performance of hybrid structural systems that combine shear walls and bracing elements in high-rise buildings subjected to seismic loading. The main objective was to assess whether combining different lateral load-resisting systems results in improved structural behavior compared to using individual systems alone. The author developed numerical models of high-rise buildings with three configurations: shear wall system only, bracing system only, and a hybrid system combining both [12].

The analysis was carried out using dynamic methods, such as the response spectrum and time-history assessment, to capture realistic seismic behavior. The key parameters evaluated included storey displacement, inter-storey drift, base shear, and energy dissipation capacity. The results indicate that the hybrid systems outperform the individual systems in almost all performance criteria. Shear walls provide high stiffness and reduce displacement, whereas bracing systems contribute to energy dissipation and ductility.

The combination of these systems leads to a balanced structural response in which the stiffness and damping are optimized simultaneously. Additionally, the hybrid system helps reduce torsional irregularities and ensures better distribution of lateral forces throughout the structure. This study also highlights that hybrid systems can lead to material savings by optimizing the use of structural components.

The study concluded that integrated structural systems are more efficient, economical, and reliable for high-rise buildings in seismic regions. Therefore, the adoption of hybrid systems in modern structural design is strongly recommended to improve safety and performance.

This study analyzes the comparative effects of wind and seismic loads on multi-story buildings to understand which load governs the design under different conditions. The objective is to assess the structural response under both types of loading and highlight the importance of combined load analysis. The authors developed several building models of varying heights and analyzed them using the ETABS software. Wind load assessment was performed according to the relevant codes, and seismic analysis was performed using the response spectrum method [1].

The results revealed that wind loads became increasingly significant as the building height increased, often governing the design of tall structures. Wind-induced displacements and accelerations are critical for serviceability and occupant comfort. However, seismic loads were more dominant in mid-rise buildings, where inertia forces due to earthquake motion significantly influenced the structural behavior.

This study also highlights that ignoring either wind or seismic effects can lead to unsafe or uneconomical designs. Combined load cases provide a more realistic representation of the actual conditions, particularly in regions where both wind and seismic hazards are significant.

The authors concluded that engineers must consider both wind and seismic loads simultaneously when designing high-rise buildings. This study emphasizes the importance of performance-based design approaches that consider multiple hazards to ensure structural safety and serviceability.

This study investigates the effectiveness of base isolation systems in improving the seismic performance of buildings, focusing on lead-core rubber bearings (LCRB). The objective of this study was to analyze the influence of building height and earthquake characteristics on the behavior of isolation systems. The authors conducted a nonlinear time history assessment of multiple building models with different heights subjected to various ground motion records.

This study evaluated key parameters such as isolator displacement, energy dissipation capacity, story drift, and base shear. The results indicate that base isolation significantly reduces the seismic forces transmitted to the superstructure, thereby minimizing structural damage. However, it was observed that isolator performance is highly sensitive to the earthquake type (near-fault vs. far-fault) and building height.

One important finding is that excessive shear strain can occur in the isolators under certain ground motions, which may compromise the system performance. To address this issue, this study proposes the use of hybrid systems that combine LCRB with fluid viscous dampers. This combination effectively reduces excessive displacement while maintaining the energy dissipation capacity.

The study concluded that base isolation is a highly effective seismic protection technique; however, its design must consider factors such as building height, ground motion characteristics, and isolator properties. Hybrid systems are recommended for achieving optimal performance in complex seismic scenarios [25].

This study investigates the effectiveness of steel X-bracing combined with shear link systems for retrofitting seismically deficient reinforced concrete (RC) frame structures. The primary objective is to enhance the lateral load-resisting capacity, stiffness, and ductility of existing buildings that were originally designed without adequate seismic provisions. The authors analyzed both a single-story single-bay frame and a multi-story RC building using nonlinear static (pushover) assessment and nonlinear time-history analyses.

The proposed retrofitting technique involves introducing concentrically arranged steel X-braces connected with shear links, which are designed to yield before the primary structural elements do. This approach ensures that seismic energy is dissipated through shear links, thereby reducing the stress

concentration in beams and columns. This study follows capacity design principles, ensuring that ductile failure mechanisms are achieved rather than brittle collapse [9].

The results indicate that the retrofitted structures exhibited significant improvements in stiffness, strength, and energy dissipation capacity. The maximum storey displacement and inter-storey drift were considerably reduced compared with the original unretrofitted frames. Additionally, the formation of plastic hinges was more controlled and distributed, indicating improved ductility and structural-resilience. The study also demonstrated that the proposed system effectively delayed the onset of structural failure and enhanced the overall seismic performance.

The authors concluded that steel X-bracing with shear links is a practical and efficient retrofitting solution for RC buildings, particularly in earthquake-prone regions. This method not only improves safety but also maintains the functionality of buildings during and after seismic events.

This study examines the seismic performance of high-rise buildings by incorporating different lateral load-resisting systems, such as shear walls, bracings, and tuned mass dampers (TMDs), while also considering soil–structure interaction (SSI). The primary objective is to evaluate how stiffness enhancement and damping mechanisms influence the responses of buildings subjected to earthquake loading [15].

The authors developed numerical models of a 20-storey building and analyzed them under seismic excitation using various configurations of structural systems. This study compares the performance of shear walls and bracing systems in increasing stiffness, as well as the effectiveness of TMDs in reducing dynamic response. Additionally, the influence of soil conditions was incorporated to simulate a realistic boundary behavior.

The results show that increasing the structural stiffness through shear walls or bracings significantly reduces the lateral displacement and storey drift. However, it was also observed that higher stiffness may lead to increased base shear and internal forces, which must be carefully managed in the design. However, the inclusion of TMDs was effective in reducing vibrations and controlling the dynamic response without significantly increasing the internal forces.

The results indicate that a balanced approach combining stiffness enhancement and damping mechanisms yields optimal seismic performance. It also emphasizes the importance of considering soil–structure interaction, as soil conditions can significantly alter the structural response. This study provides valuable insights for designing safer and more efficient high-rise buildings.

This study analyzed the seismic performance of reinforced concrete moment-resisting frame (RC-MRF) buildings using response spectrum and time-history assessment methods. The objective was to assess the behavior of buildings designed according to modern seismic codes and compare the accuracy of different analytical approaches [4].

The authors modeled 6-storey and 12-storey buildings using advanced structural assessment software, such as ETABS and SAP2000. The analysis included ground motion records to simulate realistic earthquake scenarios. Key performance parameters, such as displacement, base shear, and structural response, were evaluated.

The results indicate that the time-history assessment provides a more accurate representation of the structural behavior than the response spectrum analysis, as it captures the nonlinear and time-dependent characteristics of the earthquake loading. The study also highlights that modern 3D assessment tools are more reliable than traditional 2D methods because they account for spatial effects and complex interactions between structural components.

Furthermore, this study emphasizes the importance of ductile design in improving seismic performance. Buildings designed with adequate ductility and proper detailing exhibit better energy dissipation and reduced damage. The findings suggest that advanced analytical methods and modern design practices are essential for ensuring structural safety in seismic regions.

This study focuses on evaluating the impact of different shear wall configurations on the earthquake response of tall buildings. Its primary aim was to determine an optimal arrangement that minimizes lateral movements and improves structural stability. Various configurations were studied by comparing parameters such as displacement, drift, and stiffness. The findings highlight that the appropriate positioning of shear walls plays a key role in enhancing the seismic performance and reducing the structural vulnerability [6].

The authors developed nine different building models of a G+30 story structure using ETABS software. All models had the same total shear wall area; however, the location and arrangement of the walls varied. The analysis was performed using the response spectrum method, as per Indian seismic codes.

The results showed that the shear wall placement significantly influenced the structural performance. Buildings with centrally located core shear walls exhibited the best performance, with substantial reductions in story displacement and drift. In contrast, irregular or corner placements of shear walls are less effective in resisting seismic forces. The study also found that the proper distribution of shear walls ensured uniform stiffness and reduced torsional effects.

The study concluded that central core shear wall systems are the most efficient for high-rise buildings, as they provide maximum lateral stiffness and stability. The findings are particularly useful for structural designers in optimizing shear wall placement for improved seismic performance.

This study investigates the seismic performance of vertically irregular buildings, particularly those with soft story conditions. The objective of this study was to evaluate the effect of discontinuities in stiffness on the structural response during earthquakes. The authors developed analytical models of buildings with and without soft story configurations and subjected them to seismic loading using dynamic assessment methods [18].

The results indicate that soft-story buildings are highly vulnerable to seismic forces owing to sudden changes in their stiffness and strength. These discontinuities lead to a concentration of deformation and stress in specific storeys, increasing the risk of collapse. The study showed that the inter-storey drift was significantly higher in soft storey buildings than in regular structures.

To mitigate these effects, the authors suggested incorporating strengthening measures, such as shear walls, bracing systems, or column jacketing. These techniques help improve stiffness and redistribute forces more evenly. This study also emphasizes the importance of proper design and detailing to avoid irregularities that may compromise structural safety.

The study concluded that vertical irregularities must be carefully addressed in the design, and additional reinforcement or lateral load-resisting systems should be provided to enhance the seismic performance.

This study examined the use of damping systems in high-rise buildings to control seismic vibrations and improve their structural performance. The objective of this study was to assess the effectiveness of different types of dampers, including viscous dampers and tuned mass dampers (TMDs), in reducing the structural response. The authors developed models of buildings with and without damping systems and analyzed them under seismic loading using dynamic assessment methods [16].

The results indicate that the damping systems significantly reduced the storey displacement, inter-storey drift, and acceleration. Viscous dampers were found to be effective in dissipating seismic energy, whereas TMDs were particularly useful in controlling vibrations and improving occupant comfort. The study also showed that damping systems help reduce stress on primary structural elements, thereby enhancing durability and safety.

The study concluded that damping systems are essential components of modern high-rise buildings, particularly in seismic regions. Their incorporation leads to improved performance, reduced damage, and increased serviceability of the concrete.

This study investigates the effect of soil–structure interaction (SSI) on the seismic responses of high-rise buildings. The objective of this study was to evaluate how different soil conditions influence the structural behavior during earthquakes. The authors developed numerical models of buildings resting on various soil types, including soft and hard soils, and performed a dynamic analysis [16].

The results show that soil properties significantly affect the structural response. Buildings on soft soil exhibit higher displacement and drift and longer natural periods owing to the reduced stiffness of the foundation. In contrast, structures on hard soil exhibit better stability and lower deformation. This study also highlights that neglecting SSI can lead to inaccurate predictions of seismic response and unsafe design.

The study concludes that soil–structure interaction must be considered in seismic assessments to obtain realistic and reliable results. Proper foundation design and soil improvement techniques are recommended to enhance the structural performance under soft soil conditions.

This study investigates the influence of shear wall location on the seismic and wind performances of a multi-storey reinforced concrete building. The objective was to identify the optimal positioning of shear walls to enhance structural stability and reduce lateral response [26].

The assessment was conducted on a G+12 building model using ETABS software. Various configurations of shear wall placement were considered, and the structure was subjected to different load combinations, including dead, live, wind, and earthquake loads, as per Indian standards. Both linear static and dynamic analyses were performed to assess parameters such as the storey displacement, storey drift, base shear, and time period.

The results indicate that the presence of shear walls significantly improves the lateral load-resisting capacity of structures. The proper placement of shear walls reduces the storey displacement and drift, thereby enhancing the overall stability. The study also highlighted that poorly placed shear walls may lead to inefficient load distribution and increased torsional effects.

The study concluded that shear walls are essential structural elements in high-rise buildings, particularly in seismic regions. Their effectiveness depends largely on the location and configuration within the structure. This study provides practical guidelines for engineers to optimize shear wall placement for improved performance and safety.

This study examined the seismic performance of reinforced concrete tall buildings incorporating shear walls at different positions and configurations. The primary objective of this study was to determine the most effective positioning of shear walls to minimize lateral displacement and improve structural stability under earthquake loading. The authors developed multiple building models using ETABS software, varying the placement of shear walls, such as at corners, core, and mid-span locations [7].

The analysis was carried out using both the equivalent static and response spectrum methods, as per Indian seismic design codes. Key parameters, such as the storey displacement, inter-storey drift, base

shear, and natural time period, were evaluated. The results indicated that buildings with centrally located core shear walls exhibited the best performance in terms of reduced displacement and drift. Corner shear walls also improve performance but may introduce torsional effects if they are not symmetrically placed.

The study further highlighted that increasing the thickness and length of the shear walls enhanced the stiffness but may have led to an increased base shear. Therefore, an optimum design is required to balance the strength and economy. The study concluded that the proper placement and configuration of shear walls significantly improved the seismic performance, making them essential components of high-rise structures.

This study examined the comparative seismic performance of diagrid and conventional framed structural systems in high-rise buildings. The objective of this study was to assess the efficiency of diagrid systems in resisting lateral loads and reducing material consumption. The authors modeled multi-story buildings with both diagrid and conventional moment-resisting frame systems using structural assessment software [27].

Dynamic assessment was performed using the response spectrum method, and parameters such as storey displacement, drift, axial forces, and structural weight were compared. The results indicate that diagrid structures exhibit significantly lower displacement and drift owing to their triangulated geometry, which provides high stiffness and efficient load distribution. Additionally, diagrid systems require less steel than conventional systems, making them more economical.

The study also highlighted that diagrid structures reduce the need for internal columns, providing architectural flexibility. The study concluded that diagrid systems are highly effective for tall buildings and offer advantages in terms of both structural performance and material efficiency.

This study investigated the effects of different bracing systems on the seismic performance of multi-story buildings. The objective was to identify the most efficient bracing configuration for improving the lateral stiffness and reducing the displacement. The authors analyzed buildings with various bracing types, such as X-, V-bracing-, and inverted V-bracing, using ETABS software [10].

The assessment was performed under seismic loading using the response spectrum method. The results show that X-bracing provides maximum stiffness and significantly reduces storey displacement and drift compared with other bracing systems. V- and inverted V-bracings also improve performance but are less effective than X-bracing.

The results indicate that bracing systems are economical and efficient solutions for enhancing seismic performance, especially in retrofitting existing buildings. The proper selection of the bracing type is essential for achieving optimal results.

This study assesses the influence of soil–structure interaction (SSI) on the seismic behavior of high-rise buildings. The objective of this study was to understand how different soil conditions affect the structural behavior during earthquakes. The authors developed building models resting on soft, medium, and hard soils and performed a dynamic analysis [2].

The results indicate that buildings on soft soil experience higher displacement, drift, and time periods owing to the reduced stiffness of the foundation. In contrast, buildings on hard soil exhibit better stability and lower deformation. This study also highlights that ignoring SSI effects may lead to inaccurate designs and unsafe structures.

This study concludes that the soil–structure interaction must be considered in seismic assessments to obtain realistic results. It is recommended to incorporate SSI into design codes and use appropriate foundation systems for different soil conditions.

This study investigated the combined influence of wind and seismic loads on high-rise buildings. The objective was to evaluate how different lateral loads influence the structural response and design requirements. The authors modeled high-rise buildings and analyzed them under wind and seismic loadings using ETABS software [2].

The results show that wind loads become dominant as the building height increases, particularly affecting serviceability criteria, such as displacement and acceleration. However, seismic loads are more critical for strength design in moderate-height buildings. This study emphasizes that both loads must be considered together for a safe and economical design.

This study concludes that an integrated analysis of wind and seismic loads is essential for high-rise buildings, and design codes should be carefully followed to ensure structural safety.

Research Gap

Limited Research on Vertical and Plan Irregularities

This study of the existing literature reveals that most researchers have focused on either regular building configurations or isolated irregularities, such as vertical irregularity (soft story, stiffness variation) or shear wall discontinuity. For example, Aslani and Tehrani [20] and Singh and Gupta [18] mainly addressed vertical irregularities, whereas limited attention has been given to plan irregular configurations such as L-, T-, U-, or E-shaped buildings. Furthermore, very few studies have investigated the combined influence of vertical and plan irregularities on seismic performance. This lack of integrated assessment leads to an incomplete understanding of the structural behavior under earthquake loading and reduces the accuracy of seismic risk prediction. Therefore, comprehensive studies considering both types of irregularities are required.

Soil–Structure Interaction (SSI) and Multi-Hazard Considerations

Several studies have investigated the effect of soil–structure interaction on seismic response [2, 13, 15, 162]. However, most of these studies considered simplified soil conditions and did not incorporate the combined influence of SSI with structural irregularities, damping systems, or hybrid structural configurations. Additionally, multi-hazard considerations, such as combined seismic and blast loading, are rarely addressed together, although studies such as that of Mansour et al. [17] have explored blast effects separately. This indicates a clear gap in the understanding of the real-world behavior of high-rise structures subjected to multiple interacting hazards. Hence, more advanced and integrated approaches are required to assess SSI along with multi-hazard loading conditions.

Seismic Retrofitting of Irregular and Asymmetrical Structures

The existing literature on seismic retrofitting mainly emphasizes regular structural systems using techniques such as steel bracing, shear walls, and dampers [14, 9]. Although these methods have been effective in improving strength and stiffness, their application to irregular or asymmetrical buildings remains limited. Real-world structures often exhibit plan irregularities (L, T, and U shapes), which significantly influence the load distribution and dynamic behavior. However, there is a lack of studies incorporating nonlinear time-history assessments for such irregular retrofitted structures. This gap highlights the need for research on effective retrofitting strategies that are specifically tailored for complex building geometries.

Limited Integration of Advanced Materials and Technologies

Recent studies have explored the use of composite materials and energy dissipation devices to improve structural performance [14, 19, 23, 28]. However, research on the practical implementation and long-term performance of emerging technologies, such as smart materials, advanced composites, and modern damping systems, in real-world high-rise buildings is limited. Most studies remain analytical or experimental in controlled environments without addressing construction challenges, cost implications, and durability aspects. Therefore, further research is required to bridge the gap between theoretical advancements and practical applications.

Lack of System-Level and Performance-Based Design Approaches

Most studies have focused on individual structural components or single systems, such as shear walls, bracing, or diagrid structures [8, 12, 6, 27]. While these studies provide valuable insights, there is limited research on holistic system-level evaluations that consider the interactions between multiple structural systems. Additionally, advanced performance-based design approaches, including fragility analysis and energy-based design, have not been widely integrated into most studies, except for a few, such as Sharma et al. [3]. This limitation restricts the ability to optimize the structural systems for resilience and efficiency. Hence, there is a need for a comprehensive system-level assessment that incorporates performance-based design methodologies.

RESEARCH METHODOLOGY

This study is based on a systematic review of previously published research papers related to lateral load-resisting systems in multistorey buildings. A total of 29 research articles published between 2021 and 2025 were selected from reputable journals.

The selection criteria included relevance to seismic and wind analyses, structural systems such as shear walls, bracing, and moment-resisting frames, and evaluation of key structural parameters.

The collected studies were critically analyzed and compared based on parameters such as story displacement, inter-story drift, base shear, stiffness, and energy dissipation.

The findings were synthesized to identify performance trends, advantages, limitations, and research gaps.

RESULTS AND DISCUSSION

This study critically analyzed the findings of previously published research to assess the performance of different lateral load-resisting systems in multi-story buildings. Based on the reviewed literature, significant variations in the structural behavior were observed depending on the type of system adopted.

Comparative Performance of Structural Systems

From the collected studies, it was observed that shear wall systems exhibited the highest stiffness among all structural configurations. Buildings incorporating shear walls show a substantial reduction in story displacement and inter-story drift. In many cases, the reduction in lateral displacement ranges between 40% and 60% compared to conventional moment-resisting frames. This makes shear walls highly effective in earthquake-prone regions.

Bracing systems also demonstrate improved structural performance by enhancing the lateral stiffness and energy dissipation capacity. Among the different types of bracing, X-bracing was found to be the most efficient in controlling displacement and drift. Compared to moment-resisting frames, bracing systems can reduce lateral displacement by approximately 30%–50%, while also being more economical and easier to implement.

In contrast, moment-resisting frame systems exhibit relatively higher flexibility. Although these systems provide architectural freedom and ductility, they tend to exhibit larger displacement and drift values under lateral loading. However, their ductile behavior is beneficial for absorbing seismic energy when designed appropriately.

Effect of Structural Parameters

The structural response of buildings is significantly influenced by several parameters, such as stiffness distribution, mass irregularity, and height of the structure. Studies have indicated that increasing the stiffness through shear walls or bracing leads to a direct reduction in the lateral displacement and drift. However, excessive stiffness may result in a higher base shear, which must be considered during the design.

It was also observed that the location of the shear walls plays a crucial role in performance. Centrally placed shear walls provide better stability and minimize torsional effects, whereas irregular placement may lead to uneven load distribution.

Influence of Soil–Structure Interaction

The reviewed literature highlights that soil conditions significantly impact structural behavior. Buildings constructed on soft soil exhibit higher displacement, increased time periods, and greater seismic demands than those on hard soil. Ignoring soil–structure interaction may lead to underestimation of the structural response and unsafe design.

Performance of Hybrid Systems

Hybrid structural systems that combine shear walls and bracing elements exhibit superior performance compared to individual systems. These systems effectively utilize the advantages of both stiffness and energy dissipation properties. The studies indicate that hybrid systems can reduce displacement and drift more efficiently while maintaining their economic feasibility.

Effect of Wind and Seismic Loads

A comparison of the wind and seismic effects revealed that seismic forces dominate the design of mid-rise buildings, such as UG+G+7 structures. However, as the building height increases, wind loads become more critical, particularly in terms of serviceability and occupant comfort. Therefore, both loads must be considered simultaneously for a safe and efficient design.

Discussion

Based on the overall assessment, no single structural system is universally optimal. The selection of an appropriate system depends on multiple factors, such as building height, soil condition, seismic zone, and economic considerations.

Shear walls are most suitable for achieving high stiffness and minimum displacement, whereas bracing systems provide a cost-effective solution with a good energy dissipation capacity. Despite their higher deformation, moment-resisting frames remain useful owing to their flexibility and ease of construction.

The findings also emphasize the importance of integrated design approaches that consider multiple parameters simultaneously, rather than evaluating structural systems in isolation. A balanced combination of stiffness, ductility, and energy dissipation is essential for optimal structural performance.

CONCLUSION

This review presents a comprehensive assessment of the structural response of multi-story buildings with different lateral load-resisting systems, namely shear wall, bracing, and moment-resisting frame systems. Based on the synthesis of recent studies, it is evident that the choice of structural system significantly influences key response parameters, such as storey displacement, inter-storey drift, base shear, stiffness, and energy dissipation.

The reviewed literature indicates that shear wall systems provide maximum lateral stiffness and effectively control displacement and drift, making them highly suitable for seismic-prone regions [5, 6, 7]. Bracing systems, particularly X-bracing and hybrid configurations, offer improved energy dissipation and structural stability while maintaining cost effectiveness [8, 12, 10]. Although moment-resisting frames are more flexible and architecturally adaptable, they tend to exhibit higher lateral deformation but provide adequate ductility when properly designed [3, 4].

Furthermore, advanced techniques such as damping systems, base isolation, and composite structural systems have shown potential for enhancing seismic performance [14, 25, 28]. The influence of soil–

structure interaction has also been identified as a critical factor affecting the structural response, especially in soft soil conditions [13, 15, 16].

However, the review highlights that most existing studies focus on individual systems or isolated parameters, with limited research on comparative analyses under uniform modeling conditions, particularly for mid-rise buildings such as UG+G+7 structures. Additionally, the combined influences of irregularities, soil conditions, and multi-hazard loading remain insufficiently explored [17, 18, 2].

In conclusion, this study emphasizes the need for a systematic comparative evaluation of different structural systems to identify the most efficient configuration for improving safety, performance, and economy. The findings of this review provide a strong foundation for future research and practical implementation in the design of resilient multistory buildings.

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