Review on Seismic Analysis of Monolithic High-Rise Building and Comparison with Conventional Construction Techniques Using ETABS Software

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***Abstract*—** At present, fast-paced urbanization together with land unavailability in major cities has caused the extensive erection of tall buildings. One of the major concerns in the case of these structures is seismic safety, especially when they are located in regions that often suffer from earthquakes. While the traditional practice of using reinforced concrete (RCC) frames is a common one in construction, it tends to contribute to greater lateral displacements and storey drifts during seismic activity. Moreover, the use of the monolithic construction system with aluminum formwork has established itself as an emerging technology in the construction industry, attracting the interest of many engineers and architects because of its structural performance, speed of construction, and economy. Reinforced concrete walls and slabs in these systems are cast together, giving the walls the role of primary gravity and lateral load-resisting elements. The main focus of this review paper is to provide an all-encompassing evaluation of the previously conducted studies dealing with the seismic performance of monolithic high-rise buildings as compared to conventional RCC framed structures. The research work spans the analytical, numerical, and experimental approaches to delineate the factors such as storey displacement, storey drift, storey shear, base shear, stiffness, and overall stability of the structure that have been singled out for investigation. Shear wall configuration, wall thickness, openings, and building height effects are also part of the discussion. Monolithic structural systems are found to be superior in terms of seismic performance, material consumption and cost-effective through the literature review thus they can be considered a very good option for sustainable high-rise construction.

Keywords: *Monolithic Construction, Seismic Performance, Shear Walls, High-Rise Buildings, ETABS Analysis etc.*

I. INTRODUCTION

The rapid growth of urban populations and the increasing demand for residential and commercial spaces have resulted in the extensive development of high-rise buildings across the world. In densely populated countries such as India, vertical expansion has become an unavoidable solution to address land scarcity and infrastructure limitations. However, the structural design of high-rise buildings is governed primarily by lateral loads arising from earthquakes and wind, rather than gravity loads alone. Past earthquake events have demonstrated that inadequate lateral load-resisting systems can lead to severe structural damage or collapse, emphasizing the importance of seismic-resistant design [1].

Traditionally, reinforced concrete (RCC) framed structures consisting of beams, columns, and slabs have been the most commonly adopted construction system. In these conventional systems, masonry infill walls are treated as non-structural elements, and the lateral load resistance is mainly provided by frame action. Although such systems are economical and familiar to the construction industry, they often exhibit excessive storey displacement and drift during seismic events, especially in tall buildings [2]. This limitation has encouraged researchers and practicing engineers to explore alternative structural systems that offer greater stiffness and improved seismic performance.

One such alternative is the monolithic construction system, which has gained popularity in recent years due to advancements in formwork technology. Monolithic construction involves casting walls, slabs, staircases, and other structural components in a single continuous operation using modular aluminum or aluminum–plastic composite formwork. In this system, reinforced concrete walls act as the primary vertical and lateral load-resisting elements, replacing conventional beams and columns to a large extent [3]. The integral behavior of the structural components enhances load transfer efficiency and significantly improves the overall stiffness of the building.

Shear walls play a vital role in the seismic performance of monolithic structures. Numerous studies have established that reinforced concrete shear walls effectively control lateral displacement and inter-storey drift, thereby reducing damage during earthquakes [4]. The configuration and placement of shear walls—whether external, internal, or a combination of both—greatly influence the dynamic response of tall buildings. Symmetrical and well-distributed shear wall layouts are known to minimize torsional effects and improve seismic stability [5]. Additionally, the presence of internal walls contributes to better load distribution and redundancy in the structural system.

Another major advantage of monolithic construction is its economic and constructional efficiency. Although the initial investment in aluminum formwork is relatively high, repeated usage across multiple floors and projects leads to substantial cost savings over time. Several researchers have reported reductions in construction duration, labor requirements, material wastage, and finishing costs when compared to conventional construction methods [6]. Furthermore, the improved quality control and dimensional accuracy achieved through monolithic construction reduce the need for plastering and rework.

With increasing building heights, advanced analytical tools have become essential for evaluating structural performance. Software such as ETABS has been widely used by researchers to model and analyze high-rise buildings under seismic loading conditions. Previous studies utilizing ETABS have compared conventional and monolithic structural systems in terms of storey displacement, storey drift, base shear, and time period, consistently reporting superior seismic behavior for monolithic systems [7–9]. The influence of building height, seismic zone, soil condition, and wall thickness has also been extensively investigated.

Despite the growing body of research, there is a need for a consolidated review that critically examines the seismic performance, economic feasibility, and practical applicability of monolithic construction systems in high-rise buildings. This review paper aims to synthesize recent literature on monolithic and conventional construction systems, highlight key findings, identify research gaps, and provide guidance for future studies and real-world applications in seismic regions [10].

Fig.1. Monolithic Structure with Aluminum Formwork

II. PROBLEM IDENTIFICATION

Rapid urbanization has resulted in a growing demand for high-rise buildings, particularly in seismic-prone regions. Conventional reinforced concrete (RCC) framed structures, which primarily rely on beam-column action for lateral load resistance, often exhibit excessive storey displacement and inter-storey drift during earthquake events, leading to structural damage and reduced safety margins [1]. Numerous post-earthquake assessments have shown that such systems are vulnerable to stiffness irregularities, torsional effects, and concentration of seismic forces, especially as building height increases [2]. Although shear walls are known to enhance seismic performance, their optimal integration within conventional construction systems remains inconsistent and often constrained by architectural requirements [3].

In recent years, monolithic construction systems using aluminum formwork have been introduced as an alternative solution; however, limited consolidated research exists comparing their seismic behavior with conventional systems across varying building heights [4]. Additionally, uncertainties remain regarding their economic feasibility, construction adaptability, and performance under different seismic conditions [5]. Therefore, a systematic evaluation is required to identify the effectiveness of monolithic structural systems in improving seismic resistance, reducing structural response, and ensuring cost-efficient high-rise construction.

A. Existing System

- The existing construction practice for high-rise buildings predominantly adopts conventional reinforced concrete (RCC) framed structures, consisting of beams, columns, and slabs [1].
- Masonry infill walls are generally treated as non-structural elements and are not considered in resisting seismic forces during design [2].
- Lateral loads due to earthquakes and wind are mainly resisted through frame action, which becomes less effective as building height increases [3].
- Shear walls are sometimes incorporated, but their placement is often governed by architectural constraints rather than structural optimization [4].
- Design and analysis of such systems are commonly carried out using linear static or response spectrum methods in software such as ETABS [5].
- Conventional construction relies heavily on site-intensive activities, including formwork erection, curing, and finishing, leading to longer construction durations [6].
- The system is widely accepted due to its familiarity, availability of materials, and ease of execution by local contractors [7].

B. Drawbacks

- Conventional RCC framed structures exhibit higher storey displacement and inter-storey drift under seismic loading, increasing the risk of non-structural and structural damage [1].
- The absence or inefficient integration of shear walls results in lower lateral stiffness and poor energy dissipation capacity [2].
- Masonry infill walls, though not designed for seismic resistance, can cause irregular stiffness distribution, leading to torsional effects and soft-storey formation [3].
- Increased member sizes of beams and columns are often required to meet seismic demands, resulting in higher material consumption and cost [4].
- Construction time is longer due to repetitive formwork, labor dependency, and extensive finishing work [5].

- Quality control is difficult to maintain consistently, leading to construction defects and performance uncertainty [6].
- Overall, the system becomes less economical and less efficient for tall buildings in moderate to high seismic zones [7].

III. LITERATURE REVIEWS

A) Literature Survey:

Peng et al., (2025), This study proposes a monolithic assembled concrete shear wall system with non-connected vertical reinforcement to improve seismic performance and construction efficiency. The research develops a prefabricated system combining cast-in-place boundaries with precast wall panels. Numerical simulations of scaled specimens under cyclic lateral loading show that increasing shear-span ratios enhances ductility, while openings reduce ultimate strength but improve energy dissipation. Composite action between boundary and wall panels yields superior seismic performance compared to monolithic cast walls, highlighting the potential of the system for rapid, cost-effective seismic-resilient construction in rural and urban applications.

P.K. Vagestan et al., (2026), This paper examines the effect of shear wall placement on key seismic response metrics (e.g., base shear, bending moments) in RC multi-storey buildings modeled in ETABS. Analyses indicate that proper distribution of shear walls significantly alters the bending and shear response under lateral loads, suggesting that optimized wall locations can enhance structural performance. It also highlights differences in axial and lateral load paths with varied wall configurations, underlining the importance of strategic wall placement for earthquake resilience in high-rise designs.

F. Chen et al. (2024), Through quasi-static cyclic testing on five reduced-scale specimens, this study compares the seismic behaviour of cast-in-place (CIP) shear walls with precast (PC) shear walls featuring varied connection methods. Results show that modified connection forms (e.g., extruded sleeve connectors) significantly enhance stiffness, ductility, cracking behaviour, and load capacity compared to traditional overlapping U-bar connections. These findings support the reliability of PC systems in replicating CIP performance, offering potential for faster construction and high seismic resistance without compromising structural integrity.

D. Parmar et al. (2025), Investigating the seismic behaviour of RC buildings on sloped terrain, this study uses an SFS interaction model to compare lateral responses of various structural configurations (shear walls, bracings, etc.). Results underscore vulnerability of buildings on slope ground compared to flat sites, with bare-frame systems performing worst in terms of inter-story drift and displacement. Configurations incorporating shear walls and grade beams demonstrate reduced seismic demands, proving their effectiveness in challenging terrain conditions and urging consideration of site effects in high-rise seismic design.

Siddharth, Devendra K. Somwanshi (2024), This comprehensive review synthesizes 30+ studies on seismic behaviour of shear wall systems. It highlights key simulation methods, performance criteria, software approaches, and structural parameters influencing seismic response. The review emphasizes that shear walls markedly enhance lateral stiffness and drift control, and identifies future research gaps in composite shear walls and analytical methodologies. The paper is a valuable consolidation of trends, methodologies, and performance comparison for researchers focusing on earthquake resilience design in buildings.

S.P. Sharma & J.P. Bhandari (2024), This review discusses previous research on the influence of shear wall location on seismic performance outputs like inter-story drift and lateral displacement. It summarizes results from multiple studies demonstrating that strategic shear wall placement significantly improves seismic resistance compared to bare frames or non-optimized configurations. Key findings emphasize consistent drift reduction and enhanced energy dissipation with well-positioned shear walls in RC structures.

Chauhan and Praveen Ghidode (2025), This study emphasizes seismic performance improvement in reinforced concrete high-rise buildings with centrally placed symmetrical shear walls. The paper discusses how central shear wall placement reduces displacement and drift under seismic load compared to unsymmetrical placements. It highlights structural efficiency, improved stiffness, and reduced deformation as key benefits of optimal shear wall distribution in tall buildings.

K Keerti Kumar and Mr. Basavalingappa (2025), This work explores how different shear wall opening geometries and seismic zoning influence seismic response. Results indicate that increasing openings generally increases lateral displacement but can improve ductility. The paper also differentiates performance for various seismic zones, recommending specific configurations for optimized energy dissipation and stiffness in high-rise RC frames.

C. Balakrishna & S.N. Saishanker (2022), Modeling a 56-storey building, this study investigates shear wall performance and design optimization in ETABS. It demonstrates that strategic wall placement and design significantly reduce lateral displacement, drift, and structural response under seismic loading, highlighting the importance of optimization in improving building resilience while maintaining economical material use.

Gaurav Shreevash and Dr. S. S. Kushwah (2025), High-rise RCC models (G+14) were compared with and without shear walls and friction dampers. Results show that shear walls combined with dampers reduce displacement and improve energy dissipation, while Plus-shaped building configurations show better performance than regular layouts. Shear walls are confirmed as a key component in enhancing lateral strength and mitigating seismic impacts.

Ega Shabarinath and Mr. MD. Parvez Affani (2023), This paper reviews how varying shear wall thickness, placement, and reinforcement affect seismic responses such as displacement, drift, and base shear. Trends show increasing wall rigidity reduces seismic demand but must be balanced with ductility for optimal performance. The review underscores the dual role of shear walls in strength and deformation control.

J. Dong et al. (2025), This experimental/analytical study investigates hysteretic behaviour of reinforced concrete shear walls under cyclic loading, introducing interpretable machine learning predictions for key performance points. It reveals that shear walls significantly influence energy dissipation and stiffness degradation patterns, providing insights for improved predictive modeling of seismic performance in high-rise structures.

B) Literature Summary

- Recent studies highlight that reinforced concrete shear walls significantly enhance seismic performance by reducing storey displacement, drift, and base shear in high-rise buildings.
- Monolithic and precast shear wall systems demonstrate higher lateral stiffness and better energy dissipation compared to conventional RCC frame systems.
- Research confirms that optimized shear wall placement (central, symmetrical, and dual systems) improves seismic resistance and structural stability.
- Experimental and numerical studies show that monolithic and hybrid wall systems provide superior ductility and cracking control under cyclic loading.
- ETABS-based analytical studies validate that buildings with internal and external shear walls perform better than bare frame structures.
- Literature emphasizes reduced construction time, material consumption, and improved cost efficiency in monolithic systems.
- Advanced studies also indicate the importance of shear wall geometry, openings, and soil–structure interaction on seismic behavior.

C) Research Gap

- Limited studies directly compare monolithic construction systems with conventional RCC framed systems for high-rise buildings under identical modeling conditions.
- Most research focuses on shear wall behavior, while comprehensive system-level comparisons including slabs, walls, and load paths are scarce.
- Insufficient attention is given to combined internal and external wall configurations in monolithic high-rise buildings.
- Economic feasibility studies integrating structural performance with cost and construction time are limited.
- Few studies analyze multiple building heights (G+20, G+25, G+35) within the same seismic zone for consistent comparison.
- The influence of monolithic construction on foundation demand reduction is not adequately addressed.
- There is a lack of region-specific studies based on Indian seismic codes (IS 1893) for monolithic high-rise structures.

IV. RESEARCH METHODOLOGY

A) Criteria for selecting this study

- Rapid urbanization and land scarcity have increased the demand for high-rise residential buildings in seismic-prone regions.
- Conventional RCC framed structures often exhibit higher lateral displacement and drift under earthquake loading.
- Monolithic construction using shear walls offers improved seismic performance, faster construction, and better quality control.
- Limited comparative studies are available evaluating monolithic and conventional systems under identical seismic and loading conditions.

- The growing adoption of aluminum formwork technology necessitates systematic performance evaluation.
- Indian seismic zones require structures compliant with IS 1893, making region-specific analysis essential.
- High-rise buildings significantly influence human safety, economic investment, and urban sustainability.
- The study provides practical insights for engineers, developers, and policymakers in selecting efficient construction systems.
- Results support informed decision-making for cost-effective, safe, and resilient high-rise construction.

B) Method of analysis:

- Selection of three building heights: G+20, G+25, and G+35 storey structures with a uniform storey height of 3 m.
- Development of three structural models for each height using ETABS software.
- Modeling of conventional RCC framed system, monolithic system with external shear walls, and monolithic system with internal and external shear walls.
- Assignment of material properties as per IS codes (M30 concrete, Fe 500 steel).
- Application of dead load and live load according to IS 875 (Part 1 and 2).
- Seismic loads applied as per IS 1893 using equivalent static method in Zone III.
- Analysis of storey displacement, storey drift, storey shear, and base shear.

- Comparative evaluation of results to assess seismic performance and structural efficiency.

C) Comparison and Analysis

Table 1: Comparison and Analysis from literature parameters

Authors & Year	Structural System Studied	Storey Displacement	Storey Drift	Base Shear / Lateral Force
Peng et al. (2025)	Monolithic assembled shear wall system	Significantly reduced due to high lateral stiffness	Lower drift with improved ductility	Slightly higher base shear due to increased stiffness
Vagestan et al. (2026)	RC frame with varied shear wall placement	Reduced with optimized wall location	Drift minimized for symmetrical wall layout	Redistribution of base shear observed
Chen et al. (2024)	Precast vs cast-in-place shear walls	Comparable or lower displacement in precast walls	Improved drift control with advanced connections	Similar base shear capacity
Parmar et al. (2025)	RC buildings on sloped terrain	Higher displacement on slopes; reduced with shear walls	Drift significantly reduced using shear walls	Increased base shear due to terrain effects
Siddharth & Somwanshi (2024)	Various shear wall systems (review)	Consistent displacement reduction	Effective drift control reported	Base shear increases with stiffness
Sharma & Bhandari (2024)	RC frames with different shear wall locations	Lower displacement for central wall placement	Drift reduced by 30–60%	Improved lateral force resistance
Chauhan & Ghidode (2025)	High-rise RC with symmetrical shear walls	Significant reduction in displacement	Drift within IS code limits	Higher base shear due to stiffness
Keerti Kumar & Basavalingappa (2025)	RC high-rise with shear wall openings	Displacement increases with larger openings	Drift increases but ductility improves	Slight reduction in base shear
Balakrishna & Saishanker (2022)	56-storey RC with optimized shear walls	Major reduction in top-storey displacement	Drift controlled effectively	Optimized base shear response
Shreevash & Kushwah (2025)	RC frame with shear walls & dampers	Lowest displacement among all systems	Excellent drift control	Reduced effective seismic force
Shabarinath & Affani (2023)	Shear wall thickness & placement study	Decreases with increased wall thickness	Drift decreases but ductility reduces	Base shear increases with rigidity
Dong et al. (2025)	RC shear walls (hysteretic behavior)	Stable displacement under cyclic loading	Controlled drift degradation	High energy dissipation capacity

V. DISCUSSION

A) Synthesis of findings from literature

The synthesis of findings from the reviewed literature indicates that the incorporation of reinforced concrete shear walls significantly enhances the seismic performance of high-rise buildings when compared to conventional RCC framed systems. Monolithic and precast shear wall systems provide higher lateral stiffness, resulting in substantial reductions in storey displacement and inter-storey drift. Several studies confirm that optimal shear wall placement—particularly symmetrical and centrally located configurations—improves structural stability and energy dissipation capacity under seismic loading. Although the presence of shear walls increases base shear due to higher stiffness, the overall seismic safety and serviceability of buildings are improved. Literature also highlights the advantages of monolithic construction in terms of reduced construction time, material optimization, and cost efficiency. However, the effectiveness of these systems depends on wall configuration, openings, and soil conditions, emphasizing the need for integrated seismic design approaches.

B) Methodology for future research directions

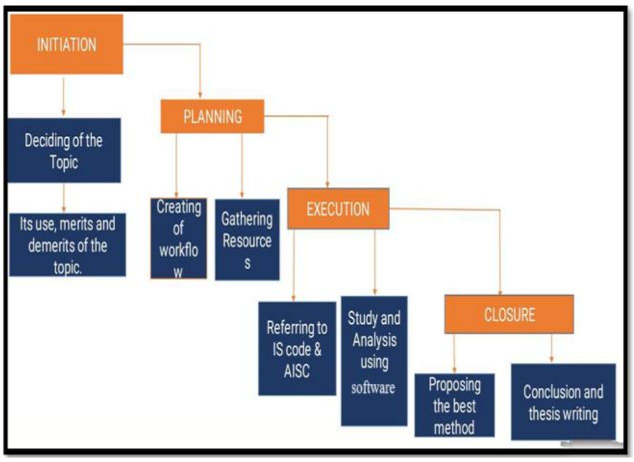

Fig. 2. Flow Diagram of system

- Selection of study parameters based on high-rise residential buildings commonly constructed in seismic regions.
- Identification of two construction systems: conventional RCC framed structure and monolithic shear wall structural system.
- Modeling of three building heights (G+20, G+25, and G+35) with uniform storey height of 3 m.
- Development of three analytical models for each height using ETABS software.
- Assignment of material properties as per Indian Standards (M30 grade concrete and Fe-500 steel).
- Definition of section properties for beams, columns, slabs, and shear walls according to design requirements.

- Application of dead load and live load as per IS 875 (Part 1 and Part 2).
- Application of seismic loads as per IS 1893 (Zone III) using the equivalent static method.
- Execution of structural analysis to obtain storey displacement, storey drift, storey shear, and base shear.
- Comparative evaluation of results among different structural systems and building heights.
- Interpretation of results to assess seismic performance, structural efficiency, and feasibility of monolithic construction.

Table 2: Structural and Seismic Parameters Considered

Category	Parameter	Value / Description	Purpose in Analysis
Building Geometry	Number of Storeys	G+20, G+25, G+35	To study height effect on seismic response
	Storey Height	3.0 m	Uniform vertical distribution
	Plan Type	Regular plan	Eliminates torsional irregularity
Material Properties	Concrete Grade	M30	Used for slabs, beams, columns, walls
	Steel Grade	Fe 500	Reinforcement material
Structural Elements	Slab Thickness	150 mm	Floor system modeling
	Beam Size	300 × 450 mm (initial)	Conventional system framing
	Shear Wall Thickness	300 mm	Lateral load resistance
Loading Parameters	Dead Load	As per IS 875 (Part 1)	Self-weight + finishes
	Live Load	As per IS 875 (Part 2)	Occupancy loading
Seismic Parameters	Seismic Zone	Zone III	Moderate seismic intensity
	Soil Type	Medium	Affects seismic forces
	Analysis Method	Equivalent Static Method	Earthquake response
Software	Analysis Tool	ETABS v15	Modeling and analysis

The table summarizes the key structural, material, and seismic parameters adopted for the seismic analysis of high-rise buildings in this study. Three building heights—G+20, G+25, and G+35—are selected to evaluate the influence of height on seismic response. Uniform storey height and regular plan configuration ensure consistent comparison among different structural systems. Material properties such as M30 concrete and Fe 500 steel are chosen as per Indian Standards to reflect practical construction practices. Shear wall thickness, slab thickness, and beam sizes define the structural behavior under lateral loads. Seismic parameters including Zone III, medium soil condition, and equivalent static analysis method as per IS 1893 ensure realistic earthquake loading representation.

VI. CONCLUSION

The present paper concludes that monolithic construction systems incorporating reinforced concrete shear walls offer significant advantages over conventional RCC framed structures in the seismic performance of high-rise buildings. Based on the reviewed literature, it is evident that shear walls substantially reduce storey displacement and inter-storey drift, thereby enhancing structural stability and occupant safety during seismic events. Monolithic and precast shear wall systems provide higher lateral stiffness, improved energy dissipation capacity, and better control of cracking under cyclic loading. Although the presence of shear walls increases base shear due to greater stiffness, this results in improved force resistance and overall seismic reliability. The literature also highlights the benefits of monolithic construction in terms of faster construction, reduced material consumption, and cost efficiency, making it suitable for large-scale housing projects. However, the effectiveness of monolithic systems depends on proper wall configuration, placement, and detailing. Overall, monolithic construction emerges as a promising, resilient, and economical solution for modern high-rise structures in seismic regions.

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