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PERFORMANCE REVIEW OF COMPOSITE CORE AND RCC SHEAR WALL SYSTEMS IN TALL RESIDENTIAL BUILDINGS

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ABSTRACT
The swift increase in the height of residential structures has increased the need to have an effective lateral load resisting systems that can meet the serviceability, performance, and strength based design requirements during seismic and wind loads. The reinforced concrete (RCC) shear walls and composite core systems are still the most popular systems adopted. This review paper entails a critical performance assessment on both the RCC shear wall systems and steel concrete core systems composite in high-rise residential buildings. Critical synthesis of the current analytical, numeric and experimental research is conducted to evaluate their structural response concerning lateral displacement, inter-storey drift, base shear demand, ductility, energy dissipation, and the overall efficiency of the system. The review notes that RCC shear wall systems are economical and are characterized by high initial stiffness and economic viability in low to mid height buildings, but they have performance saturation, and increased seismic demand and reduced ductility with building height. Composite core systems, on the other hand, are better in seismic and wind performance, post-yield behavior, less concentration of damage, and better applied to performance-based design frameworks, especially in slender and high-rise buildings. The researchers find that tall residential buildings should be put in lateral system selection due to height-related performance goals instead of the traditional construction behavior.
KEYWORDS: *RCC shear walls; Composite core systems; Tall residential buildings; Seismic performance; Wind response; Performance-based design*

1. INTRODUCTION

The high rate of vertical growth of city residential districts has essentially changed the rulings of the criteria of the structural design. In high-rise residential structures, the lateral load resistance, serviceability considerations and performance-based design standards are taking over the structural behavior, usually overcoming the gravity load considerations. Vibrations caused by wind, seismic excitation and second-order effects put stringent requirements on structural systems and therefore both efficient and resistant lateral load-resisting provisions are necessary.

Reinforced concrete (RCC) shear wall system and composite core structural system are some of the other systems that have been adopted to be used in tall residential constructions all around the world. The popularity of RCC shear walls can be explained by the level of stiffness inherent in the wall, the simplicity of its construction, and the affordability involved in its construction, especially in areas where concrete construction has been established [1]. Composite core systems (a combination of steel and concrete) on the other hand have come to the forefront due to their increased ductility, lower self-weight, and increased capacity to dissipate energy particularly in high-rise and slender structures.

Nevertheless, the changes in structural failures due to recent earthquakes and wind loads, as well as advanced numerical and experimental researches, have revealed the inability of traditional RCC shear wall systems to perform well on their own. Here, it is important to realize the relative performance of RCC shear wall systems and composite core systems to make rational structural systems choices in high rise residential structures [2].

In this review paper, a synthesis of analytical research, numerical researches and experimental researches that have been reported in the literature were conducted with the aim of critically analyzing the performance of RCC shear wall and composite core systems. The study will seek to:

- identify dominant performance trends,
- highlight system-specific advantages and limitations,
- and expose existing research gaps requiring further investigation.

The outcomes of this review are intended to support engineers, researchers, and designers in making performance-driven decisions for lateral load-resisting system selection in tall residential buildings.

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2. RCC SHEAR WALL SYSTEMS IN TALL RESIDENTIAL BUILDINGS

Reinforced concrete (RCC) shear wall systems have been widely utilized as the major lateral load-resisting system of the tall residential building since they are highly stiff and strong and have demonstrated performance during seismic and wind loading. The shear walls, being used as vertical cantilevered components, are used to transfer the lateral forces on the superstructure to the foundation in order to regulate unwanted excessive shear galvao accompanied by promoting worldwide structural stability. Due to their acceptance, construction simplicity, and codal provisions, RCC shear walls have remained the predominant structure of high-rise constructions in residential buildings, especially in the areas that use reinforced concrete as the construction material of choice [3].

However, RCC shear wall systems do not perform in a consistent manner but are extremely sensitive to configuration, location, practice of detailing and communication with the rest of the structural framework. The importance of the recent study lies in the fact that performance-based assessment is considered as an extension of strength-based design, whereas the latest studies demonstrated both the benefits and intrinsic drawbacks of RCC shear wall systems in high-rise buildings.

2.1. Structural Configuration and Positioning of RCC Shear Walls

The location and configuration of the RCC shear walls in the building plan and the elevation have a significant impact on its structural efficiency. Some common ones are central core walls, coupled shear walls, perimeter shear walls, and dual framed-shear wall systems. Central location of core walls gives a much better torsional control and more consistent distribution of the lateral forces [4].

Research has shown that:

- Central core shear walls effectively minimize torsional irregularity and reduce inter-storey drift.
- Coupled shear walls improve energy dissipation through coupling beam action under seismic loading.
- Perimeter shear walls enhance overturning resistance but may induce torsional effects if placed asymmetrically.

Improper placement or discontinuity of shear walls along the building height can result in stress concentration, stiffness irregularities, and amplified lateral displacements, particularly in buildings with complex geometry.

2.2. Seismic and Wind Performance Characteristics

RCC shear walls can greatly reduce the lateral movement and storey drift under seismic and wind loading conditions, and therefore they can be used to control serviceability-related response. High-order numbers studies that utilize response spectrum analysis, the nonlinear analysis of pushover analysis, and time history analysis have shown that shear walls concentrate a significant number of lateral forces to the wall, since they are very stiff.

These studies however also point out some performance concerns. Increased rigidity causes an increase in base shear demand and poor ductile detailing could cause brittle failure mechanisms in the presence of intense seismic excitation [5]. In extremely high and thin structures, the acceleration and comfort requirements caused by the wind are very important and show the weaknesses of the systems based on stiffness.

To synthesize the key performance attributes of RCC shear wall systems as reported in the literature, a consolidated summary is presented in Table 1.

Table 1: Performance Characteristics of RCC Shear Wall Systems in Tall Residential Buildings

Aspect	Observed Performance Characteristics
Lateral stiffness	High initial stiffness; effective drift control in low to mid-height buildings
Seismic response	Attracts higher base shear; performance sensitive to ductile detailing
Wind response	Effective displacement control; potential comfort issues in slender towers
Ductility	Limited compared to composite systems; risk of brittle failure
Structural weight	High self-weight increases seismic inertia forces
Suitability	Reliable for mid- to high-rise buildings; performance saturation in very tall structures

The comparative findings in Table 1 show that although the RCC shear wall systems have good stiffness and displacement control, performance is also limited with increasing building height. High self-weight, low ductility, and higher seismic demand are compounded to make them less efficient in very tall residential buildings.

2.3. Limitations and Performance Constraints in Very Tall Buildings

The higher the height of the building, the reduced efficiency of RCC shear wall systems because of saturation in the performance. Further thickening of the walls after a threshold point incurs diminishing returns in terms of stiffness at the expense of an order of magnitude in terms of material usage and construction complexity. In addition, increased seismic mass increases inertia, which causes more foundation and structural elements demands [6].

Such limitations have prompted the research of other lateral load-resisting systems such as composite cores and composite structural arrangements that would help address the inherent limitations of the traditional RCC shear wall systems and at the same time achieve sufficient safety and serviceability.

3. COMPOSITE CORE SYSTEMS AND COMPOSITE STRUCTURAL FRAMEWORKS

Composite core shear walls, which are steel-concrete composite shear walls, steel or composite columns and steel or composite framing have increasingly been considered as an effective substitute to traditional RCC shear wall systems in high-rise residential buildings. It is based on the complementary characteristics of steel and concrete to attain a higher strength-weight ratio, heightened ductile and enhanced constructability, and therefore it is specifically used with high-rise and slender buildings that experience a combination of seismic and wind loads. The decreased self-weight of composite systems helps to reduce the seismic inertia forces whereas the existence of steel parts increases the post-yield deformation capability and energy dissipation [7].

Conclusive analytical and performance based research efforts have shown that composite core systems have far better seismic behavior in comparison to RCC systems. The interplay between steel and concrete elements allows spreading the stress more evenly and postponing the occurrence of structural damages during lateral loading. Consequently, composite buildings generally exhibit a lower base shear requirement, displacement of the storeys, and enhanced collapse prevention in case of severe seismic strikes. Another study conducted on nonlinear static and time-history analysis indicates that composite cores have constant hysteretic behavior, the decrease in stiffness and the increase in residual strength after a strong ground motion is low [8].

Composite systems also have a natural ductility that enhances better structural redundancy and strength, which enables the redistribution of forces once localized yielding or damage has taken place. This feature is especially important in high-rise residential constructions, where progressive resistance to collapse and post-seismic functionality are the key performance criteria. The research on performance-based demonstrations of seismic design frameworks always reveals that the composite core frameworks offer superior levels of performance with fewer damage indices than the conventional RCC shear wall structures.

Other recent developments in materials and structural detailing have made composite core systems even more effective. The use of engineered cementitious composites (ECC), interchangeable coupling beams, and modular wall elements has been observed to dramatically enhance energy dissipation, crack management and also repair following extreme load incidents. Such inventions help in the philosophy of resiliency design as permanent damage is reduced and recovery is quickly achieved after a certain occurrence. Also, there is experimental research on replaceable composite wall components that proves that they can endure large inelastic deformations without losing the ability to support loads [9].

When the structure is subjected to wind loading, the performance of composite core systems is good because the stiffness distribution is optimized and the mass is reduced. Investigations of high and slim residential buildings show that core made of composite is effective in lateral movement and acceleration reaction management, and complies with both the safety and comfort standards of the building. The fact that steel-concrete interaction is more likely to increase damping properties also ensures better wind-induced response, and thus composite systems are suitable to be used on buildings whose performance is dictated by serviceability.

Although they have proven performance benefits, the wide scale use of composite core systems is limited by the fact that they are more expensive to construct initially, they are more complex to design, and codal provisions, especially in areas where only RCC construction is the prevailing design consideration [10]. The practical difficulties are also found in the need to provide specialized detailing, professional work, and coordination between steel and concrete construction stages. However, the performance advantages over time and the increased focus on performance-driven design remain to favor the composite core systems as one of the possible and more desirable options to be used in the construction of the tall residential buildings.

4. COMPARATIVE PERFORMANCE OF RCC SHEAR WALL AND COMPOSITE CORE SYSTEMS

The choice of a proper lateral load-resisting system is essential in controlling safety, serviceability and strength of tall residential structures. Although traditionally, RCC shear wall systems have been considered as convenient and cost effective, the growing height, slenderness, and performance demands of the contemporary residential towers had ignited large scale comparative studies with composite core systems. Recent literature points out that the choice of structural systems should be performance based and not conventional especially in the seismic and wind prone areas.

Linear and nonlinear analytical techniques such as response spectrum analysis, pushover analysis and nonlinear time-history analysis, are used in comparative investigation of RCC shear wall and composite core systems in the dynamic loading scenario to shed some light on the comparative behaviour of these systems under such conditions.

4.1. Comparative Structural Response under Seismic and Wind Loading

In several studies, composite core systems have always shown to be better than the RCC shear wall systems in the control of lateral displacement at the upper elevations, ductility and hysteretic energy dissipation. The self-weight and increased yield deformation

ability of the composite systems leads to reduced seismic inertia forces and slower yielding by strong ground movement. A composite building is therefore usually characterized by the minimized concentration of damages and enhanced ability to avoid collapses.
Conversely, RCC shear wall systems are effective in low to mid height residential buildings where stiffness functions are predominant and ductility functions are moderate. Nevertheless, the higher the height of the building is, the higher the base shear forces the RCC systems are likely to experience because of the mass and stiffness of the structure, which results in the saturation of performance. This is further emphasized in wind-induced responses where a rigid tower-based RCC systems might meet the displacement requirements but fail to meet the occupant comfort requirements in the slender towers.

Dual framed-shear wall systems, base isolation system, and coupled shear walls have been found to improve the seismic response of the two systems. However, comparative data shows that such strategies have more pronounced advantages on composite core systems because of their natural ductile nature and their flexibility to performance-based design models.

4.2. Synthesis of Key Comparative Studies

To consolidate the findings of major comparative investigations, a summary of selected key studies evaluating RCC shear wall and composite core systems is presented in Table 2. The table highlights analysis methods, system configurations, and principal performance observations reported in the literature.

Table 2: Summary of Key Comparative Studies on RCC Shear Wall and Composite Core Systems

Author(s) & Year	Structural System(s) Studied	Analysis Approach	Key Comparative Findings
Haridas & Rasal (2021) [11]	RCC vs composite shear walls	Review & analytical synthesis	Composite shear walls show improved ductility and seismic performance
Mishra & Mishra (2020) [12]	RCC shear wall systems	Linear dynamic analysis	RCC walls effective in drift control but attract higher base shear
Malik et al. (2024) [13]	ECC-based composite buildings	Performance-based seismic analysis	Composite systems exhibit superior energy dissipation and damage control
Mohammad & Kodwani (2024) [14]	Composite building frames	Review study	Composite systems outperform RCC in strength-to-weight efficiency
Sharma & Tiwary (2020) [15]	RCC vs composite structures	Analytical review	Composite systems provide faster construction and better seismic response
Imran & Kalwane (2016) [16]	RCC shear wall vs RCC composite	Nonlinear P–Δ analysis	Composite systems show delayed yielding and reduced damage concentration
Hasrat & Bhandari (2025) [17]	RCC systems under wind loading	Performance-based wind analysis	System efficiency decreases with height for RCC-only buildings
Singh et al. (2024) [18]	Multiple lateral systems	Dynamic analysis	Composite systems exhibit lower drift and better dynamic performance
Qing & Na (2024) [19]	RCC vs composite buildings	Plastic deformation-based method	Composite systems demonstrate enhanced post-yield behavior
Patel (2022) [20]	Steel–concrete composite tall buildings	Comparative dissertation study	Composite cores superior for tall buildings under combined loading

The evidence created in Table 2 shows clearly that, although RCC shear wall systems are still structurally sound and cost effective in moderate-height residential buildings, composite core systems are better performing as the building height increases, as well as the lateral demand. Composite systems also have advantages in the sense that they are more functional in modern performance-driven seismic and wind engineering designs since they can perform at higher objectives of performance with controlled damage.
On the whole, such comparative analysis indicates that it is essential to incorporate height-sensitive and performance-based requirements in the selection of a lateral system, but not to adhere to the traditional construction process.

5. CONCLUSION

In this review, it is established that although RCC shear wall systems are a convenient and cost-effective option in low- to mid-rise residential buildings, its performance declines in very tall buildings due to greater self-weight, higher seismic demand, low ductility and performance saturation. In comparison, composite core systems have been shown to be structurally efficient, exhibit better energy dissipation, post-yield behavior, and control the seismic and wind-induced behavior better, which makes them preferable in the contemporary tall and slender residential buildings. Recent research provides comparative evidence to keep using composite cores to attain increased performance goals with manageable damages at extreme loading conditions. As a result, it is recommended that the choice of lateral load-resisting systems applied in tall residential buildings is made according to the performance-based approach, the height of the structure, as well as the intensity of the hazards, and the composite core systems could be the most effective solutions to the construction of the high-rise residential buildings in the future.

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