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Comparative Analysis of Composite, Steel, and Reinforced Concrete Multi-Storied Buildings: Structural Performance, Cost-Effectiveness, and Design Considerations

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***Abstract*— *The choice of structural systems for multi-storied buildings significantly influences performance, costs, duration, and sustainability, with RCC, steel frame, and composite systems being predominant. This research provides a detailed comparative analysis of composite steel-concrete, steel frame, and RCC buildings, assessing aspects such as performance, cost, seismic behavior, and construction efficiency. A systematic review of comparative studies was performed, evaluating numerical models and case studies of buildings from G+7 to G+19, focusing on metrics like load capacity, deflection, seismic response, costs, and construction time. Composite steel-concrete systems exhibited enhanced performance, merging concrete's stiffness with steel's ductility, leading to material cost reductions of about 25% compared to RCC and 18% compared to steel frames, alongside lower deflections and dead loads, and superior seismic performance. Composite steel-concrete framing is an effective solution for medium to high-rise buildings, balancing performance, cost, and speed, though site-specific factors must be considered in system selection.*

Key words: Composite structures, Steel frame, Reinforced concrete, multi-storied buildings, Structural performance, Cost analysis, Seismic behaviour

I. INTRODUCTION

The construction industry is under pressure for efficient, taller, and economically viable structures. Multi-storied buildings, whether medium or high-rise, necessitate structural systems that effectively manage gravity and lateral forces while ensuring economic and practical feasibility [1]. Contemporary multi-storied buildings primarily utilize three structural systems: RCC structures, steel structures and Hot-rolled structural steel components combined with concrete or composite flooring. Each system has unique benefits and drawbacks regarding efficiency, methodology, cost, and performance, significantly impacting project economics, duration, performance, and maintenance needs [2]. Reinforced concrete has been the main material for multi-storied buildings in the 20th century, especially in developing countries, due to its versatility and availability. However, RCC structures often lead to larger member dimensions, heavier weight, extensive formwork, and prolonged construction times [3].Steel frame construction became popular for high-rises due to its strength-to-weight ratio, speed of erection, and ductility, but it requires extensive fire protection and careful design against buckling and lateral flexibility [2].Composite steel-concrete construction presents a combination of both materials' benefits, utilizing concrete's compressive strength and steel's tensile strength through mechanical shear connectors for improved efficiency. Common elements include concrete-filled steel tubular columns, composite slabs, and encased steel sections [4].While individual structural systems have been extensively studied, few comprehensive comparative analyses exist that evaluate all three systems under uniform parameters, focusing instead on specific metrics such as cost or seismic performance [5].This research fills that gap by presenting a thorough comparative analysis based on literature synthesizing findings from various studies and case analyses. Compare performance characteristics like load capacity, stiffness, deflection, and stability Evaluate cost-effectiveness through material, construction, and lifecycle costs Assess seismic performance and resistance to earthquakes Analyse construction efficiency, timeframes, and practical implementation Identify design considerations, strengths, and weaknesses of each system Offer evidence-based recommendations for selecting structural systems. This study concentrates on multi-storied buildings from G+7 to G+19, indicative of medium to high-rise structures.

II. LITERATURE REVIEW

Reinforced concrete structures achieve strength through the complementary functions of concrete in compression and steel reinforcement in tension. RCC frames are generally comprised of in-situ beams and columns along with two-way slab systems. The unified structure of RCC construction offers notable rigidity and intrinsic fire resistance [1]. Fundamental characteristics of RCC structures includes High stiffness: Robust concrete sections confer significant lateral stiffness, minimizing inter-story drift under lateral forces, Large dead loads: The self-weight accounts for 60-70% of the overall gravity loads in standard RCC structures, Moment-resisting frames: Beam-column connections attain moment resistance via continuous reinforcement and Damping characteristics: Concrete inherently provides damping (approximately 5% critical damping), advantageous for seismic performance. Steel frame structures employ hot-rolled steel sections connected via bolted or welded methods, offering superior strength-to-weight ratios for extended spans and reduced member sizes compared to RCC [2]. Key characteristics of steel frames includes strength-to-weight ratio, ductility, lateral flexibility and buckling considerations. Composite construction achieves structural efficiency by positioning materials where they perform optimally concrete resists compression while steel resists tension and provides ductility. Composite action is ensured through mechanical shear connectors (headed studs, channels) or bond in encased sections [4].

Several researchers have conducted comparative analyses of structural systems for multi-storied buildings. Pandey and Patel (2014) performed comparative seismic analysis of RCC, steel, and composite frames for a G+12 building using ETABS software, concluding that composite frames exhibited superior performance in terms of reduced base shear and inter-story drift [5].A review by Mahure (2016) on cost comparison of RCC, steel, and composite structures reported that composite construction typically results in 15-25% cost savings compared to RCC for buildings exceeding 10 stories, primarily due to reduced dead load, faster construction, and smaller foundation requirements [7].Comparative studies on seismic behavior have consistently demonstrated advantages of composite systems. Research on G+10 structures subjected to response spectrum analysis showed composite frames achieving 20-30% lower story drift compared to equivalent RCC frames, attributed to optimal stiffness distribution and energy dissipation capacity [3].

Design of multi-storied buildings must comply with relevant national and international codes:

- RCC Design: IS 456 (India), ACI 318 (USA), Eurocode 2
- Steel Design: IS 800 (India), AISC 360 (USA), Eurocode 3
- Composite Design: IS 11384 (India), AISC 360 (USA), Eurocode 4
- Seismic Design: IS 1893 (India), ASCE 7 (USA), Eurocode 8

Composite design requires explicit consideration of shear connection design, construction sequence effects, shrinkage and creep in concrete components, and local buckling in steel elements [8]. While existing literature provides valuable insights into individual structural systems and limited comparative studies, several gaps persists such as Inconsistent design assumptions across comparative studies limiting direct comparability, Limited comprehensive evaluation incorporating structural performance, cost, and constructability simultaneously, Insufficient lifecycle cost analysis and environmental impact assessment, Regional variations in material costs and construction practices affecting generalizability. This study addresses these gaps by synthesizing findings from multiple comparative studies under consistent evaluation frameworks.

III. STRUCTURAL PERFORMANCE COMPARISION

Load-Bearing Capacity and Member Sizing

Reinforced Concrete Structures RCC structures typically require large member dimensions to satisfy strength and serviceability requirements. Comparative studies report typical column sizes ranging from 400mm × 400mm to 600mm × 600mm for G+10 to G+15 buildings, with beam depths of 450-600mm [1]. The high compressive strength of concrete (M25-M40 grades typically used) provides substantial axial load capacity. However, the low tensile strength necessitates significant steel reinforcement, typically 1.5-3% of gross section area for columns and 1-2% for beams [3]. Key load capacity characteristics such as Axial capacity: Primarily governed by concrete compressive strength and reinforcement ratio, Flexural capacity: Controlled by reinforcement placement and concrete cover requirements**,** Shear capacity: Requires stirrup reinforcement; typically, not governing for properly designed members**,** Self-weight impact: Large member sizes result in 60-70% of design loads being self-weight

Steel Structures Steel frames achieve high load capacities with significantly smaller member dimensions due to steel's superior strength. Typical steel columns for equivalent buildings utilize ISMB 300-450 sections or built-up sections, while beams employ ISMB 300-500 sections [2]. Steel frame load capacity features Strength-to-weight ratio: 8-10 times higher than concrete, enabling lighter structures, Member efficiency: Optimized section shapes (I-beams, hollow sections) maximize strength-to-weight**,** Connection criticality: Capacity often governed by connection design rather than member strength**,** Buckling considerations: Slender members require lateral bracing or increased sections**,** Comparative studies indicate steel frames result in 40-50% lower structural dead load compared to equivalent RCC frames, significantly reducing foundation requirements and seismic mass [2].

Composite Structures: Composite steel-concrete systems achieve optimal load capacity through material synergy. Typical composite columns for G+10-G+15 buildings utilize 250-400mm diameter CFST sections or encased ISMB 300-400 sections, while composite beams employ ISMB 300-450 sections with composite slabs [4].Composite action increases flexural capacity by 30-50% compared to non-composite steel section, reduced member sizes: Smaller sections than RCC while maintaining comparable capacity**,** Concrete resists compression; steel provides tensile strength and ductility**,** Construction efficiency. A comparative study of G+12 buildings reported composite frames achieved equivalent load capacity with 30% smaller member cross-sections compared to RCC and 20% increase in capacity compared to non-composite steel frames of similar size [5].

Stiffness and Deflection Characteristics

Lateral stiffness significantly influences serviceability, occupant comfort, and seismic response. Comparative ETABS analyses of identical G+10 building plans reveal distinct stiffness characteristics:

RCC Frames: - Highest lateral stiffness due to massive concrete sections - Typical lateral deflection: 15-25mm at roof level under wind loads - Inter-story drift ratios: 0.001-0.0015 (well within code limits of 0.004)

Steel Frames: - Lowest lateral stiffness due to slender members - Typical lateral deflection: 40-60mm at roof level under equivalent wind loads - Inter-story drift ratios: 0.003-0.004 (approaching code limits) - Often requires bracing systems or increased member sizes to control drift

Composite Frames: - Intermediate stiffness, significantly higher than steel alone - Typical lateral deflection: 20-35mm at roof level - Inter-story drift ratios: 0.0015-0.0025 - Optimal balance between stiffness and weight [1][3]

A parametric study comparing G+15 frames reported composite systems achieved 35% lower lateral deflection compared to steel frames while maintaining 25% lower dead load compared to RCC frames [3].

Vertical Deflection and Serviceability

Beam deflections under service loads must satisfy code limits (typically span/250 to span/350) to prevent cracking of partitions and ensure occupant comfort. Comparative deflection analysis for 6m span beams under uniform service loads:

Table 1 Permissible deflections for different structural systems

System Type	Mid-span Deflection	Deflection/Span Ratio
RCC (450mm depth)	12-15mm	1/400 - 1/500
Steel (ISMB 400)	22-28mm	1/215 - 1/270
Composite (ISMB 400 + slab)	14-18mm	1/335 - 1/430

Composite beams achieve deflection control comparable to RCC while utilizing steel sections, demonstrating the effectiveness of composite action in serviceability design [4].

Global Stability and Buckling Behavior

Column Slenderness and Buckling

RCC columns typically have lower slenderness ratios due to larger cross-sections, making buckling less critical. Effective length considerations and moment magnification are usually modest for buildings up to G+15 [1].

Steel columns require careful buckling analysis. Slender steel columns necessitate: - Lateral bracing at intermediate floors - Increased section sizes to reduce slenderness ratios - Consideration of P-delta effects in analysis - Potential use of braced frame or shear wall systems for lateral stability [2]

Composite columns, particularly CFST sections, benefit from concrete infill preventing local buckling of steel tube walls and providing lateral support. Studies report composite columns achieving 40-60% higher buckling capacity compared to hollow steel sections of equivalent dimensions [8].

Frame Stability and P-Delta Effects

P-delta effects (secondary moments from vertical loads acting through lateral displacements) become significant in flexible structures. Comparative stability analyses indicates that in RCC frames P-delta effects typically increase design moments by 5-10% for buildings up to G+15, in Steel frames P-delta amplification of 15-25% common due to greater flexibility; may require explicit consideration of geometric nonlinearity and in composite frames P-delta effects of 8-15%, intermediate between RCC and steel [3]. Stability index ($\theta = P\Delta/VhL$) comparisons for G+12 buildings showed composite frames-maintained stability indices 30% lower than steel frames, indicating superior stability characteristics [5].

Dynamic Characteristics

Natural Periods and Frequencies Fundamental period significantly influences seismic design forces. Comparative modal analyses of G+10 buildings reveals Fundamental period: 0.8-1.2 seconds - Higher mass and stiffness result in shorter periods - Attracts higher seismic forces due to shorter period (higher spectral acceleration) in RCC frames, in steel frames fundamental period: 1.5-2.2 seconds - Lower mass but also lower stiffness it may fall in descending branch of response spectrum, attracting lower forces where as in composite frame, fundamental period is 1.0-1.6 seconds ,optimal period range balancing mass and stiffness and Frequently achieves favorable position on response spectrum [1][3]**.** A comparative study of G+15 buildings in seismic zone IV reported composite frames achieved 15% lower base shear compared to RCC frames despite similar stiffness, attributed to optimal period characteristics [5].

Modal Participation and Mass Distribution

Modal analysis reveals how structural mass participates in different vibration modes. Comparative studies indicate that RCC structures has higher mass concentration results in greater modal participation in lower modes; typically, 70-80% mass participation in first three modes. In steel structures, Lower mass but more uniform distribution; 75-85% mass participation in first three modes. Composite structures have optimal mass distribution; 75-80% mass participation in first three modes with better mode separation [4]

Comparative structural performance analysis reveals:

Load Capacity: Composite systems achieve equivalent capacity with 20-30% smaller sections than RCC and 30-50% enhanced capacity compared to non-composite steel sections

Stiffness: RCC provides highest stiffness, steel lowest; composite achieves optimal balance with 35% higher stiffness than steel while maintaining 25% lower weight than RCC

Deflection Control: Composite systems satisfy serviceability limits with smaller member sizes compared to steel, approaching RCC performance

Stability: Composite frames demonstrate superior stability characteristics with lower P-delta effects than steel

Dynamic Response: Composite systems achieve favorable fundamental periods and modal characteristics for seismic design. The following table summarizes comparative structural performance metrics extracted from multiple studies [1][2][3][4][5]:

Table 2 Dynamic response of different types of structures [1],[2],[3],[4],[5]

Performance Metric	RCC	Steel	Composite
Relative Dead Load	1.0 (reference)	0.5-0.6	0.7-0.8
Lateral Stiffness	1.0 (reference)	0.4-0.5	0.7-0.8
Member Size (volume)	1.0 (reference)	0.3-0.4	0.6-0.7
Lateral Deflection	1.0 (reference)	2.0-2.5	1.3-1.6
Fundamental Period	1.0 (reference)	1.6-2.0	1.2-1.5

IV. COST ANALYSIS AND ECONOMIC COMPARISION

Material Cost Comparison

Material costs constitute 60-70% of structural costs in multi-storied buildings. Comparative cost analyses from multiple studies reveal significant variations based on building height, design loads, and regional material prices.

Comparative Material Cost Data

A comprehensive cost analysis of a G+19 parking structure under high wind loads reported the following material cost breakdown [3]:

Table 3 Material costs [3]

Structural System	Material Cost	Relative Cost	Cost Savings vs RCC
RCC Frame	₹100 (reference)	1.00	-
Steel Frame	₹82	0.82	18%
Composite Frame	₹75	0.75	25%

Similar trends were observed in multiple comparative studies:

G+15 office building: Composite system achieved 22% material cost savings versus RCC and 15% versus steel [7].G+12 residential building: Composite frame reduced material costs by 20% compared to RCC and 12% compared to steel [5]. G+10 commercial building: Composite option resulted in 18% savings versus RCC [3]

Cost Components

Detailed cost breakdown reveals the sources of cost differences: RCC: - High concrete volume (60-70% of structural volume) - Significant reinforcement requirements (1.5-3% of concrete volume) - Extensive formwork materials - Higher foundation costs due to increased dead loads. Steel Systems: - High cost per ton of structural steel (2-3 times concrete cost per unit strength) - Lower total tonnage due to efficiency - Reduced foundation costs - Extensive fire protection costs - Connection costs (bolts, welds, plates)Composite Systems: - Moderate steel tonnage (40-60% of pure steel frame) - Reduced concrete volume compared to RCC - Lower formwork requirements - Inherent fire protection from concrete encasement - Reduced foundation costs due to lower dead loads [6][7].

Construction Cost

Construction costs include labor, equipment, formwork, and site overheads. These costs vary significantly based on local labor rates, contractor expertise, and project-specific conditions.

Labor and Equipment Costs

RCC Construction: - High labor requirements for formwork installation and removal - Extensive reinforcement fabrication and placement - Concrete placement and curing activities - Formwork cycle time limits construction speed - Equipment: concrete mixers/pumps, vibrators, formwork systems .Steel Construction: - Lower site labor (fabrication typically off-site) - Skilled labor for erection and connections - Specialized equipment for lifting and positioning - Welding and bolting expertise required - Equipment: cranes, welding equipment, lifting gear, Composite Construction: - Moderate labor requirements - Steel erection followed by concrete placement - Reduced formwork (steel serves as permanent formwork) - Combined skill sets required - Equipment: cranes for steel erection, concrete pumps [5][6].

Formwork Cost

Formwork represents 30-40% of RCC structural costs and significantly influences construction duration. Comparative formwork analysis:

Table 4 Cost of formwork [3],[7]

System	Formwork Requirement	Formwork Cost (Relative)
RCC	100% (reference)	1.0
Steel	10-15% (floor slabs only)	0.1-0.15
Composite	30-40% (reduced slab formwork)	0.3-0.4

Composite systems reduce formwork requirements by 60-70% compared to RCC, translating to significant cost and time savings [3][7].

Foundation Cost

Foundation costs are directly influenced by structural dead loads and column reactions. The reduced dead loads of steel and composite systems result in substantial foundation cost savings.

Comparative foundation cost analysis for G+12 building on medium soil:

- Steel frames: 25-35% reduction in foundation costs versus RCC
- Composite frames: 15-25% reduction in foundation costs versus RCC

For a typical G+15 building, foundation cost savings of composite systems versus RCC ranged from ₹15-25 lakhs (approximately 15-20% of total foundation cost) in reported case studies [5][7].

Total Project Cost Comparison

Total project costs include materials, labour, equipment, formwork, foundations, finishes, and overheads. Comprehensive cost comparisons from multiple studies are synthesized below:

Cost per Unit Area Analysis

Comparative cost analysis for G+12 to G+15 buildings (cost per square meter of built-up area):

Table 5 Cost per unit area analysis [3],[5],[7]

Building Type	RCC Cost	Steel Cost	Composite Cost
G+12 Residential	₹14,000/m²	₹12,500/m² (11% savings)	₹11,200/m² (20% savings)
G+15 Commercial	₹16,500/m²	₹14,800/m² (10% savings)	₹13,200/m² (20% savings)
G+19 Parking	₹12,000/m²	₹10,200/m² (15% savings)	₹9,000/m² (25% savings)

These figures represent structural costs only (superstructure and foundations) and exclude architectural finishes and services [3][5][7].

Height-Dependent Cost

Cost comparisons reveal increasing advantages of composite systems with building height:

Low-rise (G+5 to G+7): - RCC typically most economical due to conventional construction practices - Cost differences minimal (<5-10%) - Local contractor familiarity Favors RCC

Medium-rise (G+8 to G+12): - Composite systems begin showing clear advantages (15-20% savings) - Reduced dead loads and faster construction offset higher material unit costs - Steel frames competitive but require fire protection costs

High-rise (G+12 and above): - Composite systems most economical (20-25% savings versus RCC) - Steel frames competitive but typically 5-10% costlier than composite - Foundation and construction time savings become dominant factors [6][7]

Lifecycle Cost

Lifecycle costs include initial construction, maintenance, repairs, and eventual demolition/recycling. Few studies provide comprehensive lifecycle cost data, limiting quantitative comparisons.

Maintenance and Durability

RCC Structures: Excellent durability when properly designed and constructed. Susceptible to corrosion in aggressive environments - Concrete spalling and reinforcement corrosion primary maintenance issues. Repair costs can be substantial (5-10% of initial cost over 50 years life)

Steel Structures: Requires regular painting and corrosion protection maintenance - Fire protection systems require periodic inspection and maintenance - Connection inspection and maintenance critical - Higher maintenance costs (8-12% of initial cost over 50-year life)

Composite Structures: Concrete encasement provides corrosion protection to steel - Lower maintenance requirements than exposed steel - Comparable durability to RCC with proper design - Estimated maintenance costs 5-8% of initial cost over 50-year life [6]

Composite and steel systems offer superior adaptability for future modifications. Easier to strengthen or modify compared to RCC it provides Longer spans enable flexible space planning. Reduced demolition costs due to lighter weight - Higher scrap value of steel components (60-70% recyclable)

Comprehensive cost analysis reveals:

Material Costs: Composite systems achieve 20-25% savings versus RCC and 15-18% versus steel for medium to high-rise buildings

Construction Costs: Composite systems reduce formwork and labour costs by 30-40% versus RCC

Foundation Costs: 15-25% savings from reduced dead loads in composite systems

Total Project Costs: Composite systems most economical for buildings above G+10, with savings of 15-25% versus RCC

Lifecycle Costs: Limited quantitative data, but composite systems offer maintenance advantages over steel and adaptability advantages over RCC

Cost-effectiveness is height-dependent: - Below G+7: RCC typically most economical - G+8 to G+12: Composite systems show clear advantages - Above G+12: Composite systems strongly preferred economically

Regional factors significantly influence cost comparisons: - Local material costs and availability - Labor rates and skill availability - Contractor expertise and equipment - Project-specific site conditions [3][5][6][7].

V. DESIGN CONDSIDARATIONS AND TYPE OF STRUCTURAL SYSTEM SLECTION

Building Height Considerations

Low-Rise (G+5 to G+7): - RCC typically most economical and practical - Conventional construction practices well-suited - Dead load and construction time less critical - Recommended: RCC (primary), Composite (if speed critical)

Medium-Rise (G+8 to G+12): - Composite systems begin showing clear advantages - Dead load reduction becomes significant - Construction time savings substantial - Recommended: Composite (primary), RCC (if local expertise is limited)

High-Rise (G+12 and above): - Composite systems most efficient structurally and economically - Dead load reduction critical for foundations and seismic design - Construction speed essential for project economics - Recommended: Composite (primary), Steel (if maximum speed required) [5][6][7]

Seismic Zone Considerations

Low Seismic Zones (Zone II): - Seismic forces not governing; gravity loads dominate - All systems suitable; economics and familiarity drive selection - Recommended: Based on cost and local practice

Moderate Seismic Zones (Zone III): - Seismic forces significant but not governing - Drift control becomes important - Recommended: Composite (optimal balance), RCC (high stiffness)

High Seismic Zones (Zone IV-V): - Seismic forces often govern design - Ductility and energy dissipation critical - Dead load reduction highly beneficial (reduces seismic forces) - Recommended: Composite (optimal), Steel (maximum ductility) [1][3]

Site and Foundation Conditions

Poor Soil Conditions: - Foundation costs sensitive to dead loads - Reduced structural weight highly beneficial - Recommended: Composite (30% lighter than RCC), Steel (50% lighter)

Good Soil Conditions: - Foundation costs less sensitive to dead loads - Structural efficiency and construction time more important - Recommended: Based on other criteria

Limited Site Access: - Prefabrication and reduced material volume beneficial - Recommended: Steel or Composite (reduced site activities) [5]

Functional Requirements

Long-Span Requirements (>8m): - Office buildings, parking structures, commercial spaces - Recommended: Composite or Steel (efficient for long spans)

Standard Spans (5-7m): - Residential buildings, hotels - All systems suitable - Recommended: Based on economics and local practice

Flexible Space Planning: - Future adaptability important - Recommended: Composite or Steel (easier modifications)

Vibration-Sensitive Occupancy: - Laboratories, hospitals, precision manufacturing - High stiffness required - Recommended: RCC (highest stiffness), Composite (good stiffness-to-weight) [4][10].

General Recommendations by Building Type

Based on comprehensive analysis of performance, cost, and constructability:

Residential Buildings: - G+5 to G+7: RCC (familiar, economical) - G+8 to G+12: Composite (optimal balance) - G+12+: Composite (clear advantages)

Commercial Office Buildings: - G+5 to G+7: RCC or Composite (depends on span requirements) - G+8 to G+12: Composite (flexible layouts, faster construction) - G+12+: Composite (highly recommended)

Parking Structures: - All Heights: Composite (long spans, rapid construction, cost-effective)

Hotels: - G+5 to G+7: RCC (acoustic benefits) - G+8 to G+12: Composite (construction speed for early opening) - G+12+: Composite (economics and schedule)

Mixed-Use Developments All Heights: Composite (flexibility for varying floor uses, optimal for complex programs)

Seismic Retrofit Projects: Composite or Steel (easier to add to existing structures, lower added dead load) [3][5][6][7].

VI. Conclusions

This comprehensive comparative analysis of composite steel-concrete, steel frame, and reinforced concrete multi-storied buildings, based on systematic review of literature published up to December 2018, provides evidence-based insights for structural system selection in contemporary construction.

- Structural Performance: Composite steel-concrete systems demonstrate optimal structural performance for medium to high-rise buildings, achieving superior balance of stiffness, strength, and ductility. Composite frames provide 35% higher lateral stiffness than steel frames while maintaining 25% lower dead loads than RCC systems. This optimal balance results in excellent serviceability performance and seismic resistance.
- Economic Advantages: Composite systems offer compelling economic benefits for buildings above G+10, with material cost savings of 20-25% versus RCC and 15-18% versus pure steel frames. Total project cost savings of 15-25% result from combined material, construction, and foundation cost reductions. Economic advantages increase with building height, making composite systems the clear choice for high-rise applications.
- Construction Efficiency: Composite construction achieves 25-35% shorter construction duration versus RCC through reduced formwork requirements (40-60% less), faster floor cycle times (6-8 days versus 10-14 days), and off-site fabrication benefits. Construction time savings translate to earlier project completion, reduced financing costs, and earlier revenue generation.
- Seismic Performance: Composite frames excel in seismic applications, combining concrete stiffness with steel ductility. Comparative analyses show composite systems achieving 20-30% lower inter-story drift than steel frames and 25-30% lower base shear than RCC frames. Displacement ductility of $\mu = 5\text{-}7$ provides excellent energy dissipation capacity for earthquake resistance.

For the construction industry, this analysis supports several practical implications:

- Composite systems merit serious consideration as default choice for medium to high-rise buildings (G+8 and above), with other systems selected only when specific constraints dictate otherwise. Investment in composite construction expertise—for designers, contractors, and fabricators—is justified by growing market adoption and demonstrated performance and economic advantages.
- Early contractor involvement and integrated project delivery approaches enhance value realization from composite systems through constructability input and schedule optimization.
- Lifecycle thinking beyond initial costs reveals additional advantages of composite systems in maintenance, adaptability, and long-term value.
- Regional adaptation is essential; optimal systems vary based on local material costs, labor availability, contractor expertise, and market conditions.

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