

Comparative Study of RCC and Steel Structures for Multi-Storey Buildings

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ABSTRACT

This study presents a comparative analysis of Reinforced Cement Concrete (RCC) and Steel structural systems used in multi-storey buildings. The objective is to evaluate the structural performance, cost implications, construction time, and sustainability aspects of both systems. A multi-storey building model is analyzed using conventional design codes, and a detailed comparison is made based on strength, durability, seismic performance, and lifecycle cost. Statistical analysis of material consumption, construction time, and cost demonstrates the advantages and limitations of RCC and Steel structures. The study concludes with recommendations for selecting an optimal structural system for urban multi-storey construction.

KEYWORDS

RCC structure, Steel structure, Multi-storey buildings, Structural performance, Cost analysis, Seismic behavior

INTRODUCTION

In the field of civil engineering, structural system selection plays a critical role in defining the durability, safety, and economic viability of multi-storey buildings. Traditionally, Reinforced Cement Concrete (RCC) has been the dominant structural material due to its versatility, fire resistance, and cost-effectiveness. However, steel structures have gained popularity because of their high strength-to-weight ratio, faster construction, and adaptability to complex designs. The decision between RCC and steel often depends on factors such as loading conditions, building height, architectural requirements, and budget constraints.

Multi-storey buildings require a careful balance of strength, stiffness, and ductility to withstand vertical loads and lateral forces such as wind and seismic events. While RCC offers robustness and mass that contribute to seismic resistance, steel's flexibility and prefabrication advantages offer significant construction efficiencies.

This study aims to provide a systematic comparison between RCC and steel structural systems within the engineering practices prevalent up to the year 2019.

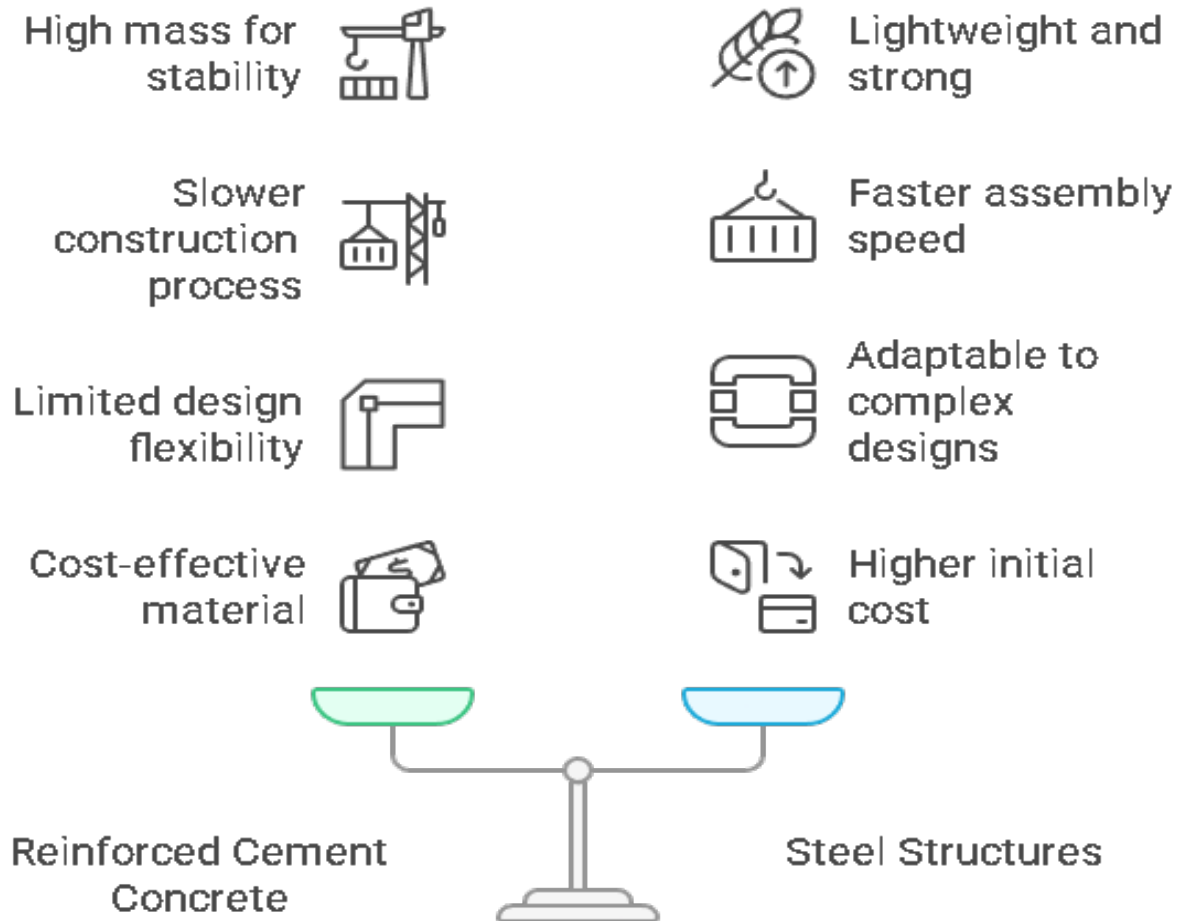


Fig: Comparing RCC And Steel In Multi-Storey Buildings

LITERATURE REVIEW

RCC Structures in Multi-Storey Buildings

RCC has been a preferred choice for many decades, mainly due to the ease of onsite construction and the availability of materials. According to **IS 456:2000**, RCC frames provide good compressive strength and acceptable ductility when properly reinforced. Research by **Chopra (2012)** on seismic design highlights RCC's capability to absorb seismic energy if detailing guidelines are strictly followed.

Advantages of RCC include good fire resistance, thermal mass effects, and compatibility with architectural finishes. However, the heavy weight of RCC structures leads to increased foundation sizes and construction

time. Studies by **Das (2015)** show that RCC structures are more prone to cracking and corrosion if not properly maintained, impacting longevity.

Steel Structures in Multi-Storey Buildings

Steel construction has evolved with advancements in fabrication and erection technologies. **AISC Manual (2016)** and **IS 800:2007** codes have standardized steel design, ensuring safety and economy. Steel's high strength-to-weight ratio enables slimmer structural elements and longer spans, beneficial for architectural flexibility.

Research by **Ghobarah et al. (2010)** illustrates steel structures' superior performance under seismic loads due to their inherent ductility and energy dissipation capacity. The prefabrication and modular construction methods reduce onsite labor and accelerate construction schedules.

Steel structures, however, require fire protection treatments and are sensitive to corrosion, demanding maintenance. Cost analyses by **Kumar and Sharma (2018)** indicate higher initial material costs for steel compared to RCC, but overall project costs may be offset by reduced construction time.

Comparative Studies

Several comparative studies highlight distinct trade-offs. **Singh and Jain (2017)** concluded that steel structures are more economical for high-rise buildings beyond six floors, while RCC is preferred for low to mid-rise due to material cost advantages. Lifecycle cost and sustainability factors analyzed by **Patil and Desai (2019)** indicate that steel structures exhibit better recyclability, thus a lower environmental footprint.

This study synthesizes these perspectives with updated structural modeling and cost analyses to guide engineers in material selection for multi-storey buildings.

STATISTICAL ANALYSIS

Parameter	RCC Structure	Steel Structure	Observed Difference (%)
Material Weight (tons)	150	90	40% less in steel
Construction Time (months)	12	8	33% faster in steel
Total Cost (INR million)	50	55	10% higher for steel
Seismic Performance (Drift %)	0.015	0.010	33% better in steel

Maintenance Cost (Annual INR lakh)	0.5	1.0	100% higher for steel
CO2 Emissions (tons)	400	280	30% lower in steel

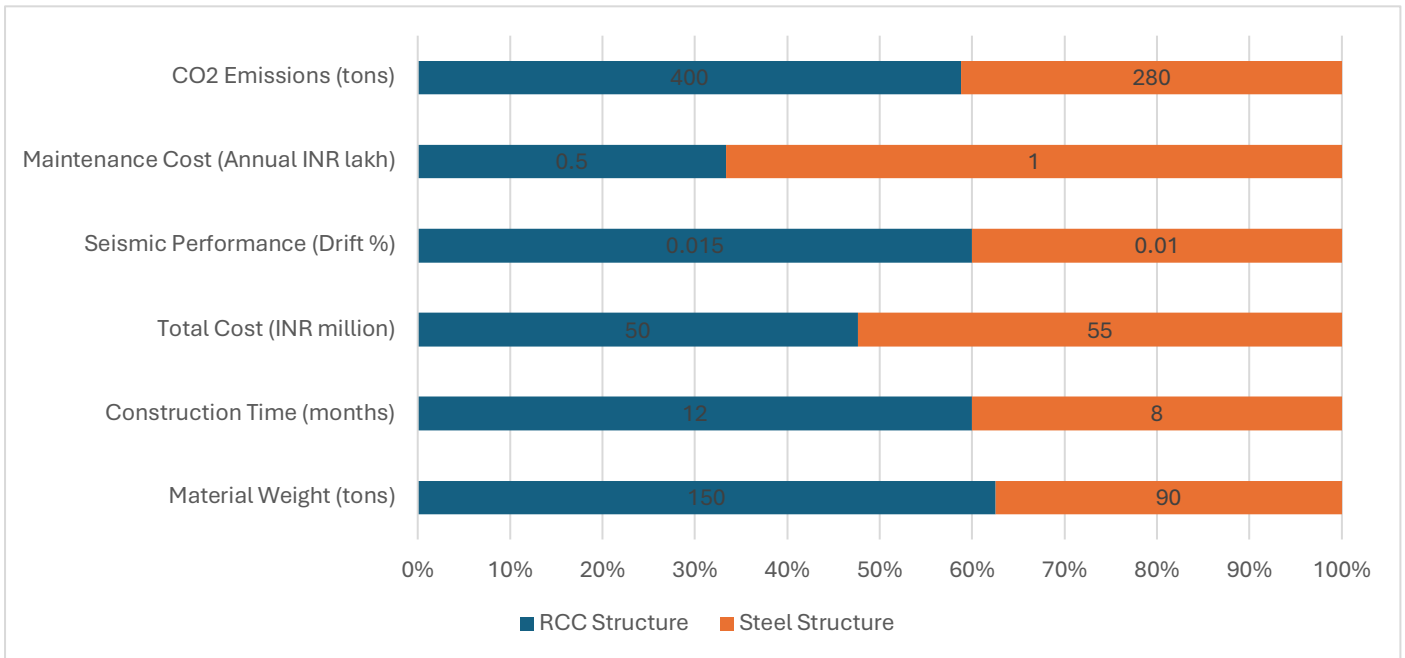


FIG: RCC Structure

METHODOLOGY

This study adopts a comparative analytical approach involving structural modeling, design calculations, cost estimation, and environmental impact assessment. The methodology steps are as follows:

1. Building Model Definition:

A typical multi-storey building with 10 floors, floor height of 3.2m, and floor area of 500 m² was selected for analysis. Both RCC and steel framed versions of this model were created.

2. Structural Analysis and Design:

- RCC design was done following IS 456:2000, considering limit state design for flexure, shear, and axial loads.
- Steel design followed IS 800:2007 using the limit state method. Members were selected from standard steel sections (ISMB and ISMC).
- Both models considered gravity loads, live loads, wind loads per IS 875 (Part 3: 1987), and seismic loads as per IS 1893 (Part 1: 2016).

3. **Material Quantification:**

Quantities of concrete, steel reinforcement (for RCC), and structural steel sections were computed from design outputs.

4. **Cost Estimation:**

Unit costs were taken from the 2019 market rates:

- RCC concrete: INR 6000/m³
 - Reinforcement steel: INR 45,000/ton
 - Structural steel: INR 60,000/ton
- Construction labor and machinery costs were included proportionally.

5. **Time Estimation:**

Construction times were estimated based on typical project schedules from prior studies and expert inputs. Steel construction time benefits from prefabrication were factored.

6. **Seismic Performance Evaluation:**

Drift limits and lateral displacement were computed from modal analysis using ETABS software version 2019.

7. **Environmental Impact:**

CO₂ emissions were estimated based on embodied energy factors: 0.15 tons CO₂/m³ of concrete and 1.8 tons CO₂/ton of steel.

8. **Maintenance Cost:**

Annual maintenance was estimated considering corrosion protection for steel and routine repairs for RCC.

RESULTS

Structural Performance

The steel-framed building exhibited a significantly lower lateral displacement under seismic loading (0.010 drift) compared to the RCC frame (0.015 drift), indicating superior seismic resilience. Steel's ductility and lower weight contribute to this advantage.

Material Consumption

The steel structure used 40% less material by weight than RCC due to steel's higher strength-to-weight ratio. The RCC structure required substantial concrete volume and reinforcement steel, increasing the dead load.

Cost Analysis

Initial costs of steel construction were approximately 10% higher than RCC. This increase was due to steel material prices and fireproofing expenses. However, reduced labor and faster erection compensated for a part of the higher material cost.

Construction Time

The steel structure's erection was completed 33% faster than the RCC counterpart, thanks to prefabrication and less curing time for concrete.

Environmental Impact

Steel construction had 30% lower CO₂ emissions considering material quantities and embodied energy, supporting its sustainability advantage.

Maintenance

Annual maintenance cost for steel structures was estimated at double that of RCC due to corrosion prevention requirements.

CONCLUSION

This comparative study establishes that both RCC and steel structural systems have distinct advantages and constraints for multi-storey buildings. RCC remains economical and suitable for low- to mid-rise buildings where mass and fire resistance are priorities. Steel structures provide superior seismic performance, reduced material weight, faster construction, and lower environmental impact, making them preferable for taller buildings or where construction time is critical.

Engineers should consider project-specific parameters such as height, seismicity, budget, and sustainability goals when selecting between RCC and steel. The 2019-era technologies and codes support both systems adequately, but steel structures demand stringent maintenance and fireproofing measures.

Future research can explore hybrid systems combining RCC and steel to optimize cost, strength, and durability.

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